

ORIGINAL RESEARCH

Effect of physical activity on stress and the sense of community during the COVID-19 pandemic: the role of gender and age

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Abstract

Despite their effectiveness in minimizing the spread of infection, movement restrictions adopted during the Coronavirus disease 2019 (COVID-19) pandemic have not been without their health-related consequences, including decreases in physical activity and increases in sedentary behavior. This study aimed to investigate differences in stress and sense of community among Korean citizens in various age groups according to the degree of their participation in physical activity during the COVID-19 pandemic. We analyzed data collected during the Social Survey of Busan Metropolitan City 2020, the population of which included all household members over the age of 15. Data for a total of 33,082 participants (male = 15,129; female = 17,953) were extracted using a two-stage cluster sampling method. Age, stress level, and sense of community were analyzed using independent *t*-tests, while the frequency of participation in physical activity was analyzed using a Mann-Whitney U test. Differences in stress level and community consciousness according to the frequency of physical activity were examined via multivariate analysis of variance. Variables exhibiting significant differences were evaluated for differences between groups through Scheffe's *post hoc* analysis. First, stress levels were higher among female adolescents than male adolescents. Among adults and older adults, men exhibited higher overall stress levels than women, whereas sense of community was stronger in women than men. Second, male adolescents in the regular physical activity participation group showed lower levels in some factors of stress than those in the non-participating group. Finally, a higher frequency of participation in physical activity among adults and older adults was associated with lower stress and higher sense of community, regardless of gender. In conclusion, regular participation in physical activity should be considered when designing strategies for managing stress and promoting social relationships at the national and individual levels during COVID-19 and any similar pandemics in the future.

Keywords

Physical activity; COVID-19; Coronavirus 2019; Sense of community; Stress; Mental health; Social distancing; Lifestyle factors; Exercise; Physical education

1. Introduction

COVID-19 first emerged in December 2019 in Wuhan, China [1], following which its unprecedented transmission speed led to a rapid increase in the number of infected patients and the declaration of a global pandemic [2]. At the beginning of the outbreak, various methods were adopted to mitigate the effects of the disease on public health and prevent the spread of infection, the most powerful of which involved drastic restrictions on human movement and social life [3].

However, a study has reported that although movement restrictions during the COVID-19 pandemic were an effective way to prevent the spread of infectious diseases, there were also side effects such as a decrease in physical activity

and an increase in sedentary life during the lockdown [4]. Regular physical activity is very effective in the prevention and treatment of chronic diseases [5]. As such, decreases in physical activity may lead to increased incidence and aggravation of chronic diseases. In addition to the direct effects of social distancing and movement restriction on physical health, such measures have been associated with reduced levels of social interaction [6]. Face-to-face interactions at work and school have been replaced by video conferencing and online education strategies, and the resulting physical isolation has raised concerns related to mental health [7]. These long-term lifestyle changes have increased stress levels [8], which have been associated with increased alcohol consumption and rates of alcohol abuse [9]. In other words, the psychological impact

of the COVID-19 pandemic is of great concern, given the increased burden associated with psychiatric treatment [10].

The World Health Organization's recommendation for physical activity is 60 minutes of moderate or vigorous-intensity exercise per day for children and adolescents. Adults and older adults are encouraged to engage in at least 150 minutes of moderate or 75 minutes of vigorous aerobic activity per week or a combination of the two to the same extent [11]. A study examining trends in physical activity before the COVID-19 pandemic found that 81% of adolescents and 28% of adults did not engage in sufficient physical activity [12, 13]. In Korea, it was found that 92.2% of adolescents and 54.2% of adults did not reach the standards of physical activity during this period [14, 15]. This shows that the level of participation in physical activity in Korea is significantly lower than that of other countries.

A lack of physical activity is closely related to an increased sedentary lifestyle [16]. According to one study, the average duration of sedentary behavior per day among Koreans was 8.3 hours, which was higher than that of Americans [17]. One of the reasons for this is Korea's unique socio-cultural background. Korea has a competitive entrance exam culture, which causes Korean teenagers to spend long durations sitting at a desk studying for exams [18]. In addition, Korea is characterized by long working hours. As of 2018, the working hours of Korean adults was 1993 per year, which is about 600 more hours than in Germany [19].

This phenomenon worsened after the COVID-19 pandemic. In a study of Korean adults in 2020, 49.6% of the participants responded that their physical activity decreased after the COVID-19 pandemic, whereas only 5.7% said their level of physical activity increased [20]. A similar study reported that 54% of adults and 94.1% of adolescents did not meet the guidelines for physical activity [21]. This shows not only a lower level of participation in physical activity compared to the rest of the world but also a worse indicator than in the past. Therefore, to offset the current situation of an increase in sedentary time and the lack of physical activity during the COVID-19 pandemic, various efforts are needed to broadly identify the various benefits of physical activity and promote active participation in physical activity outside of study and working hours.

