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ARTICLE

# Associations of Suicidal Behaviors with Physical Activity Types and Psychosocial Factors among Korean Adolescents: A Secondary Data Analysis

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**ABSTRACT: Background:** Adolescent suicide remains a pressing public health concern in South Korea and worldwide, ranking as one of the leading causes of death among youth. Identifying modifiable risk and protective factors is critical for prevention strategies. Physical activity has been suggested as one such factor due to its potential mental health benefits. This study aimed to examine whether associations between physical activity and suicidality differ by activity type and by stage of suicidal behavior, distinguishing suicidal ideation, planning, and attempts among Korean adolescents. **Methods:** This cross-sectional secondary analysis used data from the 20th Korea Youth Risk Behavior Web-based Survey (KYRBS) conducted in 2024, a nationally representative survey of Korean adolescents. The study included 54,653 middle and high school students with complete data on physical activity, suicidal ideation, planning, and attempts. Three types of physical activity (vigorous activity, muscle-strengthening activity, and ≥60 min of daily physical activity) were examined. Associations with suicidal behaviors were analyzed using multivariable logistic regression models, adjusting for psychological, behavioral, and sociodemographic covariates. **Results:** In this nationally representative sample of Korean adolescents, engaging in at least 60 min of daily physical activity was significantly associated with lower odds of suicide planning, but not ideation or attempts. In contrast, muscle-strengthening activity was linked to increased odds of both suicide planning and attempts, whereas vigorous activity showed no significant associations. Psychological factors, including generalized anxiety, sadness, stress, and loneliness, showed strong associations with suicidal behaviors and were included as covariates in the adjusted models. Female students, low academic performance, and unstable residential status were also associated with higher odds of suicidal behaviors. **Conclusion:** The associations between physical activity and suicidality differed by activity type and suicidal outcome; muscle-strengthening activity was positively associated with suicide planning and attempts in adjusted models.

**KEYWORDS:** Adolescent suicide; physical activity; mental health; Korea Youth Risk Behavior Survey; muscle-strengthening exercise; suicide behavior

## 1 Introduction

Suicide remains one of the most alarming and persistent causes of death among adolescents globally. According to the World Health Organization (WHO), it is the third-leading cause of death among individuals aged 15 to 29 [1]. In South Korea, the youth suicide rate is more than twice the average of other Organization for Economic Co-operation and Development (OECD) countries. For over a decade, suicide has consistently ranked as the leading cause of death among Korean adolescents aged 9 to 24 years, surpassing traffic

accidents, other unintentional injuries, and cancer [2]. Moreover, the onset age of suicidal ideation is decreasing, with a growing number of middle school students reporting emotional distress, self-harming behaviors, and thoughts of death [3].

Adolescence is a vulnerable transitional stage characterized by rapid biological, psychological, and social changes. During this period, adolescents undergo identity formation, experience fluctuations in their self-concept, and face increasing expectations [4]. These developmental challenges often coincide with the first onset of mental health problems such as depression, anxiety, loneliness, and low self-esteem, many of which are known precursors of suicidal behavior [5,6]. In particular, Korean adolescents report higher levels of school-related stress and perfectionism than their global peers. According to the Korea Disease Control and Prevention Agency (KDCA), 13.5% of students reported seriously considering suicide in the past 12 months, whereas 5.25% reported at least one suicide attempt [7].

Recognizing the multifactorial nature of adolescent suicide, modifiable lifestyle factors such as physical activity have emerged as early intervention targets. Regular physical activity has been linked to improved mood regulation, reduced depressive symptoms, enhanced sleep quality, and increased self-esteem [8]. Moreover, it can promote social connectedness, goal setting, and personal control, protecting mental health [9]. Thus, international guidelines recommend that adolescents engage in at least 60 min of moderate-to-vigorous daily physical activity [10,11]. Beyond these general benefits, physical activity may be linked to adolescent suicidality through neurocognitive processes related to self-regulation. During adolescence, executive control systems involved in inhibitory control and emotion regulation are still developing, which may influence how psychological distress is managed under stress [12]. Evidence suggests that regular physical activity can modulate stress reactivity and support regulatory processes relevant to impulse control and goal-directed behavior [13,14]. Such mechanisms may be particularly relevant to differences across stages of suicidal behavior, including whether psychological distress escalates toward planning or behavioral enactment rather than remaining at the level of ideation. In educational environments characterized by sustained academic pressure and limited recovery, as in Korea [15], these stress and regulation-related pathways may be especially salient when interpreting associations between activity patterns and suicidality.

In parallel, sedentary behavior has increasingly been recognized as a distinct movement behavior with independent implications for adolescent mental health, rather than merely representing the absence of physical activity. In the Korean context, prolonged sedentary time is often structurally driven by intensive academic schedules and after-school study demands, resulting in extended periods of sitting that are largely independent of intentional exercise participation [16]. Such prolonged sitting may limit opportunities for cognitive disengagement, spontaneous movement, and emotional ventilation, potentially contributing to rumination, emotional stagnation, and reduced self-regulatory capacity [17]. Accordingly, sedentary time represents an important contextual factor to consider when examining associations between physical activity patterns and suicidality among Korean adolescents.

Despite this growing body of evidence, the relationship between physical activity and suicidal behavior is far less consistent. While some studies suggest that higher levels of physical activity are associated with lower rates of suicidal ideation and attempts [18,19], others report null findings [20,21] or even a positive association under certain conditions [22]. Another challenge in existing research is that physical activity is often operationalized as an overall volume or guideline-based indicator (e.g., meeting vs. not meeting recommended levels), as commonly applied in large-scale epidemiological and surveillance-based studies of adolescent health and risk behaviors, including national school-based surveys, which can obscure heterogeneity by activity modality and psychosocial context [23,24]. Although threshold-based indicators

are often used for policy-relevant interpretation, conceptual limitations arise when physical activity is treated as a single undifferentiated construct rather than as distinct activity types. Recent work has begun to address this limitation by examining variations in activity type and prescription features (e.g., intensity, duration, and modality) and by emphasizing contextual factors related to the meaning and context of activity participation [25,26]; however, these efforts remain fragmented, often focusing on a single activity dimension or a single suicidality outcome, and have rarely been integrated into analyses that consider multiple activity types alongside distinct stages of suicidality. Ignoring such distinctions limits the interpretability and practical applicability of research findings in mental health outcomes [27]. In parallel with limitations in how physical activity has been conceptualized, outcome definitions in this literature have also been narrow. Moreover, most existing studies focus solely on suicidal ideation, failing to adequately reflect the distinct characteristics and clinical risk levels of high-risk behaviors, such as suicide planning and attempts [28]. Suicidal ideation, planning, and attempts represent qualitatively different stages of suicidality, each associated with distinct psychological risk factors and interventional needs [29].

Ideation-to-action frameworks, such as Klonsky and May's three-step theory (3ST), are particularly relevant to the present study, as they further emphasize that the emergence of suicidal ideation and the transition from ideation to suicidal behavior are driven by partly distinct processes. In 3ST, suicidal ideation is theorized to arise when psychological pain and hopelessness co-occur, whereas progression toward action is more closely linked to factors that reduce protective connections and increase the capability for suicide. From this perspective, physical activity may be differentially associated with specific stages of suicidality, for example, through pathways related to affect regulation and stress reactivity (ideation) versus self-control, impulsivity, and social connectedness (transition to planning or attempts) [29]. Therefore, examining activity types in relation to ideation, planning, and attempts separately may provide more stage-specific and clinically interpretable evidence.

