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Physiological Suboptimal Health Phenotypes among University Students within the SHS Framework and Their Association with Physical Activity

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Abstract: In recent years, insufficient physical activity has coincided with suboptimal health among university students. Drawing on the Suboptimal Health Status (SHS) framework, this study surveyed 314 students from multiple provinces/ municipalities in China. Physical activity was assessed with a physical activity level scale, and health status with the Sub-Health Measurement Scale Version 1.0 (SHMS V1.0). Correlation and multiple regression analyses were used to test associations. Physical exercise was positively associated with overall health ($r = 0.515$, $p < 0.001$) and, after adjusting for sex, only-child status, and place of origin, remained a significant predictor of better health ($\beta = 0.515$, $t = 10.512$, $p < 0.001$). Sex was associated with exercise level, whereas other demographic variables showed no significant effects on health status. These findings suggest that promoting moderate-to-vigorous physical activity and campus sport participation may improve students' physiological, psychological, and social adaptation, providing practical guidance for health promotion and exercise prescription in higher education.

Keywords: Physical Exercise; Physical Activity; Suboptimal Health; Mental Health

1.Introduction

In recent years, alongside continuous socioeconomic development, lifestyles have undergone profound changes, and insufficient physical activity among adolescents has become widespread. Among university students, health problems arising from a lack of physical activity—particularly insufficient time spent in moderate-to-vigorous physical activity (MVPA)—have become a global epidemiological concern [1][2]. In 1946, the World Health Organization (WHO) defined health not merely as the absence of disease or infirmity, but as a state of complete physical, mental, and social well-being [3][4]. As living environments continue to change rapidly, a growing number of people report feeling unwell without a clear medical diagnosis, a phenomenon termed suboptimal health status (SHS) [5]. SHS is conceptualized as a "third state" between health and disease, emphasizing the integrated dimensions of physiological, psychological, and social adaptation [6]. An increasing body of research shows that SHS is not uncommon among adolescents and university students. For example, in a survey of 11,144 Chinese students from four universities, the detection rate of SHS was 55.9% (healthy 22.81%, SHS 55.9%, disease 21.25%), and scores on the three dimensions (physiological, psychological, social) differed significantly between the SHS and healthy groups [7]. Another study reported that 40.4% of Chinese university students had mental health problems [8], and

a separate investigation found a 24.8% prevalence of depressive symptoms in this population [9]. Etiological investigations indicate that modifiable lifestyle factors are closely linked to SHS, with "insufficient physical activity" repeatedly identified as an important risk factor. Among Chinese first-year university students, those with lower levels of physical activity were more likely to be classified as SHS, alongside differences in sleep, electronic device use, and nutrition [6]. In broader student samples, items such as "physical activity" and "nutrition" within the Health-Promoting Lifestyle Profile II (HPLP-II) are particularly associated with physiological health, further supporting the theoretical pathway whereby improving exercise behavior can ameliorate somatic aspects of SHS [7].

However, in real-world settings students' engagement in moderate-to-vigorous physical activity (MVPA) is generally insufficient. In a survey of 1,668 Chinese high school students, only 30.9% met the recommendation of ≥60 minutes of MVPA per day; those who met the guideline exhibited significantly better mental health, suggesting a dose–response association between physical activity and health [10]. This aligns with the World Health Organization's guidance for daily MVPA in adolescents and indirectly reflects the current shortfall in school-stage physical activity. Insufficient MVPA is also associated with a markedly elevated risk of psychological suboptimal health: among Tibetan university students living at high altitude, compared with ≥61 minutes/day, those with ≤30 minutes/day had an odds ratio of approximately 3.0 for psychological suboptimal health, with a stable linear trend [11]. Taken together, these findings highlight that—amid academic pressure, environmental constraints, and lifestyle transitions—increasing students' MVPA is a critical leverage point for health promotion. Despite these valuable clues linking "exercise" and "health," much of the existing evidence centers on psychological outcomes. Quantitative evidence on the relationship between physical activity level (especially MVPA) and physiological (somatic) suboptimal health, including potential threshold effects and intensity-specific differences, remains relatively scarce. Accordingly, using a representative sample of young university students and validated tools for assessing health and physical activity, the present study aims to (a) describe the distributional features of physiological SHS across physical-activity levels, (b) test the dose–response relationship between MVPA and physiological suboptimal health, and (c) further explore potential moderating effects of sex, year in school, and related factors.