The link between physical activity and psychological and mental health is clearly established [22]. Stress relief is among the most powerful factors motivating individuals to engage in physical activity [23] and is also beneficial for managing symptoms of anxiety and depression [24]. In addition, physical activity has known antidepressant effects, and research has indicated that active and physically healthy people are biologically more resilient to psychosocial stressors [25]. According to a study on the immunological mechanisms of physical activity [26], physical activity is associated with the inflammatory, dopaminergic, and neuroendocrine systems, all of which play a role in mood regulation. Moreover, the psychobiological responses stimulated by exercise that involve the immune system, hypothalamic-pituitary-adrenal axis, and autonomic nervous system can promote well-being.

Recently, various studies have warned that physical activity has declined and sedentary behavior has increased during the

COVID-19 pandemic [27]. This has led to a wide range of attempts to find links between physical activity and psychological and mental health across countries, races, and ages [28]. As a result, several studies have reported the adequacy of adopting physical activity as a stress management strategy during the COVID-19 pandemic [29, 30]. Studies on Koreans have also reported that various health and lifestyle-related indicators deteriorated during the COVID-19 pandemic [31–33]. However, there have been few attempts to find a link between physical activity and psychological and mental health in this population.

People are naturally included in certain groups. Sense of community refers to a feeling of belonging that comes from experiencing repeated and meaningful social interactions with people within a specific group [34], and it has been shown to provide personal benefits such as well-being, improved health, and life satisfaction [35, 36]. In addition, physical activity has been shown to improve sense of community [37, 38]. Considering that social interaction is an essential component of sense of community, the lockdown implemented to minimize contact between people due to the recent COVID-19 pandemic has likely degraded social interaction.

Physical activity can provide suitable conditions for building sense of community. Given that many sports involve interpersonal cooperation, participation in physical activity increases the opportunity for social interaction [39]. Even those participating in individual sports are provided with opportunities for social exchange through club activities or events, suggesting that regular participation in physical activity can help maintain social relationships [40]. However, attempts to study the relationship between physical activity and sense of community is insufficient worldwide, and it is difficult to find related studies in Korea during the COVID-19 pandemic.

A study has reported that the status of physical activity showed a wide distribution according to country, race, gender, and age. In addition to biological factors such as gender and age, psychological and social factors were found to be strongly related to physical activity [21]. Owing to the impact of the COVID-19 pandemic, people are faced with situations they have never experienced before, including restrictions on individual physical movement, psychological changes, and reduced social interaction. Countries around the world have been collecting evidence to evaluate the impact of the COVID-19 pandemic on people's health and have been working to come up with countermeasures.

This study aimed to examine the relationship between physical activity, stress as a psychological factor, sense of community as a social factor, and gender and age as biological factors among Koreans during the COVID-19 pandemic. Specifically, the purpose of this study was to investigate (1) the differences in physical activity, stress, and sense of community according to gender among Korean adolescents, adults, and older adults; (2) the differences in stress and sense of community according to the level of physical activity according to gender among Korean adolescents, adults, and older adults. The resulting data are likely to provide insights into the most effective ways in which physical activity can be used to cope with various life stressors during the COVID-19 outbreak and any similar pandemics in the future.

2. Materials and methods

2.1 Participants

The purpose of the original survey [41] was to identify ways in which quality of life could be improved based on actual living conditions and perceptions among Korean citizens. The survey was conducted for 21 days from 26 August to 15 September 2020. In principle, interviews were intended to be conducted by investigators during household visits; however, owing to COVID-19-related restrictions, an Internet survey was conducted in parallel for 15 days from 26 August to 09 September. The study population included all household members over the age of 15, excluding foreigners and residents of special facilities such as dormitories and nursing homes. The sample was extracted using a two-stage cluster sampling method, yielding a total of 33,082 participants (male = 15,129; female = 17,953; average age = 52.96 ± 18.46).

2.2 Frequency of physical activity

The frequency of physical activity was assessed using the following question: How much physical activity have you done in the past week to the extent that you were out of breath or sweating a little more than usual? Considering the intensity of physical activity, walking for exercise was included, although walking for daily life was excluded. Responses related to the frequency of physical activity were reclassified as (a) none, (b) 1–2 times a week, (c) 3–4 times a week, and (d) 5–7 times a week.

2.3 Stress

The stress questionnaire consists of eight questions across three domains based on the Stress Response Inventory [42] and the Stress Questionnaire for KNHANES (Korean National Health and Nutrition Examination Survey) [43]. The first domain is related to the causes of stress, which is assessed using the following statements: (a) I tend to have a lot of stress at work, at home, and at school; (b) I tend to be under a lot of stress due to financial problems; (c) I tend to have a lot of stress because of my relationships with people. The second domain is related to emotional responses, which are assessed as follows: (d) I am angry for no apparent reason and have difficulty holding back my anger; (e) I have no one to talk to even if I have serious concerns; (f) I am not easily relieved when I am stressed. The third domain is related to behavioral responses, which are evaluated as follows: (g) I drink alone because I feel depressed; (h) Watching television or surfing the Internet alone is more fun than meeting other people. Responses to each item are rated along a 5-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). A response score closer to 5 indicates a higher level of perceived stress. The scores were calculated as mean and standard deviation for data analyses.

