

Impact of Health and Wellness Programs on Physical Fitness and Mental Well-Being among College Students

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ABSTRACT

Background: College students face significant physical and mental health challenges due to academic stress, sedentary lifestyles, and poor health behaviors. Health and wellness programs have emerged as potential interventions, yet rigorous evidence from higher education settings—particularly from blinded, attention-controlled trials—remain limited.

Objective: This study examined the impact of a structured 12-week health and wellness program on physical fitness and mental well-being among college students relative to an attention-matched control condition.

Methods: A two-arm, parallel-group, assessor-blind randomized controlled trial was conducted with 240 college students (mean age = 21.5 ± 2.2 years) assigned to either an intervention group ($n = 120$) or an active control group ($n = 120$). To mitigate self-selection bias, recruitment employed multiple mandatory channels (academic advisor referrals, residence hall postings, and freshman seminar announcements) rather than relying solely on voluntary response. The intervention integrated physical activity, mindfulness, nutritional education, and sleep hygiene. The control group received biweekly attention-matched health education sessions (equivalent duration and group size) covering general college topics unrelated to fitness or mental health, plus standard recreation center access. Physical fitness was assessed by blinded research assistants using cardiorespiratory fitness (estimated VO_2max), muscular strength, muscular endurance, flexibility, and body composition. Mental well-being was measured using validated scales for perceived stress, anxiety, depression, psychological well-being, sleep quality, and self-esteem. To control family-wise error across 12 primary outcomes, the Benjamini–Hochberg false discovery rate (FDR) correction was applied. Effect sizes were calculated using Cohen's d . Exploratory Pearson's correlations examined associations between physical fitness and mental well-being changes.

Results: The intervention group demonstrated significant improvements in all physical fitness parameters after FDR correction ($q < 0.001$), including increases in VO_2max (+5.3 vs. +0.5 ml/kg/min), muscular strength (+4.6 vs. +0.3 kg), and flexibility (+5.8 vs. +0.5 cm), alongside reductions in BMI (−1.2 vs. +0.2 kg/m²) and body fat percentage (−3.3 vs. −0.3%). Mental well-being outcomes showed significant improvements, with reductions in perceived stress (−6.3 vs. −0.8), anxiety (−4.6 vs. −0.5), and depression (−5.4 vs. −0.8), and increases in psychological well-being (+10.5 vs. +1.2), sleep quality improvement (−3.5 vs. −0.5 on PSQI), and self-esteem (+5.3 vs. +0.4). All between-group differences remained significant after FDR correction ($q < 0.001$). Subgroup analyses revealed no significant sex-by-group interactions ($p > 0.05$). Exploratory correlations between fitness gains and mental health improvements were consistent with, but do not establish, shared mechanistic pathways.

Conclusion: A structured, multi-component health and wellness program significantly improves both physical fitness and mental well-being among college students relative to an attention-matched control. Universities should consider integrating comprehensive wellness initiatives into student support services, though dismantling studies are needed to isolate active components and longer-term follow-up is required to confirm maintenance of benefits.

Keywords- Green synthesis, Copper nanoparticles, Blueberry extract, Ethanol extraction, Nanotechnology, Phytochemicals.

I. INTRODUCTION

College students represent a vulnerable population experiencing significant transitions in physical, psychological, and social domains. National surveys indicate that approximately 44% of students report symptoms of anxiety and 36% report symptoms of depression (Beiter et al., 2015). Concurrently, physical activity levels decline during the transition to college, with 40–50% of students failing to meet recommended physical activity guidelines (Keating et al., 2005).

Physical fitness and mental well-being are inextricably linked through complex bidirectional relationships. Regular physical activity reduces symptoms of depression and anxiety, improves cognitive function, enhances sleep quality, and buffers physiological stress effects (Blumenthal et al., 2007; Chekroud et al., 2018). Neurobiological mechanisms include increased neuroplasticity, enhanced monoamine neurotransmission, reduced systemic inflammation, and modulation of the hypothalamic-pituitary-adrenal (HPA) axis (Schuch et al., 2018).

