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Gamification as a Means of Increasing Students' Motivation for Physical Activity

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Abstract: Sustaining students' motivation for physical activity is a central challenge in university physical education. Gamification addresses this challenge by structuring participation around clear goals, progress feedback, achievable challenges, rewards, and social interaction. Objective: This study examines the relationship between students’ exercise patterns and psychological well-being and uses this evidence to develop a mathematically specified gamification framework for strengthening motivation, engagement, and sustained participation in university physical activity. Methods: Data came from the 2021 Chinese General Social Survey. The analytic sample included 313 enrolled tertiary students aged 18-30 years. Exercise frequency ranged from never to daily, and elevated depressive mood was defined as feeling depressed or down at least sometimes during the previous four weeks. Binary and ordinal regression models adjusted for age, sex, household registration, socioeconomic position, and education type. In addition to the observational models, a mathematical framework is specified for evaluating gamified physical-education interventions through repeated measures of motivation and activity adherence. Results: Weekly-or-more exercise was reported by 65.8% of students, while 23.5% met the elevated depressive-mood threshold. Weekly-or-more exercise was not significantly associated with elevated depressive mood after adjustment (OR = 0.86, 95% CI 0.48-1.55, p = .615). The ordinal model likewise showed no dose-response association (OR = 0.95, 95% CI 0.77-1.17, p = .628). Conclusions: Exercise frequency alone did not distinguish students by depressive mood, indicating that frequency is an incomplete description of participation. For gamified physical education, motivation should be modeled directly through documented design features and repeated motivational outcomes rather than inferred from activity frequency. The CGSS does not measure gamification or exercise motivation, so the proposed framework requires controlled testing in university PE settings with longitudinal follow-up where possible.

Keywords: Gamification; Physical Activity; Student Motivation; Physical Education; Exercise Frequency; Depressive Mood; College Students; CGSS; China.

1. Introduction

A problem which is often overlooked in university physical education is that attendance is compulsory, but motivation is not. Students can be engaged in a class and not have the interest or confidence to stay engaged outside the class. One answer to this gap is through gamification. A PE programme can make it easier for students to see what they are trying to achieve, to monitor how far they have progressed, to receive feedback, to be challenged, to be rewarded and to be able to work together in a short time frame and this can make it easier for them to see the effort they are putting in. The idea is not to make all classes a game, but to leverage some of the features of a game to help achieve this goal.

There is recent evidence to support this approach. The impact of game-based learning and gamification in physical education was generally positive for motivation, engagement, learning and health-related outcomes, but the interventions varied in their design[1]. Sotos-Martínez et al. (2024) concluded in a university experiment that a gamified physical activity program boosted intrinsic motivation and decreased amotivation. The results have implications for the role of motivation in the design of university PE, as it has been explored as an outcome rather than a design concept. Physical activity is also associated with mental health – prospective and intervention evidence: In many populations, regular physical activity has been associated with fewer depressive symptoms [3-6]. There are two strands of evidence that indicate that, if good PE is to be judged by the extent of movement, and by how the experience of participation is structured, then the "how" is as important as the "how much". More recent college-specific evidence also shows this: a 2025 meta-analysis revealed that there is an inverse association between physical activity and depression among college students, which highlights the importance of directly studying the college student population, rather than college specific data being limited to broader adult evidence [7].

It is important to go into the context of Chinese universities. The tertiary education environment is demanding and competitive, and much of what students are learning, how, and where is rapidly changing, as is their social environment and daily routine. The COVID-19 pandemic has further complicated these transitions in 2020 and 2021. Campus/course closures and restrictions limited social interaction and physical activity. In addition to sleep, alcohol consumption and mental health, there were documented reductions in physical activity during containment periods across the globe [8-10]. Educational disruption, uncertainty and changed routines were particularly impactful on university students [11-13]. Similar findings were also observed in Chinese college students: a significant psychological burden was reported among college students during the same period, and exercise was reported to have a protective effect on mental health [14-15].

These conditions also pose a practical problem in terms of motivation. Even when daily routines are thrown off, a gamified structure could offer short-term goals, progress that is noticeable, and social cues to keep them going, even if that means keeping them moving through class or during on-campus exercise or on their own. This option is particularly important in university environments where students might have the freedom to organize physical activity to a large extent.

While physical education is supported in the literature as being a health promoting environment, it is also evident in the literature that claims need to be congruent with the study design. Much of the research conducted during the pandemic was cross-sectional, and so measured activity and mental health at the same time. These designs are capable of detecting patterns but cannot determine if an exercise caused a mood change, a mood change caused an exercise change or if both were affected by some other factor. Both types of studies have strengths and weaknesses: longitudinal studies enhance the ability to establish a temporal order, but are prone to self-selection, whereas randomized trials offer greater causal evidence but are limited in scope and follow-up. The same applies to gamification: any evidence that a gamified program impacts on motivation should be from a design that measures both the program and motivation.

Based on the 2021 Chinese General Social Survey (CGSS), the present study investigates the exercise behaviors of young people and the psychological state of young people, as the empirical basis of the motivation-oriented gamification framework. Then, the analysis is extended, conceptually, to illustrate the formalization of the implementation of goals, feedback, progression, cooperation and recognition in the design and evaluation of a gamified university physical education. In addition to demographic and socioeconomic covariates, the survey contains a direct item on leisure time physical exercise and a direct item on depressive mood. It lacks gamification exposure and a validated instrument to assess motivation to exercise. The exercise-frequency/mood association is therefore tested in the empirical analysis, and the gamification aspect is developed as a pedagogical interpretation: If the exercise-frequency alone association is weak, future PE programs would benefit from testing if motivational design features can help to increase engagement and motivate sustained exercise participation beyond asking students to exercise more often.

This distinction is important because motivation, depressive mood, and gamification are different constructs. The A17 item is used as a psychological well-being indicator, rather than as an indicator of exercise motivation, as they indicated how often they were depressed or down in the past four weeks. Similarly, there is no CGSS item that reflects the exposure to points, badges, progress feedback, team challenges, or other gamified elements. These boundaries help to distinguish between gamification and an observational survey as a gamification trial.

The study's contributions are three-folded. The first is that it describes the frequency of exercise and depressive mood among a subsample of Chinese tertiary students who were not specifically selected to participate in an exercise program. Second, it compares the exercise-mood result on the binary, ordinal, weighted and sensitivity specifications. Third, and most pertinent to the title, it sets the boundaries of such a frequency-based exposure and outlines what a more powerful gamified PE study should look at: (1) motivation, (2) engagement, (3) adherence, (4) types of game elements, and (5) psychological outcomes. The contribution is thus empirical and design-based, and not a type of exposure the CGSS did not document.

Based on this, the study will focus on three related research questions. RQ1: Does there exist a positive relationship between physical-exercise frequency and higher depressive mood among the Chinese tertiary students? RQ2: Does the frequency of depressive mood change systematically with the frequency of exercise? RQ3: What are the mathematical representations and assessments of the gamification elements that could contribute to enhancing students' motivation and engagement as well as their sustained participation in university physical education activities? The first two questions are explored empirically with data from the CGSS, while the third question is the design framework for designing a purpose-built gamified PE intervention.

1.1. Literature Review and Conceptual Rationale

1.1.1. Physical activity, physical education, and mental health

Physical activity, exercise and physical education are connected but not synonymous. Physical activity is any activity that raises the body's energy consumption, and exercise is activity that is deliberately planned and regular. Physical education is a learning environment in which physical activity is taught, engaged in, assessed and socially experienced. This is important because a PE program may impact more than the time spent: it may impact competence, self-efficacy, peer belonging, enjoyment, perceived autonomy, and also use of exercise for self-regulation. Two students could be active for the same amount of time, and end up with drastically different learning and motivating experiences.

Moderate-to-vigorous physical activity has physical and mental health benefits, and current public-health guidelines call for activity at these intensities [15]. Recent syntheses also support the mental health-rationale. In prospective studies, [13] found a dose-response association between physical activity and depression. In the systematic review, [16] concluded that PA interventions were effective in lowering depression, anxiety and psychological distress in a variety of populations. Likewise, several randomized trials by [17] demonstrated the effectiveness of various exercise modalities on symptoms of depression. Overall, these findings indicate that physical activity has the potential to be a part of student well-being initiatives. More recent studies examining physical activity as related to depression among college students also suggest that overall, physical activity is correlated with depression, with the strength of the relationship differing depending on the study design and type of physical activity [18].