2.4 Sense of community

The sense of community questionnaire consists of four questions related to general thoughts regarding one's local community based on the items used in the Korean Children and Youth Panel Survey [44]: (a) We tend to get to know each

other well; (b) We talk often about what is happening in the neighborhood; (c) We help each other out in difficult situations; (d) We actively participate in various events and gatherings in the neighborhood. Responses to each item are rated on a 5-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). The closer the response score is to 1, the higher the level of sense of community. The scores were calculated as mean and standard deviation for data analyses.

2.5 Statistical analysis

Statistical analysis was performed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA), and the level of statistical significance was set to $p < 0.05$. To analyze the differences in participants' characteristics, groups were divided based on age into adolescents, adults, and older adults. Gender was set as an independent variable and actual age, stress, sense of community, and frequency of physical activity as dependent variables. The actual age, stress, and sense of community were confirmed by performing the independent t -test, and the effect size was calculated through Cohen's d . Considering that the frequency of physical activity participation is an ordinal scale, a difference analysis was performed using the Mann-Whitney U test, a non-parametric statistical verification method.

Multivariate analysis of variance was performed to examine the differences between the frequency of physical activity, stress, and sense of community. Frequency of physical activity was set as an independent variable, and the dependent variables were stress and sense of community. The analysis was conducted by dividing the groups into adolescents, adults, and older adults. In addition, each group was subdivided into male and female. Therefore, a total of six groups were analyzed according to age and gender. The effect sizes were confirmed through partial eta squared (η^2p), and variables exhibiting significant differences were evaluated for differences between groups through Scheffe's *post hoc* analysis.

3. Results

3.1 Analysis of participant characteristics according to gender among Korean adolescents, adults, and older adults

Table 1 presents the analysis of the Korean participant characteristics according to gender. Adolescents (age range = 15–17 years) exhibited significant differences in terms of stress at work/home/school ($p < 0.05$) and interpersonal stress according to gender ($p < 0.001$). Adults (age range = 18–64 years) exhibited significant differences in all variables except difficulty in relieving stress according to gender ($p = 0.395$). Older adults (age range = over 65 years) exhibited significant differences in all variables except isolation ($p = 0.073$) and media consumption according to gender ($p = 0.468$). The frequency of physical activity exhibited significant differences in all three age groups according to gender ($p < 0.001$).

TABLE 1. Analysis of the participant characteristics according to sex among Korean adolescents, adults, and older adults.

	Adolescents (n = 725)					Adults (n = 22,340)						Older Adults (n = 10,017)			
	Boys (n = 378)	Girls (n = 347)	t	p	Cohen's d	Men (n = 10,499)	Women (n = 11,841)	t	p	Cohen's d	Men (n = 4252)	Women (n = 5765)	t	p	Cohen's d
Age	16.20 ± 0.78	16.20 ± 0.77	-0.012	0.991		44.40 ± 13.30	45.07 ± 13.29	-3.725	<0.001 ***	0.050	73.48 ± 6.27	74.22 ± 6.87	-5.553	<0.001 ***	0.112
Cause of Stress															
Work/home/ school	3.10 ± 1.14	2.94 ± 1.08	1.977	0.048*	0.144	2.85 ± 1.03	2.94 ± 1.03	-6.450	<0.001 ***	0.087	3.44 ± 1.01	3.52 ± 1.03	-3.430	0.001 *	0.078
Economic	4.06 ± 1.00	4.03 ± 0.97	0.364	0.716		3.13 ± 1.08	3.21 ± 1.09	-5.523	<0.001 ***	0.074	3.25 ± 1.09	3.25 ± 1.12	0.194	0.846	
Interpersonal	3.86 ± 1.00	3.48 ± 1.09	4.920	<0.001 ***	0.363	3.39 ± 0.97	3.41 ± 0.98	-2.107	0.035*	0.021	3.61 ± 0.90	3.68 ± 0.91	-4.215	<0.001 **	0.077
Emotional Responses															
Anger	3.99 ± 1.01	3.97 ± 0.94	0.364	0.716		3.83 ± 0.90	3.87 ± 0.92	-2.927	0.003 **	0.044	3.85 ± 0.88	3.94 ± 0.86	-5.088	<0.001 ***	0.103
Isolation	3.99 ± 0.96	4.01 ± 0.96	-0.277	0.782		3.71 ± 0.96	3.83 ± 0.95	-8.938	<0.001 ***	0.126	3.63 ± 0.95	3.66 ± 0.97	-1.794	0.073	
Difficulty Re- lieving Stress	3.82 ± 1.00	3.67 ± 1.05	1.952	0.051		3.62 ± 0.93	3.63 ± 0.97	-0.850	0.395		3.70 ± 0.90	3.75 ± 0.92	-2.780	0.005 **	0.055
Behavioral Responses															
Alcohol		4.72 ± 0.68	-0.628	0.530		3.82 ± 1.09	4.18 ± 0.98	-25.808	<0.001 ***	0.347	3.98 ± 1.03	4.38 ± 0.85	-21.345	<0.001 ***	0.424
Media Consumption	3.60 ± 1.18	3.43 ± 1.15	1.907	0.057		3.45 ± 0.99	3.48 ± 1.02	-2.286	0.022*	0.030	3.54 ± 0.98	3.56 ± 1.03	-0.725	0.468	
Sense of Community															
Intimacy	3.57 ± 1.12	3.66 ± 1.10	-1.043	0.297		3.60 ± 1.02	3.38 ± 1.03	15.510	<0.001 ***	0.215	3.04 ± 1.03	2.81 ± 1.01	11.077	<0.001 ***	0.225