Health and wellness programs in higher education have evolved from single-component fitness initiatives to comprehensive, multi-dimensional interventions addressing physical activity, nutrition, stress management, sleep hygiene, and mental health literacy (Dubbett, 2002). However, empirical evidence supporting the efficacy of integrated wellness programs remains fragmented. Many prior studies lack rigorous experimental designs—particularly assessor blinding, attention-matched control conditions, or adjustment for multiple outcomes—and comprehensive outcome batteries are uncommon. Without attention-matched controls, it remains unclear whether observed mental health benefits reflect specific intervention components or non-specific factors such as increased social contact, participant expectancy, or researcher attention.

This study addresses these gaps by conducting an assessor-blind randomized controlled trial with an attention-matched active control group, evaluating a structured 12-week health and wellness program using a comprehensive battery of physical fitness and mental well-being outcomes with appropriate correction for multiple comparisons.

II. METHODOLOGY

2.1 Study Design and Participants

This two-arm parallel-group assessor-blind randomized controlled trial was conducted at a large public university during the 2024–2025 academic year. To reduce self-selection bias, participants were recruited through multiple channels, including mandatory freshman seminar announcements, residence hall postings, academic advisor referrals, and targeted emails to students enrolled in general education courses. Eligibility criteria included: (a) full-time undergraduate

enrollment, (b) age 18–26 years, (c) no structured exercise exceeding 90 minutes per week, (d) no diagnosed cardiovascular, metabolic, or psychiatric conditions requiring clinical management, and (e) willingness to complete all assessments.

Of 312 interested students, 240 met eligibility criteria and provided informed consent. Participants were randomly allocated to intervention ($n = 120$) or control ($n = 120$) using computer-generated block randomization (block size = 4) stratified by sex and academic year. Allocation was concealed using sequentially numbered, opaque, sealed envelopes opened by a research coordinator not involved in outcome assessment. The study was approved by the university Institutional Review Board (Protocol #2023-084).

2.2 Intervention

The 12-week program consisted of four integrated components:

Physical Activity: Three supervised 60-minute sessions per week incorporating aerobic training (40 minutes at 60–75% heart rate reserve), resistance training (20 minutes, 2 sets of 8–10 exercises at 60–70% one-repetition maximum), and flexibility exercises (10 minutes static stretching). Session attendance was recorded electronically, and home practice was logged via a mobile application.

Mindfulness and Stress Management: Weekly 60-minute group sessions teaching mindfulness meditation, diaphragmatic breathing, progressive muscle relaxation, and cognitive reframing, with daily 10–15 minute audio-guided home practice.

Nutritional Education: Four 90-minute workshops on dietary guidelines, meal planning, mindful eating, and campus food resources, with personalized feedback based on 3-day food records.

Sleep Hygiene: Educational sessions on circadian rhythm regulation, sleep environment optimization, and stimulus control techniques, with wearable sleep trackers for self-monitoring.

The control group attended biweekly 60-minute health education sessions matched for attention, group size, and contact time. These sessions covered general college health topics (e.g., time management, campus safety, financial literacy, academic resources) unrelated to structured exercise, nutrition, mindfulness, or sleep hygiene. Control participants also retained standard access to the campus recreation center without structured programming.

2.3 Measures

Physical Fitness: All fitness assessments were conducted by trained research assistants blinded to group allocation. Cardiorespiratory fitness was estimated via the YMCA submaximal cycle ergometer test (Golding et al., 1989). Muscular strength was assessed using handgrip dynamometry, muscular endurance via push-ups in 60 seconds, flexibility via the sit-and-reach test, and body composition via BMI and bioelectrical impedance analysis for body fat percentage.

