



RESEARCH ARTICLE

Associations between Physical Activity and Depressive Symptoms through Obesity and School Bullying among Adolescents

Evan K Kim* and Timothy Munro

Seoul International School, Republic of Korea

*Corresponding author: Evan K Kim, Seoul International School, Seongnam-si, Gyeonggi-do, 13113, Republic of Korea, Tel: 82-10-5375-0233, Fax: 82-31-759-5133



Abstract

Physical activity has been shown to be associated with improved physical and mental health conditions and can reduce the risk of depressive symptoms among adolescents. While the underlying mechanisms thought to mediate the relation between physical activity and depressive symptoms have not been well-established, the current study investigated the association of physical activity with depressive symptoms and whether this relationship would be explained by obesity and experiencing school bullying. This study is a cross-sectional analysis of the data drawn from the 2019 Youth Risk Behavior Survey including a nationally-representative sample of U.S. high school students (N = 13677, Female N = 6885 (49.4%)). Self-report measures of physical activity (i.e., Youths' participation in vigorous physical activity, physical education, and sports teams, score range = 0-3), depressive symptoms (yes/no), school bullying experience (yes/no), and obesity (yes/no) were used to conduct a series of binary logistic regression models. Among the total sample of 9th-12th graders, 44.1% of students reported that they were physically active for a total of at least 60 minutes per day on 5 or more days per week, and half of the participants were involved in physical education programs (52.2%) and 1 or more sports teams (57.4%). Regarding depressive symptoms, 36.7% of students reported feeling sad or hopeless almost every day for two weeks or more in a row during the past 12 months. After controlling the student's sociodemographic factors (i.e., age, sex, race/ethnicity, grade), higher levels of physical activity significantly decreased the odds of depressive symptoms by 16.4% (OR = 0.836; 95% CI = 0.805, 0.868; $p < 0.001$) as well as being obese by 20.2% (OR = 0.798; 95% CI = 0.757, 0.841; $p < 0.001$) and being bullied at school by 5.3% (OR = 0.947; 95% CI = 0.905, 0.991; $p = 0.019$). In a subsequent analysis including

obesity and school bullying as simultaneous regressors with physical activity, the magnitude of the association between physical activity and depressive symptoms was attenuated (OR = 0.825; 95% CI = 0.791, 0.860; $p < 0.001$), and obesity (OR = 1.276; 95% CI = 1.137, 1.431; $p < 0.001$) and school bullying (OR = 3.572, 95% CI = 3.231, 3.948; $p < 0.001$) were significantly associated with increased odds of depressive symptoms. These findings suggest that physical activity is inversely related to depressive symptoms and may help to mitigate the negative effects of mood disorders among adolescents via biological and psychosocial processes (i.e., obesity, school bullying). Elucidating the processes underpinning the effects of physical activity on depressive symptoms among adolescents may provide the necessary impetus for schools and policy makers to prioritize the promotion of physical activity.

Keywords

Depressive symptoms, Physical activity, Obesity, School bullying, Adolescent

Introduction

Depression is one of the most common psychiatric symptoms occurring in adolescents. According to data from the 2017 National Survey on Drug Use and Health, in 2017, 13% of U.S. teens aged 12 to 17 (or 3.2 million) said they had experienced at least one major depressive episode in the past year, up from 8% (or 2 million) in 2007 [1]. Depressive symptoms can result in severe impairments that interfere with or limit one's ability to carry out major life activities, and depressed adolescents are also significantly more apt to demonstrate suicidal ideation accompanied by a concomitant sense of

helplessness and hopelessness [2]. Therefore, studies in the psychology, health, and well-being of adolescents have increasingly focused on risk and protective factors related to youth depressive symptoms.

A substantial literature provides an empirical rationale for the physical and psychosocial benefits of regular physical activity among adolescents [2,3]. Research indicates that youth who engage in regular physical activity are less likely to become overweight [4,5] and also report better psychological well-being, including lower levels of depressive symptoms [6,7]. Numerous hypothetical mechanisms have been given as to why participation in physical activity may be inversely related to depressive symptoms during adolescence. Some explanations suggest that active or athletic lifestyles are indirectly associated with reduced risks of depressive symptoms via biological and social factors [2,6]. For example, research has shown exercise to have positive biological effects on brain chemistry, eating a healthy diet, and the development of social competence [8,9]. Physical activity provides an opportunity for social interaction (relatedness), mastery in the physical domain (self-efficacy and perceived competence), improvements in self-perception of appearance (body image), and independence (autonomy) [9]. Also, physical activity (e.g., cardiorespiratory fitness) has been identified to be beneficial for brain structures that support executive functioning and cognitive control, including neural networks supportive of executive functioning, which can reduce the risk of depressive symptoms [10]. However, to our best knowledge, these underlying mechanisms thought to mediate the relation between physical activity and depressive symptoms have not been well-established by nationally representative and school-based empirical research.