Not all students or settings will benefit from these. Effectiveness may differ depending on the type of exercise, supervision, intensity, preference, and baseline symptoms; and the social setting in which they are undertaken. The competitive session can be stimulating to some and demoralizing to others. Similarly, a compulsory course can serve as a structure that diminishes students' sense of autonomy if they believe that they may not be successful or that they are being evaluated. Physical-activity education is not only about exercise dose, it's about the design of physical-activity education. Evidence on the mental health effects of school-based interventions reveals potential benefits, but this is not guaranteed and the quality of evidence is variable [19]. Similarly, [20] highlighted that physical activity is best used as part of a supportive system.

These are particularly applicable to university PE. Students are still developing their physical activity habits as they adjust to the additional autonomy and responsibilities of college, as well as increased academic workload. True, a good PE programme must have enough exercise dose, but it must also build skills to a high level, be inclusive, provide psychological safety and have reasons for pupils to keep coming back. The frequency of exercise is a good measure at an aggregate level, but is not a measure of the quality of the experience. That's where gamification comes in.

1.1.2. *Gamification, motivation, and sustained physical activity*

Gamification and Game-based learning are not synonymous. While game-based learning involves the game as the learning activity, gamification involves the addition of some game elements to an activity that is already an activity (in this case physical education/exercise). In University PE, points or badges can be used, but so can be less obvious: levels of difficulty, personal progress displays, immediate feedback, team missions and recognition of consistent participation. It is important to consider if the design provides a clear and explicit rationale for initiating, sustaining and revisiting activity [4].

Motivation is responsive to the use of these features. The leaderboard can stimulate some students and demoralise others, and a reward can make some students focus on earning the one or make others focus on the prize. Gamification is therefore more believable when it provides challenge that can be met, choice that's within the game, mastery that can be achieved, social cooperation where other people are involved, and feedback that's useful. It is an important factor in PE because there may be differences in fitness, confidence and previous sport experience levels in the same class.

Evidence that is promising and in development. [4] identified that gamification and game-based approaches in PE were often linked with higher levels of motivation and engagement. More directly related to higher education, [2] found that when physical activity was gamified, rather than non-gamified, there was an increase in intrinsic motivation and a decrease in amotivation among university students. These results indicate that the mode of participation might be an independent factor, aside from exercise frequency.

The main pedagogical justification for the title is this evidence. The present CGSS analysis is unable to assess if gamification increases the motivation as there is no gamification exposure or direct measure of exercise-motivation included in the survey. It can, however, provide an indication as to whether or not frequency of exercise, alone, is highly correlated with the available psychological outcome. This is why the next step is to more accurately capture the motivational process itself, rather than making inferences based on how much exercise students do, in a purpose-built gamified PE study.

A future gamified PE program can be considered as a design vector $g = (g1, g2, g3, g4, g5)$ with the elements indicating goal structure, feedback, challenge/progression, social cooperation and reward/recognition. Then, the measurement of motivation (M) and sustained activity or adherence (A) should be taken as a measure of the two rather than as a measure of gamification. It is important to note that this notation does not produce new variables which are not found in the CGSS; rather it is a description of what a direct test of the title would need to document and estimate.

$$GDI_j = \sum_{k=1}^{5} \omega_k g_{jk}, \qquad \sum_{k=1}^{5} \omega_k = 1.$$

Here, GDI_j denotes the Gamification Design Index for class j; g_{jk} represents the implemented level of goals, feedback, challenge/progression, social cooperation, and reward/recognition; and ω_k represents the relative contribution assigned to each component. The index provides a transparent mathematical representation of intervention intensity and is proposed for future experimental testing rather than calculated from the CGSS data.

1.1.3. *Exercise and mood during the COVID-19 period*

COVID-19 provided an unprecedented opportunity to examine the relationship between movement and mental health in a natural setting. Travel opportunities, organized sports and spontaneous movement opportunities were curtailed during Lockdowns and during days of distancing. Large multicountry studies showed significant differences in physical activity and sedentary behavior [21-22]. At the onset, guidance was given to keep people active and practice infection control [23]. The evidence from a subsequent systematic review demonstrated that there was widespread reduction in activity but this was variable depending on population and assessment method (Stockwell et al., 2021). These behavioral shifts were accompanied by higher uncertainty and psychological stress, and systematic-review evidence showed that there was significant mental-health impact in the general population [24].

Several studies have been published that indicate that those who were more active throughout the pandemic had improved psychological results. In a study by[25], it was reported that more active adults reported less depressive and anxiety symptoms during the periods of self-isolation. In Italy, [26]found a relationship between physical activity and psychological well-being and in [27]) showed the same connection between physical activity and psychological well-being among adults. [28] identified links between change in activity and sedentary time and mental health in a large sample from the USA. Physical activity was also related to mental health and well-being early in containment in a multicountry analysis [28], and to mental health during lockdown in Austria (Pieh et al., 2020). The researchers at [29] found that decreased levels of physical activity correlated with greater depression and anxiety. A rapid review also concluded broadly, highlighting significant design constraints [30].

These studies are applicable but do not provide a consistent protection effect. Physical activity was just one aspect of a pandemic pattern of behaviour. [31] reported that the physical activity, sleep, smoking and alcohol changes are linked to depression, anxiety and stress. Similarly, [22] reported concurrent physical activity, diet, and sleep changes. [32] suggested that there exists a pre-existing trend of physical inactivity and sedentary lifestyle that may be exacerbated by the pandemic and would go beyond a single outcome. [33] emphasized the positive and practical aspects of activity during restriction. Physical activity, then, was an important health behaviour during lockdown, but not an alternative to comprehensive health care, as [33] noted.

It also had an impact on the lives of the university students both inside and outside of class. Gallo et al. (2020) described the alterations in physical activity and energy intake of university students in Australia during isolation. During confinement, physical activity and sedentary time were found to change in university students by [34].[32] found a change in mental health and movement behavior among University of Birmingham students. [22] reviewed the existing literature and determined that overall, university students have low levels of physical activity. Son et al. (2020) found that there were a significant amount of mental health impacts among college students, and that stress was associated with disruption of academic and daily living.

China is a context of particular relevance during the early stage of the pandemic. Chinese college students were found to experience anxiety with psychological stress by [29]. Later, [30] published longitudinal relationships between physical activity and mental health issues among college students in China. The results are consistent with the hypothesis that exercise is associated with psychological adjustment, and also illustrate the need for temporal ordering. It is not the same to assess exercise and mental health at one time point as to be able to assign a structured intervention.

1.1.4. From association to intervention

If motivation is supposed to increase, the students have to be exposed to a defined gamified program, in that case a claim is made that is not backed up by any design. The study would have to report on the elements of the game used, the number of days of game delivery, whether students had a comparison condition with the same exercise content played, fidelity of implementation, and the change in motivation from baseline to follow-up. Alongside attendance and physical activity, motivation needs to be measured, as a program can be fun without increasing activity, or more fun without increasing intrinsic motivation. These requirements can't be met from the cross-sectional survey data, by simply adding the covariates.

The same goes for the present exercise-mood analysis. More active students may have different social support, campus resources, sleep patterns, health, academic stress, and/or personality than less active students. Exercise may influence mood and mood may influence willingness to exercise. The lack of time order can be partially removed by statistical adjustment, though not completely. The estimated odds ratios are hence associations and can not be interpreted as an estimate of exposure to gamification, rather as a proxy of it.

The same applies to a null association. It does not indicate that PE or gamification doesn't work. A frequency item does not indicate how long, how intense, how much fun, how much autonomy, how much feedback, how much social interaction, or how an activity is presented. Two students may be doing the same amount of exercise yet possibly have very different motivational experiences. Some of the features of a gamified program may be entirely unrelated to what is measured by CGSS and thus impact persistence or enjoyment. The correct inference is tighter: For this sample, the measured mood outcome was associated with or not associated with frequency of exercise.

