





Association between fear of COVID-19 and depression and its effect modification by physical activity: Results from the Korea Community Health Survey 2020

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GLOSSARY OF TERMS

- KCHS : The Korea Community Health Survey
- COVID-19 : Coronavirus disease 2019
- PHQ-9 : Patient Health Questionnaire-9
- IPAQ : International Physical Activity Questionnaire
- MET : Metabolic equivalent
- SES : Socioeconomic status
- OR : Odds ratio
- CI : Confidence interval
- ICC : Intraclass correlation
- RERI : Relative excess risks due to interaction



ABSTRACT

Association between fear of COVID-19 and depression and its effect modification by physical activity: Results from the Korea Community Health Survey 2020

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Background: Since the outbreak of the Coronavirus disease 2019 (COVID-19), global health has been threatened and many people were disrupted in their daily lives. During the COVID-19 pandemic, fear has exacerbated psychological symptoms, and mental health problems have increased globally. Moreover, physical activity is well-known to prevent psychological distress. Therefore, this study aimed to investigate the association between the fear of COVID-19 and depression in Korean adults, and clarify if physical activity acted as an effect modifier in this association.



Methods: In this cross-sectional study, we included 210,906 adults from the Korea Community Health Survey in 2020. Information on fear of COVID-19 and depressive symptoms (Patient Health Questionnaire-9 [PHQ-9]) was obtained. The fear of COVID-19 was measured by summing up the scores of five types of fear (i.e., infection, death, public criticism, a family member getting infected, and economic loss) and then dividing them into quartiles ("very low," "low," "high," and "very high"). Depression was defined as a PHQ-9 score of 10 and over. To examine the association between fear of COVID-19 and depression, a multiple logistic regression model and multilevel analysis including community-level variables were conducted. Moreover, the effect modification of physical activity in this association was examined. All analyses were also conducted separately by sex.

Results: Among 210,906 individuals, 5,964 (2.83%) were defined to have depression (PHQ-9 \geq 10). The proportion of "very high" fear of COVID-19 was higher in the depressed group than in the reference group (depression, 33.64%; reference, 24.69%). When fully adjusted for the potential confounders, there was a significant association between fear of COVID-19 and depression. The odds ratio (OR) for depression increased as the level of fear increased (low, OR=1.14, 95% CI=1.14-1.15; high, OR=1.46, 95% CI=1.45-1.47; very high, OR=1.86, 95% CI=1.85-1.87). As a result of the multilevel analysis, the individual factors better explained the association than the community-level factors. In addition, a negative effect modification of the physical activity was observed. The OR for depression in the "very high" fear group was lower in the high physical activity group than in the low-



to-moderate physical activity group (low-to-moderate physical activity, OR=1.82, 95% CI = 1.63-2.03; high physical activity, OR=1.46, 95% CI=1.12-1.90; p-interaction = 0.0003). The results were similar when stratified by sex.

Conclusion: This study examined the association between fear of COVID-19 and depression and its effect modification by physical activity in the Korean population. Overall, higher fear of COVID-19 was significantly associated with depression. In addition, engaging in a higher level of physical activity mitigated the effect of fear of COVID-19 on depression. Our findings suggest that higher fear of COVID-19 is related to a higher level of depressive symptoms, and also, physical activity can be a protective factor in this association.

Keywords : COVID-19, fear of COVID-19, depression, physical activity



I. INTRODUCTION

1. The impact of the outbreak of the COVID-19

Since the outbreak of coronavirus disease 2019 (COVID-19), global health has been threatened and many people have been disrupted in their daily lives. The COVID-19 pandemic is considered a traumatic event that causes both physical and psychological harm. Exposure to substantial traumatic experiences is associated with a higher burden of mental illness,¹ and previous research has reported that during the COVID-19 pandemic, people are under extreme stress, therefore resulting in a high risk of mental illnesses such as anxiety and depression.^{2, 3}

To reduce the rapid transmission of the virus, the government in different countries took unprecedented measures, such as lockdown and social distancing.⁴⁻⁶ This led to public fear and people started to stock foods and limit social interactions.⁶⁻⁸ Fear is a motivational state triggered by particular stimuli that leads to a defensive behavior to escape from danger and increase the chance of survival.⁹ It is a distinguishable feature of infectious disease compared to other conditions.¹⁰ During the previous outbreaks of Severe Acute Respiratory Syndrome and Ebola, public fear had exacerbated the detrimental effects of the disease itself.¹¹ With no exception, the extremely high infection and mortality rate of COVID-19 have made people worry about getting infected through contact with each other.^{10, 12} Hence, fear of COVID-19 results in patients and their families being stigmatized and socially excluded, making them vulnerable to serious mental problems such as depression,



irritability, anxiety, and anger.^{6, 13-15} Therefore, the importance of controlling public reactions and examining the fear of COVID-19 has been emphasized. ^{6, 16}

COVID-19 is a disaster that has affected the whole society, not specific individuals. Large metropolitan cities were known to be prone to virus transmission due to the mobility of population, urbanization, and mass influx of foreigners from overseas.¹⁷⁻²⁰ Moreover, both residential density and connectivity were significantly associated with the spread of COVID-19 in Korea²⁰ which may imply that the impact of COVID-19 may vary between the districts. In addition, the number of COVID-19 confirmed cases was significantly associated with worse mental health.²¹ One study in Scotland reported that urban areas and lower access to green space were related to psychological distress, which suggests that environmental variables are also important factors influencing mental health during the COVID-19 pandemic.²¹ Therefore, not only the effect of individual-level factors but also regional-level factors should be considered when investigating mental health during the COVID-19 pandemic.

2. Fear of COVID-19 and mental health

There are several studies that investigated the association between fear of COVID-19 and depression. One systematic review and meta-analysis study reported a moderate to strong correlation between fear of COVID-19 and depression (Fisher's z=0.40).²² Some research about fear of COVID-19 and mental health focused on the vulnerable populations such as



students or healthcare workers.²³⁻²⁵ A cross-sectional study among university students in China²⁶ and employees in Pakistan²⁷ showed similar results that the fear of COVID-19 was positively associated with depression measured by the Beck Depression Inventory-II (BDI-II) and the Patient Health Questionnaire (PHQ-9), respectively. The fear of COVID-19 due to the quarantine and lockdown increased uncertainties about the students' academic and career endeavors^{28, 29} and provoked depression and anxiety about people's future careers.³⁰

Additionally, there are some evidence found in general population. Among the US population, 67.3% were very or extremely concerned about COVID-19, and 48.8% have self-isolated to avoid COVID-19.³¹ In the Greek population, the fear of COVID-19 measured by the Fear of COVID-19 Scale (FCV-19S) was significantly associated with depression assessed by PHQ-9.³² According to a study of the Japanese population, the fear of COVID-19 (FCV-19S) was positively related with depression (Depression Anxiety Stress Scales [DASS]), and there was a moderating effect of ego-resiliency.³³ However, most of these studies were conducted in a small number of participants and lack generalizability. Therefore, a study using a large number of study population is necessary to represent the national general population.

3. Physical activity during the COVID-19 pandemic

During the COVID-19 period, people were less engaged in physical activity compared to the pre-pandemic period.³⁴⁻³⁷ According to a systematic review, physical activity dropped



in both men and women, regardless of age.37 In Spain, during the confinement, vigorous physical activities and walking time dropped by 16.8% and 58.2%, respectively, and sedentary time increased by 23.8%.³⁸ In the Korean population, the average number of steps per month decreased in 2020 compared to 2019, and as the level of social distancing increased physical activity had decreased.³⁹ When investigating the change in physical activity in different demographic groups, older age was generally related to a decreased level of physical activity during the lockdown period.⁴⁰⁻⁴² In addition, those who were married, university educated, and living in urban areas were more likely to have a lower level of physical activity compared to their counterparts.^{39, 41} In terms of gender, several studies have investigated the disparities in physical activity during the COVID-19 pandemic. Studies in different countries including Italy,^{43, 44} and the UK⁴⁵ conducted an online survey measuring the physical activity behavior during the COVID-19 pandemic using the International Physical Activity Questionnaire (IPAQ). Women were less physically active than men before the pandemic, but the reduction of exercise was greater in men than in women.⁴³⁻⁴⁵ Therefore, it is important to take gender into account when examining the physical activity status during the period of COVID-19 pandemic.

A well-known way to improve mental health is physical activity.^{46, 47} Besides, the importance of physical activity has been recognized by governments in many countries, hence physical activity being one of the few reasons people leave their homes during the lockdown.⁴⁸ In some previous research, physical activity was related to better psychological health such as lower levels of depression, stress, or anxiety during the



COVID-19 pandemic.⁴⁹ Furthermore, reduced physical activity after the outbreak of COVID-19 was associated with higher mental distress,⁵⁰ while those who reported increased physical activity showed lower anxiety.⁵¹ In a study in Italy, the effect of outdoor activities on psychological well-being during the COVID-19 period (May to September, 2021) was assessed.⁵² After participating in the activities, psychosocial factors were significantly improved among the participants, confirming the beneficial impact of physical activity on mental well-being.⁵² Thus, it seems clear that in situations of worldwide social disaster accompanied by psychosocial fragility such as the COVID-19 pandemic, governments and policymakers should take physical activity into account as a potential intervention.