Many studies have not consistently accounted for critical variables known to influence both physical activity engagement and suicide risk [30]. These include psychological indicators such as generalized anxiety disorder (GAD), stress, sadness, and loneliness, as well as behavioral and contextual factors such as sleep, fatigue recovery, sedentary time, academic performance, and family living arrangements. Particularly in the Korean context, where academic stress, appearance anxiety, and social conformity are deeply embedded in cultural elements, the psychological meaning and social function of physical activity may differ substantially from those in other populations [31,32]. Within this context, muscle-strengthening activities may reflect motivations and social meanings that are distinct from those underlying general physical activity. Among adolescents, strength-focused exercise may be more closely intertwined with appearance-related concerns, body image pressures, or performance-oriented goals [33], particularly within sociocultural environments that emphasize academic achievement and physical standards. These contextual differences underscore the importance of examining muscle-strengthening activities separately when assessing associations between physical activity and suicidality.

Given the inconsistencies and conceptual limitations of prior research, as well as the unique sociocultural stressors faced by Korean adolescents, it is essential to reconsider how different types and patterns of physical activity relate to distinct stages of suicidality. Accordingly, this study focuses on whether associations between physical activity and suicidality differ by activity type and by stage of suicidal behavior, distinguishing suicidal ideation, planning and attempts. In particular, beyond overall physical activity, we examine muscle-strengthening activities as a conceptually distinct form of physical activity that may be embedded in different motivational and psychosocial contexts among adolescents. By explicitly adjusting for key psychological, behavioral, and contextual factors, this study aims to estimate, within the

constraints of an observational design, the independent associations of specific physical activity types with different stages of suicidality in the Korean adolescent population.

## 2 Methods

### *2.1 Study Design and Population*

This study conducted a cross-sectional secondary analysis of the 20th Korea Youth Risk Behavior Web-based Survey (KYRBS) in 2024 by the KDCA. The KYRBS is an annual, nationally representative survey monitoring health-related behaviors among Korean adolescents, targeting students from middle school first to high school third grade, using stratified, multistage clustered sampling with weights to ensure national representativeness.

The 2024 KYRBS collected data from approximately 60,000 students across 800 schools using anonymous self-administered online questionnaires. This study only included students with complete data on physical activity, suicidal behaviors, and key covariates. After excluding cases with missing or inconsistent data, 54,653 participants were included in the final analysis.

### *2.2 Study Variables*

#### *2.2.1 Suicidal Behavior*

The primary outcome variables in this study were three forms of suicidal behavior assessed through self-reporting: suicidal ideation, suicide planning, and suicide attempt. Each variable was measured using a yes-or-no response, asking about experiences within the past 12 months, with responses dichotomized as 0 (No) or 1 (Yes).

#### *2.2.2 Physical Activity*

The main independent variables in this study were three types of physical activity reported over the previous seven days. These included vigorous physical activity (e.g., running or playing sports that cause rapid breathing or sweating for at least 20 min), muscle-strengthening activities (e.g., push-ups, sit-ups, or weight training), and daily general physical activity lasting at least 60 min, regardless of intensity. Each activity was originally assessed as the number of days (0–7 days) performed in the past week.

For analytical purposes, these frequency-based variables were recoded into binary indicators to reflect whether adolescents met recommended activity thresholds. Adolescents were assigned a value of 1 if they reported engaging in vigorous-intensity activity or muscle-strengthening activity on three or more days per week or engaging in at least 60 min of general physical activity five or more days per week; all others were coded as 0. These thresholds were defined by the researchers based on the World Health Organization's physical activity guidelines for adolescents, which recommend at least 60 min of moderate-to-vigorous physical activity daily, including vigorous-intensity or muscle-strengthening activities at least three times per week [34]. Because the KYRBS assesses physical activity as the number of days per week rather than daily duration, adherence to the ≥60 min/day recommendation was operationalized as engaging in at least 60 min of activity on five or more days per week. This operationalization is consistent with the definition of physical activity practice rates used in Korean national health surveillance, which applies a ≥60 min on ≥5 days per week criterion to better reflect behavioral patterns among Korean adolescents [35]. These physical activity indicators were not mutually exclusive, and adolescents could meet more than one criterion. We acknowledge that dichotomizing frequency-based physical activity variables may reduce sensitivity and obscure potential dose–response relationships. Because the primary aim was to align

exposure definitions with commonly used surveillance thresholds and to maintain comparability across activity types, we used binary indicators in the main analyses; alternative specifications (e.g., multi-category or continuous days/week) were not pursued in the present manuscript.

#### *2.2.3 Covariates and Confounder Selection*

Covariates were selected a priori based on prior literature [5,30] and the availability of variables in the KYRBS, focusing on factors that may be associated with both physical activity engagement and suicidal behaviors. These covariates were included to estimate the independent associations of physical activity types with suicidal ideation, planning, and attempts in multivariable logistic regression models. The analysis included a range of psychological and behavioral covariates known to influence suicidal behavior among adolescents.

Mental health indicators included generalized anxiety, sadness/despair, loneliness, and perceived stress. Generalized anxiety was measured using the Generalized Anxiety Disorder-7 (GAD-7) scale, with total scores categorized into four levels: normal (0–4), mild (5–9), moderate (10–14), and severe (15–21). The participants also reported whether they had experienced persistent sadness or despair, feelings of loneliness, or perceived stress over the past year. All variables were binary (0 = No, 1 = Yes), except for stress, which was dichotomized into low (none/slight) and high (moderate/severe/very severe).

Health-related behavioral and lifestyle covariates included sleep-related factors, sedentary time, and subjective health status. Sleep-related variables included perceived recovery from fatigue through sleep (categorized as sufficient or insufficient), average sleep duration on weekdays and weekends, and average daily sedentary time (hours). Subjective health status was assessed using a single item and categorized as good (very good/good) or poor (fair/poor/very poor).

Sociodemographic and family context covariates included gender (male/female), school grade (middle and high school, first to third grade), academic score, and socioeconomic status (high, mid-high, middle, mid-low, and low). Residence (with family, relatives, alone, dormitory, childcare facility) and family structure (both parents, one parent, stepparent, other family members, none) were also included, all of which have been shown to influence adolescent mental health and suicidal behavior using literature reviews [6,19].

Variable selection followed the KYRBS coding manual and prior studies, and all listed covariates were included in the multivariable models as potential confounders. Several psychological variables included in this study (e.g., generalized anxiety, sadness/despair, loneliness, and perceived stress) may plausibly function both as confounders and as intermediates on the pathway between physical activity and suicidal behaviors. In the present analysis, these variables were treated as confounders to obtain conservative estimates of the associations between physical activity and suicidality. We acknowledge that this approach may attenuate associations if some variables lie on the causal pathway; however, it was chosen to reduce residual confounding in a large-scale observational dataset. Correlations among covariates were examined to assess multicollinearity prior to regression analysis.