The two levels of the paper are combined in Figure 1. The top line shows the observational CGSS analysis of exercise frequency and depressive mood after adjusting for covariates. The lower pathway shows how the proposed gamification mechanism is expected to be connected to student motivation, engagement or adherence, and to sustained physical activity, via goals, feedback, progression, cooperation and recognition. The two layers are conceptually intertwined, but analytically distinct.

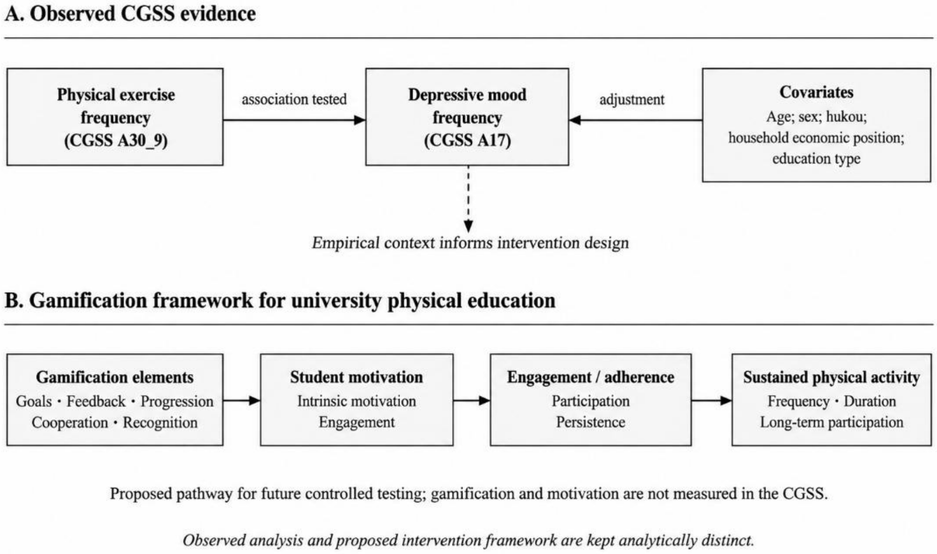

Figure 1. Integrated empirical and gamification framework. The upper pathway represents the observational CGSS analysis, while the lower pathway specifies the motivation-oriented mechanisms to be evaluated in gamified university physical education.

1.1.5. Depressive mood as a contextual psychological outcome

While the CGSS focuses on the motivation of students to be physically active, there is no validated tool measuring students' motivation in the CGSS. The psychological outcome is available as A17: How often during the last four weeks did you feel depressed or down? Depressive mood is thus regarded as a background variable of psychological health and wellbeing. It can't be used as a proxy of motivation, enjoyment, engagement, or response to gamification.

A17 is still to be interpreted with caution. The opinions of feeling depressed or down sometimes, often or always do not constitute a clinical diagnosis of depression. It does not set the standards for clinical severity, duration, impairment or symptom counts. Elevated depressive mood (sometimes, often, and always) is used as the elevated category for this study, and rarely and never are used as the comparison category. Pathological thresholds are not used and the original five-level item is also kept in an ordinal model.

Maintaining its scope does not cause one survey question to become more of a construct than it is data; it is just a question. Cronbach's alpha does not apply to a single item and confirmatory factor analysis is not useful without a multi-items latent scale. The same flow is followed for the title: Motivation and Gamification are mentioned only if there is supporting evidence, and neither is measured directly in A17.

1.1.6. Empirical hypotheses and gamification-oriented interpretation

The statistical hypotheses involve the variables that are actually observed. The first is a pragmatic threshold hypothesis: that students who report several times a week or daily exercise will have a lower likelihood of having elevated depression mood compared to those who do not exercise as often. The second is a dose-response hypothesis that each additional category of increasing exercise frequency should be associated with a decreasing category of depressive mood after controlling for measured covariates.

These are association hypotheses. Neither gamification nor exercise motivation is measured in the CGSS, so there is no hypothesis that gamification caused any change in motivation. The gamification argument, on the other hand, is used to make sense of the results in practice and to define a testable intervention: a program in which game design features are intentionally provided, and motivation, participation, and well-being are assessed pre- and post-intervention.

2. Materials and Methods

2.1. Study design and data source

This study is a secondary cross-sectional analysis of the public-use 2021 Chinese General Social Survey. The data supplied for use in Stata (CGSS2021.dta) was made up of 700 variables and 8,148 respondent records, where the unit of observation was the individual respondent. No new subjects were recruited, contacted, or given to an exercise condition for the present analysis. The design is thus incapable of estimating a randomized treatment effect.

The variables used in the analysis were included in the survey: physical-exercise frequency (A30_9), depressive mood (A17), education status (A7a), education level (A7b), demographic measures, relative household economic position (A64), and survey weight. The other health and behavior questions such as vigorous exercise, alcohol and sleep were provided in the D and E questionnaire modules. These were omitted from the age-eligible student sample because they were not all administered to all students. Primary exposure and/or primary outcome were therefore not defined using them.

There was no direct measurement of gamification in the CGSS, nor was there an item in the analytic set to provide a validated measure of motivation toward physical activity. In the current models, gamification is instead considered as a design approach rather than an empirical exposure. The data observed are utilized to estimate the relationship between exercise frequency and mood, and the mathematical extension below outlines how the relationship between exercise frequency and motivation could be tested directly in a future PE trial based on the concept of gamification. This separation ensures that the proposition in the title is not assumed from variables that were not collected.

2.2. Eligibility criteria and analytic sample

The analytic population were tertiary students who were enrolled at the time of the survey. The respondents were first asked about A7b, and were then asked about a tertiary level category in A7a. The education categories eligible to be included were: adult higher-education college, regular higher-education college, adult higher-education bachelor, regular higher-education bachelor and postgraduate or above. This resulted in 340 tertiary respondents who were currently studying.

This was the main age category restriction which was applied (18-30 years). Age was estimated as being approximately 2021 minus reported year of birth. This restriction was set at the traditional college-age range and limited heterogeneity from older adult learners resulting in 313 respondents. Sensitivity analysis extended the age range to all registered tertiary students (with valid ages) currently enrolled from ages 18 to 50 years, and determined if the substantive conclusion was sensitive to the primary age restriction.

The sample-selection process is illustrated in Figure 2, which highlights the data lost in the process of going from the full CGSS 2021 file to the primary complete-case regression sample. All 313 age-eligible students (100%) had a valid exercise-frequency response. Two respondents provided responses that were either not usable or refused to respond to the depression-mood item and 12 respondents did not provide or refused to provide a response to the relative household economic position item. The main complete-case regression sample thus consisted of 300 students. The core variables were sparsely missing, whereas the variables from the modular D and E questionnaires had large amounts of structural missingness and were not dealt with as ordinary item nonresponse.

2.3. Measures

Table 1 summarizes each variable, its operational definition, and its analytic role, distinguishing eligibility variables, the primary exposure and outcome, covariates, and the survey weight used for sensitivity analysis. Physical-exercise frequency was measured with CGSS item A30_9, which asked how often the respondent participated in physical exercise during free time in the previous year. Response categories were never, a few times per year or less, a few times per month, several times per week, and daily. For the ordinal exposure, these categories were coded from 0 to 4 in increasing frequency. For the primary binary contrast, several times per week and daily were coded as weekly-or-more exercise, while the other three categories were coded as less-than-weekly exercise.