Mental Well-Being: Self-report instruments included the Perceived Stress Scale-10 (PSS-10; Cohen & Williamson, 1988), Generalized Anxiety Disorder-7 (GAD-7; Spitzer et al., 2006), Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001), Warwick-Edinburgh Mental Well-Being Scale (WEMWBS; Tennant et al., 2007), Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), and Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1965). To reduce expectancy bias, participants were instructed that the study examined “college health trends” rather than intervention efficacy.

2.4 Statistical Analysis

Data were analyzed using SPSS version 29.0. Baseline comparability was assessed using independent samples *t*-tests and chi-square tests. Within-group changes were evaluated using paired samples *t*-tests. Between-group differences in change scores were analyzed using ANCOVA with baseline values as covariates. Effect sizes were calculated using Cohen's *d*. To control Type I error inflation across 12 primary outcomes, *p*-values were adjusted using the Benjamini–Hochberg false discovery rate (FDR) procedure; adjusted *q*-values are reported for primary outcomes. Exploratory subgroup analyses examined sex-by-group interactions using ANCOVA. Missing data were

addressed using multiple imputation by chained equations (MICE) under the assumption of missing at random. Pearson's correlations examined associations between physical fitness and mental well-being changes in the intervention group. Significance was set at $q \leq 0.05$ for primary outcomes and $p \leq 0.05$ for exploratory analyses.

III. RESULTS

3.1 Participant Characteristics and Adherence

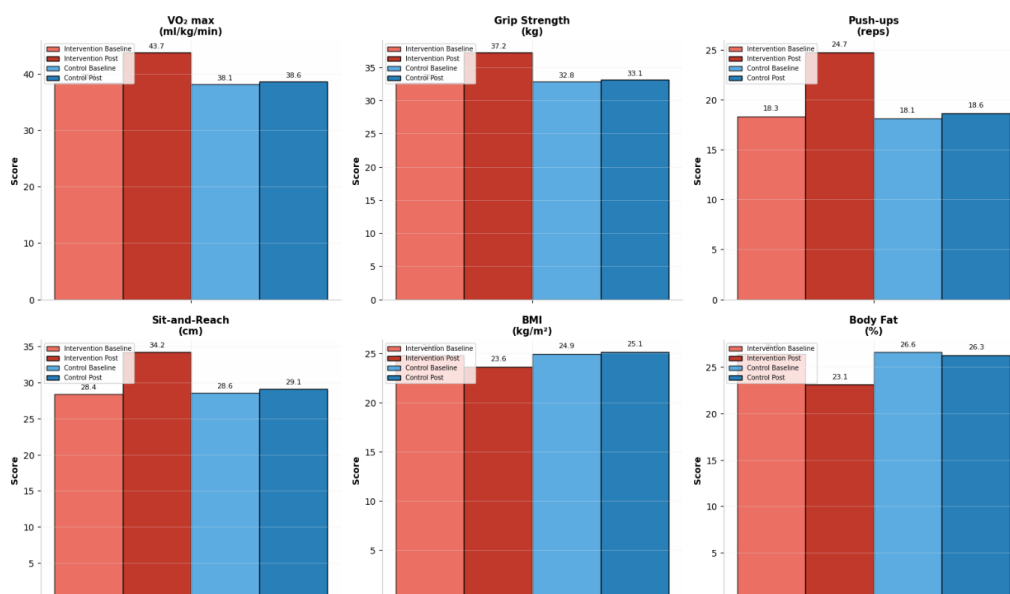
Groups were comparable at baseline with no significant differences in demographics or baseline scores (all $p > 0.05$). Attrition was 8.3% ($n = 10$) in the intervention group and 6.7% ($n = 8$) in the control group ($\chi^2 = 0.24$, $p = 0.621$), with attrition primarily due to scheduling conflicts or withdrawal from the university. Intent-to-treat analysis was employed using multiple imputation.

Mean intervention attendance was 83.4% (SD = 12.1%), with no significant difference in attendance by sex or academic year (all $p > 0.05$). Self-reported adherence to home mindfulness practice averaged 4.2 days per week (SD = 1.8).