Informed by literature suggesting the roles of school peers and obesity on youth physical and mental health [8], the present study hypothesized that experiences of obesity and school bullying would explain the association between physical activity and depressive symptoms among adolescents. First, a substantial body of research documents a negative correlation between high levels of physical activity and obesity [5,11]. Furthermore, several evidence-based studies have shown that obese teens have a higher incidence of mental health problems, including depressive symptoms, than non-obese teens [12]. Studies have found that higher rates of peer victimization occur more in obese than non-obese teens [13]. Also, self-worth/esteem of physical appearance and body dissatisfaction were identified as mediators that could potentially explain the relationship between obesity and depressive symptoms among adolescents [14]. Informed by the literature, a rational conclusion is that youth obesity can significantly explain the association between physical activity and depressive symptoms.

Additionally, researchers have proposed that the

interpersonal support that physical activity/education and sports participants receive from teachers, teammates, and friends may provide youth with a therapeutic environment that reduces the risk of depressive symptoms [9,15]. While youths' participation in various physical activities and education classes can provide adolescents with opportunities to establish positive social relationships, high levels of physical activity and engagement in physical education classes are expected to be related to reduced risks for being bullied on school property, which can, in turn, influence the development of depressive symptoms among high school students. Prior research has reported that youth team sports participation was negatively associated with peer victimization via enhancing their personal growth and social skills that are often needed to deal with bullying situations [16,17]. Also, physical education teachers and sports coaches may not only help students improve their physical status and social skills, but also play a proactive role in the face of bullying episodes [18].

To date, considerable research has examined youth physical activity and its various positive effects including reductions in depressive symptoms. Little research, however, has tested the factors to explain this association between physical activity and lower likelihood of depressive symptoms among adolescents. Therefore, the present study examined if obesity and being bullied on school property would mediate the effects of physical activity on decreased risks of depressive symptoms. Using a nationally representative sample of U.S. high school students, we tested the associations of physical activity, obesity, school bullying experience, and depressive symptoms. We hypothesized that physical activity would be negatively associated with obesity and being bullied on school property, which in turn would be related to depressive symptoms after controlling for the effect of physical activity on depressive symptoms.

Methods

Participants and study design

Data were drawn from the Youth Risk Behavior Surveillance System (YRBSS) [19], a cross-sectional, biennial survey led by Centers for Disease Control and Prevention (CDC). The YRBSS is the largest public health surveillance system in the U.S., monitoring a broad range of health-related behaviors among high school students, and including a nationally-representative sample of U.S. high school students. YRBSS procedures were approved by the CDC institutional review board and detailed in prior studies [20]. Participants in this study were comprised of 13,677 students in grades 9 to 12 who completed the 2019 YRBSS survey.

Measures

Depressive symptoms: To assess a common depressive symptom [21], participants responded to a

single question regarding their thoughts and feelings: “During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?” The responses were coded dichotomously (0 = No, 1 = Yes).

Physical activity score: Physical activity score was assessed by 3 items. First, frequency of physical activity was assessed with an item: “During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?” Original response categories from 0 to 7 days were recoded dichotomously (0-4 days (= 0]) vs. 5-7 days (= 1). Also, students reported the frequency of their physical education classes using the item: “In an average week when you are in school, on how many days do you attend physical education (PE) classes?” Responses were coded by 0 days (= 0) vs. 1 or more days (= 1). Finally, the number of sports teams that students engaged in was assessed: “During the past 12 months, on how many sports teams did you play? (Count any teams run by your school or community groups”). Responses were coded by 0 teams (= 0) vs. 1 or more teams (= 1). These 3 dichotomous items were created based on the YRBSS guideline correctly classifying students as meeting the recommended level of physical activity (i.e., youth’s participation in vigorous physical activity) and were summed to create the reliable and valid scale of physical activity (range = 0-3), covering various activities related to physical health [22-24].