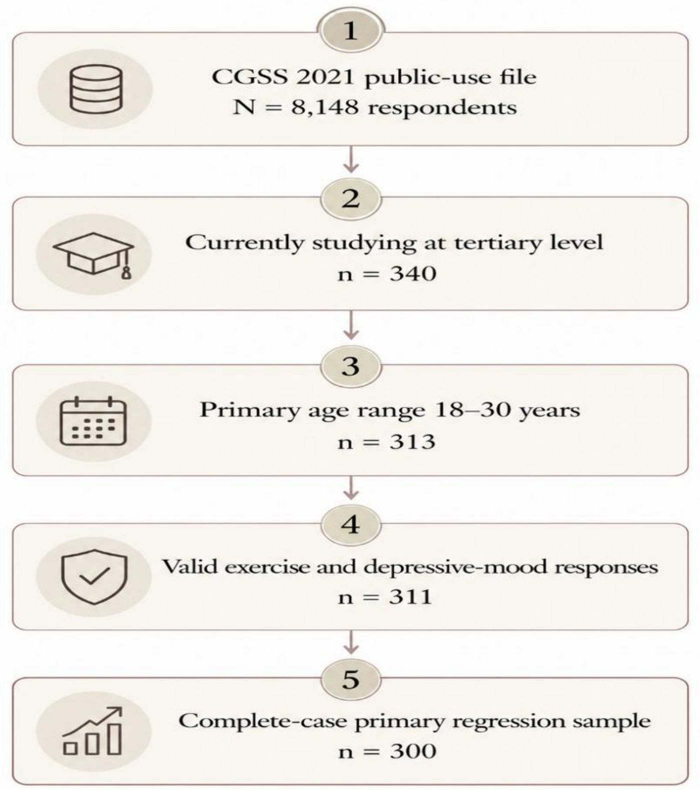

Figure 2. Sample-selection flow from the full CGSS 2021 file to the primary complete-case regression sample.

Table 1. Variable definitions and analytic roles.

Construct	CGSS variable	Operationalization	Role
Current tertiary enrollment	A7a + A7b	A7b = currently studying and A7a in tertiary-level categories	Sample eligibility
Approximate age	A3_1	2021 minus reported birth year; restricted to 18-30 years in primary analysis	Control / eligibility
Physical exercise frequency	A30_9	Never=0; a few times/year or less=1; a few times/month=2; several times/week=3; daily=4	Primary exposure
Weekly-or-more exercise	A30_9 derived	Several times/week or daily=1; lower frequency=0	Primary binary exposure
Depressive mood frequency	A17	Never=0; rarely=1; sometimes=2; often=3; always=4	Primary ordinal outcome
Elevated depressive mood	A17 derived	Sometimes/often/always=1; rarely/never=0	Primary binary outcome
Sex	A2	Female=1; male=0	Control
Household registration	A18	Agricultural hukou=1; non-agricultural/other=0	Control
Relative household economic position	A64	Below average, average, above average; unknown/refusal treated missing	Control
Education type	A7a derived	Adult higher education, graduate, regular tertiary	Control

Survey weight	weight	Supplied CGSS weight; used only in sensitivity analysis	Sensitivity

Note. Variable labels and operational definitions were taken from the supplied CGSS 2021 working file. Derived variables were created only from listed source items.

The primary outcome was from CGSS item A17: "In the past 4 weeks, how often did the respondent feel depressed or down? The responses were rated from never to always and were coded for analysis from 0 to 4. A binary elevated-mood indicator was generated by combining the response options sometimes, often and always together, and rarely, never together. If respondents did not indicate their answer as one of the other options, the responses “Do not know” and “Refuse to answer” were considered missing. The value of at least occasional mood experience was selected for the binary threshold to distinguish it from "rare or absent mood experience" and is not meant as a clinical threshold.

Gamification wise, A30_9 is a behavioural frequency measure not an engagement measure. It does not separate the students' enjoyment, habit, course requirements, competition, rewards, social support, and personal goals for exercising. This restriction is key to the interpretation: a paper about motivation needs to be complemented by future studies on: activity measures and direct motivational instruments; and documented gamification features.

On conceptual grounds, selection of covariates was not done based on models significance and only variables available for the student subsample were included. Age was treated as a continuous variable and sex (A2) was dichotomized as female or male. Household registration (A18) was dichotomised into agricultural and non-agricultural/other. Relative household economic position (A64) was re-coded as below average, average or above average; unknown and refused responses were coded as missing. Type of education was categorized as regular tertiary, graduate or adult higher. These variables were not chosen from the list of variables that might be on the causal pathway between exercise and mood.

The supplied survey weight was not utilized in the primary analysis as the study targeted a filtered student subpopulation, and the working file did not include all the complex survey design metadata necessary for design-based variance estimation. Therefore, the weighted modeling was considered a sensitivity analysis to the main complete case model and not as a substitute to it.

2.4. Missing data and data-quality checks

Prior to modeling, values were screened. N = 313 (Primary age-eligible) were no missing responses regarding the exercise frequency. 0.6% of the sample was not usable for two depressive-mood responses. There were 12 (3.8%) non-substantive or missing responses among the 262 respondents who answered the question on relative household economic position. No imputation was done as the missingness of the core variables was minimal and 300 cases were available for the parsimonious model.

The D and E modules also comprised additional health-behaviour variables, such as smoking, alcohol consumption, quality of sleep and the level of vigorous exercise. Almost two thirds of the student subsample were not able to provide data on these variables because the relevant modules were not completed by all respondents. This structural missingness is different from the regular item nonresponse. A general index of “abnormal behavior” would have significantly decreased the number of samples and variables in the modules from different assignments. It would also have resulted in a composite that the survey has not directly measured. For these reasons, the A17 depressive-mood item was the primary outcome.

Categorical frequency distributions were examined for sparse cells. Of the age-eligible students with valid responses, three responded that they often and two responded that they always had depressive mood. The higher levels were thus rare in these classes. This led to the use of the binary elevated-mood outcome for the primary logistic model and the use of the original 5-level item in an ordinal sensitivity model. The frequency of exercise was more balanced except for the “never” group. Therefore, prevalence estimates were reported for each category and a confidence interval was calculated for each estimate, without being interpreted as a smooth dose-response pattern.

2.5. Mathematical and Statistical Analysis

2.5.1. Observational statistical models

Descriptive statistics summarized age, sex, education type, hukou, relative household economic position, exercise frequency, and depressive-mood frequency. Within each exercise-frequency category, the percentage of students with elevated depressive mood was calculated. Wilson 95% confidence intervals were used for these proportions because some groups were small. Spearman rank correlation assessed the ordinal association between exercise frequency and depressive-mood frequency. A chi-square test compared elevated-mood prevalence between weekly-or-more and less-than-weekly exercise groups.

The primary multivariable model was binary logistic regression with elevated depressive mood as the outcome and weekly-or-more exercise as the focal exposure. Let Xi denote the ordinal exercise-frequency score (0-4), Wi = 1(Xi >= 3) denote weekly-or-more exercise, Yi denote the ordinal depressive-mood score (0-4), and Di = 1(Yi >= 2) denote elevated depressive mood. Let Zi be the vector of prespecified covariates: age, sex, agricultural hukou, household economic position, and education type. The primary model was written as:

$$\log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 W_i + \mathbf{Z}_i^T \boldsymbol{\gamma}$$

Here p_i = P(D_i = 1 | W_i, Z_i). The coefficient beta_1 is reported as an odds ratio through exp(beta_1); OR = 1 indicates no association. HC3 heteroskedasticity-consistent standard errors were used for the primary logistic model, and effect estimates are reported with 95% confidence intervals and two-sided p values.

$$\log\left(\frac{P(Y_i \le k)}{P(Y_i > k)}\right) = \theta_k - \left[\alpha X_i + \mathbf{Z}_i^T \boldsymbol{\gamma}\right], \qquad k = 0, 1, 2, 3$$

The proportional-odds specification uses the original five-level depressive-mood outcome. The parameter alpha represents the change in cumulative log-odds associated with a one-category increase in exercise frequency, conditional on the same covariates. This formulation makes the dose-response test explicit rather than relying only on the weekly threshold.

$$L_w(\boldsymbol{\beta}) = \sum_i w_i \left\{ D_i \log(p_i) + (1 - D_i)\log(1 - p_i) \right\}$$

For the survey-weighted sensitivity model, w_i denotes the supplied CGSS survey weight. The weighted objective above changes the contribution of each respondent to estimation but does not convert the filtered analysis into a full design-based survey analysis because replicate-weight and complete complex-design information were not available.

The exercise association was evaluated in three alternative specifications. First, exercise frequency was modeled as an ordinal score rather than dichotomized at the weekly threshold. Second, an ordered logistic model retained the original five-level depressive-mood outcome together with the ordinal exercise score. Third, the binary logistic model was re-estimated using the survey weight supplied in the file. Two additional sensitivity analyses expanded the age range to all currently enrolled tertiary students aged 18–50 and added self-rated physical health to the primary covariate set.