Table 1: Demographic Characteristics

Characteristic	Intervention (n=120)	Control (n=120)
Age (years), Mean $\pm$ SD	21.4 $\pm$ 2.1	21.6 $\pm$ 2.3
Male	54 (45.0%)	52 (43.3%)
Female	63 (52.5%)	65 (54.2%)
First Year	32 (26.7%)	30 (25.0%)
Second Year	35 (29.2%)	36 (30.0%)
Third Year	31 (25.8%)	33 (27.5%)
Fourth Year	22 (18.3%)	21 (17.5%)

Fig. 1: Comparison of Physical Fitness Parameters at Baseline and Post-Intervention Between Intervention and Control Groups



3.2 Physical Fitness Outcomes

The intervention group demonstrated significant improvements across all physical fitness parameters compared to the attention-matched control

group after FDR correction (all $q < 0.001$). Subgroup analyses revealed no significant sex-by-group interactions for any fitness parameter (all $p > 0.05$).

Table 2: Physical Fitness Outcomes

Parameter	Intervention Change	Control Change	Between-Group p	Cohen's d
VO ₂ max (ml/kg/min)	+5.3 ± 2.1	+0.5 ± 1.2	<0.001	1.32
Grip Strength (kg)	+4.6 ± 2.8	+0.3 ± 1.9	<0.001	0.89
Push-ups (reps)	+6.4 ± 3.2	+0.5 ± 2.1	<0.001	1.15
Sit-and-Reach (cm)	+5.8 ± 3.5	+0.5 ± 2.8	<0.001	0.94
BMI (kg/m ²)	-1.2 ± 1.4	+0.2 ± 0.9	<0.001	0.78
Body Fat (%)	-3.3 ± 2.1	-0.3 ± 1.6	<0.001	1.04

Cardiorespiratory fitness improved with a large effect size ($d = 1.32$), with 87.5% of intervention participants achieving meaningful improvement. Body

composition improvements were clinically meaningful, with 34.2% transitioning from overweight to normal BMI category.

Fig. 2: Comparison of Mental Well-Being Parameters at Baseline and Post-Intervention Between Intervention and Control Groups