Obesity: Weight was measured without shoes to the nearest quarter pound using a physician balance scale. Height was measured to the nearest quarter inch using a physician portable scale stadiometer. Body Mass Index (BMI) was calculated as weight in kilograms/height in meters squared. Then, age, gender, and BMI were used to classify youths as obese when the BMI percentile was at or above the 95th percentile for BMI by age and sex (0 = No, 1 = Yes).

Bullied on school property: Participants reported if they were bullied at school during the past 12 months. The survey question asked: “During the past 12 months, have you ever been bullied on school property?” Responses were coded dichotomously (0 = No, 1 = Yes).

Sociodemographics: A priori sociodemographic covariates were selected based on their association with the key study variables such as physical activity and depressive symptoms in the extant literature [8,9]. Demographic variables include age (12 years or younger, 13 years, 14 years, 15 years, 16 years, 17 years, and 18 years or older), gender (female vs. male), and grade (9th, 10th, 11th, 12th). Race/ethnicity variable was created using two questions: 1) “Are you Hispanic or Latino?” (response options “yes” or “no”) and 2) “What is your race?” (response options “American Indian or Alaska Native”, “Asian”, “Black or African American”, “Native Hawaiian or other Pacific Islander”, or “White”). The responses were recoded into 5 categories (White, Hispanic/Latino, Black or African American, Asian, All other races/ethnicities).

Statistical analysis

First, descriptive results for each study variable were evaluated. Since YRBSS employs a complex sampling scheme requiring the consideration of sampling weights [20], unweighted frequency and weighted percentages (%) were presented in Table 1. Then, we tested a

Table 1: Descriptive results.

Variables	Unweighted N	Weighted %
Gender		
Female	6885	49.4
Male	6641	50.6
Age		
12 years or younger	60	0.3
13 years	27	0.1
14 years	1699	11.9
15 years	3473	24.8
16 years	3628	25.6
17 years	3102	23.7
18 years or older	1616	13.7
Grade		
9 th grade	3637	26.6
10 th grade	3717	25.5
11 th grade	3322	24.3
12 th grade	2850	23.6
Race/ethnicity		
Non-Hispanic white	6668	51.2
Hispanic/Latino	3038	26.1
Black/African American	2040	12.2
Asian	618	5.1
Other ^a	875	5.4
Physical activity score, Mean (SD) ^b	1.39 (1.04)	-
Physical activity (5+ days vs. 0-4 days)	5625	44.1
Physical education (1+ days vs. 0 days)	5423	52.2
Sports teams (1+ teams vs. 0 teams)	5545	57.4
Obese		
No	10345	84.5
Yes	1795	15.5
Bullied on school property		
No	10744	80.5
Yes	2703	19.5
Depressive symptoms		
No	8495	63.3
Yes	4926	36.7

N = 13677. ^aOther category included American Indian/Alaska Native, Native Hawaiian/other Pacific Islander, and multi-ethnic/multi-racial options. ^bPhysical activity score was coded by sum of 3 binary items (range = 0-3).

Table 2: Associations of physical activity, physical activity, obesity, school bullying, and depressive symptoms.

Model A: Association of physical activity with obesity		
Predictors	Outcome: Obesity	
	OR (95% CI)	<i>p</i>
Physical activity	0.798 (0.757, 0.841)	< 0.001
Model B: Association of physical activity with school bullying		
Predictors	Outcome: School bullying	
	OR (95% CI)	<i>p</i>
Physical activity	0.947 (0.905, 0.991)	0.019
Model C: Association of physical activity with depressive symptoms		
Predictors	Outcome: Depressive symptoms	
	OR (95% CI)	<i>p</i>
Physical activity	0.836 (0.805, 0.868)	< 0.001
Model D: Association of physical activity, obesity, and school bullying with depressive symptoms		
Predictors	Outcome: Depressive symptoms	
	OR (95% CI)	<i>p</i>
Physical activity	0.825 (0.791, 0.860)	< 0.001
Obesity	1.276 (1.137, 1.431)	< 0.001
School bullying	3.572 (3.231, 3.948)	< 0.001

N = 13677. Each binary logistic regression model controlled for participants' gender, age, grade, and race/ethnicity variables.

series of binary logistic regression models to examine associations among study variables including physical activity, obesity, school bullying, and depressive symptoms (see Model A, B, C, D in Table 2). Based on the procedural basic steps for mediation analysis suggested by Baron and Kenny [25], we tested three sets of regression: 1) Model A & B: X (i.e., physical activity) → M (i.e., obesity, school bullying); 2) Model C: X (i.e., physical activity) → Y (i.e., depressive symptoms); and 3) Model D: X + M → Y. Each regression model adjusted for participants' age, gender, race/ethnicity, and grade. Odds ratio (OR) and 95% confidence interval (95% CI) were reported, and statistical significance was based on two-tailed hypothesis tests at the 0.05 level. All analyses were performed using the IBM SPSS Software Version 27 [26].