2.5.2. Mathematical specification of gamified physical education

$$M_{ijt} = \beta_0 + \beta_1 G_j + \beta_2 T_t + \beta_3 (G_j \times T_t) + u_j + v_{ij} + \varepsilon_{ijt}$$
$$A_{ijt} = \gamma_0 + \gamma_1 G_j + \gamma_2 T_t + \gamma_3 (G_j \times T_t) + u_j^* + v_{ij}^* + \eta_{ijt}$$

For a future controlled gamified PE evaluation, M_{ijt} represents the motivation score of student i in class j at time t, while A_{ijt} represents activity participation or adherence. G_j indicates gamified versus standard PE, and T_t represents measurement occasion. The interaction coefficients β_3 and γ_3 quantify whether motivation and activity change differently over time under gamified PE. The class-level and student-level random effects account for clustering and repeated observations.

No machine-learning model was used. The study question was inferential rather than predictive; the primary sample contained 300 complete cases, and both the exposure and outcome were low-dimensional survey items. A machine-learning pipeline would not address the causal limitations of the design and would reduce interpretability. Accordingly, no black-box predictive model or feature-importance analysis was fitted. This choice maintained consistency between the method and the research question.

All analyses were conducted in Python 3.13.5. Data handling used pandas 2.2.3 and NumPy 2.3.5; statistical models were implemented with statsmodels 0.14.6, and supporting calculations used SciPy 1.17.0.

Figures were created with Matplotlib 3.10.8. Figure 3 summarizes the analytical workflow from eligibility screening and variable recoding through model estimation, sensitivity checks, and bounded interpretation. The analysis script and pre-generated tables and figures are provided in the reproducibility package. A two-sided $p < .05$ was used as a conventional significance threshold, while effect sizes and confidence intervals were emphasized over significance labels.

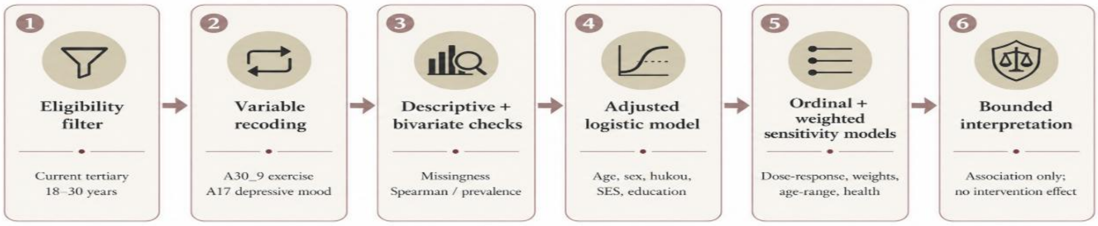

Figure 3. Reproducible analytical workflow from tertiary-student eligibility through bounded interpretation.

2.6. Ethical and reporting considerations

No new participants were recruited, contacted or offered to an intervention and no individuals were found in the de-identified public use survey file. No effort was made to identify respondents. The materials provided for this analysis did not contain the consent wording from the original CGSS or the name or approval number of an ethics committee. This manuscript makes no inferences nor creates any details about such. Only verified ethics and consent information from official CGSS source should be included at the time of the submission.

The analysis is based on a conservative reporting principle in that it explains associations rather than claims the data is a randomized experiment. The term "intervention" is only used when referring to experimental literature or designing future physical-education programs. This boundary is necessary to avoid giving the impression that a population association is an assessed curricular treatment.

3. Results

3.1. Sample characteristics

There were 313 tertiary students currently enrolled who were eligible for the primary age sample. The mean approximate age was 21.09 years (SD = 2.11; range, 18–30), and 169 participants (54.0%) were women. The majority of students were in regular tertiary education (80.2%), followed by graduate education (11.2%) and adult higher education (8.6%). 158 students reported having agricultural hukou; 50.5% reported having agricultural hukou. As for the relative household economic position, 68.4% indicated an "average" position, 17.3% "below average," 10.5% "above average," and 3.8% responded "missing" or "non-substantive.

Exercise was often, but not always, common. Two-thirds of the students (23.3%) said they did exercise every day and 133 students (42.5%) said they did several times a week. Overall, 206 students (65.8%) fulfilled the weekly-or-more definition. A further 20.8% exercised a few times a month, 8.9% a few times a year or less and 4.5% never exercised. Table 2 gives the demographic profile and the distributions of exercise frequency and depressive mood.

Table 2. Characteristics of the age-eligible tertiary-student sample.

Characteristic	Category/statistic	n or mean	% or SD
Sex	Female	169	54.0
	Male	144	46.0
Education type	Regular tertiary	251	80.2
	Graduate	35	11.2
	Adult higher education	27	8.6
Hukou	Agricultural	158	50.5
	Non-agricultural/other	155	49.5
Household economic position	Below average	54	17.3
	Average	214	68.4

	Above average	33	10.5
	Missing	12	3.8
Exercise frequency	Never	14	4.5
	A few times/year or less	28	8.9
	A few times/month	65	20.8
	Several times/week	133	42.5
	Daily	73	23.3
Depressive mood	Never	121	38.7
	Rarely	117	37.4
	Sometimes	68	21.7
	Often	3	1.0
	Always	2	0.6
	Missing	2	0.6
Age, years	Mean (SD)	21.09	2.1
Weekly-or-more exercise	Yes	206	65.8
Elevated depressive mood	Yes	73	23.5

Note. Primary age-eligible sample n = 313. Depressive-mood percentages use the full age-eligible denominator; two respondents had missing outcome data.

Depressive mood was generally absent or infrequent. Among the 311 students with valid A17 responses, 121 reported never feeling depressed or down during the previous four weeks and 117 reported rarely. Sixty-eight reported sometimes, three often, and two always. Under the prespecified binary definition, 73 students met the elevated depressive-mood threshold, corresponding to 23.5% of valid respondents. The number of events was adequate for a parsimonious adjusted model, but the rare "often" and "always" responses did not support separate category-specific regression estimates.

3.2. Bivariate relationship between exercise and depressive mood

The unadjusted pattern did not show a monotonic dose-response relationship. Figure 4 shows the depression mood prevalence before adjustment according to exercise frequency categories. The prevalence rates were 14.3% for students who never exercised, 40.7% for those who exercised a few times per year or less, 23.1% for those who exercised a few times per month, 21.1% for those who exercised several times per week, and 23.6% for those who exercised daily. The pattern thus did not decrease monotonically with increasing exercise frequency. The two lowest exercise frequency groups had very wide confidence intervals, and the resulting point estimates should be interpreted with caution.

The Spearman correlation between exercise frequency and depressive-mood frequency was small and not statistically significant (rho = -0.047, p = .410), providing no evidence of a monotonic ordinal relationship. When exercise was dichotomized, elevated depressive mood was reported by 26.4% of students who exercised less than weekly and 22.0% of those who exercised weekly or more, a difference of 4.4 percentage points. The chi-square test was not significant (chi-square = 0.55, p = .460). Table 3 brings these bivariate results together, allowing the correlation, group prevalences, and chi-square comparison to be read in the same context. Internal-consistency reliability was not reported because both focal measures are single items rather than multi-item scales.

Table 3. Bivariate associations between exercise and depressive mood.

Analysis	Comparison	N	Estimate	p
Spearman correlation	Exercise frequency vs depressive-mood frequency	311	-0.047	.410
Prevalence	Less than weekly exercise: elevated depressive mood	106	26.4%	
Prevalence	Weekly-or-more exercise: elevated depressive mood	205	22.0%	

Chi-square	Weekly exercise group vs elevated depressive mood	311	0.55	.460

Note. Prevalence values are unadjusted. The chi-square test compares weekly-or-more with less-than-weekly exercise.