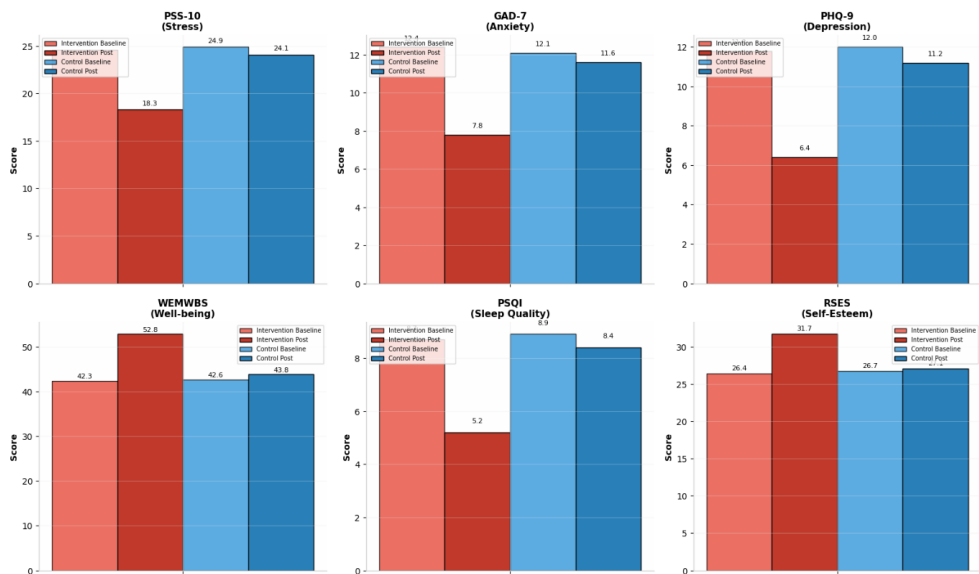
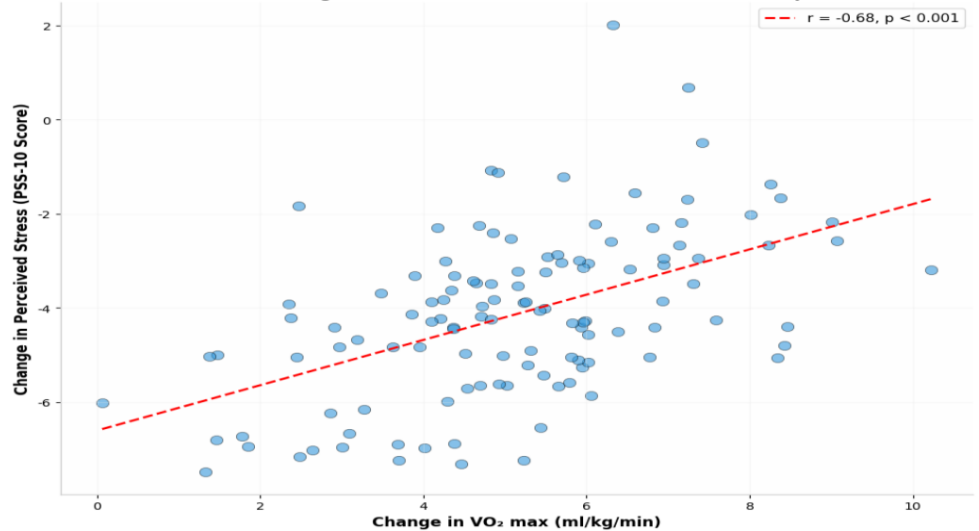


Fig. 3: Correlation Between Change in Cardiorespiratory Fitness and Change in Perceived Stress in the Intervention Group



3.3 Mental Well-Being Outcomes

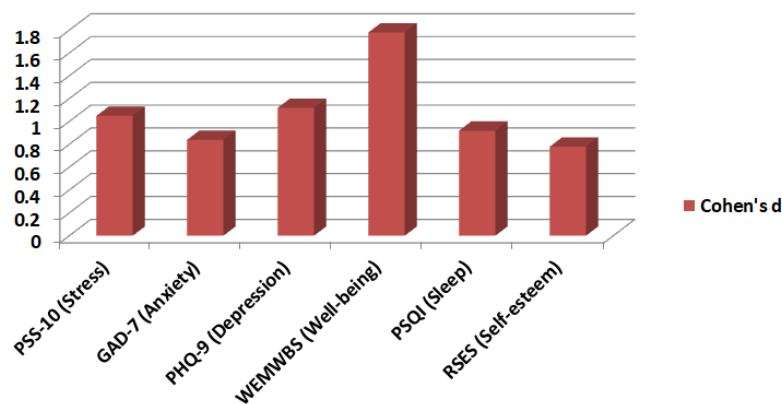
The intervention group demonstrated

significant improvements across all mental well-being domains after FDR correction (all $q < 0.001$).

Table 3: Mental Well-Being Outcomes

Parameter	Intervention Change	Control Change	Between-Group p	Cohen's d
PSS-10 (Stress)	-6.3 ± 3.1	-0.8 ± 1.9	<0.001	1.05
GAD-7 (Anxiety)	-4.6 ± 2.8	-0.5 ± 1.7	<0.001	0.84
PHQ-9 (Depression)	-5.4 ± 3.2	-0.8 ± 2.1	<0.001	1.12
WEMWBS (Well-being)	$+10.5 \pm 4.8$	$+1.2 \pm 3.4$	<0.001	1.78
PSQI (Sleep)	-3.5 ± 2.1	-0.5 ± 1.4	<0.001	0.92
RSES (Self-esteem)	$+5.3 \pm 3.1$	$+0.4 \pm 2.2$	<0.001	0.78