Results

Descriptive statistics

Among 13677 students in grades 9 to 12 who completed the 2019 YRBSS survey, 49.4% of students were female, and respondents reported their race/ethnicity as 51.2% Non-Hispanic White, 26.1% Hispanic/Latino, 12.2% African American, 5.1% Asian, and 5.4% other race/ethnicity group. Students ranged in age from 12 to 18 years (Mean = 16.01 years, *SD* = 1.25 years). In terms of physical activity related variables, 44.1% students reported that they were physically active (for a total of at least 60 minutes per day) in 5 or more days in the past week, and 52.2% of students had 1 or more days of physical education classes in an average week. Also, 57.4% of students reported that they were involved in 1 or more sports teams in the past 12

months. Generally, the mean of the summed physical activity score of these 3 items was 1.39 (*SD* = 1.04) while 24.0% students reported that they did not engage in any physical activities. Of participating students, 15.5% were considered obese, and 19.5% reported experiences of being bullied on school property in the past 12 months. Finally, 36.7% of our sample reported depressive symptoms (i.e., feeling sad and hopeless) during the past 12 months.

Associations among physical activity, obesity, school bullying, and depressive symptoms

As presented in Table 2, a series of linear regression models was tested to identify associations of the study variables. We first examined associations of physical activity with two factors which are proposed to be influenced by physical activity: 1) Obese and 2) Bullied at school. After controlling for the participants' sociodemographic factors (i.e., age, gender, race/ethnicity, grade), physical activity was significantly associated with reduced odds of being obese (OR = 0.798, 95% CI = 0.757, 0.841, *p* < 0.001; see Model A in Table 2) and being bullied at school (OR = 0.947, 95% CI = 0.905, 0.991, *p* = 0.019; see Model B in Table 2). The results indicated that high levels of physical activity score were negatively associated with being obese and bullied on school property among high school students.

We then examined the main effects of physical activity on depressive symptoms (see Model C in Table 2). Increases in physical activity scores significantly reduced the odds of depressive symptoms by 16.4% (OR = 0.836, 95% CI = 0.805, 0.868, *p* < 0.001) after controlling for sociodemographic factors. Finally, we tested a model

to identify additional associations of obesity and school bullying with depressive symptoms after controlling for physical activity and sociodemographic factors (see Model D in Table 2). When the regression model included physical activity, obesity, and school bullying variables simultaneously, being obese (OR = 1.276, 95% CI = 1.137, 1.431, $p < 0.001$) and being a target of school bullying (OR = 3.572, 95% CI = 3.231, 3.948, $p < 0.001$) significantly and additionally increased the odds of depressive symptoms after controlling for the effects of physical activity effects on depressive symptoms (OR = 0.825, 95% CI = 0.791, 0.860, $p < 0.001$). The results indicated that the main influences of physical activity on depressive symptoms were significantly explained or mediated by obesity and school bullying variables.

In summary, four regression models that we examined displayed that physical activity was negatively associated with being obese and bullied at school (Model A and B), which in turn were related to depressive symptoms after explaining the effect of physical activity on depressive symptoms (Model D).

Discussion

Informed by prior research identifying the psychosocial benefits of physical activity among youths, the current study conducted a series of models to examine associations of physical activity with obesity, school bullying experiences, and depressive symptoms. We identified that physical activity was negatively associated with depressive symptoms and that this relationship was significantly mediated by obesity and being bullied on school property, which were negatively related to physical activity. These findings were consistent with our hypothesized pathways to link physical activity to depressive symptoms via obesity and school bullying experiences.

