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Associations of physical activity by intensity (moderate vs. vigorous) with depression and suicidal thoughts among middle school students in South Korea

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한국 중학생의 신체활동 정도와 우울 및 자살사고 간의 관련성

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Abstract This study examined the associations of physical activity by intensity with depression and suicidal thoughts among middle school students in South Korea. This study used data from the Survey of Korean Youth Health Risk Behavior. The samples were middle school students (Total 37,420). Logistic regression analysis were used. For depression, 33% of males and 43% of females felt depressed, whereas 17.8% of males and 27.7% of females experienced suicidal thoughts. In regression, both moderate physical activity and vigorous physical activity were associated significantly with a lower incidence of depression. In suicidal thoughts, moderate physical activity was associated with a lower incidence of suicidal thoughts among female students. In path analysis, vigorous physical activity had a direct and indirect effect on depression and suicidal thoughts. Physical activity is a potential mediator in decreasing depression and suicidal thoughts among middle school students.

요 약 본 논문은 한국 중학생의 신체활동이 우울 및 자살사고에 영향을 미치는지 조사하고자 시행되었다. 자료분석을 위해 청소년건강행태 온라인 조사 자료를 이용하였다. 연구대상자는 전국 중학생으로 표본수는 총 37,420명이다. 분석방법은 로지스틱 회귀분석을 사용하였다. 분석결과, 남학생의 33%, 여학생의 43%가 우울한 경험이 있다고 응답하였고, 남학생의 17.8%, 여학생의 27.7%가 자살사고의 경험이 있다고 응답하였다. 회귀분석 결과, 중등도 신체활동과 고강도 신체활동 모두 우울발생에 대해 낮은 가능성을 보인 반면, 자살사고에 대해서는 여학생에서만 중등도 신체활동이 자살사고 발생에 대해 낮은 가능성을 보였다. 경로분석결과, 중등도 신체활동은 우울과 자살사고에 유의한 영향이 없었으나, 반면 격렬한 신체활동은 직간접적으로 우울과 자살사고에 영향을 미치는 것으로 나타났다. 신체활동은 남녀 중학생의 우울 및 자살을 예방할 수 있는 중요한 매개역할을 담당하는 것으로 분석된다.

Key Words : Adolescents, Exercise, Depression, Suicide

1. Introduction

More than a million people commit suicide every year in globally[1]. Suicides in Korea show a sharp increase from the late 1990s. Korea now has the highest suicide rates among OECD countries (around 22 deaths per 100000 individuals)[2]. An increase in the suicide rate is a health concern, as well as a social problem. Suicide, one of the main causes of death among adolescents and young adults, is gradually increasing, particularly among adolescents[3]. According to a study in the United States, the number

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of patients visiting the emergency room for suicide attempts continuously increased between 1992 and 2001. Moreover, out of the patients visiting the emergency room for suicide attempts, the number of adolescents under the age of 15 years sharply increased during the study. Hence, there is an urgent need to develop adolescent suicide prevention programs[4]. Depression is one of the strongest predictors of suicide among adolescents[5]. Previous studies have revealed that depressive-anxious symptoms and use of antidepressants by patients suffering from a major depressive disorder predicted suicidal behavior[6,7]. Depressed patients were likely to die by attempting suicide during the follow-up period in the prospective study[8]. Depression is also a major public health concern among children and adolescents. According to the results of a meta-analysis which who analyzed 26 studies examining juvenile and adolescent depression rates[9], the depression rate in adolescents under 13 years old was 2.8% and the depression rate for adolescents between 13 and 18 years old was found to be 5.6%. Depression symptoms that begin in adolescence continue to be a determinant of mental health throughout their entire lives[10]. Depression during adolescence was found to be a significant predictor of current suicidal behavior (suicidal thoughts, suicide plans, and suicide attempts) and future suicidal behavior (i.e. during adulthood)[11]. Specific stresses and mentioning death (e.g. writing, thoughts, or talking about death or dying) can be other indicators of suicidal behavior in adolescence[12].