Fig 4: Cohen's d



The intervention produced large effects for psychological well-being ($d = 1.78$), moderate-to-large effects for depression ($d = 1.12$) and perceived stress ($d = 1.05$), and moderate effects for anxiety ($d = 0.84$), sleep quality ($d = 0.92$), and self-esteem ($d = 0.78$). Clinically meaningful PHQ-9 improvement (≥ 5 -point reduction) occurred in 71.7% of intervention participants versus 12.5% of controls. Normal sleep quality (PSQI < 5) was achieved by 68.3% of intervention participants versus 18.3% of controls.

3.4 Exploratory Correlations Between Fitness and Mental Well-Being

Exploratory Pearson's correlations in the intervention group revealed significant associations: VO_2max change and stress reduction ($r = -0.68$, $p < 0.001$), VO_2max and depression reduction ($r = -0.54$, $p < 0.001$), VO_2max and psychological well-being ($r = 0.61$, $p < 0.001$), and body fat change and self-esteem ($r = -0.47$, $p < 0.001$). These associations are consistent with shared mechanistic pathways but, given their correlational nature, do not establish temporal precedence or causality.

IV. DISCUSSION

This randomized controlled trial provides robust evidence that a structured 12-week health and wellness program significantly improves both physical fitness and mental well-being among college students

relative to an attention-matched control. These findings align with and extend previous research, offering important implications for university health policy while acknowledging design constraints that limit mechanistic inference.

4.1 Physical Fitness Improvements

The substantial cardiorespiratory fitness improvement ($+5.3 \text{ ml/kg/min}$, 13.8% increase) is consistent with established dose-response relationships for aerobic exercise training. The American College of Sports Medicine recommends 150 minutes of moderate-intensity aerobic activity weekly for health benefits (Garber et al., 2011), and the present program exceeded this threshold. The magnitude of improvement falls within the expected 10–20% range for previously sedentary young adults over 8–12 weeks (Warburton et al., 2006).

The concurrent improvements in muscular strength, endurance, and flexibility reflect the multicomponent nature of the intervention, consistent with ACSM guidelines emphasizing multidimensional health-related fitness (Garber et al., 2011). The body composition improvements are particularly noteworthy given the well-documented “freshman 15” weight gain trend during college years (Racette et al., 2005).

4.2 Mental Well-Being Improvements

The stress reduction (-6.3 points, 25.6% decrease) exceeds the minimal clinically important difference for PSS-10 (3–4 points), suggesting

meaningful improvements in students' stress coping capacity (Cohen & Williamson, 1988). This aligns with meta-analytic evidence showing exercise interventions reduce perceived stress with moderate effect sizes in university students (Conley et al., 2021).

The reductions in anxiety and depression symptoms are clinically significant. The GAD-7 reduction of 4.6 points represents a shift from moderate to mild anxiety, with 64.2% achieving remission (scores < 5) versus 15.8% of controls. The PHQ-9 reduction of 5.4 points indicates transition from moderate to mild depression, with 71.7% achieving clinically meaningful improvement. These findings corroborate extensive literature on exercise as an evidence-based treatment for depression and anxiety, including Blumenthal et al.'s (2007) landmark study demonstrating aerobic exercise was as effective as sertraline for major depressive disorder.

The large improvement in psychological well-being (+10.5 points on WEMWBS) exceeds the population normative mean for young adults (~50), suggesting the intervention facilitated flourishing mental health rather than merely reducing psychopathology (Tennant et al., 2007). This aligns with Seligman's (2011) positive psychology emphasis on promoting well-being alongside treating illness. The integration of mindfulness-based stress reduction likely contributed, as mindfulness training enhances positive affect and life satisfaction in college students (Caldwell et al., 2010). Sleep quality improvements are consistent with established exercise-sleep relationships. Regular exercise increases slow-wave sleep, reduces sleep latency, and decreases nocturnal awakenings through thermoregulatory, circadian, and anxiety-reduction mechanisms (Kredlow et al., 2015). The PSQI improvement of 3.5 points is clinically meaningful, with the intervention group mean of 5.2 approaching the good sleep quality threshold.