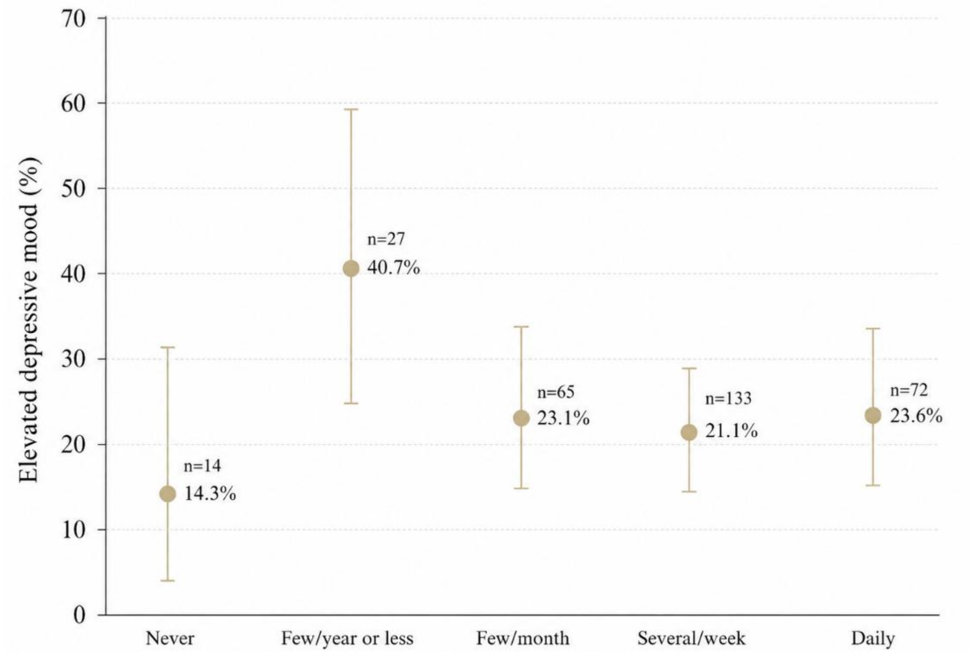

Figure 4. Prevalence of elevated depressive mood across exercise-frequency categories. Error bars show Wilson 95% confidence intervals.

3.3. Primary regression models

In the unadjusted logistic model, weekly-or-more exercise was associated with an odds ratio of 0.79 for elevated depressive mood compared with less frequent exercise (95% CI 0.45-1.37, p = .394). An OR of 0.79 corresponds to 21% lower estimated odds, but the confidence interval included 1.00 and also allowed for higher odds. The unadjusted data therefore did not provide statistically reliable evidence of an association.

Adjustment for age, sex, hukou, household economic position, and education type did not materially change the result. The adjusted odds ratio for weekly-or-more exercise was 0.86 (95% CI 0.48-1.55, p = .615), corresponding to 14% lower estimated odds. Because the confidence interval included 1.00, the data remained compatible with lower odds, no association, or higher odds of elevated depressive mood. The corresponding average marginal effect was an estimated 2.6 percentage-point lower probability, which should be interpreted cautiously given the uncertainty in the focal estimate. Figure 5 displays the adjusted odds ratios and 95% confidence intervals for the primary model; the reference value of OR = 1.00 represents no association. In practical terms, the adjusted model does not support describing weekly-or-more exercise as protective, because the confidence interval spans both appreciably lower and higher odds of elevated depressive mood.

The conclusion was unchanged when exercise frequency was treated as a five-level ordinal predictor. In the adjusted binary logistic model, each one-category increase in exercise frequency was associated with an OR of 0.96 (95% CI 0.73-1.27, p = .783), equivalent to 4% lower estimated odds, but the confidence interval included 1.00. In the ordered-logit model retaining the five-level depressive-mood outcome, each one-category increase in exercise frequency yielded an OR of 0.95 (95% CI 0.77-1.17, p = .628), again providing no evidence of a dose-response association. Table 4 presents the primary and alternative model estimates side by side so that the consistency of the exercise coefficient across specifications can be assessed directly. Across specifications, the exercise estimates were close to 1.00 and all confidence intervals included the null value, indicating that the overall finding was not an artifact of the weekly exercise threshold. Thus, neither the weekly threshold nor the ordinal specification produced a statistically reliable exercise-mood pattern.

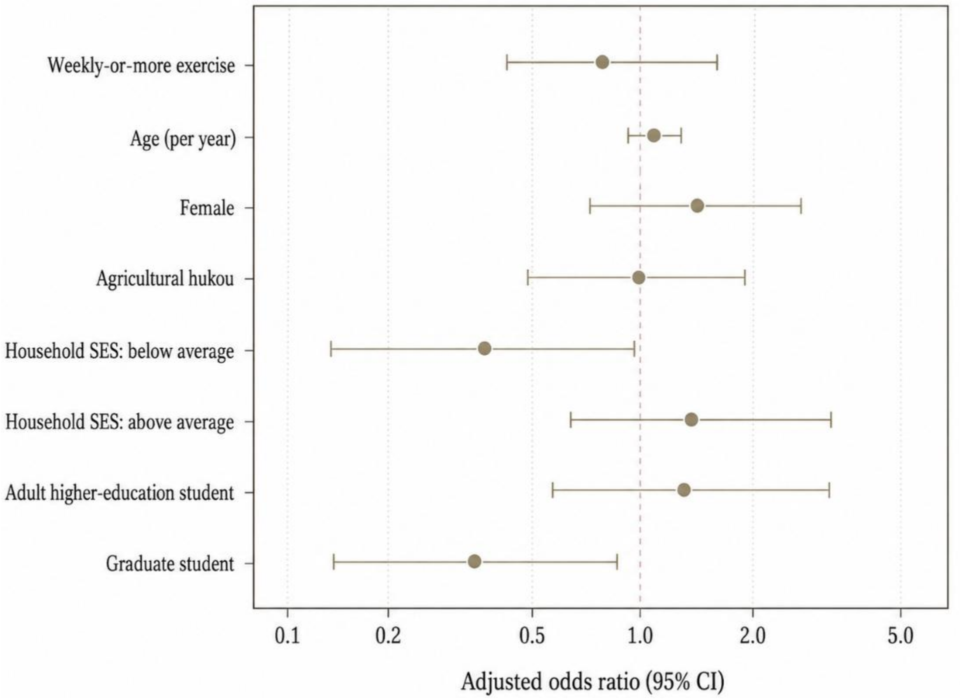

Figure 5. Adjusted odds ratios for elevated depressive mood in the primary logistic-regression model. Points show odds ratios; horizontal lines show 95% confidence intervals.

Table 4. Primary and alternative model estimates.

Model	N	OR	95% CI low	95% CI high	p
Unadjusted logistic: weekly-or-more exercise	300	0.79	0.45	1.37	.394
Adjusted logistic (HC3): weekly-or-more exercise	300	0.86	0.48	1.55	.615
Adjusted logistic (HC3): one-category increase in exercise	300	0.96	0.73	1.27	.783
Adjusted ordinal logit: one-category increase in exercise	300	0.95	0.77	1.17	.628

Note. Odds ratios are reported with 95% confidence intervals. Adjusted models include age, sex, hukou, household economic position, and education type. HC3 = heteroskedasticity-consistent covariance estimator.

3.4. Sensitivity analyses

The survey-weighted adjusted model produced an OR of 0.90 for weekly-or-more exercise (95% CI 0.49-1.67, p = .749). This estimate was close to the unweighted adjusted OR of 0.86 and did not change the substantive conclusion. When the age range was expanded to include all currently enrolled tertiary students aged 18–50, the OR was 0.79 (95% CI 0.46-1.37, p = .406). The wider age range therefore did not reveal an association that was absent from the primary analysis.

A second sensitivity model added self-rated physical health to the covariate set. Weekly-or-more exercise remained unrelated to elevated depressive mood (OR = 0.93, 95% CI 0.50-1.76, p = .833), corresponding to only 7% lower estimated odds and a confidence interval that included 1.00. Self-rated health was associated with depressive mood, but because the temporal ordering among health, exercise, and mood was unclear, it was included only as a sensitivity covariate. Table 5 summarizes the sensitivity estimates before presentation and shows that none materially altered the primary conclusion. Taken together, these checks reinforce rather than overturn the primary finding.

Table 5. Sensitivity analyses for the weekly-or-more exercise contrast.

Sensitivity analysis	N	OR	95% CI low	95% CI high	p
Survey-weighted adjusted logistic	300	0.90	0.49	1.67	.749
All currently enrolled tertiary students, age 18-50	327	0.79	0.46	1.37	.406
Additional adjustment for self-rated physical health	300	0.93	0.50	1.76	.833

Note. All sensitivity models estimate the weekly-or-more exercise contrast and include the core covariates unless otherwise stated.