### *2.3 Data Analysis*

All statistical analyses were conducted using SPSS Windows software version 29.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were estimated using the Complex Samples module to account for the stratified, clustered, and weighted design of KYRBS, applying sampling weights, stratification variables, and primary sampling units to ensure national representativeness.

Complex sample logistic regression models incorporating the survey design variables were initially specified to examine associations between physical activity and suicidality outcomes. However, due to sparse

outcome distributions and limited within-cluster variability for suicidality measures, design-based logistic regression models did not converge across the examined exposure–outcome combinations. Therefore, associations were estimated using conventional bivariate and multivariable logistic regression models.

Descriptive statistics (frequencies and weighted percentages) were used to summarize the sample characteristics, and Pearson's correlations were examined to assess multicollinearity. Associations between physical activity types and suicidal behavior were examined using bivariate and multivariable logistic regression models, adjusting for mental health indicators, sleep-related variables, and sociodemographic covariates. Statistical significance was set at $p < 0.05$, and effect sizes were reported as odds ratios (ORs) with 95% confidence intervals (CIs). Formal moderation analyses using interaction terms were not conducted, as the primary objective of this study was to estimate overall adjusted associations rather than subgroup-specific effects.

### *2.4 Ethical Considerations*

This study uses publicly available, de-identified secondary data from the 2024 KYRBS. The KYRBS dataset ensures complete participant anonymity using personally identifiable information, and confidentiality measures protect all responses, so no personally identifiable information was accessible to the researchers. According to the official guidelines, confidentiality is legally protected under Articles 33 and 34 of the Statistics Act, which prohibit the disclosure or misuse of individual responses.

The study protocol was reviewed by the Institutional Review Board (IRB) of Chung-Ang University and was granted an official exemption from the IRB review as it involved secondary analysis of anonymized data with no direct interaction with human participants (IRB No. 1041078-20250609-HR-181). In accordance with this exemption, the requirement for informed consent was waived by the IRB.

## 3 Results

### *3.1 Demographic and Characteristics*

This analysis included 54,653 adolescents from the 2024 KYRBS, a nationally representative survey. As shown in Table 1, the sample was nearly evenly split by gender (49.8% male and 50.2% female) and included students from the first year of middle school to the third year of high school. Each grade accounted for roughly 15%–18% of the sample. Most students reported average-to-above-average academic performance (mid: 30.1%; mid–high: 24.9%; high: 11.7%), with only 10.5% reporting low performance. Socioeconomic status was also concentrated in the mid (48.2%) to mid-high (31.2%) range, with only 1.8% reporting a low status. Most students (96.4%) lived with their families; few resided in dormitory rooms (2.0%), with relatives (0.7%), alone (0.4%), or in care facilities (0.4%). Most participants (86.0%) lived with both parents, 4.1% lived with one parent, and a few lived with stepparents or extended families. A total of 9.5% of the participants did not report their family structure. These demographic factors were included as covariates to control for confounding variables. All percentages were calculated according to the KYRBS Complex Sampling Design.

**Table 1:** General characteristics of participants (N = 54,653).

| Variable | Frequency (%) |
|---|---|
| **Gender** | |
| Male | 49.8 |
| Female | 50.2 |

**Table 1:** *Cont.*

| Variable | Frequency (%) |
|---|---|
| **Grade (Age)** | |
| Middle School 1st (14) | 17.5 |
| Middle School 2nd (15) | 16.9 |
| Middle School 3rd (16) | 16.2 |
| High School 1st (17) | 16.7 |
| High School 2nd (18) | 17.5 |
| High School 3rd (19) | 15.2 |
| **Academic Scores** | |
| High | 11.7 |
| Mid-High | 24.9 |
| Middle | 30.1 |
| Mid-Low | 22.9 |
| Low | 10.5 |
| **Socioeconomic Status** | |
| High | 10.4 |
| Mid-High | 31.2 |
| Middle | 48.2 |
| Mid-Low | 8.5 |
| Low | 1.8 |
| **Residence** | |
| With Family | 96.4 |
| With Relatives | 0.7 |
| Alone | 0.4 |
| Dormitory | 2.0 |
| Childcare Facility | 0.4 |
| **Family Structure** | |
| Both Biological Parents | 86.0 |
| Only One Biological Parent | 4.1 |
| Stepparent | 0.1 |
| Other Family Members (Grandparents/Siblings) | 0.1 |
| No Family Members | 0.2 |
| No response | 9.5 |

Note: Values are presented as weighted percentages.

### *3.2 Correlations among Independent and Covariate Variables*

This section presents correlations among independent and covariate variables to describe their relationships and to assess potential multicollinearity prior to multivariable analyses. Pearson's correlation coefficients were calculated to examine the relationships between the independent and covariate variables (Table 2). Given the large sample size, most correlations reached statistical significance; therefore, interpretation focused on the magnitude of correlations and their relevance for assessing potential multicollinearity rather than on statistical significance alone. No correlation exceeded the absolute value of 0.70, indicating that multicollinearity was not a concern in subsequent regression analyses. Consistent with prior large-scale survey analyses, many statistically significant correlations were small in magnitude, underscoring the need for multivariable models to evaluate independent associations. The highest observed correlation was between GAD and stress (r = 0.460), followed by GAD and sadness or despair (r = 0.423) and GAD and loneliness (r = 0.489), all of which were consistent with known comorbidity patterns among mental health variables and their roles as covariates in the regression models. Regarding the physical activity variables, vigorous activity, muscle-strengthening activity, and ≥60 min daily activity showed moderate correlations (r = 0.410–0.468), indicating some conceptual overlap while remaining within acceptable ranges

for independent inclusion in multivariable models. Other covariates, such as sleep patterns, recovery from fatigue, and sedentary time, exhibited low to modest correlations with both physical activity and mental health variables, further supporting the suitability of these variables for inclusion in multivariable models. No evidence of problematic multicollinearity was observed, supporting the inclusion of these variables in the adjusted logistic regression models.

**Table 2:** Pearson correlation coefficients among independent and covariate variables.

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Vigorous Activity** | 1 | | | | | | | | | | | |
| **2. Muscle Activity** | 0.427** | 1 | | | | | | | | | | |
| **3. ≥ 60 min Activity** | 0.468** | 0.410** | 1 | | | | | | | | | |
| **4. GAD total score** | −0.059** | −0.057** | −0.042** | 1 | | | | | | | | |
| **5. Sadness and despair** | 0.001 | 0.017** | 0.010* | 0.423** | 1 | | | | | | | |
| **6. Loneliness** | −0.026** | −0.028** | −0.013** | 0.489** | 0.377** | 1 | | | | | | |
| **7. Recovery from fatigue** | 0.078** | 0.065** | 0.055** | −0.165** | −0.122** | −0.123** | 1 | | | | | |
| **8. Perception of stress** | −0.057** | −0.061** | −0.043** | 0.460** | 0.333** | 0.364** | −0.173** | 1 | | | | |
| **9. Average daily sedentary time** | −0.070** | −0.098** | −0.073** | 0.064** | 0.010* | 0.042** | −0.091** | 0.071** | 1 | | | |
| **10. Weekend sleep duration** | 0.060** | 0.040** | 0.043** | −0.079** | −0.047** | −0.052** | 0.115** | −0.087** | −0.087** | 1 | | |
| **11. Weekday sleep duration** | 0.099** | 0.064** | 0.077** | −0.102** | −0.066** | −0.078** | 0.315** | −0.098** | −0.137** | 0.215** | 1 | |
| **12. Health perception** | −0.179** | −0.178** | −0.159** | 0.297** | 0.181** | 0.218** | −0.181** | 0.268** | 0.068** | −0.069** | −0.095** | 1 |

Note: Values represent Pearson correlation coefficients. These indicate the linear relationship between variables; *$p < 0.05$; **$p < 0.01$.