Researchers in South Korea have explained that South Korean adolescents face many challenging issues and responsibilities (e.g. schoolwork, employment, appearance, career choices, relationships, personality, self-identity, problems with the opposite sex, social reputation and rank) in the demanding society[13]. The homogeneous and rigid social atmosphere of South Korea neglects adolescents who have failed in challenging tasks, which results in health problems, such as depression and suicidal behaviors, as well as behavioral problems among adolescents. In suicidal behaviors of general population (total 6,510) in Korea, the incidence rates of suicidal thoughts, suicidal plan, and suicidal attempt were 15.2%, 3.3%, and 3.2%, respectively[14]. To subdue the increasing suicide rates among adolescents in Korea, different methods for preventing and treating depressive symptoms have been proposed. Physical activity has gradually emerged as an effective treatment for adolescent depression that has fewer possible side effects and is cost effective than other therapies or programmes[15,16].

Physical activity is associated with mental health benefits, including enhanced emotional health[17,18], improved cognitive functioning[19], and better quality of life[20]. In clinical patient, level of physical activity were low in adolescent psychiatric patient compared with the general population[21]. These benefits from participation in regular physical activity could mediate a lower risk of suicidal behaviors among physically active people than people who are sedentary. The relationship between physical activity and suicidal behaviors may be explained by biological mechanisms which serotonergic functioning may play a role in suicidal behaviors[22,23]. Mood improvements related with physical activity may increase levels of serotonin, which is hormone secreted in brain[23]. Theoretically, physical activity may be associated with suicidal behaviors as results of hormone response that occur with physical activity. The associations between physical activity and symptoms of depression also have shown in cross-sectional and prospective study[24,25]. Physical activity can be used as a stand-alone treatment approach or in combination with medication and/or psychological therapy for depression[26].

There have been many studies investigating the associations between psychosocial factors and Korean adolescents' depression and suicidal behaviors[27,28]; however, studies evaluating whether physical activity effectively is related with depression and suicide variables (suicidal thoughts, suicidal plans, suicidal attempts) are infrequent. In addition, there are some

issues that clearly require further evidence and debate, such as potential gender difference and the amount and intensity of physical activity. UK Physical activity guidelines were definite including time and intensity of physical activity(for example, 75 minutes of vigorous intensity activity spread across the week)[29]. But, the evidence on guidelines of physical activity is less in South Korea, Therefore, the aim of this study is to examine the associations of intensity of physical activity with depression and suicidal thoughts in a representative population-based sample of South Korean adolescents.

2. Method

2.1 Participants and data

This study used data from the fourth online survey of Youth Health Risk Behavior by the Korean Center for Disease Control. The Korea Youth Health Risk Behaviors Web-based Survey (KYRBWS) has been administered annually since 2005 to assess the nationwide prevalence of adolescent health risk behaviors among middle and high school students, to assess whether those behaviors change over time, and to examine the co-occurrence of health risk behaviors. The health risk behaviors that this survey focuses on include tobacco use, unhealthy dietary practices, inadequate physical activity, alcohol and other drug use, sexual behaviors, and violent behaviors. KYRBWS is a rich data source that supports research on a wide range of topics despite of some limitations it has. Limitations include possible self-reporting bias, possible selection bias resulting from not including school drop-outs, and use of low-level scales such as dichotomy or nominal scales.

Data collection was done through online survey. Well-trained data collectors explained the objective of the survey and the entire survey of process to the students before the administration of the survey. The survey, which took 45 to 50 minutes, was administered twice, approximately two weeks apart, in computer room of each selected school. The students were required to visit the KYRBWS website and logged in with a unique number, which was assigned to each student to assure anonymity. After logging in, the students completed the self-reported questionnaire. The students' responses were automatically stored in the database of the KYRBWS. This study analyzed the data only from the middle school students. Total sample were 37,420 middle school students.