4. Study objectives and hypotheses

During the outbreak of infectious disease, psychological responses have a significant impact on the transmission of the disease and development of the emotional distress.⁵³ Psychological factors play a critical role when obeying public health guidelines and coping with the infection and losses.⁵⁴ Therefore, psychological and psychiatric aspects should not be overlooked. In sum, the COVID-19 pandemic situation has negatively impacted mental health, and greater fear of COVID-19 was associated with higher symptoms of mental illness. However, although evidence about the relationship between the fear of COVID-19 and depression was found in many countries, this association among the Korean population



still needs to be examined.

It is widely known fact that physical activity has a positive influence on mental health, which makes it even more crucial since the level of physical activity had dropped during the COVID-19 pandemic. Moreover, the effect of physical activity on the psychological conditions during the COVID-19 remains still unclear. Therefore, this study is aimed to investigate the association between the fear of COVID-19 and depression in Korean adults, and clarify if physical activity acts as an effect modifier (Figure 1).

This study raises the following hypotheses: 1) Higher fear of COVID-19 is associated with a higher risk of depression, and 2) High level of physical activity can reduce the negative effect of the fear of COVID-19 on depression.





Figure 1. Assumed structure of relationship of fear of COVID-19 (exposure; X) and depression (outcome; Y) with physical activity (effect modifier; W) and confounders (covariates; C)



II. MATERIAL AND METHODS

1. Data source and participants

The data used in this cross-sectional study was derived from the Korea Community Health Survey (KCHS) 2020. The KCHS is nationally representative data produced by the Korean Centers for Disease Control and Prevention (KCDC). It is designed to provide community health statistics that formulate and assess community health care policy.⁵⁵ It has been conducted in 17 cities and provinces with 250 districts. The questionnaires of the KCHS designed by the KCDC and health professionals cover personal health behaviors and prevention such as smoking, drinking, high blood pressure control, physical activity, quality of life, and medical service use.⁵⁵

Of the 229,269 participants in the KCHS 2020, 17,686 who had unavailable data, those who did not answer or were not applicable in at least one item of the fear of COVID-19, were excluded. Among the remaining 211,583 participants, those without information about Patient Health Questionnaire-9 (PHQ-9) items (n=677) were also excluded. Finally, a total of 210,906 participants (women, 54.8%; mean age of 54.6 ± 17.8) were included in the analysis. Figure 2 shows a flow chart of the selection of the study population.





Figure 2. Flow diagram of the study population



2. Measurement

(1) Assessment of the fear of COVID-19

Unlike the previous years' surveys, due to the outbreak of COVID-19 and the pandemic situation, questionnaires about COVID-19 were additionally included in the KCHS 2020. Fear of COVID-19 included fear of infection, dying from infection, public criticism, a vulnerable family member getting infected, and economic loss (Appendix 1). Each item was assessed by the following statements: "I fear getting infected with COVID-19," "I fear dying if I get infected with COVID-19," "I fear being criticized by others if I get infected with COVID-19," "I fear being criticized by others if I get infected with COVID-19," and "I fear me and my family suffering from economic loss due to the COVID-19 pandemic." Participants answered each item using a 5-point scale from 1 (strongly agree) to 5 (strongly disagree). These questions about fear of COVID-19 were validated in a previous study.⁵⁶ The Cronbach's alpha coefficient for internal consistency was 0.73. The Pearson's correlation between each item varied from 0.31 to 0.48. These values suggest that the scale employed to quantify the fear of COVID-19 has a reasonable internal consistency and internal homogeneity.⁵⁶ Several previous studies have also used this scale to measure the fear of COVID-19.⁵⁶⁻⁵⁸

We recoded the scales from 0 (strongly disagree) to 4 (strongly agree) and summed up the scores of the five items as other previous studies^{56, 58} did to measure the level of the fear of COVID-19. Therefore, the total score of the fear of COVID-19 ranged from 0 to 20, higher



score indicating higher fear about COVID-19. Moreover, in this study, we classified the score by quartiles into "very low," "low," "high," and "very high."

(2) Assessment of depression

Depression was measured by using the Korean version of PHQ-9, which was validated by Cronbach's alpha of 0.81 and test-retest reliability of 0.89.⁵⁹ The nine items (anhedonia, depressed mood, trouble sleeping, feeling tired, change in appetite, guilt/self-blame, trouble concentrating, feeling restless/slowed down, and suicidal thoughts) consisted in the PHQ-9 captures depression over the previous two weeks (Appendix 2). Each item is measured by a 4-point scale from 0 (not at all) to 3 (almost every day). Depression was defined having the sum of scores of all items greater than or equal to 10.^{60, 61}

(3) Covariates

Covariates were age, sex, socioeconomic status (SES), lifestyle factors, and physical activity. SES consisted of monthly household income, marital status, education level, and employment status. Monthly household income was divided into quartiles (<1.5, 1.5 to 3.0, 3.0 to 5.0, and >5.0 million Won/month). Marital status was categorized as not married, married, divorced, and bereaved. Education level was divided into two groups as middle school level and under (\leq 9 years of education), and high school level and over (>9 years of education). Employment status was classified as currently employed or not. Lifestyle



status and alcohol consumption were classified into three groups (never, current, and past). Physical activity was measured using the International Physical Activity Questionnaire-Short Forms (IPAQ-SF). The Korean version of IPAQ-SF was validated by the Spearman Rho of 0.267 for validity, and the median Kappa score of 0.471 and the median Spearman Rho of 0.542 for reliability.⁶² The participants were assessed about three types of activity, which are vigorous-intensity activities, moderate-intensity activities, and walking. They were asked how many days during the last week they were engaged in each type of activity, respectively. If they answered more than one day, they also had to answer how many hours and minutes they spent doing the activity per day. Also, when considering metabolic equivalent (MET) values, walking, moderate physical activity, and vigorous activity were calculated as 3.3 METs, 4.0 METs, 8.0 METs, respectively.⁶³ Based on these answers the level of physical activity was dichotomized into low-to-moderate, and high based on the IPAQ scoring protocol.⁶³ High physical activity included "vigorous activity on at least 3 days and accumulating at least 1500 MET-minutes/week" or "7 or more days of any combination of walking, moderate or vigorous activities accumulating at least 3000 MET-

factors included smoking status, alcohol consumption, and physical activity. Smoking

minutes/week."63

We also used the variables related to the area of residence when conducting multilevel analysis. Community-level variables used in the multilevel analysis were urbanicity, the number of COVID-19 cases per 100,000, and the percentage of park area. The urbanicity was categorized into metropolitan("Gu"), urban("Si"), and rural("Gun") based on the



administrative district of South Korea. The number of COVID-19 confirmed cases per 100,000 was obtained from the Korea Disease Control and Prevention Agency (KDCA). Due to the limitation of data availability, the COVID-19 confirmed cases at city and province levels were used. Since the KCHS was held between August 15 and October 31, we used the data of cumulative confirmed cases of COVID-19 on September 30. For each region, COVID-19 cases per 100,000 was calculated. Lastly, the green area ratio was calculated by dividing the park area (m²) of each district by the whole area (m²) of each district using the data obtained from the Korean Statistical Information Service.



3. Statistical analysis

(1) Main analysis

We compared general characteristics between the reference group (PHQ-9<10) and the depression group (PHQ-9 \ge 10) using the independent t-test and chi-square test. The association between the fear of COVID-19 and depression was analyzed using the multiple logistic regression model, adjusting for the potential confounders. A multilevel analysis was conducted to determine which individual-level and community-level variables influenced depression. The confounders were chosen by reviewing previous studies, which were both associated with fear and depression.^{56, 64-66} In this study, we investigated the effect of individual-level variables, such as age, sex,⁶⁷ SES,^{68, 69} and lifestyle factors, ^{70, 71} and community-level variables such as urbanicity, number of COVID-19 confirmed cases, and the proportion of green areas.

Moreover, stratified analysis according to physical activity classified based on the IPAQ scoring protocol⁶³ (low-to-moderate, high) was also performed using the multiple logistic regression model to investigate the effect modification of the physical activity. In addition, we conducted all analyses stratifying by sex.

To represent the entire population of South Korea, population weights were applied to all statistical analyses. P-values of <0.05 were considered as statistically significant. All statistical analyses were performed using the SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).



(2) Sensitivity analysis

To confirm the robustness of the finding, we conducted additional analyses. As the sensitivity analysis, we conducted the analysis applying different cut-offs(PHQ-9 \geq 5, PHQ-9 \geq 15) when defining depression. In the main analysis, the exposure variable, the fear of COVID-19 was used as a categorical variable classified by the quartiles. We also investigated the odds ratio for depression per one-unit increase of the fear of COVID-19. P-values of <0.05 were considered as statistically significant. All statistical analyses were performed using the SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

(3) Ethical approval

Informed consent was obtained from all the participants of KCHS. This study did not require ethical review or approval because it used publicly accessible data and did not acquire any personally identifiable information.



III. RESULTS

1. Characteristics of the study population

The demographic characteristics of the study population are demonstrated in Table 1. Among the 210,906 participants, 5,964 (2.83%) were defined to have depression (PHQ- $9\geq10$). The depression group were more consisted of women (68.71%) and older (mean age = 56.5) than the reference group (women, 54.32%; mean age, 54.6). In terms of SES, compared to the reference group, the depression group had lower income, lower education level, and more than half were unemployed (60.08%). They were also more likely to be current smokers and have lower physical activity levels than the reference group. Lastly, the proportion of "very high" fear of COVID-19 (score>17) was higher in the depression group than in the reference group (depression, 33.64%; reference, 24.69%).