### *3.3 Association between Physical Activity and Suicidal Behaviors*

Table 3 presents the crude associations between physical activity types and suicidal behaviors. Engaging in vigorous physical activity was associated with lower odds of suicidal ideation (OR = 0.904, $p < 0.001$), but not with planning or attempts. Muscle-strengthening activities were significantly associated with lower odds of suicidal ideation (OR = 0.897, $p < 0.001$). In contrast, it was associated with significantly higher odds of both suicide planning (OR = 1.167, $p < 0.001$) and suicide attempts (OR = 1.368, $p < 0.001$). Similarly, adolescents engaging in at least 60 min of physical activity per day showed lower odds of suicidal ideation (OR = 0.878, $p < 0.001$), whereas no significant associations were observed for planning or attempts.

**Table 3:** Cross-tabulation between physical activity and suicidal behavior (N = 54,653).

| Physical Activity | Suicidal Behavior | Yes (%) | No (%) | $p$ ($\chi^2$) | OR | 95% CI | $p$ (logistic) |
|---|---|---|---|---|---|---|---|
| **Vigorous** | Ideation | 12.1 | 87.9 | <0.001 | 0.904 | 0.859–0.952 | <0.001 |
| | Plan | 4.9 | 95.1 | 0.991 | 1.000 | 0.924–1.081 | 0.991 |
| | Attempt | 2.7 | 97.3 | 0.329 | 0.950 | 0.857–1.053 | 0.330 |
| **Muscle-strengthening** | Ideation | 11.8 | 88.2 | <0.001 | 0.897 | 0.845–0.952 | <0.001 |
| | Plan | 5.4 | 94.6 | <0.001 | 1.167 | 1.070–1.273 | <0.001 |
| | Attempt | 3.5 | 96.5 | <0.001 | 1.368 | 1.225–1.526 | <0.001 |
| **≥60 min** | Ideation | 11.6 | 88.4 | <0.001 | 0.878 | 0.820–0.939 | <0.001 |
| | Plan | 4.7 | 95.3 | 0.469 | 0.963 | 0.869–1.067 | 0.470 |
| | Attempt | 2.9 | 97.1 | 0.430 | 1.054 | 0.925–1.201 | 0.427 |

Note: Values are weighted percentages; OR = odds ratio; CI = confidence interval.

Table 4 presents the results of the multivariate logistic regression analyses, adjusted for mental health, sleep-related, and sociodemographic covariates. All specified covariates were included in the regression models; for brevity, Table 4 displays selected covariates. Muscle-strengthening activity remained

significantly associated with higher odds of suicide planning (OR = 1.389, $p < 0.001$) and suicide attempts (OR = 1.505, $p < 0.001$), whereas no significant association was observed for suicidal ideation. Engaging in at least 60 min of physical activity per day was significantly associated with reduced odds of suicide planning (OR = 0.859, $p = 0.035$). For suicidal ideation, a non-significant inverse trend was observed (OR = 0.913, $p = 0.075$), whereas no significant association was found for suicide attempts. Vigorous physical activity showed no significant association with suicidal ideation, planning, or attempts in the adjusted models. The inverse association observed in unadjusted analyses was attenuated after adjustment, suggesting that the crude association was partly explained by psychological distress and sleep- or behavior-related covariates.

Severe generalized anxiety disorder (GAD) was strongly associated with higher odds of suicidal ideation, planning, and attempts (ORs > 4.1, $p < 0.001$). Sadness, loneliness, and stress were also independently associated with higher odds of suicidal outcomes ($p < 0.001$). Female students, low academic performance, and low socioeconomic status were associated with higher odds of suicidal behavior. Moreover, living alone or in facilities was significantly associated with higher odds of suicide attempts (ORs > 2.8, $p < 0.001$).

Across models, the direction and magnitude of the associations differed between crude and adjusted analyses. Several associations observed in the bivariate models were attenuated after adjustment for sociodemographic characteristics and mental health indicators, suggesting the presence of confounding effects. Nevertheless, key activity-type–specific associations, particularly those involving muscle-strengthening activity and suicide planning and attempts, remained statistically significant in the fully adjusted models.

**Table 4:** Multivariate logistic regression analysis of factors associated with suicidal behaviors (N = 54,653).

| Variable | | Suicidal Ideation OR [95% CI] | *p* | Suicidal Plan OR [95% CI] | *p* | Suicidal Attempt OR [95% CI] | *p* |
|---|---|---|---|---|---|---|---|
| **Physical Activity** | | | | | | | |
| Vigorous | | 1.048 [0.970–1.132] | 0.234 | 1.080 [0.966–1.207] | 0.175 | 0.921 [0.795–1.066] | 0.921 |
| Muscle-Strengthening | | 1.031 [0.943–1.127] | 0.506 | 1.389 [1.227–1.572] | <0.001 | 1.505 [1.284–1.765] | <0.001 |
| ≥60 min | | 0.913 [0.826–1.009] | 0.075 | 0.859 [0.746–0.989] | 0.035 | 0.968 [0.808–1.160] | 0.728 |
| **Mental Health Factors** | | | | | | | |
| GAD (ref = Normal) | Mild | 1.836 [1.689–1.996] | <0.001 | 1.800 [1.569–2.065] | <0.001 | 1.677 [1.394–2.017] | <0.001 |
| | Moderate | 2.637 [2.383–2.918] | <0.001 | 2.711 [2.319–3.170] | <0.001 | 2.772 [2.255–3.407] | <0.001 |
| | Severe | 4.100 [3.635–4.624] | <0.001 | 4.470 [3.779–5.287] | <0.001 | 4.112 [3.300–5.124] | <0.001 |
| Sadness/Despair | | 3.922 [3.661–4.202] | <0.001 | 3.315 [2.807–3.501] | <0.001 | 3.112 [2.680–3.615] | <0.001 |
| Loneliness | | 2.320 [2.162–2.491] | <0.001 | 2.113 [1.899–2.351] | <0.001 | 2.059 [1.785–2.375] | <0.001 |
| Stress | | 2.097 [1.938–2.269] | <0.001 | 1.655 [1.459–1.876] | <0.001 | 1.381 [1.170–1.628] | <0.001 |
| **General Characteristics** | | | | | | | |
| Gender (Female) | | 1.256 [1.171–1.347] | <0.001 | 1.228 [1.108–1.360] | <0.001 | 1.180 [1.033–1.348] | 0.015 |
| SES (ref = High) | Mid-High | 0.969 [0.862–1.088] | 0.591 | 0.864 [0.733–1.019] | 0.083 | 0.892 [0.718–1.109] | 0.304 |
| | Middle | 0.940 [0.839–1.053] | 0.285 | 0.850 [0.724–0.998] | 0.047 | 0.841 [0.68–1.038] | 0.106 |
| | Mid-Low | 1.290 [1.124–1.481] | <0.001 | 1.121 [0.926–1.356] | 0.241 | 1.058 [0.827–1.355] | 0.652 |
| | Low | 1.361 [1.099–1.685] | 0.005 | 1.358 [1.036–1.779] | 0.026 | 1.363 [0.984–1.889] | 0.063 |
| Residence (ref = Family) | Relatives | 1.385 [0.940–2.039] | 0.099 | 1.112 [0.653–1.894] | 0.696 | 1.627 [0.905–2.926] | 0.104 |
| | Alone | 2.625 [1.811–3.804] | <0.001 | 2.343 [1.478–3.715] | <0.001 | 4.803 [3.040–7.589] | <0.001 |
| | Dormitory | 1.033 [0.864–1.237] | 0.719 | 1.108 [0.857–1.433] | 0.433 | 1.199 [0.862–1.668] | 0.281 |
| | Childcare Facility | 1.806 [1.125–2.900] | 0.014 | 1.915 [1.095–3.348] | 0.023 | 2.845 [1.580–5.126] | <0.001 |