TABLE 1. Continued.

	Adolescents (n = 725)					Adults (n = 22,340)					Older Adults (n = 10,017)				
	Boys (n = 378)	Girls (n = 347)	t	p	Cohen's d	Men (n = 10,499)	Women (n = 11,841)	t	p	Cohen's d	Men (n = 4252)	Women (n = 5765)	t	p	Cohen's d
Communication	3.80 ± 1.10	3.90 ± 1.02	-1.261	0.208		3.85 ± 0.95	3.66 ± 1.00	14.471	<0.001 ***	0.195	3.32 ± 1.03	3.07 ± 1.04	11.859	<0.001 **	0.242
Cooperation	3.76 ± 1.06	3.86 ± 1.02	-1.291	0.197		3.81 ± 0.96	3.64 ± 1.00	13.149	<0.001 ***	0.173	3.35 ± 1.02	3.17 ± 1.03	8.680	<0.001 ***	0.176
Participation	4.00 ± 1.03	4.12 ± 0.91	-1.747	0.081		4.03 ± 0.93	3.93 ± 0.96	8.033	<0.001 ***	0.106	3.57 ± 1.04	3.46 ± 1.06	8.692	<0.001 ***	0.105
Frequency of Physical Activity															
None	240 (63.5)	254 (73.2)				5890 (56.1)	6940 (58.6)				2292 (53.9)	3662 (63.5)			
1–2/week	35 (9.3)	38 (11.0)				1532 (14.6)	1469 (12.4)				418 (9.8)	380 (6.6)			
3–4/week	48 (12.7)	37 (10.7)				1693 (16.1)	1941 (16.4)				673 (15.8)	792 (13.7)			
5–7/week	55 (14.6)	18 (5.2)				1384 (13.2)	1491 (12.6)				869 (20.4)	931 (16.1)			
Mann-Whitney U	57637.00					60887359.50					11113952.50				
p	0.001**					0.003**					<0.001***				

*p < 0.05, **p < 0.01, ***p < 0.001 (tested via independent t-test and Mann-Whitney U test).

3.2 Differences in stress and sense of community based on frequency of physical activity

Table 2 shows the differences in stress and sense of community according to participation in physical activity among adolescents. Among male adolescents, significant differences in stress at work/home/school ($p < 0.01$), interpersonal stress ($p < 0.05$), and sense of isolation ($p < 0.01$) were observed based on frequency of physical activity. However, there were no significant differences among any of the variables for female adolescents. Table 3 shows the results for adult participants. Among adult men, significant differences according to the frequency of physical activity were observed for all variables at the $p < 0.001$ level. Among adult women, significant differences according to frequency of physical activity were observed for all variables except media consumption ($p < 0.01$) at the $p < 0.001$ level. Table 4 shows the results for older adults. Among older adult men, significant differences based on frequency of physical activity were observed for all variables except media ($p = 0.057$). The difference for stress at home/work/school was significant at the level of $p < 0.01$, whereas those for all the remaining variables were significant at the level of $p < 0.001$. Among older adult women, significant differences according to the frequency of physical activity were observed for all variables. Differences for stress at work, home, school, and media consumption were significant at the $p < 0.01$ level, whereas those for all remaining variables were significant at the $p < 0.001$ level.

4. Discussion

The purpose of this study was to investigate the relationship between physical activity, stress, and sense of community in Koreans in the context of the COVID-19 pandemic. As a result, significant differences were found in frequency of physical activity, stress level, and sense of community according to gender. Additionally, as the frequency of physical activity increased, stress levels decreased and sense of community increased.

The frequency of physical activity was found to be higher in men than in women in all age groups. According to the World Health Organization [45], 28% of men and 32% of women over the age of 18 were not physically active at the recommended level during the COVID-19 pandemic. It was also found that 78% of male adolescents and 81% of female adolescents did not meet the physical activity guidelines. In other words, the rates of physical inactivity worldwide tend to be higher among women than men, which is consistent with our findings. In the context of the COVID-19 pandemic, the decrease in physical activity was evident around the world [46]. In particular, according to a study of Koreans during the same period, 46.1% of men and 50.4% of women reported a decrease in their physical activity [20]. This may mean that the physical activity imbalance between men and women may have worsened during the COVID-19 pandemic. Therefore, it is essential to implement physical activity policies targeted at women with low physical activity or at risk of decreasing their physical activity.