Table 2 shows the demographic characteristics of the study population by sex. In both men and women, compared to the reference group, the depression group was older, had lower income, was less educated, was unemployed, and had a lower level of physical activity. In addition, in both sexes, the proportion of "very high" fear of COVID-19 (score>15) was higher in the depression group than in the reference group (men: depression, 27.17%; reference, 19.91%) (women: depression, 36.58%; reference, 28.72%). When compared between men and women, women were more likely to have higher fear, but its statistical significance was not examined in this study.

	Total (N=210,906)						
	Reference (PHQ-9<10)	Depression (P				
	N=204,942	2 (97.17%)	N=5,964 (2	p-value			
Sex, Female, N(%)	111,315	(54.32)	4,098	(68.71)	<.0001		
Age, Years, Mean(SD)	54.6	(17.70)	56.5	(20.19)	<.0001		
Monthly household income, N(%)					<.0001		
<1.5 million Won	49,394	(24.31)	2,506	(42.33)			
1.5-3 million Won	46,629	(22.95)	1,303	(22.01)			
3-5 million Won	50,429	(24.82)	1,133	(19.14)			
>5 million Won	56,766	(27.93)	978	(16.52)			
Education level, N(%)					<.0001		
Under high school	67,927	(33.18)	2,659	(44.61)			
High school and above	136,780	(66.82)	3,301	(55.39)			
Employment status, N(%)					<.0001		
Not employed	79,749	(38.92)	3,581	(60.08)			
Employed	125,139	(61.08)	2,379	(39.92)			
Marital status, N(%)					<.0001		
Not married	34,973	(17.07)	1,211	(20.32)			
Married	137,388	(67.07)	2,974	(49.91)			
Divorced	8,643	(4.22)	553	(9.28)			
Bereaved	23,837	(11.64)	1,221	(20.49)			
Cigarette use, N(%)					<.0001		
Never smoker	134,325	(65.55)	3,860	(64.72)			
Current smoker	32,867	(16.04)	1,150	(19.28)			
Past smoker	37,727	(18.41)	954	(16.00)			
Alcohol use, N(%)					<.0001		
Never drinker	49,771	(24.29)	1,610	(27.00)			
Current drinker	118,475	(57.81)	2,926	(49.06)			
Past drinker	36,680	(17.90)	1,428	(23.94)			
Physical activity, N(%)					<.0001		
Low-to-moderate physical activity ¹	166,688	(81.64)	5,127	(86.42)			
High physical activity ²	37,484	(18.36)	806	(13.59)			
Fear of COVID-19*, N(%)					<.0001		
Very low (score ≤ 12)	53,370	(26.04)	1,279	(21.45)			
Low (12 < score \leq 15)	67,125	(32.75)	1,588	(26.63)			
High (15 < score \leq 17)	33,837	(16.51)	1,091	(18.29)			
Very high (17< score)	50,610	(24.69)	2,006	(33.64)			
Mean (SD)	14.7	(3.77)	15.4	(3.91)	<.0001		

Table 1. General characteristics of the study population by depression

 IMean (SD)
 II.4.7
 (3.77)
 II.5.4
 (3.91)

 "Low and moderate physical activity : not applicable to high physical activity

 "High physical activity : ' \geq 3 days of vigorous-intensity activity achieving total physical activity of

 \geq 1500 MET-minutes/week' or ' \geq 7 days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving total physical activity of \geq 3000 MET-minutes/week'

 *Fear of COVID-19 is divided by the quartiles with the cut-off scores of 12, 15, and 17.



	Men (N	=95,493)		_	Women (N=115,413)				_
Refe (PHC	erence 2-9<10)	Depi (PHC	ression 2-9≥10)	_	Refe (PHQ	rence -9<10)	Depr (PHC	ression 2-9≥10)	-
N=9	93,627	N=	1,866	n valua	N=11	1,315	N=	4,098	n voluo
(98	.05%)	(1.95%)		p-value	(96.45%)		(3.55%)		p-value
53.5	(17.44)	54.7	(19.60)	0.010	55.4	(17.87)	57.3	(20.41)	<.0001
				<.0001					<.0001
19,155	(20.63)	745	(40.23)		30,239	(27.40)	1,761	(43.29)	
21,928	(23.62)	429	(23.16)		24,701	(22.38)	874	(21.48)	
24,647	(26.54)	374	(20.19)		25,782	(23.36)	759	(18.66)	
27,122	(29.21)	304	(16.41)		29,644	(26.86)	674	(16.57)	
				<.0001					<.0001
23,089	(24.69)	676	(36.25)		44,838	(40.33)	1,983	(48.42)	
70,430	(75.31)	1,189	(63.75)		66,350	(59.67)	2,112	(51.58)	
				<.0001					<.0001
26,396	(28.20)	962	(51.58)		53,353	(47.94)	2,619	(63.96)	
67,212	(71.80)	903	(48.42)		57,927	(52.06)	1,476	(36.04)	
				<.0001					<.0001
19,822	(21.18)	507	(27.21)		15,151	(13.62)	704	(17.19)	
66,902	(71.50)	1,035	(55.56)		70,486	(63.35)	1,939	(47.34)	
4,078	(4.36)	204	(10.95)		4,565	(4.10)	349	(8.52)	
2,768	(2.96)	117	(6.28)		21,069	(18.93)	1,104	(26.95)	
				<.0001					<.0001
28,555	(30.50)	436	(23.37)		105,770	(95.02)	3,424	(83.55)	
30,249	(32.31)	765	(41.00)		2,618	(2.35)	385	(9.39)	
34,807	(37.18)	665	(35.64)		2,920	(2.62)	289	(7.05)	
				<.0001					<.0001
11,394	(12.17)	217	(11.63)		38,377	(34.48)	1,393	(33.99)	
66,331	(70.85)	1,126	(60.34)		52,144	(46.85)	1,800	(43.92)	
15,892	(16.98)	523	(28.03)		20,788	(18.68)	905	(22.08)	
	Ref (PHC) N=9 (98) 53.5 19,155 21,928 24,647 27,122 23,089 70,430 26,396 67,212 19,822 66,902 4,078 2,768 28,555 30,249 34,807 11,394 66,331 15,892	Men (N Reference (PHQ-9<10) N=93,627 (98.05%) 53.5 (17.44) 19,155 (20.63) 21,928 (23.62) 24,647 (26.54) 27,122 (29.21) 23,089 (24.69) 70,430 (75.31) 26,396 (28.20) 67,212 (71.80) 19,822 (21.18) 66,902 (71.50) 4,078 (4.36) 2,768 (2.96) 28,555 (30.50) 30,249 (32.31) 34,807 (37.18) 11,394 (12.17) 66,331 (70.85) 15,892 (16.98)	Men (N=95,493)Reference (PHQ-9<10)Depr (PHQN=93,627N=(98.05%)(1. 53.5 (17.44) 54.7 19,155(20.63)74521,928(23.62)42924,647(26.54)37427,122(29.21)30423,089(24.69)67670,430(75.31)1,18926,396(28.20)96267,212(71.80)90319,822(21.18)50766,902(71.50)1,0354,078(4.36)2042,768(2.96)11728,555(30.50)43630,249(32.31)76534,807(37.18)66511,394(12.17)21766,33166,331(70.85)1,12615,892(16.98)523	Men (N=95,493)Reference (PHQ-9<10)Depression (PHQ-9≥10)N=93,627 N=1,866 (98.05%)N=1,866 (1.95%)53.5(17.44)54.753.5(17.44)54.719,155(20.63) (26.54)745 (40.23) (21,928 (23.62)24,647(26.54) (26.54)374 (20.19) (27,122 (29.21)23,089(24.69) (75.31)676 (36.25) (36.25) (70,43026,396(28.20) (27.131)962 (51.58) (57,212 (71.80)26,396(28.20) (27.150)962 (51.58) (57,212 (71.80)19,822(21.18) (1.35) (55.56) 	$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$

Table 2. General characteristics of the study population by sex and depression

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Men (N=95,493) Women (N=115,413) Reference Depression Reference Depression (PHQ-9<10) (PHQ-9≥10) (PHQ-9<10) (PHQ-9≥10) N=93,627 N=1,866 N=111,315 N=4,098 p-value p-value (98.05%) (1.95%) (96.45%) (3.55%) Physical activity, N(%) <.0001 <.0001 Low-to-moderate physical activity¹ 70,455 (75.66) 1,488 (80.38) 96,233 (86.65) 3,639 (89.15) High physical activity² 22,659 (24.33)363 (19.61) 14,825 (13.35)443 (10.85) Fear of COVID-19*, N(%) <.0001 <.0001 Very low (score ≤ 12) 29,439 (31.44)532 (28.51) 23,931 (21.50) 747 (18.23) Low (12 < score ≤ 15) 31,338 (33.47) 520 (27.87)35,787 (32.15)1,068 (26.06)High (15 < score ≤ 17) 14,206 (15.17) 307 (16.45) 19,631 (17.64) 784 (19.13)Very high (17< score) 18,644 (19.91) 507 (27.17) 31,966 (28.72) 1,499 (36.58) Mean (SD) 14.1 (3.85)14.6 (4.16)<.0001 15.2 (3.63) 15.7 (3.73) <.0001

Table 2. General characteristics of the study population by sex and depression (continued)

Low and moderate physical activity : not applicable to high physical activity

²High physical activity : \geq 3 days of vigorous-intensity activity achieving total physical activity of \geq 1500 MET-minutes/week' or ' \geq 7 days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving total physical activity of \geq 3000 MET-minutes/week'

*Fear of COVID-19 is divided by the quartiles with the cut-off scores of 12, 15, and 17.