2.2 Measurements

2.2.1 General characteristic variables

General characteristics were divided into socio-demographic variables and clinical variables. Socio-demographic variables included gender, grade, parents' education, academic achievement (school grade), family economic status, living situation and participation in physical education each week. Clinical variables included obesity (Body Mass Index, BMI) and existence of chronic illness. Self-reported height and weight were used to calculate BMI as weight (kg) divided by height squared (m^2) and classified individuals as obese (BMI $\geq$ 30 kg/m^2), overweight (25 kg/m^2 $\leq$ BMI <30 kg/m^2), normal (18.5 kg/m^2 $\leq$ BMI< 25 kg/m^2), or underweight (BMI< 18.5 kg/m^2). The question used to determine whether the participants were suffering from chronic illness was 'Have you had any of the following long term illnesses?' It was coded 'yes' if they responded yes to any of the following diseases: atopic dermatitis, rhinitis, asthma, gastritis, enteritis, cancer (malignant tumor, leukemia), cardiac disorder (congenital malformation), diabetes, or other illnesses. If they responded no to all of the diseases, it was coded 'no.' Father's and mother's education were classified separately as below middle school, high school, or at least some college. The participant's academic achievement(school grades) was classified as high, moderate, or low based on the response to the question 'How did you do in school last year?' and the family economic status was also recoded

as high, moderate, or low.

The participant's living situation was based on the responses to the question, 'Do you live with your parents?' and the possible responses were 'living with both father and mother,' 'living with only father or only mother,' and 'living with neither father nor mother.' Responses to the question, 'How many hours did you actually play on the playground or in the gym during P.E. in the past week?' were recoded as 0 for less than one hour and 1 for one or more hours.

2.2.3 Independent variable

Experience with drinking alcohol was measured using the responses to the question, 'How many days in the last month did you drink more than one glass of alcohol?' Responses were recorded as 0 for no days and 1 for a day or more. Since middle school is a time in which many South Korean students experiment with alcohol, it was important to distinguish experimentation from habitual drinking. In order to accurately measure the number of students who were involved with habitual drinking, it was asked as how many days 'in the past month' they had drunk more than a glass, as opposed to simply 'in the past'. For smoking experience, they were asked, 'How many days in the past month did you smoke cigarettes?' Their responses were classified as 0 for no days and 1 for a day or more. For stress, the question, 'Do you usually feel stress?' was asked. Responses were classified into three categories: high, moderate, and low. For illegal substance use, responses were classified as 'yes' or 'no' based on whether or not they used one or more of the following: illegal substances, diet pills, stimulant pills, sleeping pills, or other drugs at the time of the survey.

Physical activity was measured by intensity: moderate physical activity or vigorous physical activity. Moderate physical activity was recorded as 0 for no days per week or 1 for a day or more per week, based on responses to the question, 'How many days did you get out of breath from playing or doing activities such as playing table tennis, carrying light things, doing recreational swimming, playing non-competitive volleyball or badminton, for more than 30 minutes in the past week?'. Vigorous physical activity was coded as either 0 for no days per week or 1 for a day or more per week, based on the question 'How many days in the past week have you been out of breath or sweat a bit from exercising such as jogging, playing soccer, playing basketball, doing Taekwondo, climbing, riding a bike, doing competitive swimming, or carrying heavy things?'

2.2.4 Dependent variables

Dependent variables included perceived depressive symptoms and suicidal thoughts. Whether the participants suffered from perceived depressive symptoms was based on responses to the question 'In the past year, have you ever felt so sad or depressed that you wanted to end your life for a period of over two weeks?' Their responses were classified as 0 for no and 1 for yes. The presence of suicidal thoughts was measured by responses to the question, 'Have you ever seriously considered suicide in the past year?' Their responses were classified as 0 for no and 1 for yes.

2.3 Data analysis

Data were analyzed using 18.0 SPSS for Win. The analysis was carried out separately for males and females to see the difference in prevalence and association of depression and suicidal thoughts among adolescents according to gender. Chi-square analysis was used to examine the gender difference of behavioral variables (alcohol drinking behavior, smoking behavior, stress, illegal substances), physical activity level, depression, and suicidal thoughts.

To assess whether physical activity was associated with depression and suicidal thoughts of adolescents in South Korea, stepwise logistic regressions were conducted separately for the two dependent variables. The effects of physical activity intensity on depression and suicidal thoughts are presented (1) as unadjusted

odds ratios, (2) as odds ratios adjusted for socio-demographic variables, and (3) as odds ratios adjusted for potential confounders (alcoholic drinking behavior, smoking behavior, stress, illegal substance use) that were revealed as potential confounders from the previous literature. Meanwhile, socio-demographic variables and potential confounders were defined as co-variables in steps of the logistic regression. Non-participants in physical activity were assigned as the reference group.

AMOS version 22.0 was used to assess pathways between physical activity by intensity and dependent variables(depression and suicidal thoughts). Missing data were excluded from analyses.