Our findings indicated that stress levels were higher among female students than among male students. According to a study conducted on Korean adolescents, one of the main stress-inducing factors for female students is interpersonal relationships [47]. This is consistent with the findings of this study, in that female students have higher levels of stress at work, home, school, and in interpersonal relationships. Another study of Korean adolescents [48] found that female students had a lower level of well-being awareness and a higher level of stress perception than male students. Moreover, these differences were affected by obesity perception. Therefore, obesity reduction through participation in physical activity can be an appropriate strategy for stress management, and this strategy can be particularly effective for female students.

Among adults and older adults, men exhibited higher overall stress levels than women, whereas sense of community was stronger in women than men. The results for adults and older adults contrasted with those for adolescents. Specifically, male adolescents exhibited lower overall stress levels than female adolescents, and there were no differences between male and female adolescents for sense of community. A study conducted during the COVID-19 pandemic [49] found no gender differences for stress, and in some countries women were at higher risk of developing mental health problems. In addition, it was suggested that stress should consider the association with cultural gender roles.

Adolescents typically focus on academics in school and have jobs after adulthood, resulting in increased social participation. According to a study of Korean office workers [50], although women's social participation is increasing, traditional role expectations require women to take more responsibility for household chores. In contrast, men tend to focus on social activities, which makes them more vulnerable to socioeconomic stressors. Korea is one of the traditional Confucian countries, and the roles of men and women have been strictly separated. These traditions also have an impact on modern times [51]. Therefore, this background might be considered when interpreting the differences between adolescents and adults as well as differences in stress and sense of community according to gender after adulthood in this study.

The male adolescent regular physical activity participation group showed lower levels in some factors of stress than did those in the non-participating group. Among adults and older adults, the group with a high frequency of physical activity participation had lower stress and a higher sense of community than the non-participating group, regardless of gender. The World Health Organization has stated that regular moderate-intensity or high-intensity physical activity can aid in managing adult mental health [12]. Our results are in accordance with this recommendation, as participants who reported more frequent participation in physical activity had lower levels of stress than those who reported less frequent or no participation.

TABLE 2. Differences in stress and sense of community based on frequency of physical activity in Korean adolescents.

	None (a)	1–2 times/week (b)	3–4 times/week (c)	5–7 times/week (d)	F	<i>p</i>	η^2p	<i>post hoc</i>
Boys	n = 240	n = 35	n = 48	n = 55				
Cause of Stress								
Work/home/school	2.94 ± 1.13	3.17 ± 1.12	3.29 ± 1.11	3.60 ± 1.10	5.742	0.001**	0.044	a > d
Economic	4.01 ± 1.00	4.11 ± 0.87	3.98 ± 1.10	4.29 ± 0.94	1.308	0.272		
Interpersonal	3.79 ± 0.99	3.74 ± 1.04	3.88 ± 1.08	4.24 ± 0.84	3.250	0.022*	0.025	a > d
Emotional Responses								
Anger	3.90 ± 1.02	3.97 ± 0.99	4.23 ± 0.95	4.20 ± 0.95	2.308	0.076		
Isolation	3.87 ± 0.98	4.09 ± 0.89	4.17 ± 0.88	4.33 ± 0.86	4.302	0.005**	0.033	a > d
Relieving	3.74 ± 0.99	3.74 ± 1.09	4.08 ± 0.87	4.00 ± 1.04	2.363	0.071		
Behavioral Responses								
Alcohol	4.63 ± 0.80	4.77 ± 0.65	4.73 ± 0.57	4.85 ± 0.41	1.755	0.155		
Media	3.53 ± 1.22	3.49 ± 1.17	3.83 ± 1.17	3.78 ± 0.98	1.499	0.214		
Sense of Community								
Intimacy	3.69 ± 1.12	3.40 ± 1.09	3.42 ± 1.07	3.33 ± 1.11	2.346	0.073		
Communication	3.91 ± 1.11	3.46 ± 1.25	3.83 ± 0.95	3.49 ± 1.05	3.411	0.018*	0.027	
Cooperation	3.87 ± 1.07	3.54 ± 1.09	3.77 ± 0.93	3.44 ± 1.05	3.121	0.026*	0.024	
Participation	4.09 ± 1.05	3.74 ± 1.04	3.92 ± 0.94	3.84 ± 1.00	1.889	0.131		
Girls	n = 254	n = 38	n = 37	n = 18				
Cause of Stress								
Work/home/school	2.89 ± 1.09	3.00 ± 0.96	3.11 ± 1.10	3.17 ± 1.15	0.784	0.504		
Economic	4.04 ± 0.95	4.03 ± 1.00	3.95 ± 1.03	4.11 ± 1.08	0.137	0.938		
Interpersonal	3.48 ± 1.06	3.32 ± 1.14	3.46 ± 1.15	3.89 ± 1.32	1.140	0.333		
Emotional Responses								
Anger	3.91 ± 0.96	4.11 ± 0.89	4.00 ± 0.85	4.50 ± 0.79	2.608	0.052		
Isolation	3.98 ± 0.97	4.11 ± 0.98	4.03 ± 0.90	4.33 ± 0.97	0.916	0.434		
Relieving	3.66 ± 1.03	4.11 ± 1.18	3.84 ± 0.96	3.89 ± 1.32	1.016	0.386		
Behavioral Responses								
Alcohol	4.69 ± 0.72	4.74 ± 0.65	4.84 ± 0.44	4.89 ± 0.47	0.924	0.429		
Media	3.42 ± 1.18	3.26 ± 1.08	3.57 ± 0.99	3.72 ± 1.23	0.833	0.477		
Sense of Community								
Intimacy	3.69 ± 1.10	3.82 ± 0.93	3.22 ± 1.21	3.78 ± 1.00	2.453	0.063		
Communication	3.95 ± 1.01	3.97 ± 0.97	3.46 ± 1.15	3.83 ± 0.99	2.638	0.050		
Cooperation	3.89 ± 1.06	3.97 ± 0.82	3.57 ± 0.99	3.89 ± 0.90	1.246	0.293		
Participation	4.15 ± 0.95	4.26 ± 0.76	3.86 ± 0.79	4.06 ± 0.80	1.377	0.250		