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2. Assessing the association between the fear of COVID-19 and depression using a multilevel approach

The odds ratios (ORs) and 95% confidence intervals (CIs) for depression according to the fear of COVID-19 are shown in Table 3. Overall, the OR for depression increased as the level of fear of COVID-19 increased. When adjusted for all potential confounders including community-level variables (Model 3), the ORs in each level of fear were 1.14 (95% CI = 1.14-1.15) in the "low" fear group, 1.46 (95% CI = 1.45-1.47) in the "high" fear group, and 1.86 (95% CI = 1.85-1.87) in the "very high" fear group, respectively (reference="very low" fear) (Figure 3).

Among the community-level variables, the more rural areas showed lower ORs for depression (urban, OR = 0.98, 95% CI = 0.84-1.16; rural, OR = 0.72, 95% CI = 0.61-0.84) (Table 3). Higher COVID-19 cases and larger green area showed greater OR for depression, but it was not statistically significant. The intraclass correlation (ICC) was 7.22, which means that the community-level variables can explain the association between the fear of COVID-19 and depression by 7.22. Therefore, individual-level variables better explain the association than the community-level variables.



We also conducted separate analyses according to sex. First, in men (Table 4), when adjusted for both individual-level and community-level factors, compared to the "very low" fear group, the OR for depression increased as the level of fear of COVID-19 increased. The ORs for depression were 1.22 (95% CI = 1.21-1.23), 1.48 (95% CI = 1.47-1.50), and 1.84 (95% CI = 1.82-1.86) in the "low," "high," and "very high" fear group, respectively (Figure 4). A similar trend was observed in women. In women (Table 5), the ORs for depression were 1.10 (95% CI = 1.09-1.11), 1.45 (95% CI = 1.44-1.46), and 1.87 (95% CI = 1.85-1.88) in the "low," "high," and "very high" fear group, respectively compared to the "very low" fear group (Figure 4).



		Case N (%)		Model 1 ^a			Model 2 ^b			Model 3 ^c		
				OR 95% CI		OR 95% CI		OR	5 CI			
Fixed Effects Intercept				0.03	(0.03 -	0.03)	0.06	(0.05 -	0.06)	0.06	(0.05 -	0.07)
Individual-level	factors											
Fear of COV	ID-19											
Very low	(N=54,649)	1,279	(2.34)					Reference	e		Reference	e
Low	(N=68,713)	1,588	(2.31)				1.15	(1.14 -	1.15)	1.14	(1.14 -	1.15)
High	(N=34,928)	1,091	(3.12)				1.45	(1.44 -	1.46)	1.46	(1.45 -	1.47)
Very high	(N=52,616)	2,006	(3.81)				1.88	(1.86 -	1.89)	1.86	(1.85 -	1.87)
Sex												
Men								Reference	e		Reference	9
Women							2.55	(2.53 -	2.56)	2.57	(2.55 -	2.58)
Age							0.99	(0.99 -	0.99)	0.99	(0.99 -	0.99)
Monthly hou	sehold income											
< 1.5 million	Won							Reference			Reference	9
1.5 - 3 millior	n Won						0.60	(0.59 -	0.60)	0.59	(0.59 -	0.59)
3 - 5 million V	Won						0.50	(0.50 -	0.51)	0.50	(0.50 -	0.50)
> 5 million W	on						0.38	(0.38 -	0.38)	0.38	(0.38 -	0.38)
Education lev	vel											
Under high sc	hool							Reference	e		Reference	e
High school a	nd above						0.72	(0.72 -	0.73)	0.72	(0.71 -	0.72)
Employment	status											
Not employed	1							Reference	e		Reference	e
Employed							0.62	(0.61 -	0.62)	0.62	(0.61 -	0.62)
Marital statu	IS											
Not married								Reference	9		Reference	9
Married							0.72	(0.72 -	0.73)	0.72	(0.71 -	0.72)
Divorced							1.49	(1.48 -	1.51)	1.48	(1.47 -	1.49)
D 1							1 00	ù 07	1.00	1.07	i oc	1 00

Table 3. Association between fear of COVID-19 and depression using a multilevel approach (N=210,906)

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]	Model 1 ^a		Model 2 ^b		Model 3 ^c	
	Case N	(%)	OR	95% CI	OR	95% CI	OR	95% CI	[
Cigarette use									
Never smoker						Reference		Reference	
Current smoker					2.84	(2.82 - 2.86)	2.87	(2.85 - 2.	.89)
Past smoker					1.99	(1.97 - 2.00)	2.00	(1.99 - 2.	.01)
Alcohol use									
Never drinker						Reference		Reference	
Current drinker					1.08	(1.07 - 1.08)	1.08	(1.08 - 1.	.09)
Past drinker					1.30	(1.29 - 1.31)	1.31	(1.30 - 1.	.32)
Physical activity									
Low-to-moderate physical activity						Reference		Reference	
High physical activity					0.94	(0.94 - 0.95)	0.95	(0.94 - 0.	.95)
Community-level factors									
Urbanicity									
Metropolitan (Gu)								Reference	
Urban (Si)							0.98	(0.84 - 1.	.16)
Rural (Gun)							0.72	(0.61 - 0.	.84)
COVID-19 cases/100,000									
<10.75								Reference	
10.75-22.20							0.99	(0.82 - 1.	.19)
22.20-33.24							1.12	(0.89 - 1	.40)
≥33.24							1.16	(0.97 - 1.	.37)
Green area (%)									
<10%								Reference	
≥10%							1.15	(0.93 - 1.	.42)
<i>ICC</i> † (%)						7.22			
^a Model 1 : null model									

Table 3. Association between fear of COVID-19 and depression using a multilevel approach (N=210,906) (continued)

^bModel 2 : Model 1 + individual-level factors

"Model 2 : Model 1 + marvadar level factors "Model 3 : Model 2 + community-level factors $\dagger ICC = \{0.2559/(0.2559+3.29)\} = 0.0722$

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				Model 1 ^a				Model 2 ^b	•	Model 3 ^c			
		Case N	(%)	OR	95%	6 CI	OR	95%	6 CI	OR	95%	CI	
Fixed Effects													
Intercept				0.02	(0.02 -	0.02)	0.12	(0.11 -	0.14)	0.13	(0.10 -	0.16)	
Individual-level factors													
Fear of COVID-19													
Very low	(N=29,971)	532	(1.78)					Reference	e]	Reference		
Low	(N=31,858)	520	(1.63)				1.24	(1.23 -	1.25)	1.22	(1.21 -	1.23)	
High	(N=14,513)	307	(2.12)				1.49	(1.48 -	1.51)	1.48	(1.47 -	1.50)	
Very high	(N=19,151)	507	(2.65)				1.87	(1.85 -	1.89)	1.84	(1.82 -	1.86)	
Age							0.98	(0.98 -	0.98)	0.98	(0.98 -	0.98)	
Monthly he	ousehold income												
< 1.5 million Won								Reference	e]	Reference		
1.5 - 3 milli	on Won						0.58	(0.58 -	0.59)	0.57	(0.56 -	0.58)	
3 - 5 millior	n Won						0.46	0.46 -	0.47)	0.46	(0.46 -	0.46)	
> 5 million	Won						0.33	(0.33 -	0.34)	0.33	(0.33 -	0.34)	
Education 1	level												
Under high	school							Reference	<u>)</u>	Reference			
High school	and above						0.61	(0.61 -	0.62)	0.60	(0.60 -	0.61)	
Employme	nt status								,			,	
Not employ	ed						Reference		1	Reference			
Employed	cu						0.56	(0.55 -	0.56)	0.57	(0.56 -	0.57)	
Marital ata	tuc						0.50	(0.55	0.50)	0.07	(0.50	0.07)	
Not married	lus						Deference		Pafarance				
Married	L						0.91	(0.90 -	0.92)	0.90	(0.89 -	0.91)	
Divorced							1 77	(0.90 - (1.74 -	(1.72)	1 74	(1.72 -	(1.77)	
Bereaved							1.77	(1.74 - (1.48 -	1.77	1.74	(1.72 - (1.49 - 1))	1.77)	
Dereaveu							1.51	(1.40 -	1.54)	1.52	(1.4) -	1.55)	

Table 4. Association between fear of COVID-19 and depression using a multilevel approach in men (N=95,493)

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			Ν	Model 1 ^a		Model 2 ^b		Model 3 ^c		
	Case N	(%)	OR	95% CI	OR	95%	CI	OR	95%	CI
Cigarette use Never smoker Current smoker Past smoker					2.12 1.49	Reference (2.10 - (1.47 -	2.14) 1.50)	2.12 1.49	Reference (2.10 - (1.48 -	2.14) 1.51)
Alcohol use Never drinker Current drinker Past drinker					0.88 1.44	Reference (0.87 - (1.42 -	0.89) 1.46)	0.87 1.44	Reference (0.86 - (1.42 -	0.88) 1.46)
Physical activity Low-to-moderate physical activity High physical activity					0.93	Reference (0.92 -	0.93)	0.94	Reference (0.93 -	0.95)
Community-level factors Urbanicity Metropolitan (Gu)									Reference	
Urban (Si) Rural (Gun)								0.96 0.66	(0.78 - (0.54 -	1.17) 0.81)
COVID-19 cases/100,000 <10.75 10.75-22.20 22.20-33.24 ≥33.24								1.07 1.11 1.23	Reference (0.85 - (0.84 - (1.00 -	1.36) 1.47) 1.53)
Green area (%) <10% ≥10%								1.13	Reference (0.87 -	1.46)
<i>ICC</i> † (%)						9.79				
"Model I : null model										