3. Result

3.1 General characteristics of the participants

The 37,420 participants were comprised of 19,620 (52.4%) male and 17,800 (47.6%) female students. Grades were similar for male and female students; the percentage of first-year students was the highest. 33.5% of male students and 34.7% of female students were found to be underweight. Males showed a higher predisposition to obesity than female students, with obesity being present in 1.2% of male students and 0.3% of female students. In regards to academic achievement, over 40% of both male and female students responded 'high'[Table 1].

[Table 1] Descriptive results
(n=37,420 /male 19,620, female 17,800)

Variables		Total (n/%)	Male (n/%)	Female (n/%)
Grade	1	12876(34.4)	6916(35.2)	5960(33.5)
	2	12384(33.1)	6405(32.6)	5979(33.6)
	3	12160(32.5)	6299(32.1)	5861(32.9)
BMI	Underweight	12758(34.1)	6578(33.5)	6180(34.7)
	Normal	21227(56.7)	10729(54.7)	10498(59.0)
	Overweight	2565(6.9)	1760(9.0)	805(4.5)
	Obese	276(0.7)	228(1.2)	48(0.3)
Academic achievement	High	15194(40.6)	7997(40.8)	7197(40.4)
	Moderate	10039(26.8)	5242(26.7)	4797(26.9)
	Low	12187(32.6)	6381(32.5)	5806(32.6)
Father's education	Below middle school	2554(6.8)	1361(6.9)	1193(6.7)
	High school	14175(37.9)	6912(35.2)	7263(40.8)
	Above college	13667(36.5)	7071(36.0)	6596(37.1)
Mother's education	Below middle school	2682(7.2)	1348(6.9)	1334(7.5)
	High school	17993(48.1)	8691(44.3)	9302(52.3)
	Above college	9408(25.1)	4953(25.2)	4455(25.0)
Chronic illness	Yes	12032(32.2)	6020(30.7)	6012(33.8)
	No	25388(67.8)	13600(69.3)	11788(66.2)
Family SES	High	13236(35.4)	7617(38.8)	5619(31.6)
	Moderate	17392(46.5)	8623(44.0)	8769(49.3)
	Low	6792(18.2)	3380(17.2)	3412(19.2)
Living with	two parents	32370(86.5)	16993(86.6)	15377(86.4)
	one parent	4032(10.8)	2097(10.7)	1935(10.9)
	not living with parents	1018(2.7)	530(2.7)	488(2.7)
Participation in PA class	Yes	35206(94.1)	18451(94.0)	16755(94.1)
	No	2213(5.9)	1168(6.0)	1045(5.9)

Non-respondents were excluded
BMI Body Metabolic Index, SES Socio-Economic Status, PA Physical Activity

3.2 Gender differences in physical activity, depression, suicidal thoughts, and behavioral variables

Results from the chi-square test of physical activity, depression, suicidal thoughts and behavioral variables are shown in [Table 2]. It shows that smoking experience ($p<.001$), stress ($p<.001$), use of illegal substances ($p<.001$), moderate physical activity ($p<.001$), vigorous physical activity ($p<.001$), depression ($p<.001$), and suicidal thoughts ($p<.001$) were significantly different between male and female.

[Table 2] Control variables on physical activity(PA), depression, and suicidal thoughts

Variables†	Male n	Male %	Female n	Female %	P for Chi-square
Alcohol					
Yes	3557	18.5	3187	18.1	.300
No	15698	81.5	14464	81.9	
Smoking					
Yes	1631	8.5	978	5.5	.000***
No	17571	91.5	16651	94.5	
Stress					

High	7000	35.7	8706	48.9	
Moderate	8212	41.9	6653	37.4	.000***
Low	4407	22.5	2441	13.7	
Illegal substances					
Yes	968	4.9	1107	6.2	.000***
No	18651	91.5	16691	93.8	
Moderate PA					
Yes	15709	80.1	11401	64.1	.000***
No	3911	19.9	6399	35.9	
Vigorous PA					
Yes	16742	85.3	10726	60.3	.000***
No	2878	14.7	7074	39.7	
Depression					
Yes	6477	33.0	7650	43.0	.000***
No	13141	67.0	10149	57.0	
Suicidal thoughts					
Yes	3487	17.8	4931	27.7	.000***
No	16131	82.2	12868	72.3	

* p<0.05 **p<0.01 ***p<0.001
† Non-respondents were excluded

3.3 Effect of physical activity on depression and suicidal thoughts

The results of the stepwise logistic regression model showing the effects of physical activity on depression and suicidal thoughts are presented in [Tables 4].