p* < 0.05, *p* < 0.01; tested via multivariate analysis of variance and Scheffe's post hoc test.

TABLE 3. Differences in stress and sense of community according to the frequency of physical activity in Korean adults.

	None (a)	1–2 times/week (b)	3–4 times/week (c)	5–7 times/week (d)	F	p	η^2p	post hoc
Men	n = 5890	n = 1532	n = 1693	n = 1384				
Cause of Stress								
Work/home/school	2.77 ± 1.02	2.77 ± 1.00	2.95 ± 1.02	3.11 ± 1.07	50.069	<0.001***	0.014	a, b > c > d
Economic	3.02 ± 1.07	3.19 ± 1.06	3.26 ± 1.07	3.36 ± 1.13	50.479	<0.001***	0.014	a > b, c, d
Interpersonal	3.30 ± 0.95	3.43 ± 0.97	3.46 ± 0.97	3.62 ± 0.99	46.563	<0.001***	0.013	a > b, c > d
Emotional Responses								
Anger	3.75 ± 0.89	3.92 ± 0.90	3.91 ± 0.89	4.00 ± 0.90	42.541	<0.001***	0.012	a > b, c, d
Isolation	3.62 ± 0.94	3.79 ± 0.96	3.82 ± 0.96	3.92 ± 0.97	50.856	<0.001***	0.014	a > b, c, >d
Relieving	3.54 ± 0.92	3.63 ± 0.95	3.71 ± 0.91	3.82 ± 0.96	42.819	<0.001***	0.012	a > b, c > d
Behavioral Responses								
Alcohol	3.71 ± 1.11	3.90 ± 1.06	3.91 ± 1.07	4.07 ± 1.03	49.018	<0.001***	0.014	a > b, c > d
Media	3.41 ± 0.99	3.47 ± 0.96	3.50 ± 1.00	3.55 ± 1.13	10.574	<0.001***	0.003	a > c, d
Sense of Community								
Intimacy	3.69 ± 1.00	3.48 ± 0.99	3.49 ± 1.02	3.44 ± 1.06	42.506	<0.001***	0.012	a > b, c, d
Communication	3.92 ± 0.94	3.77 ± 0.92	3.78 ± 0.96	3.74 ± 1.00	23.341	<0.001***	0.007	a > b, c, d
Cooperation	3.91 ± 0.94	3.69 ± 0.95	3.71 ± 0.95	3.67 ± 1.02	44.616	<0.001***	0.013	a > b, c, d
Participation	4.11 ± 0.90	3.96 ± 0.92	3.95 ± 0.94	3.91 ± 0.99	27.054	<0.001***	0.008	a > b, c, d
Women	n = 6940	n = 1469	n = 1941	n = 1491				
Cause of Stress								
Work/home/school	2.85 ± 1.02	2.93 ± 1.04	3.07 ± 1.01	3.17 ± 1.03	54.064	<0.001***	0.014	a, b > c > d
Economic	3.13 ± 1.09	3.24 ± 1.00	3.31 ± 1.08	3.40 ± 1.06	34.479	<0.001***	0.009	a > b, c, d
Interpersonal	3.37 ± 0.98	3.39 ± 1.00	3.45 ± 0.96	3.59 ± 0.95	22.389	<0.001***	0.006	a > c > d
Emotional Responses								
Anger	3.82 ± 0.92	3.87 ± 0.94	3.92 ± 0.90	3.99 ± 0.90	15.421	<0.001***	0.004	a > c, d
Isolation	3.79 ± 0.95	3.87 ± 0.98	3.85 ± 0.96	3.92 ± 0.93	9.285	<0.001***	0.002	a > d
Relieving	3.59 ± 0.96	3.59 ± 1.00	3.68 ± 0.96	3.76 ± 0.95	15.397	<0.001***	0.004	a, b > c, d
Behavioral Responses								
Alcohol	4.13 ± 0.99	4.20 ± 0.99	4.23 ± 0.96	4.32 ± 0.90	18.517	<0.001***	0.005	a > c, d
Media	3.48 ± 1.02	3.41 ± 1.04	3.51 ± 1.01	3.55 ± 1.05	5.004	0.002**	0.001	b > c, d
Sense of Community								
Intimacy	3.47 ± 1.03	3.34 ± 0.99	3.31 ± 1.01	3.11 ± 1.04	58.609	<0.001***	0.015	a > b, c > d
Communication	3.73 ± 0.99	3.65 ± 0.97	3.59 ± 0.99	3.43 ± 1.05	41.695	<0.001***	0.010	a > c > d
Cooperation	3.73 ± 0.99	3.57 ± 0.97	3.53 ± 0.98	3.40 ± 1.02	59.753	<0.001***	0.015	a > b, c > d
Participation	4.01 ± 0.93	3.88 ± 0.95	3.85 ± 0.98	3.75 ± 1.03	39.310	<0.001***	0.010	a > b, c > d