Taken together, the primary and sensitivity analyses do not provide clear support for either prespecified empirical hypothesis. Higher exercise frequency was not reliably associated with lower depressive-mood frequency, and weekly-or-more exercise was not reliably associated with lower odds of elevated depressive mood after adjustment. The confidence intervals remain compatible with a modest benefit, no association, or a modest increase in odds. The most appropriate interpretation is therefore not that exercise has no psychological value, but that this cross-sectional sample does not establish a stable exercise-frequency/mood relationship.

For the gamification-focused question, this result is best treated as a boundary condition rather than a test of the intervention. Students with higher exercise frequency did not show a clear advantage on the measured mood indicator, so frequency alone does not capture the full psychological experience of participation. The analysis cannot determine whether a gamified program would increase motivation, adherence, or well-being because those variables were not measured.

4. Discussion

4.1. Principal finding

One of the most important empirical results was that there was no clear difference in the effect of exercise frequency alone on depressive mood. The 95% CI for the weekly or more exercise group included 1.00 and the ordinal analysis also was not significant. This is not a surprise for a paper focused on gamification as exercise has its own worth and frequency is merely a description of participation. The CGSS frequency item does not measure how students feel about the activity (e.g., accessibility, reward, social, etc.).

This is where gamification can come into play as a PE design strategy. Gamification can make progress visible, allow breaking down larger objectives into more manageable, offer feedback and make social motivations to participate. Generally positive motivational and engagement results were reported in gamification and game-based PE research (Camacho-Sánchez et al., 2023) and university physical-activity intervention gamification resulted in higher intrinsic motivation and lower amotivation (Sotos-Martínez et al., 2024). The findings address the motivational issue contained in the title, while the CGSS analysis provides population context regarding frequency of exercise habits and mood.

It is not permissible to combine the two types of evidence into a single claim. It does not appear that gamification positively impacts motivation as revealed by the CGSS, and the association is not held causal by the intervention literature. They complement each other in value. Both the survey result and the literature on gamification provide guidelines to what can be tried when the aim is to make the people feel more motivated and more willing to continue their exercise, but they do not agree on which factor should not be strictly considered. Evaluation of future efforts should then measure motivation, real activity, attendance and psychological well being independently of each other rather than as a single entity.

4.2. Why a clear association may not appear

The weak pattern observed could be due to several causes. First, it is possible that the differences in exposure are not meaningful, and thus, frequency may misclassify them. One student may be exercising several times a week doing some active team sports and another student may be doing some lighter, shorter activity. If intensity, duration, or enjoyment or social interactions are important to psychological benefit, the frequency only item merges separate experiences, and can weaken an association.

First, reverse causality could be an issue. Depressive mood may decrease energy and motivation to exercise, or may be used as a coping mechanism. These pathways may function concurrently and a cross-sectional survey cannot differentiate them. In contrast, Zhang et al. (2020) longitudinally tracked Chinese college students and found that exercise was related to the change in mental-health problems throughout the pandemic. Differences in findings are not surprising, considering differences in temporal structure of the two designs.

Thirdly, the context for the 2021 was very different. Opportunities for physical activity may have changed on campus, due to outbreak control restrictions, or because of remote/hybrid teaching, or due to regional variations, or due to the students' mental state. Large activity and mental health (Maugeri et al., 2020; Meyer et al., 2020; Wolf et al., 2021) fluctuations were reported in international studies during the pandemic. Home, outdoor, campus sport or informal exercise with other contexts may thus refer to the same reported exercise frequency.

Fourth, psychological adjustment is a multi-dimensional process. Physical activity may affect sleep, anxiety, perceived stress, self-esteem, social belonging and/or academic engagement without having an objectively statistically significant effect on the single A17 mood item. Physical activity has been embedded in a larger network of sleep and health-related activities by Stanton et al. (2020) and Martínez-de-Quel et al. (2021). A PE program can therefore have an impact on multiple domains even if one mood indicator does not change significantly.

Fifth, the student subsample limits precision. A total of 300 students and 73 elevated-mood cases were included in the primary complete-case regression.There were a total of 300 students and 73 elevated-mood cases in the primary complete-case regression. It is sufficient for small effects and for large interaction testing, but has limited precision for a parsimonious model. That uncertainty is reflected in the width of the odds-ratio confidence interval in the exercise. Nonsignificant results should thus be interpreted using the estimate and interval, not just the p value.

The explanations also suggest that a motivation intervention can be effective even when a frequency/association is weak. Gamification is not just summoning students to a new exercise regime, it's a different experience of goals, progress, feedback and social participation. Those changes do not, and cannot, be interpreted as more sustainable activity from one survey, but are a fact for a new intervention designed to achieve that result.

4.3. Mathematical and pedagogical framework for gamification-driven motivation

This study made a main contribution to the field of gamified physical education through the development of a framework for motivation. Gamification is defined as a set of interwoven elements – clear goals, timely feedback, calibrated challenge and progression, social cooperation and recognition of progress. These factors are thought to affect the motivation at the initial stage and the continued involvement at the later stage. In Section 2.5, a mathematical specification was given which can be used to test whether these changes are greater than those seen under normal PE.

Students' fitness, confidence and success or embarrassment in PE will vary, and this is important when considering the design. One public leaderboard can encourage the more active student, but may disempower the less confident student. More inclusive designs can highlight personal growth, challenge levels, team collaboration and feedback to the individual. Rewards can be used sparingly to indicate progress, and the overall experience foster competence, choice and social connection. In this way, gamification can be defined as a method for the arrangement of learning environment, not as a method to replace effective teaching.

The outcomes of a gamified program should also be aligned with its goals. For the aim of motivation, future research needs to assess intrinsic motivation, identified regulation, and extrinsic regulation, and amotivation using a valid instrument. For aims that involve behavior, attendance, and self-report, then session completion and objectively recorded activity should be evaluated along with self-report. Psychological outcomes (depressive symptoms, well-being) may also be included as secondary outcomes, but not as a substitute for motivation. This separation would enable researchers to see if students become even more motivated, even more active, or if they become more motivated, more active, neither, or none.

One direct test might take the form of a randomized design at the class level, with the standard PE class compared to the same PE content, presented as a packaged gamification activity for 8-12 weeks. The gamified condition should record the design vector g_j for each class j which includes the goals, the feedback, the challenge/progression, the social cooperation, and the reward/recognition. Motivation should be assessed multiple times at baseline, throughout the intervention, at the end of the intervention and again at follow-up. Measurement of activity and motivation should be repeated throughout baseline, during the intervention, at the end of the intervention, and at the follow-up. A mixed effects model could then account for the extra change in PE time associated with gamification.

Gamification must not be overdone, either. It can enhance engagement, but it cannot be offered as a mental-health intervention. Those students who continue to show depression symptoms outside PE may need to be assessed and supported beyond the PE context. The purpose of a gamified PE program is not as broad – it is intended to make participation more accessible, meaningful and sustainable, ensure that it is inclusive, and that there are clear pathways to suitable help.

4.4. Relationship to pandemic-era student evidence

The evidence from the pandemic generally aligns with the current recommendations to continue with physical activity, but acknowledges the influence of a broader context on student behaviour. Gallo et al., (2020), Romero-Blanco et al., (2020) and López-Valenciano et al., (2021) found that university-student activity has been hindered or decreased. Savage et al. (2020) found that movement change over time was related to mental health, and Son et al. (2020) found that factors related to academic and daily life stressors are not covered by exercise alone. Combined, these studies place physical activity as a part of a larger behavioral system, and not a single exposure.

Chinese college students' mental health also showed evidence of being influenced by several factors. Although the current CGSS analysis did not show any links between anxiety and academic or economic or social conditions, Cao et al. (2020) found such relationships using different measures and a study design that did not focus on a time lag. The present result thus does not contradict the broader literature, in that it demonstrates that the results of an annual measure of frequency of leisure-time activity and one recent measure of mood may not replicate those found in studies conducted in purpose-built longitudinal or intervention settings.