2.Methods

2.1 Participants

This study targeted university students from multiple provinces and municipalities in China and employed a randomly sampled online survey. A total of 320 questionnaires were collected. After excluding submissions with abnormal completion times or invariant response patterns, 314 valid questionnaires remained, yielding a valid response rate of 98.13%. Among the valid sample, 121 were male (38.50%) and 193 were female (61.50%). By residence, 154 participants (49.00%) were from rural areas and 160 (51.00%) from urban areas. Regarding only-child status, 107 (34.10%) were only children and 207 (65.90%) were non–only children.

2.2 Measures

2.2.1 Sociodemographic characteristics

The first section of the questionnaire collected sociodemographic information, including sex, place of origin, education level, and only-child status.

2.2.2 Physical Activity Rating Scale

Physical exercise behavior was quantified using the Physical Activity Rating Scale revised by Liang Deqing (PARS-3) [12]. The scale comprises three dimensions—exercise intensity, exercise duration, and exercise frequency—each rated on a five-point Likert scale (1 = lowest, 5 = highest). Exercise volume was calculated as: exercise volume = intensity × (duration − 1) × frequency, where intensity, duration, and frequency denote the raw scores of each dimension. The raw composite score was then mapped onto a 0–100 standardized interval and categorized into three levels: low (0–19), moderate (20–42), and high (43–100) exercise volume. In this study, the scale showed good internal consistency (Cronbach's α = 0.769 > 0.70) and, given its wide use among Chinese scholars, is considered a mature instrument with acceptable reliability and validity.

2.2.3 Sub-Health Measurement Scale Version 1.0 (SHMS V1.0)

Based on the WHO definition of health and adapted to Chinese sociocultural contexts and lifestyles through Delphi expert

consultation, item analysis, and item screening, Xu et al. developed the SHMS V1.0 as a quantitative measure of suboptimal health; large-sample testing has demonstrated satisfactory reliability and validity [13]. The instrument contains 9 dimensions and 39 items covering physiological, psychological, and social health. Items 1–15 form the physiological subscale, items 16–28 the psychological subscale, and items 29–39 the social subscale. Responses use a five-point Likert format, with higher scores indicating better health at the dimension, subscale, and total-scale levels. In the present study, internal consistency was excellent (Cronbach's α = 0.919).

2.3 Statistical Analysis

Data were processed using SPSS 26.0. Correlation and regression analyses were conducted to examine the association between physical exercise and suboptimal health.

3.Results

Table 1. Correlation between physical exercise and suboptimal health (N = 314)

	1.Gender	2.Only-child status	3.Place of origin	4
4.Physical exercise	-0.140*	-0.002	0.055	——
5.Suboptimal health	-0.105	0.005	-0.057	0.515***

Note: ***P<0.001, **P<0.01, *P<0.05

As shown in Table 1, Pearson correlations indicated a significant positive association between physical exercise and (better) health status (r = 0.515, p < 0.001), suggesting that higher exercise levels were linked to better overall health and a lower degree of suboptimal health. Sex was negatively correlated with exercise level (r = −0.140, p < 0.05), indicating that male students reported higher levels of physical exercise than female students.

Table 2. Effects of physical exercise on suboptimal health (N = 314)

	Suboptimal health					
	Model1			Model2		
	β	t	p	β	t	p
1.Gender	-0.105	-1.861	0.064	-0.032	-0.662	0.508
Only-child status	0.030	0.517	0.606	0.036	0.706	0.480
Place of origin	-0.063	-1.071	0.285	-0.095	-1.879	0.061
2.Physical exercise				0.515	10.512	0.000
R^2		0.015			0.274	
F		1.557			29.205***	

Note: ***P<0.001, **P<0.01, *P<0.05

As shown in Table 2, linear regression indicated that sex, only-child status, and place of origin did not predict suboptimal health (ps > .05). In contrast, physical exercise positively predicted health status on the SHMS V1.0 (β = 0.515, t = 10.512, p < .001), i.e., higher exercise levels were associated with better health (lower suboptimal health).