Note: All multivariable models adjusted for the complete set of covariates specified in Section 2.2.3; for brevity, only selected covariates are displayed in the table; Logistic regression estimates were obtained using conventional (non-design-based) models because design-based complex-sample logistic regression did not converge for the examined combinations; OR = odds ratio; CI = confidence interval; SES = socioeconomic status.

## 4 Discussion

This study examined the associations between different types of physical activity and suicidal behaviors among Korean adolescents, using nationally representative data from the Korea Youth Risk Behavior Web-based Survey. This study aimed to determine whether specific forms of physical activity act as protective or risk-modifying factors for adolescent suicidality. Suicidal ideation, planning, and attempts

were examined as distinct stages of suicidality. Guided by ideation-to-action frameworks such as the three-step theory (3ST), the present discussion interprets these findings with attention to stage-specific mechanisms underlying suicidal ideation, planning, and attempts. Rather than viewing physical activity as uniformly protective or harmful, the results are considered in terms of how different activity types may relate differently to distinct stages of suicidality.

Overall, the associations between physical activity and suicidality differed by activity type and stage. In the fully adjusted models, muscle-strengthening activity was positively associated with suicide planning and attempts, whereas other activity types showed different patterns across outcomes. These findings should not be interpreted as evidence that muscle-strengthening exercise is inherently harmful to adolescents' mental health. Rather, the observed associations may reflect underlying contextual or psychological factors such as appearance-related concerns, weight-control motives, or pre-existing emotional distress that influence both exercise patterns and suicidal behaviors. Given the cross-sectional design of the study, the possibility of reverse causality and residual confounding cannot be excluded; accordingly, the findings should be interpreted as associations that may reflect underlying vulnerabilities or contextual factors rather than effects of the activity itself. Importantly, these associations were evaluated after adjustment for key confounding factors, including mental health indicators and lifestyle-related covariates that are closely linked to both physical activity engagement and suicidality. The persistence of activity-type–specific patterns in the fully adjusted models supports the relevance of distinguishing physical activity types when interpreting different stages of suicidality.

In light of these adjusted findings, one possible hypothesis is appearance-driven motivation. Adolescents with body dissatisfaction or a distorted body image may prioritize strengthening muscles to achieve idealized physical standards over maintaining health [36]. Studies have suggested that appearance-motivated exercise may be associated with depressive symptoms, anxiety, and disordered eating behaviors [37,38]. This can lead to compulsive exercise or performance-enhancing supplement use [39], both of which are associated with negative psychological outcomes [40]. A second possible explanation involves impulsivity. Although muscle-strengthening activities may help reduce psychological distress and regulate emotions [41], frequent engagement may also reflect heightened impulsivity or sensation-seeking tendencies [42]. Among those with suicidal thoughts, such traits may function as triggers accelerating the progression from thought to action [43]. In this context, impulsivity may represent one factor that could weaken potential protective associations of exercise. Such traits may also be relevant to the progression from suicidal thoughts to suicidal actions, a hypothesis that requires direct empirical testing. Within an ideation-to-action perspective, such factors may be particularly relevant to the transition from suicidal thoughts to planning or attempts, rather than to the initial emergence of suicidal ideation.

Mental health factors showed the strongest and most consistent association with suicidal behavior. Higher GAD scores showed a dose-response relationship [44], and sadness, loneliness, and perceived stress were significant predictors. These results support prior evidence that psychological distress is a major correlate of adolescent suicidality, and highlight the need for early detection strategies [45,46]. Sociodemographic characteristics were also significant. Female students were more likely to report all forms of suicidal behavior, consistent with global trends [47]. Low academic achievement and socioeconomic disadvantages were also associated with higher odds of suicidal behavior, suggesting that these stressors may intensify mental health challenges [48,49]. The increased vulnerability among adolescents living alone or in institutional care is particularly notable, indicating the critical role of stable caregiving environments. These findings call for integrated prevention efforts that combine mental health screening with structural support for socially and economically marginalized youths. In applied settings, engagement in muscle-strengthening

activity among distressed adolescents may therefore warrant closer attention to underlying psychological vulnerabilities, as discussed above, rather than being viewed as inherently harmful. Concerning general physical activity, engaging in at least 60 min of daily activity was significantly associated with reduced odds of suicide planning, but not with ideation or attempts. Its limited protective association suggests that while physical activity may offer mental health benefits [50], it may not be sufficient as a standalone preventive strategy against severe suicidal outcomes. The effectiveness of physical activity may also vary depending on the consistency, intensity, and subjective meaning that it holds for each adolescent [51,52]. By contrast, vigorous physical activity showed no statistically significant association with any form of suicidal behavior in the adjusted models. This pattern is consistent with the mixed evidence in the existing literature, in which high-intensity exercise has produced inconsistent outcomes depending on individual differences in physiological tolerance, motivation, and environmental stressors [53]. For distressed adolescents, vigorous activity may be perceived as demanding, potentially limiting accessibility and therapeutic engagement [54]. From a stage-based perspective, this pattern suggests that general physical activity may be more relevant to intermediate stages of suicidality, such as planning, than to either ideation or attempts.