These design differences do not contradict but rather they are informational. Longitudinal studies are more convincing for the ordering of the events, randomized trials are more convincing regarding the effects of causal intervention and broad social surveys are useful for describing a population and identifying the presence of associations outside of purpose-built samples. A more robust gamification evidence base should be innovative in the following ways: randomize implementation, experiment with multiple measures of motivation and activity, and report the elements of the game actually provided in an open and clear way.

4.5. Methodological contribution

A methodological contribution of the study is separating between three things that may be confused: frequency of exercise, motivation and gamification. The first and the CGSS measure the second and third are not measured. If a leisure-time frequency item is used as evidence of a gamified PE effect, this would stretch the data. Separate them so that the analysis can still be used to inform intervention design without assuming that the intervention has been tested.

The methodological contribution is the link between an observational exercise behavior and psychological well-being assessment and a formally specified gamification framework for motivation-oriented physical education. Eligible students and the items of exposure and outcome were identified first. Next, statistical methods were selected to compare these measures. Where there was little or no data supporting the creation of a multi-item scale, no scale was constructed and machine learning was not added because it would not address the causal problem. Reasonable coding and modelling decisions were tested through sensitivity analyses, and the primary outcome was not sensitive to these decisions.

This is also a way to enhance the reproducibility. All numerical outputs can be referred to a specified CGSS variable and coding rule. As illustrated in figure 2, the analytic sample was generated, and primary, alternative and sensitivity estimates are separated in tables 4 and 5. The analysis script provided is used to generate the reported outputs of CGSS2021.dta. Reproducibility does not eliminate the limitation of the study design, it reveals the limitation and exposes it to testing.

4.6. Strengths and limitations

There are a number of strengths to the study. It utilises publicly available data from a Chinese survey and only analyses the data of respondents who were currently enrolled in tertiary education. The exposure and outcome are derived from the same core survey and not subsampled from merged module-specific samples. The binary, ordinal, weighted and health-adjusted specifications are examined for the focal association. Most important for the title, the manuscript clearly distinguishes between the observed frequency of exercise and the unmeasured level of motivation and gamification, providing a clear separation between the empirical results and the suggested intervention framework.

First, this is a cross-sectional design, which does not allow for temporal ordering. The study is not able to tell if exercise affected mood, mood affected exercise or an unmeasured factor affected both. This limitation can't be fixed by statistical adjustment.

Second, there is limited measurement. Exercise frequency is self-reported and includes no information about duration, intensity, type of exercise, participation in a PE class or access to gamified elements. Single item is used to assess depressive mood, not a validated multi-item clinical scale. Elevated is an analytical term and NOT a diagnostic term. Observed associations might be influenced by measurement error in either variable, and neither variable is a direct measure of motivation.

Thirdly, sample size and representativeness is limited. There were only 313 respondents to the parent survey who met the primary age and enrollment criteria and 300 respondents who were included in the complete case regression. Exercise-frequency groups were very small for the lowest frequencies. Survey weights were provided, which were used only in a sensitivity model and not for full survey design-based variance estimation, due to the absence of full survey-design metadata. The results are not, therefore, to be interpreted as exact national results for all Chinese college students.

Fourthly, there is always some residual confounding. The model is adjusted for socio-economic factors and demographic factors, but cannot (and does not need to) account for all factors which might affect exercise and mood. Examples of this include academic workload, campus climate, social support, chronic illness, personality, previous mental-health history, sleep, and local COVID-19 restrictions. Others were not available for the full analytic sample and others did not measure in the survey.

Fifthly, the scope of the outcome is limited. The primary analysis is based on one of the psychological indicators. Other topics, such as smoking, alcohol consumption, sleep and vigorous physical activity, are included in the D and E modules, but would drastically decrease the sample size if included in combination. Items that were not folded into the primary outcome were a composite of different constructs and differed by the set of respondents.

The main drawback of the title is the lack of measurement of gamification and physical activity motivation. The paper cannot, therefore, quantify the impact that points, feedback, challenges, rewards or other game design features have on student motivation. Gamification argument is based on the above intervention literature and is used as a guide for further design; CGSS results are only the context of the exercise-frequency and mood. The core thesis in the title needs to be tested with a purpose built study with direct motivational outcomes.

Lastly, this study bears the unique imprint of the year 2021. Restrictions due to the pandemic may have been a barrier to activities and/or survey responses. This is because the outcomes are more likely to be applicable to students' wellbeing in that time and less likely to be a useful reference to subsequent school environments. More detailed assessments of physical activity and gamified PE exposure should be used in post-pandemic studies and accompanied by an assessment of the outcomes on motivation and mental health.

5. Conclusions

For tertiary students currently enrolled in the CGSS-2021 file (18-30 years), exercise frequency was not clearly linked to frequency of depressive-mood symptoms. Slightly reduced odds of elevated depressive mood, but with uncertain estimates of the association, and corresponding overall pattern remained across ordinal, weighted, wider-age, and health-adjusted sensitivity analyses. The empirical result does not therefore lend any support to the notion that frequency is the only parameter that determines a significant psychological difference between students. The results show that exercise frequency is not enough to explain students' psychological and motivational experience of exercise. This constraint reinforces the need to look at the format of participation instead of just the frequency at which students are active. In the context of university physical education, gamification can be used systematically to structure goals, progression feedback, levels of difficulty, collaboration and reward for students' activity. The proposed mathematical framework transforms these design features into measurable intervention elements and relates them to multiple measures of motivation and activity adherence. The present CGSS analysis, therefore, serves as the behavioral and psychological context from which the framework of the intervention of gamified physical education was derived, and future controlled studies will be able to determine if the PE intervention of gamification can produce meaningful changes in motivation, engagement, and sustained participation. Additional variable definitions and analytical specifications are provided in Supplementary Tables 6 and 7.

Supplementary Materials:

Table 6. Summary of variables, operational definitions, and analytical roles

Construct	CGSS variable	Operationalization	Analytical role
Current tertiary enrollment	A7a + A7b	Currently studying (A7b) and tertiary-level education category (A7a)	Sample eligibility
Approximate age	A3_1	2021 minus reported birth year; primary analysis restricted to 18–30 years	Control / eligibility
Physical exercise frequency	A30_9	Never=0; few times/year or less=1; few times/month=2; several times/week=3; daily=4	Primary exposure
Weekly-or-more exercise	Derived from A30_9	Several times/week or daily=1; lower frequency=0	Primary binary exposure
Depressive mood frequency	A17	Never=0; rarely=1; sometimes=2; often=3; always=4	Primary ordinal outcome
Elevated depressive mood	Derived from A17	Sometimes/often/always=1; rarely/never=0	Primary binary outcome
Sex	A2	Female=1; male=0	Control
Household registration	A18	Agricultural hukou=1; non-agricultural/other=0	Control
Relative household economic position	A64	Below average, average, above average; unknown/refusal treated missing	Control
Education type	A7a derived	Adult higher education, graduate, regular tertiary	Control

Survey weight	weight	CGSS supplied survey weight; used in sensitivity analysis	Sensitivity analysis

Table 7. Analytical models and sensitivity analyses

Analysis	Outcome	Exposure	Adjustment / purpose
Descriptive analysis	Exercise and depressive mood distributions	Exercise frequency categories	Sample description
Spearman correlation	Depressive-mood frequency	Ordinal exercise frequency	Test monotonic association
Binary logistic regression	Elevated depressive mood	Weekly-or-more exercise	Primary adjusted association
Ordinal logistic regression	Five-level depressive mood	Exercise frequency score	Dose-response sensitivity
Survey-weighted logistic regression	Elevated depressive mood	Weekly-or-more exercise	Weight sensitivity analysis
Age 18–50 sensitivity model	Elevated depressive mood	Weekly-or-more exercise	Age restriction sensitivity
Health-adjusted model	Elevated depressive mood	Weekly-or-more exercise	Additional covariate sensitivity

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Data Availability

The analysis used the Chinese General Social Survey 2021 public-use dataset. The public Figshare record supplied for the project is

https://figshare.com/articles/dataset/Chinese_General_Social_Survey_2021/30041488. The exact working file analyzed was CGSS2021.dta. The accompanying reproducibility package contains analysis code and derived tables and figures, but it does not redistribute the raw dataset.

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Conflict of Interest

Conflict-of-interest information was not supplied. The final submission should include the authors' verified declaration.

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