In male students, the odds ratio of vigorous physical activity to depression was 0.837 (p<.001). It means that before adjusting for control variables, male students who did vigorous physical activity were 0.837 times less likely to have symptoms of depression than other students who did not participate in those activities. Even when general characteristic variables (vigorous PA OR=0.780, p<.001) and behavioral variables (vigorous PA OR=0.784, (p<.001) were adjusted, it statistically showed a similar odds ratio for male students; thereby vigorous physical activity was still confirmed as a protective factor, which can reduce the risk of having depression symptoms. Moderate physical activity was also shown to be a protective factor in reducing the risks of having depression symptoms before adjusting and after adjusting for control variables in male students. In female students, both vigorous physical activity and moderate physical activity showed a statistically similar odds ratio in the steps of adjusted control variables; therefore, vigorous physical activity and moderate physical activity were each a protective factor for reducing the risk of having depression symptoms for female students, regardless of control variable adjustments. Conversely, in regards to suicidal thoughts, only moderate physical activity showed a statistically significant odds ratio in step of adjusting for general characteristic variables (moderate PA OR=0.856, p<.01).

Vigorous physical activity showed a significant odds ratio (vigorous PA OR=0.929, p<.05) to the reduction of risk of having suicidal thoughts in female students. After adjusting both general characteristic and behavioral variables, moderate physical activity showed a statistically significant odds ratio (moderate PA OR=0.918, p<.05) to the reduction of the risk of having suicidal thoughts.

[Table 4] Logistic regression model using physical activity

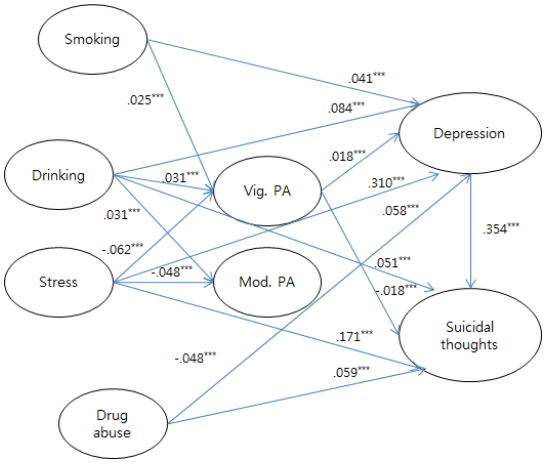
Variables	Physical activity		Depression OR	Suicidal thoughts OR
Male				
Unadjusted OR	Vig	Yes	0.837***	0.930
		No	1	1
	Mod	Yes	0.830***	0.923
		No	1	1
Adjusted for socio-demographic variables	Vig	Yes	0.780***	0.905
		No	1	1
	Mod	Yes	0.810***	0.856**
		No	1	1
Adjusted for alcohol, smoking, stress, & use of illegal substances	Vig	Yes	0.784***	0.930
		No	1	1
	Mod	Yes	0.813***	0.889
		No	1	1
Female				
Unadjusted OR	Vig	Yes	0.815***	0.929*
		No	1	1
	Mod	Yes	0.931*	0.962
		No	1	1
Adjusted for socio-demographic variables	Vig	Yes	0.785***	0.925
		No	1	1
	Mod	Yes	0.889**	0.924
		No	1	1
Adjusted for alcohol, smoking, stress, & use of illegal substances	Vig	Yes	0.769***	0.935
		No	1	1
	Mod	Yes	0.872***	0.918*
		No	1	1

OR Odds Ratio, PA Physical Activity, Vig Vigorous, Mod Moderate
* p<0.05 **p<0.01 ***p<0.001

3.4 Structural equation model examining pathways between physical activity and dependent variables

The modified model is depicted in Fig. 1. Results suggested that the fit of the model was relatively unadequate according to recommended cut off points at, CFI=.91, NFI=.89, RMSEA=.12.