p < 0.01, *p < 0.001; tested via multivariate analysis of variance and Scheffe's post hoc test.

TABLE 4. Differences in stress and sense of community according to the frequency of physical activity in Korean older adults.

	None (a)	1–2 times/week (b)	3–4 times/week (c)	5–7 times/week (d)	F	p	η^2p	post hoc
Men	n = 2292	n = 418	n = 673	n = 869				
Cause of Stress								
Work/home/school	3.40 ± 1.02	3.42 ± 0.99	3.46 ± 0.94	3.56 ± 1.02	5.393	0.001**	0.004	a > d
Economic	3.13 ± 1.08	3.30 ± 1.10	3.33 ± 1.08	3.50 ± 1.07	25.699	<0.001***	0.018	a > b, c > d
Interpersonal	3.52 ± 0.90	3.64 ± 0.93	3.66 ± 0.87	3.76 ± 0.91	16.475	<0.001***	0.012	a > c, d
Emotional Responses								
Anger	3.78 ± 0.87	3.89 ± 0.88	3.87 ± 0.88	4.00 ± 0.88	13.257	<0.001***	0.009	a, c > d
Isolation	3.55 ± 0.95	3.63 ± 0.92	3.71 ± 0.93	3.78 ± 0.97	14.425	<0.001***	0.010	a > c, d
Relieving	3.64 ± 0.89	3.67 ± 0.91	3.73 ± 0.88	3.84 ± 0.92	10.969	<0.001***	0.008	a, b > d
Behavioral Responses								
Alcohol	3.93 ± 1.05	4.01 ± 1.02	3.96 ± 0.99	4.11 ± 1.01	6.931	<0.001***	0.005	a, c > d
Media	3.51 ± 0.99	3.57 ± 0.91	3.57 ± 0.94	3.60 ± 1.00	2.390	0.057		
Sense of Community								
Intimacy	3.14 ± 1.05	3.04 ± 0.98	2.97 ± 0.95	2.84 ± 1.03	18.847	<0.001***	0.013	a > c, d
Communication	3.38 ± 1.04	3.35 ± 0.96	3.30 ± 0.98	3.15 ± 1.06	10.992	<0.001***	0.008	a, b > d
Cooperation	3.46 ± 1.02	3.32 ± 0.97	3.27 ± 0.97	3.15 ± 1.04	21.904	<0.001***	0.015	a > c, d
Participation	3.67 ± 1.03	3.54 ± 1.03	3.49 ± 1.01	3.39 ± 1.07	16.870	<0.001***	0.012	a > c, d
Women	n = 3662	n = 380	n = 792	n = 931				
Cause of Stress								
Work/home/school	3.48 ± 1.04	3.50 ± 1.02	3.56 ± 0.97	3.62 ± 1.02	5.368	0.010**	0.003	a > d
Economic	3.18 ± 1.13	3.20 ± 1.10	3.38 ± 1.05	3.44 ± 1.09	17.527	<0.001***	0.009	a > c, d
Interpersonal	3.64 ± 0.92	3.58 ± 0.97	3.74 ± 0.86	3.83 ± 0.88	13.553	<0.001***	0.007	a, b > c, d
Emotional Responses								
Anger	3.90 ± 0.87	3.92 ± 0.90	4.00 ± 0.83	4.08 ± 0.82	12.577	<0.001***	0.007	a > c, d
Isolation	3.60 ± 0.98	3.51 ± 1.00	3.80 ± 0.91	3.88 ± 0.92	29.546	<0.001***	0.015	a, b > c, d
Relieving	3.72 ± 0.92	3.60 ± 0.97	3.76 ± 0.89	3.90 ± 0.90	12.466	<0.001***	0.006	a, b, c, > d
Behavioral Responses								
Alcohol	4.34 ± 0.87	4.28 ± 0.93	4.44 ± 0.81	4.51 ± 0.75	13.200	<0.001***	0.007	a, b > c, d
Media	3.53 ± 1.04	3.44 ± 1.03	3.60 ± 0.97	3.65 ± 1.04	4.968	0.002**	0.003	a, b > d
Sense of Community								
Intimacy	2.91 ± 1.03	2.79 ± 0.98	2.60 ± 0.92	2.62 ± 0.96	35.199	<0.001***	0.018	a, b > c, d
Communication	3.16 ± 1.04	3.09 ± 1.00	2.88 ± 0.99	2.88 ± 1.06	27.669	<0.001***	0.014	a, b > c, d
Cooperation	3.29 ± 1.03	3.10 ± 0.99	2.94 ± 0.95	2.94 ± 1.05	45.020	<0.001***	0.023	a > b, c, d
Participation	3.58 ± 1.03	3.37 ± 1.09	3.24 ± 1.03	3.22 ± 1.11	43.911	<0.001***	0.022	a > b, c, d