4.Discussion

Drawing on a sample of 314 university students from multiple provinces and municipalities in China, and using two widely adopted, psychometrically sound instruments—the revised Physical Activity Rating Scale and the Sub-Health Measurement Scale Version 1.0 (SHMS V1.0)—this study examined the association between physical exercise and health status in undergraduates. We observed a moderately large positive correlation between physical exercise and the SHMS total score (r = 0.515, p < .001). After adjusting for sex, only-child status, and place of origin, physical exercise remained a significant positive predictor of health status (β = 0.515, t = 10.512, p < .001). In other words, within this sample, students who

exercised more tended to be healthier (i.e., exhibited less suboptimal health, as higher SHMS scores indicate better health). Although sex was significantly associated with exercise level, sex, only-child status, and place of origin did not directly predict health status (ps > .05), suggesting that the direct effects of these demographic variables on SHMS were limited in this dataset.In terms of concordance with prior research, our findings reinforce the conclusion that higher levels of moderate-to-vigorous physical activity (MVPA) are associated with better mental health and lower psychological suboptimal health. Among Tibetan university students residing at high altitude (n = 8,721), those reporting ≤30 minutes/day of MVPA had a substantially higher risk of psychological suboptimal health than those reporting ≥61 minutes/day (overall adjusted OR ≈ 2.99), underscoring a pattern whereby insufficient activity is linked to elevated suboptimal-health risk [11]. In a national sample of Chinese high school students, only 30.9% met the guideline of ≥60 minutes/day of MVPA, and those meeting the guideline had a significantly lower prevalence of mental health problems, further supporting, at the population level, the link between meeting activity recommendations and better mental health [10]. Although our undergraduate sample was not stratified by MVPA minutes per se, the effect observed on the continuous "exercise volume" measure was directionally consistent with these MVPA-threshold studies, suggesting cross-instrument robustness of the exercise–health association. It is noteworthy that the moderating role of sex in the relationship between exercise and psychological/suboptimal health is not consistent across studies. In the high-altitude Tibetan sample, the association between MVPA and psychological suboptimal health was significant in men but not in women [11], whereas in the Chinese high school sample, MVPA compliance was higher among boys, and compliance was associated with better mental health [10]. In the present study, sex correlated with exercise level but did not directly predict SHMS scores. This heterogeneity implies that sex may influence health outcomes indirectly—e.g., via differential likelihood of meeting MVPA guidelines, differences in body composition, preferences for activity types, or varying social/academic pressures. Future work should test stratified and interaction models in larger samples with more granular exposure and outcome definitions.

In sum, this study documents a significant association between greater physical exercise and better health (less suboptimal health) among university students, converging with findings from multiple Chinese populations and different measurement approaches [10][11]. Longitudinal and intervention studies—ideally incorporating objective activity monitoring and comprehensive control of confounders—are warranted to clarify causal pathways and dose–response functions. Further, examining mediators and moderators such as sex, adiposity distribution, sleep, and academic stress will help build a stronger evidence base for precision "exercise-for-health" strategies in higher-education settings.

Limitations and Future Directions

This study has several limitations that warrant cautious interpretation. First, the cross-sectional, self-report design identifies associations rather than causality and cannot rule out reverse causation (e.g., healthier individuals being more inclined to exercise) or common method bias. Second, the geographic coverage and institutional types represented in the sample were limited, and potential influences of seasonality and the academic calendar on activity and health were not controlled, constraining external validity and the statistical power for stratified or interaction tests. Future research can proceed along several actionable pathways: prioritize prospective cohort designs, cross-lagged panel models, and randomized controlled interventions to strengthen internal validity; and combine JITAI (just-in-time adaptive interventions) with behavioral-economics incentives (e.g., commitment devices, loss-aversion-framed rewards) to improve adherence and long-term maintenance. These steps would help develop a scalable, sustainable, and evaluable "exercise-for-health" intervention framework targeting suboptimal health among university students.

Conclusion

In this university sample, physical exercise was significantly and positively associated with health status: the more sufficiently students exercised, the higher their SHMS V1.0 dimension and total scores—indicating better overall health and a lower risk of suboptimal health. This association remained robust after controlling for basic sociodemographic factors, suggesting that physical exercise may be a key modifiable determinant of multidimensional health (physical, psychological, and social adaptation) among undergraduates. Given the widespread shortfall in moderate-to-vigorous physical activity (MVPA)

on Chinese campuses, our findings support university-based strategies that increase students' daily activity—especially sustainable MVPA combining aerobic and muscle-strengthening components—to reduce the suboptimal-health burden and improve population health. Future longitudinal and intervention studies are warranted to verify causal pathways and dose–response functions, and to examine the mediating or moderating roles of sleep, diet, sedentary behavior, and academic stress, thereby informing more actionable, comprehensive health-promotion programs in higher-education settings.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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