 Table 4. Association between fear of COVID-19 and depression using a multilevel approach in men (N=95,493) (continued)

^bModel 2 : Model 1 + individual-level factors

^cModel 3 : Model 2 + community-level factors $\dagger ICC = \{0.3570/(0.3570+3.29)\} = 0.0979$

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					Model 1 ^a		Model 2 ^b			Model 3 ^c		
		Case N	(%)	OR	95% CI	OR	95%	o CI	OR	95%	CI	
Fixed Effects												
Intercept				0.04	(0.03 - 0.04)	0.09	(0.08 -	0.10)	0.09	(0.07 -	0.11)	
Individual-lev	el factors											
Fear of CO	VID-19											
Very low	(N=24,678)	747	(3.03)				Reference			Reference		
Low	(N=36,855)	1,068	(2.90)			1.10	(1.09 -	1.11)	1.10	(1.09 -	1.11)	
High	(N=20,415)	784	(3.84)			1.43	(1.42 -	1.44)	1.45	(1.44 -	1.46)	
Very high	(N=33,465)	1,499	(4.48)			1.87	(1.85 -	1.88)	1.87	(1.85 -	1.88)	
Age						0.99	(0.99 -	0.99)	0.99	(0.99 -	0.99)	
Monthly ha	ousehold income											
< 1.5 million	n Won						Reference			Reference		
1.5 - 3 million Won						0.61	(0.61 -	0.61)	0.60	(0.60 -	0.61)	
3 - 5 million Won						0.55	(0.55 -	0.56)	0.55	(0.54 -	0.55)	
> 5 million '	Won					0.43	(0.43 -	0.43)	0.43	(0.43 -	0.43)	
Education l	evel											
Under high	school						Reference			Reference		
High school	and above					0.80	(0.80 -	0.81)	0.80	(0.80 -	0.81)	
Employme	nt status											
Not employ	ed						Reference			Reference		
Employed						0.66	(0.66 -	0.66)	0.65	(0.65 -	0.66)	
Marital sta	tus											
Not married							Reference			Reference		
Married						0.67	(0.66 -	0.67)	0.66	(0.66 -	0.67)	
Divorced						1.35	(1.34 -	1.37)	1.35	(1.33 -	1.36)	
Bereaved						0.98	(0.97 -	0.99)	0.97	(0.96 -	0.98)	

 Table 5. Association between fear of COVID-19 and depression using a multilevel approach in women (N=115,413)



			Ν	Aodel 1 ^a		Model 2 ^b		Model 3 ^c		
	Case N	(%)	OR	95% CI	OR	95% CI	OR	95%	CI	
Cigarette use Never smoker Current smoker Past smoker					3.82 2.34	Reference (3.79 - 3.85) (2.32 - 2.37)	3.91 2.34	Reference (3.87 - (2.32 -	3.94) 2.37)	
Alcohol use Never drinker Current drinker Past drinker					1.18 1.20	Reference (1.17 - 1.19) (1.19 - 1.20)	1.19 1.21	Reference (1.19 - (1.20 -	1.20) 1.21)	
Physical activity Low-to-moderate physical activity High physical activity					0.97	Reference (0.96 - 0.98)	0.97	Reference (0.96 -	0.98)	
Community-level factors Urbanicity Metropolitan (Gu) Urban (Si) Rural (Gun) COVID-19 cases/100,000 <10.75							0.99 0.75	Reference (0.84 - (0.63 - Reference	1.18) 0.89)	
10.75-22.20 22.20-33.24 ≥33.24							0.94 1.11 1.11	(0.77 - (0.87 - (0.93 -	1.15) 1.40) 1.33)	
Green area (%) <10% ≥10%							1.16	Reference (0.93 -	1.45)	
<i>ICC</i> † (%)						7.99				
^a Model 1 : null model										

 Table 5. Association between fear of COVID-19 and depression using a multilevel approach in women (N=115,413) (continued)

^bModel 2 : Model 1 + individual-level factors ^cModel 3 : Model 2 + community-level factors $\dagger ICC = \{0.2858/(0.2858+3.29)\} = 0.0799$





Figure 3. Odds ratios for depression by the fear of COVID-19 in the total study population (N=210,906)



Figure 4. Odds ratios for depression by the fear of COVID-19 stratified by sex



3. Assessing the effect modification of the physical activity in the association between the fear of COVID-19 and depression

To investigate the role of physical activity in the association between the fear of COVID-19 and depression, we stratified the analysis by the level of physical activity (Table 6). After the full adjustment, overall, the OR for depression increased as the level of fear of COVID-19 increased in the low-to-moderate physical activity group. However, in the high physical activity group, no noticeable difference in the OR according to the level of fear of COVID-19 could be observed. Moreover, the OR was lower in the high physical activity group compared to the low-to-moderate physical activity group. For example, the OR of the "very high" fear group was 1.82 (95% CI = 1.63-2.03) in the low-to-moderate physical activity group. This effect modification of physical activity on the association between the fear of COVID-19 and depression was statistically significant (p-interaction = 0.0003).

When examined the association by sex, in men (Table 6, Figure 6), the OR for depression increased as the level of the fear of COVID-19 in the low-to-moderate physical activity group, whereas in the high physical activity group, the OR decreased as the level of fear increased. The OR for depression in the "very high" fear group compared to the "very low" fear group was 1.77 (95% CI = 1.46-2.13) in men with low-to-moderate physical activity, and 1.46 (95% CI = 1.00-2.12) in men with high physical activity (p-interaction = 0.0017). In women (Table 6, Figure 7). The OR for depression showed a dose-response relationship



in the low-to-moderate physical activity group. However, the association between the fear of COVID-19 and depression was not even significant in the high physical activity group. The OR for depression in the "very high" fear group compared to the "very low" fear group was 1.85 (95% CI = 1.62-2.13) and 1.34 (95% CI = 0.98-1.84) in women with low-to-moderate and high physical activity, respectively (p-interaction = 0.0341).

When we calculated the relative excess risks due to interaction (RERI), negative additive effect modification was also found between the fear of COVID-19 and physical activity (Appendix 3). In the total study population, the RERI for the "very high" fear of COVID-19 was -0.31 (95% CI [-0.51, -0.12]). In addition, the RERIs for the "very high" fear of COVID-19 were -0.22 (95% CI = -0.48–0.05), and -0.46 (95% CI [-0.71, -0.21]) in men and women, respectively.

In addition, we also conducted sensitivity analyses by applying different cut-offs for depression. First, we used the cut-off PHQ-9 score of 5 when defining depression. The ORs for depression of the "very high" fear group compared to the "very low" fear group were 1.54 (95% CI = 1.46-1.63) in the low-to-moderate physical activity group, and 1.37 (95% CI = 1.21-1.55) in the high physical activity group (p-interaction = 0.0116) (Appendix 4). Second, we defined depression as a PHQ-9 score ≥ 15 . The ORs for depression in the "very high" fear group compared to the "very low" fear group was 1.95 (95% CI = 1.61-2.35) in the low-to-moderate physical activity group, and 1.54 (95% CI = 0.96-2.47) in the high physical activity group, and 1.54 (95% CI = 0.96-2.47) in the high physical activity group (p-interaction = 0.2232) (Appendix 5). Moreover, we examined the ORs for depression per one-point increment in fear of COVID-19 (Appendix 6). The OR



in the low-to-moderate physical activity group was 1.06 (95% CI = 1.05-1.08) while it was 1.03 (95% CI = 1.01-1.06) in the high physical activity group (p-interaction = 0.0101). The results of these analyses support the robustness of our main results that the physical activity have protective effect on the association between the fear of COVID-19 and depression.



			Low-to-m	oderate p	ohysical	activity ¹		High physical activity ²							
Fear of COVID-19		Ν	Case N	(%)	OR	95% CI		Ν	Case N	(%)	OR	95% CI		p- interaction [§]	
Total [†]	Very low	43,669	1,076	(2.46)		reference		10,812	195	(1.80)		reference			
	Low	56,474	1,325	(2.35)	1.04	(0.93 -	1.16)	12,010	255	(2.12)	1.38	(1.08 -	1.77)	0.0002	
	High	28,531	942	(3.30)	1.49	(1.32 -	1.68)	6,257	142	(2.27)	1.25	(0.93 -	1.68)	0.0003	
	Very high	43,141	1,784	(4.14)	1.82	(1.63 -	2.03)	9,211	214	(2.32)	1.46	(1.12 -	1.90)		
Men [‡]	Very low	22,251	426	(1.91)	reference			7,592	102	(1.34)		reference			
	Low	24,398	396	(1.62)	1.03	(0.86 -	1.25)	7,313	121	(1.65)	1.65	(1.18 -	2.30)	0.0017	
	High	10,899	242	(2.22)	1.43	(1.15 -	1.78)	3,516	62	(1.76)	1.51	(0.98 -	2.33)	0.0017	
	Very high	14,395	424	(2.95)	1.77	(1.46 -	2.13)	4,601	78	(1.70)	1.46	(1.00 -	2.12)		
Women [‡]	Very low	21,418	650	(3.03)		reference		3,220	93	(2.89)		reference			
	Low	32,076	929	(2.90)	1.06	(0.92 -	1.21)	4,697	134	(2.85)	1.09	(0.78 -	1.52)	0.0241	
	High	17,632	700	(3.97)	1.52	(1.31 -	1.77)	2,741	80	(2.92)	1.00	(0.69 -	1.45)	0.0341	
	Very high	28,746	1,360	(4.73)	1.85	(1.62 -	2.13)	4,610	136	(2.95)	1.34	(0.98 -	1.84)		