Consistent with prior studies, we found significant associations of physical activity with reduced risks for obesity, school bullying, and depressive symptoms. First, adolescents who participated in more frequent physical activities and physical education classes or participated in team sports showed lower likelihood to have depressive symptoms during high school [4,6,7]. This finding suggests that physical activity may be a potential protective factor that can reduce the risk of depressive symptoms. As depressive symptoms are maintained by negative, automatic thoughts and passive, withdrawn behaviors, prior research based on a cognitive-behavioral framework suggested the ways in which physical activities are associated with a reduction of depressed mood [9]. Behavioral and physical activation seeks to promote engagement with activities that are reinforcing and consistent with the long-term future-oriented goals of individuals, which are negatively related to the patterns of avoidance and withdrawal, typically shown among individuals with depressed mood [9]. These activation strategies

include self-monitoring, structuring, scheduling of daily activities, rating of degree of pleasure and accomplishment experienced during engagement of daily physical activities, and exploring various behaviors related to achieving goals [27].

Engagement in frequent physical activities, physical education programs, and team sports were negatively associated with lower risks for being obese and being bullied in school, and these factors additionally explained association between physical activity and depressive symptoms among high school students. Prior studies have displayed that obese youth had a higher probability of displaying negative mental health symptoms than non-obese youth [12]. Obesity is associated with several developmental factors that could contribute to the development of depressive symptoms [9] including greater rates of bullying, social isolation, and low self-esteem [28]. Also, physical activity including involvement in physical education programs and team sports facilitates social development, positive self-perception, and positive affect by providing the opportunities to feel accepted by peers (i.e., peer acceptance) and promote positive peer social interactions [2,29]. The benefits of youth physical activity can reduce the risk of school bullying, a proximal influence on the development of depressive symptoms [2].

Considering all relationships of physical activity, obesity, school bullying, and depressive symptoms that we found in the present study, we suggest that physical activity may play an important role in youth's psychosocial well-being as well as it may serve as protection against mental health problems. Exploration of the intricate mediating process between physical activity and depressive symptoms can improve our understanding of protective mechanisms, which will benefit youth with depressed mood, parents, teachers, community youth organizations, and mental health clinicians for at-risk youth. Since searching for health protective factors has been in the focus of effective treatments for youths with mental health problems, the types of interventions addressing physical activity that will prevent proximal risk factors (e.g., obesity, school bullying) to depressive symptoms merit further prevention research.

Some limitations should be noted. This study utilized the cross-sectional correlational study design using the 2019 YRBSS survey. Therefore, the causality or directionality of the study variables may not be determined when the potential bidirectional and reciprocal influences between physical activity, obesity, school bullying, and depressive symptoms are considered. Future studies utilizing a longitudinal cohort survey may be needed to investigate the underlying causal mechanisms. Also, this study was based on a youth self-report questionnaire, raising concerns

related to potential self-report bias issues. For example, retrospective self-report questionnaires were used to assess depressive symptoms in the past 12 months and could be exaggerated in a negative direction relative to the average ratings given to the moods contemporaneously [30]. The subjective assessment of physical activity could also be overestimated due to the potential social desirability bias (i.e., the tendency of survey respondents to answer questions in a manner that will be viewed favorably by others) [31]. Finally, since a single item was used to assess depressive symptoms and school bullying in the YRBSS survey, the detailed information about these factors such as levels of depressive symptoms or types of school bullying (e.g., physical, verbal, exclusion, cyber) was not investigated. These measurement issues should be addressed in future research using measures constructed with multiple items or objective measurements such as ecological momentary assessment which can minimize the problem of retrospective memory biases compared to traditional self-report measures.

Conclusion

The present study extended the research evaluating the association between physical activity and depressive symptoms among U.S. high school students by investigating how this relationship was explained by obesity and school bullying. The finding of pathways linking physical activity to depressive symptoms via obesity and school bullying can increase our understanding of biological and psychosocial benefits of physical activity in adolescents. Improving our understanding of how physical activity reduced the risk of depressive symptoms in adolescents may assist in the design of interventions to optimize their possible impact on the mechanisms that confer protection against youth depressive symptoms.

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Conflict of Interest Statement

The authors have no conflicts of interest relevant to this article to disclose.

Authors' Contribution

EKK conceptualized and designed the study, analyzed and interpreted the data, drafted the initial manuscript, and reviewed and revised the manuscript. TM reviewed the manuscript for intellectual content and revised the manuscript. All authors approved of the final manuscript as submitted and agree to be accountable for all aspects of the work.

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