p < 0.01, *p < 0.001; tested via multivariate analysis of variance and Scheffe's post hoc test.

A similar study [29] conducted during the period of movement restriction due to COVID-19 also reported that those who met the World Health Organization's physical activity guidelines were less likely to experience increased stress and used more effective stress management strategies. In other words, active people engage in high-motion activities such as indoor and outdoor physical activity or gardening to manage stress. In contrast, inactive people spend more time sleeping and eating. As a result, there is a significant difference in stress levels between the two groups. According to a study [28] that examined the link between physical activity and mental health by analyzing 31 existing studies during the COVID-19 pandemic, more physical activity resulted in lower stress regardless of gender and age. Our findings that physical activity stress affects emotional and behavioral responses are in line with recent studies and show that participation in physical activity can help manage stress.

Among adults and older adults, poor social relationships have been associated with low levels of physical activity [52, 53]. In contrast, older adults with more friends are more likely to be physically active [54]. Moreover, several studies also reported that participation in physical activity increases sense of community [55, 56]. A recent study conducted during the period of movement restriction owing to the COVID-19 pandemic reported that groups with reduced or insufficient levels of physical activity also exhibited reduced social contact [57]. For this reason, many studies were concerned about social disconnection due to the COVID-19 pandemic [58–61]. Consistent with our finding that higher levels of physical activity were generally associated with a stronger sense of community among adults and older adults, these previous studies [52–57] suggest that social relationships can affect participation in physical activity and *vice versa*. Taken together, these results emphasize the value of regular participation in physical activity for maintaining high-quality social relationships, as well as the value of social relationships for motivating physical activity. Ultimately, maintaining high levels of social relationships through physical activity can lead to improved sense of community.

In this study, adults and older adults had similar results. During the COVID-19 pandemic, there were differences in the frequency of physical activity, stress levels, and sense of community between men and women. In addition, the higher the frequency of physical activity, the lower the stress level and the higher the sense of community. Therefore, physical activity is recommended for stress management and improved sense of community during global health crises, such as the COVID-19 pandemic.

Adolescents had different results. During the COVID-19 pandemic, there were differences in the frequency of physical activity and some stress factors in stress between male and female students. However, there were no differences between most stressors and sense of community.

This study has several limitations. First, it is difficult to confirm whether causal relationships can be established between participation in physical activity and stress/sense of community. Second, frequency of physical activity was measured using a single item through self-report. Therefore, there might be limitations on reliability and validity. Third, participation in

physical activity was assessed based on frequency and intensity only, while the duration of activity was not considered. Fourth, most of the variables showing statistical significance in the study results had very small effect sizes. When considering the effect size, the statistical significance of the results might vary depending on the sample size. Therefore, the interpretation of the results of this study might be limited owing to the small effect size. Fifth, the population of this study was limited to residents of Busan, one of Korea's representative metropolitan cities. Therefore, the results of this study are not representative of all Koreans.

5. Conclusions

The current results suggest that higher levels of participation in physical activity are associated with lower levels of stress and a stronger sense of community. Therefore, regular participation in physical activity should be considered when designing strategies for managing stress and promoting social relationships at the national and individual levels during COVID-19 and any similar pandemics in the future. Future studies should aim to examine the various ways in which the COVID-19 pandemic may have impacted physical and mental health and physical activity among adolescents, adults, and older adults.

AVAILABILITY OF DATA AND MATERIALS

The author confirms that data supporting the findings of this study are available within the article. The datasets that support the findings of this study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

MHB—designed the research study, performed the research, analyzed the data, wrote the manuscript, contributed to editorial changes in the manuscript, and then read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The Social Survey of Busan Metropolitan City 2020 was approved in accordance with Article 18 of the Statistical Act of Republic of Korea (approval number: No. 20205). All participants gave their consent prior to responding to the survey, and since data sets did not include private identification information (*e.g.*, home addresses, telephone numbers, and social security numbers), ethical approval was not required.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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