Table 6. Association between fear of COVID-19 and depression stratified by physical activity and sex

Low and moderate physical activity : not applicable to high physical activity

²High physical activity : \geq 3 days of vigorous-intensity activity achieving total physical activity of \geq 1500 MET-minutes/week' or ' \geq 7 days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving total physical activity of \geq 3000 MET-minutes/week'

†Adjusted for sex, age, monthly household income level, education level, employment status, marital status, cigarette use, and alcohol use

‡Adjusted for age, monthly household income level, education level, employment status, marital status, cigarette use, and alcohol use

§P-value for multiplicative interaction of fear of COVID-19 and physical activity





Figure 5. Odds ratios for depression by the fear of COVID-19 stratified by physical activity in the total study population (N=210,906)





Figure 6. Odds ratios for depression by the fear of COVID-19 stratified by physical activity in

men (N=95,493)



Figure 7. Odds ratios for depression by the fear of COVID-19 stratified by physical activity in women (N=115,413)



IV. DISCUSSION

1. Summary of findings

This study examined the association between the fear of COVID-19 and depression and its effect modification by physical activity in the Korean population. Overall, higher level of the fear of COVID-19 was significantly associated with higher risk of depression. As a result of the multilevel analysis, the districts accounted for 7.22% of the variability in the rate of depression. Additionally, engaging in a higher level of physical activity mitigated the effect of the fear of COVID-19 on depression. These results were similar when stratified the analysis by sex.



2. Discussion of the study results

1) Depression in COVID-19 pandemic

When the 2020 KCHS was taking place (16 August – 31 October, 2020), Korea was in the midst of the second wave of COVID-19 (13 August – 18 September, 2020). The level of social activities gradually increased as summer began, and COVID-19 incidence has dramatically increased especially in the metropolitan areas to 300 cases a day.⁷² Hence, the Korean government elevated the social distancing level of Seoul. By September 19, 2020, the second wave had come to an end as no more than 100 new cases occurred daily, since social activities had been drastically limited. Finally, in October, the social distancing level was downgraded by the Korean government (Figure 8).

In our study, only 2.83% of the study population reported moderate to severe depression (PHQ-9≥10) in 2020. Compared with other countries, it is a relatively low prevalence. In China, among 1210 respondents who participated in a survey from January to February, 2020, 16.5% answered they had moderate to severe depression.⁷³ Another study conducted in Hong Kong conducted a survey from April to May, 2020 which showed a result of 19% of 500 respondents suffering from depression.⁷⁴ However, these studies were conducted in the initial stage of COVID-19 and the number of respondents is insufficient to guarantee generalizability. Moreover, there are some previous studies that showed an increase of depressive symptoms at the initial stage of the COVID-19 crisis, then decrease after June, 2020.^{75, 76} Community bonding and social support formed by government management



against the COVID-19 pandemic may have reduced negative emotions and stress, and generated resilience to the COVID-19 pandemic.⁷⁷⁻⁷⁹ In a cross-sectional study in Korea, the Korean population tolerated, withstood, and adjusted to changes during the COVID-19 pandemic, despite strong government measures such as social distancing and quarantine.⁸⁰ Since the KCHS was conducted between August 16 to October 31, 2020, the relatively low rate of depression in our study population may be due to the adaptation and resilience to the COVID-19 pandemic.





Figure 8. Cumulative number of confirmed COVID-19 cases in Korea



2) Fear of COVID-19 and depression

The result of this study that the fear of COVID-19 was associated with depression is in line with previous studies. In a cross-sectional study in Iran, 413 adults with a mean age of 57.72 showed a significant positive relationship between fear of COVID-19 and depression.⁸¹ Another study of the older population aged 50 and above in Pakistan showed a significant positive correlation of fear of COVID-19 with depression.⁸² The authors explained this association by the moderating role of self-efficacy based on the protective factor model of the resilience theory and the relationship between close contact with confirmed cases and depression.⁸²⁻⁸⁴ Similarly, the results of an analysis of 1,034 individuals in 75 cities in Turkey showed that the fear of COVID-19 could significantly predict depression.⁸⁵ There are several more studies that have also reported a significant positive relationship between fear of COVID-19 and depression among the general population supporting our results.^{7,86} A study conducted in Korea also showed that the fear of COVID-19 is associated with increased anxiety and depressive symptoms.⁸⁷ They used the Korean version of Fear of COVID-19 scale (KF-COVID-19S) which is the most widely used scale to measure the fear of COVID-19 worldwide.¹⁰ Another study used an online survey measuring lifestyles and depression after the outbreak of COVID-19 among 104 Korean adults aged over 20 years.⁸⁸ Depression was measured with the Center for Epidemiological Studies-Depression Scale and a significant increase in depression was observed after the onset of COVID-19. Among 1,014 individuals who participated in another online survey in Korea, 17.5% had reported depression (PHQ-9≥10).⁶⁶ In addition,



the fear of COVID-19, especially the fear of being infected was highly likely to increase the probability of getting depression.

Stressors are defined as "conditions of threat, challenge, demands, or structural constraints that question the operational integrity of an organism solely by the fact of its occurrence or existence",⁸⁹ and can cause mental distress in individuals.⁹⁰ A pandemic fits this definition since it can be concerned as a traumatic event for those who are affected or as a general threat.⁹⁰ Therefore, according to the stress process model,⁹¹ fear represents the experience of stress related to the macro-stressor of COVID-19 which results in decreased mental health.⁹⁰ Factors such as social support and resilience may act as potential moderators of the association between the fear of COVID-19 and psychological distress,^{90, 92} however, since it was not considered in our study, a further analysis regarding these factors would be needed.

3) The role of physical activity

A novel finding of this study is that physical activity diminished the negative effect of the fear of COVID-19 on depression. We investigated the effect of physical activity on the association between the fear of COVID-19 and depression. The effect modification of physical activity was observed both in the multiplicative and additive scale. Using the additive effect modification is especially important when assessing the significance of public health.⁹³ The results of the additive effect modification in our study showed that the



risk for depression in the people with very high fear and high physical activity was lower than the expected risk. This indicates that there would be less number of people who would suffer from depressive symptoms when engaged in higher physical activity. This kind of information would be useful for targeting subpopulations, for example, those with low physical activity, when applying interventions and implementing public policies.

In line with our results, in a study with a sample of 459 Arabian participants, the fear of COVID-19 was correlated with general distress, and the moderation effect of physical activity between the association was observed.⁹⁴ Those who were engaged in physical activity showed lower stress than those who were not. Similarly, a study of adolescents in the United Kingdom reported that higher fear of COVID-19 was associated with higher depressive symptoms, and physical activity mitigated the negative effect of fear of COVID-19 on mental health.⁴⁸ These results can be backed by ample evidence about the positive effect of physical health on psychological distress.^{47, 95, 96} Furthermore, one study reported that the type of activity is an important determinant of psychological health rather than just the duration and intensity.⁹⁷ Physical activity for a long duration (1 hour/day) was related to a lower distress level, but this association varied based on the exercise performed, such as occupational physical activity and leisure-time physical activity.⁹⁷ Since the physical activity measured in our study did not distinguish the type of activity performed, further study should consider the varied effect depending on the type of physical activity. Indeed, physical activity has been shown to improve mental health in a variety of ways, and some of these pathways may be particularly significant during the COVID-19 pandemic.48



Physical activity, for example, can have an immediate beneficial effect on mood and sensations of vitality,⁹⁸ as well as distract from negative thoughts and stress gained from Coronavirus fear.^{48, 99} Physical activity can also help to restore the daily routine that has been severely disrupted due to the lockdown. As a result, it can create a sense of control and mastery, which might affect one's well-being.^{48, 99}

In terms of sex-difference, a slightly different pattern of effect modification could be observed between men and women. In women with high physical activity, the association between the fear of COVID-19 and depression showed no significance. Moreover, as the level of fear of COVID-19 increased, the difference of the risk for depression between low-to-moderate and high physical activity group increased. Some previous studies reported evidence that women were more vulnerable to the fear of COVID-19.^{67, 100} Researchers argue that gender disparities in risk perception may be caused by deeply rooted gender roles and structures that create inequality in the allocation of labor and power relations, and differences in trust in authoritative persons and organizations.^{67, 101} In one cohort study in Korea about physical activity and depression reported that men should be more physically active than women to reduce depressive symptoms.¹⁰² Another cross-sectional study among Belgian population indicated that vigorous activities enhanced mental health in men, while moderate activities were enough to benefit women which may have resulted due to biological differences.¹⁰³ Further research would be needed to investigate the sex difference of the mental health in the COVID-19 pandemic.



4) Depression in community-level

According to our multilevel analysis results, more urbanized areas were associated with a higher risk of depression. Urbanicity is a well-known risk factor for mental distress because of several characteristics of urban areas such as air pollution, traffic noise, a lack of social bonds, and crime.^{104, 105} In terms of the pandemic, prior evidence supported our results by urban environment being expected to be highly influenced by virus dissemination due to high population density, severe air pollution, and particular risks related to lifestyle.^{106, 107} A narrative review also described that the air pollution is associated with higher risk of virus spread and severity of the COVID-19, which could have been caused by the particulate matter creating an optimal environment for the virus to survive for hours spreading over long distances.¹⁰⁷ Therefore, further studies with urbanicity measured with a more complex index would be necessary.