The Chi Square test was 8533.94 with 1 degree of freedom, significant at <.001. The model explained 12% of the variance in depression and 22% of the variance in suicidal thoughts. The path coefficient for the total effect of vigorous physical activity on depression was significant at .018 (p<.001). However, the direct effect of moderate physical activity on depression was not significant. The association between vigorous physical activity and suicidal thoughts was also significant(β =−.018, p<.001). The indirect pathway from vigorous physical activity to suicidal thoughts was also significant(β=.007, p<.001). Vigorous physical activity was negatively associated with suicidal thoughts(direct coefficient β=−.018, p<.001), however, was positively associated with depression(direct coefficient β=.018, p<.001). The lack of direct and indirect pathway between moderate physical activity and both dependent variables(depression, suicidal thoughts) indicated that moderate physical activity did not show any associations depression and suicidal thoughts.



***p<.01

[Fig. 1] Path diagram of physical activity

[Table 5] Direct and indirect effect in association among physical activity and dependent variables

Dependent	Predictor	Direct effect	Indirect effect	Total effect	R^2
Depression	Smoking	.040***	.001***	.041***	.122
	Drinking	.084***	.001***	.085***	
	Stress	.310***	-.002***	.308***	
	Drug abuse	.058***	-	.058***	
	Mod. PA	-	-	-	
	Vig. PA	.018***	-	.018***	
Suicidal thoughts	Smoking	.034***	.014***	.048***	.221
	Drinking	.051***	.029***	.080***	
	Stress	.171***	.111***	.282***	
	Drug abuse	.059***	.020***	.079***	
	Mod. PA	-	-	-	
	Vig. PA	-.018***	.007***	-.011***	
	Depression	.354***	-	.354***	
Mod. PA	Smoking	.-	-	-	.003
	Drinking	.031***	-	.031***	
	Stress	-.048***	-	-.048***	
	Drug abuse	-	-	-	
Vig. PA	Smoking	.025***	-	.025***	.006
	Drinking	.031***	-	.031***	
	Stress	-.062***	-	-.062***	
	Drug abuse	-	-	-	

PA Physical Activity, Vig Vigorous, Mod Moderate
***p<.01

4. Conclusion

This study analyzed the data of the online survey for fourth Korean Youth Health Risk Behavior and examined the associations of physical activity by intensity with depression and suicidal thoughts among South Korean adolescents. Firstly, the prevalence of depression was higher in female students than male student. This corresponds to the result of previous study[30]. In depression study[31], girls has more complex path structure between multi-independent variables and mental health (e.g. depression) than boys. For example, in girl, factors as body image or perceived obesity have a more significant direct and indirect effect on girls' mental health than boys'. There are few possible explanations for the differences in gender. Biological features based on sex seemed to be the main mechanism for gender differences in depression symptoms.

Male and female students have biological differences due to the manifestation of secondary sexual characteristics even at the same age. Physical activity had a positive influence on mood and anxiety disorders in male students but did not influence female students[24]. This phenomenon was analyzed from internal factors of humans, such as hormones or physiological reactions, have a greater effect on mood and anxiety disorders or symptoms than external factors. It has been shown that females have higher rates of mental health problems, such as depression and anxiety, than males, Adolescent mental health problems that arise in early-onset disorders (e.g. behavior disorders or autism) showed higher prevalence rates in males and adolescent-onset disorders, such as depression and anxiety, showed higher prevalence rates in females[32]. These differences of depression prevalence rate between males and females can be found in different stress reaction mechanisms by gender. Generally, if the people are under stress, the body responds by releasing corticotrophin releasing hormone (CRH) from the hypothalamus, which stimulates the secretion of the stress hormone (cortisol); therefore, depression and stress-related disorders can arise. Females secrete more CRH than males, and females have higher sensitivity to depression[33]. In particular, endogenous E2 and/or progesterone secreted during adolescence stimulate stress reactions, causing adolescent female students to be more susceptible to depression[34-36]. Moreover, if the goal of increasing physical activity among female students is weight reduction, physical activity can become a risk factor for depression. For example, disappointment when weight goals are not reached has effects on psychological burden. Regardless of whether female students were subjectively overweight or not, obesity and related variables must be controlled for when researchers examine how physical activity can have a different effect on feelings and anxiety disorders, including depression[31,32].