In the Korean context, the psychological meaning of physical activity may be shaped by sociocultural stressors that are closely linked to the covariates included in this study. Intense academic competition and performance-oriented evaluation [55], reflected in the elevated vulnerability among adolescents with lower academic achievement, may coexist with chronic stress, insufficient sleep, and poor recovery from fatigue [56], all of which were assessed in the present models. Under such conditions, engagement in physical activity may not necessarily function as a restorative behavior, but rather as an additional domain of performance pressure. Appearance-related concerns may be particularly salient in Korea, where societal emphasis on physical appearance is reinforced by a highly developed beauty and cosmetic industry and pervasive visual standards in media and social platforms [57]. Although body image dissatisfaction is a global phenomenon, the intensity of appearance evaluation and normalization of aesthetic modification in the Korean context may amplify appearance-driven exercise motivations. Such pressures may interact with anxiety, stress, and loneliness, key psychological variables measured in this study, making muscle-focused exercise more susceptible to being pursued for external validation rather than health promotion. Moreover, strong norms of social comparison and conformity within peer groups may further intensify psychological distress [58]. In environments where relative standing and peer evaluation are emphasized, adolescents may experience heightened stress and loneliness when failing to meet academic or appearance-related expectations [59]. These sociocultural dynamics may contribute to the clustering of psychological vulnerabilities observed in this study and help explain why certain patterns of physical activity, particularly muscle-strengthening behaviors, show complex associations with suicidality after adjustment for mental health and lifestyle-related factors.

International studies have reported heterogeneous associations between physical activity and suicidality, with effects varying by activity type, intensity, and psychosocial context [60,61]. The present findings add to this mixed evidence by demonstrating activity-type–specific patterns after adjustment for major psychological and sociodemographic factors. Further replication across countries and multi-year datasets is needed to clarify how cultural and structural contexts may modify these associations. In this regard, a socio-ecological framework provides a useful lens for interpreting how individual, interpersonal, and structural factors interact to shape adolescent suicidality, as reflected in the present findings. At the individual level, psychological distress indicators, including generalized anxiety, sadness, loneliness, and perceived stress, showed the strongest associations with suicidal behaviors, underscoring mental health vulnerability as a proximal context. At the interpersonal and family-related level, living arrangements and

family structure were associated with elevated odds of suicidal behaviors, highlighting the importance of daily social support and supervision. At the school and structural level, academic performance and socioeconomic status reflected broader performance pressure and resource constraints that may exacerbate psychological distress and limit access to adaptive coping resources, including health-promoting physical activity. This multi-level interpretation suggests that physical activity should not be considered in isolation as a sole suicide prevention effort. Because the KYRBS encompasses multiple behavioral and psychosocial domains, including sleep patterns, fatigue recovery, sedentary behavior, and mental health, prevention efforts may benefit from integrated approaches rather than single-behavior interventions. Sedentary time was included as a covariate to reflect the broader behavioral context of Korean adolescents, for whom prolonged sitting is often driven by academic demands rather than by inactivity alone. Extended sedentary periods may reduce opportunities for cognitive disengagement and emotional regulation, potentially reinforcing stress, rumination, and psychological distress [62]. From this perspective, sedentary behavior should be understood as a contextual factor that may interact with academic pressure and mental health vulnerability, rather than as a simple absence of physical activity. School and community-based programs that combine mental health screening, sleep and fatigue management, reduction of sedentary time, and accessible physical activity opportunities may be more appropriate for addressing the clustered vulnerabilities observed in this study. Such integrated strategies align with a socio-ecological approach to adolescent suicide prevention and may better address the complex pathways linking physical activity and suicidality.

This study had several limitations. First, the cross-sectional design limited the interpretation of the directionality between physical activity and suicidal behavior. Second, self-reported measures may be subject to reporting bias, particularly in sensitive domains such as mental health and suicidality. Third, although the KYRBS employs a complex sampling design, logistic regression analyses could not be estimated using design-based methods due to sparse cell counts and limited within-cluster variability for suicidality outcomes. As a result, the reported associations are based on conventional logistic regression models and may underestimate standard errors. Fourth, suicidal ideation, planning, and attempts were assessed as separate binary outcomes and are not mutually exclusive; these behaviors may co-occur within individuals. Therefore, stage-specific analyses should be interpreted as examining overlapping outcomes rather than distinct, non-overlapping groups. Fifth, physical activity exposures were operationalized using threshold-based binary indicators, and dose–response relationships using multi-category or continuous measures could not be examined, which may have reduced sensitivity to graded associations. Sixth, although a wide range of covariates was included, unmeasured confounders, such as peer relationships, school connectedness, or family communication, may still influence the observed associations. Seventh, the scope of this study did not analyze effect modification across demographic or psychosocial subgroups, which may limit insight into potential heterogeneity in associations between physical activity types and suicidality. Finally, because this study was based on a single survey year, it had limitations in examining temporal trends or determining whether the observed associations are stable across different KYRBS waves. Future research should more explicitly consider the psychological context of exercise and potential risks, including compulsive or appearance-driven patterns. Longitudinal designs and qualitative approaches may help clarify causal mechanisms and identify subgroups for which exercise functions as a protective or maladaptive coping strategy.

This study provides valuable insights into the relationship between adolescent physical activity and suicidal behavior. While particular forms of physical activity may offer protective effects, others, particularly muscle-strengthening exercises, may show complex psychological correlations depending on contextual

and individual factors. Effective suicide prevention strategies for adolescents should encourage general physical activity and consider its type, context, and underlying motivations. Comprehensive approaches that integrate mental health screening, targeted interventions, and structural support systems are essential for addressing the diverse needs of at-risk youths. Additionally, future research should explore how motivational factors, peer influence, and digital exposure interact with physical activity behaviors to shape suicide risk.

## 5 Conclusions

This study examined the associations between three distinct types of physical activity and suicidal behaviors among Korean adolescents using data from a nationally representative Korea Youth Risk Behavior Web-based Survey. The findings indicated that associations between physical activity and suicidality varied by activity type and suicidal outcome. Specifically, engaging in at least 60 min of general physical activity per day was associated with reduced odds of suicide planning, whereas vigorous activity showed no significant association. In contrast, muscle-strengthening activity was associated with a distinct pattern across suicide-related outcomes in the adjusted models. Mental health factors, such as anxiety, stress, and loneliness, were consistently associated with all forms of suicidal behavior, and sociodemographic variables, including female students, low academic performance, and unstable living arrangements, further increased vulnerability. These findings highlight the importance of targeted screening and interventions, especially for high-risk adolescents, alongside broader social efforts to address structural inequalities.

In school and community settings, physical activity programs may serve as practical platforms for early identification and support. School-based physical education classes, after-school sports programs, and community physical activity initiatives in Korea could integrate routine screening for psychological distress and suicidality. School nurses, counselors, and physical education teachers may be well positioned to notice students who engage intensively in muscle-strengthening activities while exhibiting high levels of distress or pronounced body image concerns, and to facilitate timely referral to mental health services. At the population level, public health messaging should avoid portraying exercise as a universal solution to mental health problems and instead emphasize physical activity that is safe, enjoyable, socially connected, and responsive to adolescents' psychological needs. From a stage-based perspective informed by ideation-to-action frameworks, these findings suggest that physical activity may function differently across stages of suicidality. Regular daily physical activity may be more relevant to intermediate stages such as suicide planning, potentially through mechanisms related to stress regulation, problem-solving capacity, or access to social support, rather than to the initial emergence of suicidal ideation or the transition to attempts. Framing physical activity within stage-specific prevention strategies may help clarify when and how activity-based interventions can most effectively complement broader suicide prevention efforts.