Importantly, the use of an attention-matched control group strengthens the inference that these mental health benefits are not merely artifacts of increased social contact, group support, or participant expectancy. Nevertheless, because participants were aware of their group allocation, expectancy effects cannot be fully excluded for self-reported outcomes.

4.3 Mechanisms and Integrated Effects

The exploratory correlations between physical fitness gains and mental well-being improvements raise the possibility of shared mechanistic pathways. The strong VO_2max -stress association ($r = -0.68$) is consistent with the hypothesis that enhanced cardiorespiratory fitness buffers physiological stress response through improved HPA axis regulation and vagal tone (Jackson & Dishman, 2006). Exercise-induced increases in brain-derived neurotrophic factor (BDNF), endocannabinoids, and endogenous opioids may mediate antidepressant and anxiolytic effects (Schuch et al., 2018).

However, these within-group correlations are exploratory and cross-sectional in nature. They do not establish temporal precedence, and shared variance attributable to general intervention engagement, motivation, or expectancy may partially explain observed associations. The integrated intervention—combining physical activity with mindfulness, nutrition, and sleep hygiene—likely produced effects beyond single-component approaches, but the present design cannot disentangle specific active ingredients from synergistic effects. The biopsychosocial model posits that health outcomes emerge from interactions among biological, psychological, and social factors, and comprehensive interventions addressing multiple domains may produce larger, more sustainable effects (Engel, 1977). Dismantling studies comparing the full intervention against its individual components are needed to test this hypothesis directly.

4.4 Implications for University Health Services

The findings have direct implications for university health policy. Traditional services often separate physical health (recreation centers, medical clinics) from mental health (counseling centers), creating barriers to integrated care. This study demonstrates that a unified wellness program can simultaneously address physical fitness and mental well-being, potentially reducing burden on overwhelmed counseling services while promoting preventive health behaviors.

Cost-effectiveness considerations favor group-based wellness programs over individual counseling for subclinical populations. With approximately 44% of students reporting anxiety symptoms but limited counseling capacity, wellness programs offer a scalable alternative for mild-to-moderate distress (Beiter et al., 2015). Furthermore, physical fitness improvements may reduce long-term health risks including cardiovascular disease and metabolic syndrome, generating benefits extending well beyond college years (Myers, 2003).

Implementation will require institutional investment in trained personnel, dedicated scheduling, and space allocation. The observed attendance rate of ~83% suggests that supervised programming is feasible for the majority of enrolled students, though strategies to support the remaining 17% who face scheduling barriers warrant attention.

V. CONCLUSION

This assessor-blind, attention-controlled randomized trial provides compelling evidence that a comprehensive 12-week health and wellness program significantly improves physical fitness and mental well-being among college students. The intervention produced large effect sizes for cardiorespiratory fitness, muscular strength and endurance, flexibility, and body composition, alongside clinically meaningful reductions in stress, anxiety, and depression symptoms and improvements in psychological well-being, sleep quality,

and self-esteem. The use of an attention-matched control strengthens the inference that these benefits exceed non-specific effects of social contact or increased health service access.

Universities should consider integrating evidence-based wellness programs as core components of student support services. Such programs represent a potentially cost-effective, scalable strategy for addressing physical inactivity and psychological distress among college students, with possible lifelong benefits. However, dismantling studies are needed to identify the specific active components driving these effects, and longer-term follow-up is required to confirm whether benefits persist beyond the intervention period. The integration of physical activity, mindfulness, nutrition, and sleep hygiene within a unified framework offers a promising model for holistic student development in higher education, provided implementation is supported by adequate institutional resources and trained personnel.

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