The difference between male and female students also showed not only in depression rates but also in descriptive frequency of other variables in this study. Smoking behavior, stress, illegal substances except alcohol, and alcoholic drinking behavior showed significant differences between males and females. Physical activity and suicidal thoughts also showed differences between the gender groups.

In study analyzed Korean Youth Health Risk Behavior Survey[37-38], gender differences were revealed in physical activity, depression, suicidal behaviors(suicidal ideation, suicidal plan, suicidal attempt). In the logistic results of physical activity on depression and suicidal thoughts, both moderate physical activity and vigorous physical activity had a significant association with depression among both males and females. Conversely, the association of physical activity with suicidal thoughts showed different results in males and in females, depending upon whether the exogenous variables were adjusted for or not. Previous studies have shown inconsistent results of physical activity association on adolescent mental health based on intensity of activity. Tao et al. (2007) explained how low-moderate physical activity (MET≥4) and vigorous physical activity (MET≥7.5) affected adolescents' health risk behaviors and psychopathological problems[39]. Low-moderate physical activities had a positive effect on depression and psychoticism; conversely, vigorous physical activity was shown to have a positive influence on overdrinking, suicidal thoughts, general mental health problems, and hostility. In a meta-analysis which explained on how physical activity affects anxiety and depression in adolescents between the ages of 11 and 19 years[16], five articles out of 16 stated that physical activity has a positive influence on anxiety and depression. On the other hand, another six articles found that there was no influence on anxiety and depression in adolescents based upon the intensity of physical activity.

In this study, findings differed among male and female according to steps for adjusting the exogenous

variables. For male, the association between moderate physical activity and low incidence of suicidal thoughts was weakened after controlling for alcohol drinking, smoking, stress, and use of illegal substance, because the variables are at least moderately correlated. However, for female, the significant association between moderate physical activity and low incidence of suicidal thoughts showed in the final step when level of moderate physical activity was adjusted for socio-demographic variables and potential confounders (i.e., alcohol drinking, smoking, stress, and use of illegal substances). Possibly, these gender differences may result from the different exogenous variables mediating between moderate physical activity and the suicidal thoughts. Kim (2012) analysed that less physical activity was prominent among risk factor as exogenous variables of suicidal ideation for Korean female adolescents[40].

In conclusions, after step-wised adjusting with confounding variables, the association of physical activity on adolescent mental health showed different results based on the intensity of physical activity as well as gender. However, path analysis suggest that vigorous physical activity was more meaningful predictor on depression and suicidal thoughts than moderate physical activity. Finding also support that vigorous physical activity affect as key mediators of health habits(smoking, drinking, stress, drug abuse) effect on depression and suicidal thoughts. By all means according to different analysis, this results support that the application of physical activity for improving mental health(depression and suicidal thoughts) among Korean middle school students was needed.

This study may contribute to evidence supporting the use of physical activity in the management and treatment of depression and suicidal thoughts. Although physical activity is associated with decreased risk of developing mental health problems throughout many studies, there is no definitive physical activity recommendation for depression and suicidal thoughts that it is likely that different formula of frequency, intensity, and duration of physical activity. The findings of this study also suggest the need for strategic programs that increase the intensity of physical activity, and prevent depression and suicidal behaviors among adolescents in South Korea. These programs for using of physical activity should be tried and tested for cost effectiveness in school health policies.

5. Limitation

This study has some limitations. Physical activity in this study was only classified by subjective intensity and was not measured with metabolic equivalents (METs) that could be comparatively objective. Another limitation in this study is that depression was measured as self-reported depressive symptoms by using the one question. Also, the use of a single item self-reported measure of suicidal thoughts does not allow for the capturing of the entire spectrum of suicidal behaviors. Only perceived depressive symptoms and suicidal thoughts of students' mental health domains were included in analyzing due to secondary analysis. In addition, the generalizations of our finding are limited by the usual difficulties of a retrospective assessment of depression and suicidal thoughts in cross-sectional design. Despite these limitations, this study will make an important contribution to the study on the relationship between physical activity and depression or suicide behaviors among adolescents. Another advantage of this study is that it estimates associations of physical activity by intensity with depression and suicidal thoughts on the basis of nationally representative data in South Korea.

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