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## References


1. World Health Organization. Suicide. Suicide fact sheets. 2025 [cited 2026 Jan 1]. Available from: https://www.who.int/news-room/fact-sheets/detail/suicide.
2. Youth Policy Evaluation Center. Cause of death in adolescents. Adolescent mortality statistics. 2024 [cited 2026 Jan 1]. Available from: https://www.ypec.re.kr/board?menuId=MENU00747.
3. Young E, Szucs LE, Suarez NA, Wilkins NJ, Hertz M, Ivey-Stephenson A. Disparities and trends in middle school students' suicidal thoughts and behaviors: Results from the youth risk behavior survey, 2015–2019. J Adolesc Health. 2024;74(4):720–8. [CrossRef].
4. Pfeifer JH, Berkman ET. The development of self and identity in adolescence: Neural evidence and implications for a value-based choice perspective on motivated behavior. Child Dev Perspect. 2018;12(3):158–64. [CrossRef].
5. Liu RT, Miller I. Life events and suicidal ideation and behavior: A systematic review. Clin Psychol Rev. 2014;34(3):181–92. [CrossRef].
6. Kwon M, Kim SA, Lee YJ. Factors related to suicidal ideation in adolescents according to types of stress. Iran J Public Health. 2023;52(11):2343–52. [CrossRef].
7. Korea Disease Control and Prevention Agency. The 19th (2023) Korean youth risk behavior survey statistics. 2024 [cited 2026 Jan 1]. Available from: http://www.kdca.go.kr/yhs.
8. Fu Q, Li L, Li Q, Wang J. The effects of physical activity on the mental health of typically developing children and adolescents: A systematic review and meta-analysis. BMC Public Health. 2025;25(1):1514. [CrossRef].
9. Peluso MAM, de Andrade LHSG. Physical activity and mental health: The association between exercise and mood. Clinics. 2005;60(1):61–70. [CrossRef].
10. Ministry of Health and Welfare, Korea Health Promotion and Development Institute. Physical activity guidelines for Koreans. Korean national PA guidelines. 2023 [cited 2026 Jan 1]. Available from: http://www.khepi.or.kr.
11. World Health Organization. Physical activity. PA fact sheets. 2024 [cited 2026 Jan 1]. Available from: https://www.who.int/news-room/fact-sheets/detail/physical-activity.
12. Sun F, Zhang F, Ho KY, Zhang B, Wang Z, Tse AC. Physical activity and executive functions in adolescents: The mediating role of sleepiness. Int J Environ Res Public Health. 2022;19(19):12972. [CrossRef].
13. Mücke M, Ludyga S, Colledge F, Gerber M. Influence of regular physical activity and fitness on stress reactivity as measured with the trier social stress test protocol: A systematic review. Phys Med. 2018;48(11):2607–22. [CrossRef].
14. Guzmán-Muñoz E, Concha-Cisternas Y, Jofré-Saldía E, Castillo-Paredes A, Molina-Márquez I, Yáñez-Sepúlveda R. Physical activity and its effects on executive functions and brain outcomes in children: A narrative review. Brain Sci. 2025;15(11):1238. [CrossRef].
15. Yeom YO, Hong YP, Kim KM, Lee YL, Lim MH. The relationships between academic burnout, mental health, parental achievement pressure, and academic demand in high school students. Stress. 2020;28(2):61–7. [CrossRef].
16. Kim J, Kim H, Jang SI, Park EC. Association between sedentary behavior and depression among South Korean adolescents. BMC Psychiatry. 2022;22(1):622. [CrossRef].
17. Chandrasekaran B, Pesola AJ, Rao CR, Arumugam A. Does breaking up prolonged sitting improve cognitive functions in sedentary adults? A mapping review and hypothesis formulation on the potential physiological mechanisms. BMC Musculoskelet Disord. 2021;22(1):274. [CrossRef].

18. Lee SB. Physical activity program to prevent youth suicide: Development and application effects. J Creative Info Cult. 2023;9(4):389–97. (In Korean). [CrossRef].
19. Bakken V, Lydersen S, Skokauskas N, Sund AM, Kaasbøll J. Protective factors for suicidal ideation and suicide attempts in adolescence: A longitudinal population-based cohort study examining sex differences. BMC Psychiatry. 2025;25(1):106. [CrossRef].
20. Fabiano N, Gupta A, Fiedorowicz JG, Firth J, Stubbs B, Vancampfort D, et al. The effect of exercise on suicidal ideation and behaviors: A systematic review and meta-analysis of randomized controlled trials. J Affect Disord. 2023;330:355–66. [CrossRef].
21. Fabiano N, Gupta A, Wong S, Tran J, Mohammad IY, Bal S, et al. Physical activity, suicidal ideation, suicide attempt and death among individuals with mental or other medical disorders: A systematic review of observational studies. Neurosci Biobehav Rev. 2024;158:105547. [CrossRef].
22. Smith AR, Fink EL, Anestis MD, Ribeiro JD, Gordon KH, Davis H, et al. Exercise caution: Over-exercise is associated with suicidality among individuals with disordered eating. Psychiatry Res. 2013;206(2–3):246–55. [CrossRef].
23. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1·6 million participants. Lancet Child Adolesc Health. 2020;4(1):23–35. [CrossRef].
24. Vella SA, Sutcliffe JT, Fernandez D, Liddelow C, Aidman E, Teychenne M, et al. Context matters: A review of reviews examining the effects of contextual factors in physical activity interventions on mental health and wellbeing. Ment Health Phys Act. 2023;25:100520. [CrossRef].
25. White RL, Babic MJ, Parker PD, Lubans DR, Astell-Burt T, Lonsdale C. Domain-specific physical activity and mental health: A meta-analysis. Am J Prev Med. 2017;52(5):653–66. [CrossRef].
26. Liutsko L, Leonov S, Pashenko A, Polikanova I. Is frequency of practice of different types of physical activity associated with health and a healthy lifestyle at different ages? Eur J Investig Health Psychol Educ. 2024;14(1):256–71. [CrossRef].
27. Huang W, Wong TL. Exercise prescriptions for young people's emotional wellbeing: A systematic review of physical activity intensity, duration, and modality. Front Psychol. 2025;16:1552531. [CrossRef].
28. Yoo JY, Kim KM. The effect of Physical Activities on the mental health in Korean Middle School Adolescents: Based on the Web-based Survey on Adolescents Health Behavior from 2013. J Digit Convergence. 2014;12(11):395–405. [CrossRef].
29. Klonsky ED, May AM. The three-step theory (3ST): A new theory of suicide rooted in the "ideation-to-action" framework. Int J Cogn Ther. 2015;8(2):114–29. [CrossRef].
30. Vancampfort D, Hallgren M, Firth J, Rosenbaum S, Schuch FB, Mugisha J, et al. Physical activity and suicidal ideation: A systematic review and meta-analysis. J Affect Disord. 2018;225:438–48. [CrossRef].
31. Lee J, Lee Y. The association of body image distortion with weight control behaviors, diet behaviors, physical activity, sadness, and suicidal ideation among Korean high school students: A cross-sectional study. BMC Public Health. 2016;16(1):39. [CrossRef].
32. Kim K, Zhou Z, Ren X, Bu X, Jia X, Shao Q. Physical activity and mental health trends in Korean adolescents: Analyzing the impact of the COVID-19 pandemic from 2018 to 2022. Open Med. 2024;19:20240978. [CrossRef].
33. Joensberg E, Fagermyr H, Haugen T, Sandgren SS. The associations between passion for resistance training and muscle dysmorphia. Perform Enhanc Health. 2025;13(3):100343. [CrossRef].
34. World Health Organization. Physical activity. Be healthy be mobile. 2025 [cited 2026 Jan 1]. Available from: https://www.who.int/initiatives/behealthy/physical-activity.
35. Korea Disease Control and Prevention Agency. Trends and associated factors of physical activity among Korean adolescents. National Health Statistics Plus No.01. Cheongju, Republic of Korea: Korea Disease Control and Prevention Agency; 2025.
36. Freire GLM, da Silva Paulo JR, da Silva AA, Batista RPR, Alves JFN, do Nascimento JRA Jr. Body dissatisfaction, addiction to exercise and risk behaviour for eating disorders among exercise practitioners. J Eat Disord. 2020;8:23. [CrossRef].
37. Noetel M, Miskovic-Wheatley J, Crosby RD, Hay P, Madden S, Touyz S. A clinical profile of compulsive exercise in adolescent inpatients with anorexia nervosa. J Eat Disord. 2016;4:5. [CrossRef].