Moreover, our study found that cities or provinces with a higher number of COVID-19 cases had higher odds of depression, however, the association was not statistically significant. A cross-sectional study in Japan also reported no relationship between the number of COVID-19 cases and psychological distress, which used national representative data of 28,000 participants collected between August to September, 2020.¹⁰⁸ However, a study in Bangladesh conducted in April, 2020 reported that depression and suicidal ideation was concentrated in the areas where the number of COVID-19 cases was especially high.¹⁰⁹ This difference in the results may be contributed by the difference in the period of the data collection and the trend of the proliferation of the confirmed cases in each countries. In



addition, we used city and province-level numbers due to the limitation of the data availability. Therefore, using a more detailed level of information (e.g., number of confirmed cases in district-level) might show different results.

Additionally, the percentage of the green area of the residential district showed no association with depression. Several previous studies have reported a negative relationship between green spaces and mental distress during the COVID-19 pandemic.¹¹⁰⁻¹¹⁴ However, some of these studies included private green space such as indoor plants or gardens¹¹⁴ and measured the green space using aerial imagery within specific radial buffers around the participants' addresses.¹¹⁰ In this study, we only included public parks at the district level. Hence, a more detailed investigation and measurement such as the usage and access of the green area might change the result.

5) Recommendations and implications for public health

According to the results of this study, a higher level of fear was associated with higher risk of depressive symptoms. To reduce fear, researchers say trust is important, therefore it is crucial that people hear reliable messages about COVID-19.¹¹⁵ Consistent and supportive measures are necessary at both the public and individual levels. Fake news should be recognized rapidly, or false claims would spread into the public perception through social media. In addition, the health authorities, press, or media, and scientific community must be aware of their announcement and be precise and consistent as their words have effects



and may generate confusion and fear.¹¹⁵ Moreover, many studies have revealed that socioeconomic and health-related factors can predict fear, thus governments should respond in accordance with these demands, and create an effective and reliable communication system to combat the pandemic.⁶⁹

However, fear is rather subjective concept than objective. The thresholds for fear and reactions to stress might differ between people. Thus, enhancing physical activity can be another measure for alleviating depressive symptoms. Some research reported that not only the objective measure of green space but also the residents' usage and perception of the green space are important in maintaining mental health during the COVID-19 period.^{110, 113,} ¹¹⁶ According to a study among Korean adults, 64.9% reported a decrease in visits to green spaces after the COVID-19 outbreak, which was also associated with major depression.¹¹³ In addition, worse mental health status was found in participants who were less likely to visit or spent less time in green space.^{110, 116} These results may support the findings in our study of the protective role of physical activity in the association between the fear of COVID-19 and depression. Therefore, it is important to encourage people to actually visit and engage in physical activity in green space rather than just enlarging the green area. Therefore, researchers recommend an increased physical activity of 200-400 minutes weekly to compensate for the lack of activity due to the limitation of exercise during the pandemic.¹¹⁷ The most generally advised aerobic exercises during the COVID-19 pandemic are walking, climbing stairs, and running.¹¹⁸ Strength training such as lifting, and stand-tosit are recommended for 2 to 3 sessions weekly.¹¹⁷ Many free online videos and resources



for physical activity and exercise are also easily accessible.¹¹⁹ Possible recommendations for local governments and policymakers would be keeping public parks open and equipping them with facilities that can attract people such as running tracks, courts for sports, benches, and green grass. Moreover, it would be also important to locate parks or green spaces where people can access easily wherever they live, and carry out ongoing monitoring and evaluation in the long term.¹²⁰ Environmental and political interventions should interact with individual and social interventions to enhance and sustain physical activity during or even after the pandemic.¹²¹ Government action is needed to create infrastructures for physical activity in communities, such as expanding spaces and upgrading the quality of parks and facilities. For example, Sydney and Mexico City created cycle lanes to encourage physical activity during the COVID-19 pandemic.¹²² This measure demonstrates how political actions can significantly achieve goals for physical activity.



3. Strengths and Limitations

The strength of this study is that we used a large, representative dataset constructed by the national institution. The KCHS is a community-based sample that includes both urban and rural residents, which strengthens the generalizability of the findings in Korean adults and allows for a conviction on statistical analysis. Moreover, to our knowledge, this is the first research that examined not only the relationship between fear of COVID-19 and depression, but also the effect modification of physical activity in the Korean community. Furthermore, we analyzed the association and the role of physical activity separately by sex. When investigating physical activity and mental health, especially gender differences must be considered.⁴⁸ Some studies have revealed that men appear to be more physically active than women,¹²³ and women tend to experience higher levels of psychological distress than men,^{124, 125} which was also consistent in the COVID-19 pandemic.^{48, 100, 126, 127} Lastly, we evaluated the effect modification of physical activity both multiplicatively and additively. Not only multiplicative scale but additive scale is also important and more relevant when assessing the effect modification in terms of public health.⁹³ Since COVID-19 is still showing off its impact on human health and new viruses are expected to emerge in the near future, this study can serve as the foundation for implementing health policy and the basis for future studies.

Several limitations of this study should be considered when interpreting its results. First, since this study design is cross-sectional, a causal relationship between the variables cannot be ensured. However, the PHQ-9 scale, which was used to measure depression in our study,



captures depressive symptoms over the previous two weeks. In addition, the fear of COVID-19 was measured based on the experience since the outbreak of the COVID-19, which was more than 6 months before the point of the survey. Thus, we can assume that the experience or the fear of COVID-19 precedes the onset of depressive symptoms. Second, the analysis among people who are vulnerable to fear of COVID-19 such as students and healthcare workers was not conducted in this study. Therefore, in order to investigate the impact of fear of COVID-19 on mental health in a deep manner, further studies targeted to these vulnerable populations should be considered. Lastly, there may be unmeasured confounders due to the lack of data sources, such as the history of COVID-19 confirmation or quarantine experience. However, we adjusted for several potential confounders including demographic characteristics, socioeconomic status, and lifestyle factors. If possible, future research should take more information on COVID-19-related experiences into consideration.



V. CONCLUSION

Our study observed the association between fear of COVID-19 and depression (PHQ-9≥10). Higher fear was associated with a higher risk of depression, however, high physical activity counteracted the effect of fear on depressive symptoms. Based on the empirical results of this study, policy makers and healthcare providers can recognize the necessity of managing the fear of COVID-19 during the pandemic, and undertake actions to prevent mental illness, for example by encouraging people engage in high level of physical activity.



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APPENDIX

Appendix 1. Questionnaire about the fear of COVID-19 in the Korea Community Health Survey 2020

Q.	Q. How concerned are you about the followings due to the COVID-19 pandemic?									
ⓓ	🕽 Strongly agree ② Agree ③ Neutral ④ Disagree ⑤ Strongly disagree									
1	I fear getting infected with COVID-19.	12345								
2	I fear dying if I get infected with COVID-19.	12345								
3	I fear being criticized by others if I get infected with COVID-19.	12345								
4	I fear my family members who are vulnerable (e.g., elderly, infant, or patient) getting infected with COVID-19.	123456*								
5	I fear me and my family suffering from economic loss due to the COVID-19 pandemic.	12345								

*[®] Not applicable

Appendix 2. Questionnaire about depressive symptoms in the Korea Community Health Survey 2020 (PHQ-9)

Q. pr	Q. Over the last 2 weeks, how often have you been bothered by any of the following problems?								
1	${ m I\!\!I}$ Not at all ${ m 2\!\!O}$ Several days ${ m 3\!\!I}$ More than half the days ${ m 4\!\!I}$ Nearly everyday								
1	Little interest or pleasure in doing things	1234							
2	Feeling down, depressed, or hopeless	1234							
3	Trouble falling or staying asleep, or sleeping too much	1234							
4	Feeling tired or having little energy	1234							
5	Poor appetite or overeating	1234							
6	Feeling bad about yourself — or that you are a failure or have let yourself or your family down	1234							
7	Trouble concentrating on things, such as reading the newspaper or watching television	1234							
8	Moving or speaking so slowly that other people could have noticed? Or the opposite — so fidgety or restless that you have been moving a lot more than usual	1234							
9	Thoughts that you would be better off dead, or thoughts of hurting yourself in some way	1234							



					Fear o	of COVID-1	19			
		Very low			Low		High	Very high		
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	
Total	Low-to-moderate physical activity	reference		1.10	(0.98,1.23)	1.62	(1.44,1.83)	2.02	(1.81,2.25)	
	High physical activity	0.85	(0.69,1.05)	1.27	(1.05,1.53)	1.20	(0.95,1.53)	1.34	(1.09,1.65)	
	RERI (95% CI)			0.25	(0.05,0.45)	-0.12	(-0.31,0.07)	-0.31	(-0.51,-0.12)	
Men	Low-to-moderate physical activity	r	reference		(0.86,1.26)	1.45	(1.17,1.80)	1.84	(1.52,2.22)	
	High physical activity	0.84	(0.64,1.12)	1.39	(1.07,1.82)	1.27	(0.88,1.84)	1.08	(0.79,1.50)	
	RERI (95% CI)			0.37	(0.06,0.69)	0.07	(-0.22,0.36)	-0.22	(-0.48,0.05)	
Women	Low-to-moderate physical activity	r	eference	1.06	(0.92,1.22)	1.53	(1.32,1.78)	1.88	(1.64,2.15)	
	High physical activity	1.16	(0.85,1.56)	1.27	(0.99,1.63)	1.16	(0.85,1.58)	1.51	(1.15,1.99)	
	RERI (95% CI)			0.08	(-0.16,0.32)	-0.31	(-0.54,-0.07)	-0.46	(-0.71,-0.21)	

Appendix 3. Association between fear of COVID-19 and depression and the relative excess risks due to interaction (RERI)