38. Edlund K, Johansson F, Lindroth R, Bergman L, Sundberg T, Skillgate E. Body image and compulsive exercise: Are there associations with depression among university students? Eat Weight Disord. 2022;27(7):2397–405. [CrossRef].
39. Guo S, Kamionka A, Xue Q, Izydorczyk B, Lipowska M, Lipowski M. Body image and risk of exercise addiction in adults: A systematic review and meta-analysis. J Behav Addict. 2025;14(1):39–54. [CrossRef].
40. Piplios O, Yager Z, McLean SA, Griffiths S, Doley JR. Appearance and performance factors associated with muscle building supplement use and favourable attitudes towards anabolic steroids in adolescent boys. Front Psychol. 2023;14:1241024. [CrossRef].
41. Zhang X, Jiang C, Zhang X, Chi X. Muscle-strengthening exercise and positive mental health in children and adolescents: An urban survey study. Front Psychol. 2022;13:933877. [CrossRef].
42. Smith KE, Lavender JM, Leventhal AM, Mason TB. Facets of impulsivity in relation to diet quality and physical activity in adolescence. Int J Environ Res Public Health. 2021;18(2):613. [CrossRef].
43. Sarkisian KL, Van Hulle CA, Hill Goldsmith H. Brooding, inattention, and impulsivity as predictors of adolescent suicidal ideation. J Abnorm Child Psychol. 2019;47(2):333–44. [CrossRef].
44. Li J, Zhang Y, Siu Man Chan B, Tan SN, Lu J, Luo X, et al. Associations between anxiety, depression, and risk of suicidal behaviors in Chinese medical college students. Front Psychiatry. 2022;13:1012298. [CrossRef].
45. Chen YL, Kuo PH. Perceived stress, resilience, and their effects on suicidal behaviors in early adolescence. Eur Child Adolesc Psychiatry. 2020;29(10):1383–94. [CrossRef].
46. Saeed F, Gürcan A, Shoib S, Amanda TW, Ransing R, Bhandari SS, et al. Association between loneliness and suicidal behaviour: A scoping review. Turk J Psychiatry. 2023;14:27080. [CrossRef].
47. Ivey-Stephenson AZ, Demissie Z, Crosby AE, Stone DM, Gaylor E, Wilkins N, et al. Suicidal ideation and behaviors among high school students—Youth risk behavior survey, United States, 2019. MMWR Suppl. 2020;69(1):47–55. [CrossRef].
48. Brockington MP. The effects of suicide exposure in adolescents: Absences, academic performance, and behavior [dissertation]. Lynchburg, VA, USA: Liberty University; 2023. 138 p.
49. Madigan A, Daly M. Socioeconomic status, subjective social status, and depressive symptoms and suicidality. J Affect Disord. 2023;320:96–104. [CrossRef].
50. Uddin R, Burton NW, Maple M, Khan SR, Tremblay MS, Khan A. Low physical activity and high sedentary behaviour are associated with adolescents' suicidal vulnerability: Evidence from 52 low- and middle-income countries. Acta Paediatr. 2020;109(6):1252–9. [CrossRef].
51. Zhang G, Feng W, Zhao L, Zhao X, Li T. The association between physical activity, self-efficacy, stress self-management and mental health among adolescents. Sci Rep. 2024;14:5488. [CrossRef].
52. Zhang K, Liu M, Yin Z, Kong N, Gong H. The effect of exercise motivation on adolescents' subjective well-being: Chain mediation of physical activity and Social-emotional competency. BMC Public Health. 2025;25(1):1698. [CrossRef].
53. Kracht CL, Pochana SS, Staiano AE. Associations between moderate to vigorous physical activity, sedentary behavior, and depressive symptomatology in adolescents: A prospective observational cohort study. J Phys Act Health. 2023;20(3):250–7. [CrossRef].
54. Yang W, Chen H, Liu W, Qu S, Ge Y, Song J. Efficacy of vigorous physical activity as an intervention for mitigating depressive symptoms in adolescents and young adults: A comprehensive systematic review and meta-analysis. Front Behav Neurosci. 2025;19:1479326. [CrossRef].
55. Kwak CW, Ickovics JR. Adolescent suicide in South Korea: Risk factors and proposed multi-dimensional solution. Asian J Psychiatry. 2019;43:150–3. [CrossRef].
56. Kim JY, Kim Y, Kim DH. The Relationship between Academic Stress and Sleep Disorders in Adolescents: Mediating Effect of Difficulties in Emotions Regulation. Locality Glob. 2025;49(3):109–32. (In Korean). [CrossRef].
57. Holliday R, Elfving-Hwang J. Gender, globalization and aesthetic surgery in South Korea. Body Soc. 2012;18(2):58–81. [CrossRef].
58. Jiang Y, Bong M, Kim SI. Conformity of Korean adolescents in their perceptions of social relationships and academic motivation. Learn Individ Differ. 2015;40:41–54. [CrossRef].

59. Lan Z, Liu H, Huang X, Wang Q, Deng F, Li J. The impact of academic pressure and peer support on adolescents' loneliness: A polynomial regression and response surface analysis. Psychol Res Behav Manag. 2023;16:4617–27. [CrossRef].
60. Roh S, Mun W, Kim G. Associations between physical activity, mental health, and suicidal behavior in Korean adolescents: Based on data from 18th Korea youth risk behavior web-based survey (2022). Behav Sci. 2024;14(3):160. [CrossRef].
61. Huo M, Yang Z, Yang L, Chen S. Can sports participation be a protective factor against suicide-related outcomes in adolescents: A systematic review. Front Psychol. 2024;15:1341795. [CrossRef].
62. Hoare E, Milton K, Foster C, Allender S. The associations between sedentary behaviour and mental health among adolescents: A systematic review. Int J Behav Nutr Phys Act. 2016;13(1):108. [CrossRef].