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_			Low and	moderate j	physical	activity			_					
Fear of COVID-19		Ν	Case N	(%)	OR 95% CI		Ν	Case N	(%)	OR	95% CI		p- interaction	
Total	Very low	43,669	5,148	(11.79)		reference		10,812	1,125	(10.41)		reference		
	Low	56,474	7,382	(13.07)	1.16	(1.11 -	1.23)	12,010	1,378	(11.47)	1.21	(1.08 -	1.35)	0.0116
	High	28,531	4,728	(16.57)	1.56	(1.47 -	1.65)	6,257	825	(13.19)	1.40	(1.23 -	1.59)	0.0116
	Very high	43,141	7,365	(17.07)	1.54	(1.46 -	1.63)	9,211	1,128	(12.25)	1.37	(1.21 -	1.55)	
Men	Very low	22,251	2,173	(9.77)	reference		7,592	675	(8.89)	reference				
	Low	24,398	2,383	(9.77)	1.11	(1.02 -	1.20)	7,313	681	(9.31)	1.25	(1.09 -	1.44)	0 1555
	High	10,899	1,362	(12.50)	1.54	(1.40 -	1.70)	3,516	377	(10.72)	1.44	(1.21 -	1.71)	0.1555
	Very high	14,395	1,830	(12.71)	1.52	(1.39 -	1.60)	4,601	416	(9.04)	1.34	(1.13 -	1.59)	
Women	Very low	21,418	2,975	(13.89)		reference		3,220	450	(13.98)		reference	e	
	Low	32,076	4,999	(15.58)	1.22	(1.14 -	1.30)	4,697	697	(14.84)	1.15	(0.98 -	1.35)	0.0460
	High	17,632	3,366	(19.09)	1.59	(1.48 -	1.71)	2,741	448	(16.34)	1.36	(1.14 -	1.63)	0.0462
	Very high	28,746	5,535	(19.25)	1.58	(1.48 -	1.69)	4,610	712	(15.44)	1.40	(1.19 -	1.65)	

Appendix 4. Association between fear of COVID-19 and depression(PHQ-9≥5) stratified by physical activity and sex



			Low and n	noderate	physical a	activity			High j	physical	activity	r		
Fear of COVID-19		Ν	Case N	(%)	OR	OR 95% CI		Ν	Case N	(%)	OR 95% CI		CI	p- interaction
Total	Very low	43,669	326	(0.75)		reference			52	(0.48)		reference	;	
	Low	56,474	370	(0.66)	0.93	(0.76 -	1.14)	12,010	69	(0.57)	1.26	(0.79 -	2.00)	0 2222
	High	28,531	282	(0.99)	1.45	(1.17 -	1.81)	6,257	46	(0.74)	1.15	(0.70 -	1.89)	0.2232
	Very high	43,141	642	(1.49)	1.95	(1.61 -	2.35)	9,211	64	(0.69)	1.54	(0.96 -	2.47)	
Men	Very low	22,251	127	(0.57)		reference		7,592	27	(0.36)		reference	•	
	Low	24,398	114	(0.47)	1.07	(0.77 -	1.49)	7,313	36	(0.49)	1.72	(0.93 -	3.18)	0.7611
	High	10,899	75	(0.69)	1.43	(0.97 -	2.10)	3,516	20	(0.57)	1.47	(0.75 -	2.90)	0.7611
	Very high	14,395	160	(1.11)	2.13	(1.54 -	2.95)	4,601	22	(0.48)	1.99	(1.05 -	3.76)	
Women	Very low	21,418	199	(0.93)		reference		3,220	25	(0.78)		reference	•	
	Low	32,076	256	(0.80)	0.85	(0.66 -	1.10)	4,697	33	(0.70)	0.82	(0.44 -	1.52)	
	High	17,632	207	(1.17)	1.43	(1.10 -	1.86)	2,741	26	(0.95)	0.84	(0.43 -	1.66)	0.1397
	Very high	28,746	482	(1.68)	1.84	(1.46 -	2.33)	4,610	42	(0.91)	1.12	(0.64 -	1.96)	

Appendix 5. Association between fear of COVID-19 and depression(PHQ-9≥15) stratified by physical activity and sex



		I	low and r	noderate	physical	activity	High physical activity									
		Ν	Case N	(%)	OR	95% CI		95% CI		Ν	Case N	(%)	OR	95%	CI	p- interaction
Total	Fear of COVID-19	171,815	5,127	(2.98)	1.06	(1.05 -	1.08)	38,290	806	(2.10)	1.03	(1.01 -	1.06)	0.0101		
Men	Fear of COVID-19	71,943	1,488	(2.07)	1.05	(1.03 -	1.07)	23,022	363	(1.58)	1.04	(1.01 -	1.08)	0.2265		
Women	Fear of COVID-19	99,872	3,639	(3.64)	1.07	(1.06 -	1.09)	15,268	443	(2.90)	1.02	(0.99 -	1.06)	0.0162		

Appendix 6. Association between fear of COVID-19 as a continuous variable and depression stratified by physical activity and sex

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Appendix 7. The strengthening the reporting of observational studies in epidemiology (STROBE) Statement— Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation	Page No
Title and abstract	1	(<i>a</i>) Indicate the study's design with a commonly used term in the title or the abstract	viii
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	vii-ix
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10-13
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-11
Bias	9	Describe any efforts to address potential sources of bias	14-15
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-11
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	14
		(b) Describe any methods used to examine subgroups and interactions	14
		(c) Explain how missing data were addressed	8-9
		(d) If applicable, describe analytical methods taking account of sampling strategy	14

 (\underline{e}) Describe any sensitivity analyses

15



	Item No	Recommendation	Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8-9, 16
		(b) Give reasons for non-participation at each stage	•
		(c) Consider use of a flow diagram	9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	16
		(b) Indicate number of participants with missing data for each variable of interest	17-18
Outcome data	15*	Report numbers of outcome events or summary measures	16
Main results	16	(<i>a</i>) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	20-21
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done-eg analyses of subgroups and interactions, and sensitivity analyses	29-31
Discussion			
Key results	18	Summarise key results with reference to study objectives	35
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	47
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	36-46
Generalisability	21	Discuss the generalisability (external validity) of the study results	47
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	-

Appendix 7. The strengthening the reporting of observational studies in epidemiology (STROBE) Statement— Checklist of items that should be included in reports of cross-sectional studies (*continued*)

*Give information separately for exposed and unexposed groups.



ABSTRACT(KOREAN)

코로나바이러스감염증 19에 대한 염려와 우울증 사이의 연관 성 및 신체활동의 효과 변경:2020 지역사회건강조사 결과

연세대학교 대학원 보건학과

김지민

배경 및 목적 :

코로나바이러스감염증 19(코로나19) 발생 이후, 전 세계적으로 공중 보건이 위협받고 있으며 많은 사람들이 일상생활에 지장을 받고 있다. 이전의 많은 연구들은 코로나19 범유행 기간 동안, 정신 건강 문제가 세계적으로 증가했다고 보고했다. 또한, 신체활 동은 심리적 고통을 완화하는 것으로 잘 알려져 있다. 따라서 본 연구의 목적은 우리 나라 성인에서 코로나19에 대한 염려와 우울증의 연관성을 규명하고, 신체활동이 이 에 미치는 영향을 확인하는 것이다.

연구 방법 :

본 연구는 2020년 지역사회건강조사 자료를 활용한 단면연구이다. 성인 210,906명에 대한 코로나19에 대한 염려와 우울 증상에 대한 데이터를 활용하였다. 개인 레벨의 변수와 지역 레벨의 변수를 모두 포함하는 다층 분석과 로지스틱 회귀모형을 이용하 여 코로나19에 대한 염려와 우울 증상 사이의 연관성을 분석하였다. 또한, 이 연관성



에서의 신체활동의 효과 변경에 대한 분석을 시행하였다.

연구 결과 :

210,906명 중 5,964명(2.83%)이 중간 이상의 우울증상이 있는 것으로 나타났다 (PHQ-9 ≥10). 코로나19에 대한 염려 수준이 높아질수록 우울 증상에 대한 OR도 증가하였다. 다층 분석 결과, 개인적인 요인들이 지역적인 요인들보다 이 연관성을 더 잘 설명하 였다. 또한, 신체활동이 코로나19에 대한 염려가 우울 증상에 미치는 영향을 낮추는 것으로 관찰되었다. '매우 높은' 수준의 염려에서의 우울 증상에 대한 OR이 신체 활동 이 높은 군(OR=1.46, 95% CI=1.12-1.90)보다 낮은 군(OR=1.82, 95% CI=1.63-2.03)에서 더 높았다. 이러한 신체활동의 영향에 대한 p-값은 통계적으로 유의하였다 (p-interaction = 0.0003).

결론 및 고찰 :

본 연구는 우리나라 성인에서 코로나19에 대한 염려와 우울증의 연관성 및 이에 대해 신체활동이 미치는 영향을 분석하였다. 전반적으로 코로나19에 대한 염려가 높을수록 우울증에 대한 오즈가 증가하였다. 또한, 코로나19에 대한 염려가 우울증에 미치는 부 정적인 영향이 신체활동에 의해 완화되었다. 본 연구 결과는 코로나19에 대한 더 높 은 염려가 더 높은 수준의 우울증 증상과 관련이 있으며, 또한 신체 활동이 이 연관 성을 예방하는 요인이 될 수 있음을 시사한다.

핵심어 : 코로나 19, 코로나 19 로 인한 염려, 우울증, 신체활동