RISK PERCEPTION AND PHYSICAL ACTIVITY AMONG UNIVERSITY STUDENTS DURING COVID-19 PANDEMIC: AN EXTENDED HEALTH BELIEF MODEL

Seiyeong Park[1] and Chung Gun Lee[1,2]

[1]Institute of Sport Science, [2]Department of Physical Education,
College of Education, Seoul National University, Seoul, South Korea

Abstract. The study examined the impact of perceptions toward coronavirus disease 2019 (COVID-19) and participation in physical activity (PA) among university students (73 males and 77 females) in Seoul, South Korea. An online questionnaire based on an Extended Health Belief Model was used to collect data for a gender-stratified multiple regression analysis, which revealed that both male and female students (β = 432 and 396; *p*-value <0.01 and <0.05, respectively) were more participatory in vigorous PA if they had higher self-efficacy. Male students participated more in moderate (M)PA when they perceived fewer barriers to PA (β = -161, *p*-value <0.05), while females took part in MPA when they perceived a low risk of COVID-19 infection (β = -76, *p*-value <0.05). The findings of this research, highlighting the different perceptions on COVID-19 and PA participation among male and female university students, can form a basis for developing effective intervention programs in future pandemics in South Korea.

Keywords: college student, COVID-19, Extended Health Belief Model, physical activity, risk perception

Correspondence: Chung Gun Lee, Department of Physical Education, College of Education, Seoul National University, 513 Sports and Culture Research Bldg 71-1, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, South Korea
Phone: +82 2 880 7647 Email: cgl81@snu.ac.kr

INTRODUCTION

The World Health Organization (WHO) officially declared the spread of coronavirus disease 2019 (COVID-19) a global pandemic on 11 March 2020 (WHO, 2020). In response, the international

community collaborated to develop and distribute COVID-19 vaccines at unprecedented speed, significantly reducing the risk of severe illness (Sagg, 2022). However, COVID-19 continues to persist as new variants emerge, sustaining the risk of future large-scale public health threats (Otto *et al*, 2021; WHO, 2023). Since the virus primarily spreads through close contact with infected individuals, governments worldwide have implemented various pandemic control measures, including social distancing, contact tracing and temporary closures of public facilities. While these measures were effective in curbing the spread of the virus, they also disrupted daily life, caused economic downturns and increased social isolation (Amatriain-Fernández *et al*, 2020; Ammar *et al*, 2020).

Restrictions on access to recreational facilities and public spaces reduced physical activity (PA) time and dramatically increased sedentary time. A 2020 national sports participation survey during the pandemic in Korea reported a significant decline in PA compared to 2019 (MCST, 2019; MCST, 2020). The top three reasons cited were limited time for PA (56.9%), restricted access to PA facilities (36.1%) and concerns related to contracting COVID-19 (36.0%) (MCST, 2020). Notably, the Korean government classified PA facilities and gyms as high-risk spaces for viral transmission and imposed temporary closures, reducing accessibility and participation opportunities (Roh *et al*, 2023; MOHW, 2020).

College students were among the population most affected during the COVID-19 pandemic. They faced disruptions, such as a shift to online learning, cancellation of in-person classes, restrictions on social gatherings and extracurricular activities, including job searching, debating and sports activities. These disruptions significantly decreased the overall level of PA among college students, as they adopted unhealthy behaviors that include overeating, consuming

processed foods and engaging in sedentary activities (Ammar *et al*, 2020; Romero-Blanco *et al*, 2020; Robinson *et al*, 2021). While college students are generally healthier than other age groups, the health behaviors during this formative period are critical to their long-term well-being. Since regular PA is essential for strengthening the immune system and maintaining good health (Poobalan *et al*, 2010; Sallis and Pratt, 2020; da Silveira *et al*, 2021), researchers should explore strategies to promote stable PA habits and address the reduction in PA levels under the current circumstances.

Theoretical studies are crucial for identifying the factors that influence PA behavior and effective methods for determining effective intervention strategies. Well-validated theories have been instrumental in designing and implementing interventions by revealing the variables influencing PA behavior and their mechanisms (Nigg *et al*, 2012; Sheeran *et al*, 2017). However, earlier research faced challenges, including inconsistent application of theories, partial investigations due to study constraints and an overemphasis on only a few key variables with cafeteria-style theorizing (Harrison *et al*, 1992; Abraham and Sheeran, 2005; Nigg and Jordan, 2005; Rhodes and Nigg, 2011). These issues can reduce the effectiveness of interventions and weaken the predictive power of theoretical models. However, several researchers have addressed these challenges by improving the consistency of the theoretical frameworks and the definition of key variables, leading to more reliable intervention outcomes (Rhodes and Pfaeffli, 2010; Rhodes *et al*, 2012).

A Health Belief Model (HBM) has been developed to identify behavior determinants at the individual and community levels (Cao *et al*, 2014; Harrison *et al*, 1992). As the theory centers on individuals' perception of disease risk, HBM has been widely applied to reduce risk-related behaviors,

including vaccinations, diabetes self-management, use of condoms, medication adherence, and PA (Harrison *et al*, 1992; Carpenter, 2010). HBM posits several key constructs: perceived susceptibility, which refers to an individual's belief of their risk of contracting a disease; perceived severity, belief of the seriousness of the condition and its consequences; perceived benefits, belief that a specific behavior can reduce risk or mitigate the condition; and perceived barriers, belief of the obstacles or costs associated with adopting the behavior. Together, these perceptions influence the likelihood of engaging in health-promoting behaviors (Carpenter, 2010; Skinner *et al*, 2015).

To enhance the model's predictive power, additional constructs have been proposed, such as self-efficacy - the confidence in one's ability to execute a specific behavior, forming the Expanded Health Belief Model (EHBM) (Strecher *et al*, 1986; Rosenstock *et al*, 1988; Carpenter, 2010; Skinner *et al*, 2015; McArthur *et al*, 2018). As self-efficacy has proven to be a strong predictor of health behavior, validated by measurement tools, EHBM provides a robust framework for developing and evaluating interventions aimed at increasing PA participation (Noar *et al*, 2007).

In this paper, we applied the EHBM to explore how perceptions related to COVID-19 and PA influence participation in PA among Korean university students during the COVID-19 outbreak. Findings from this research may be used to support the maintenance and promotion of PA participation among Korean university students and to provide empirical evidence to inform academic research and policy recommendations for designing PA interventions targeting Korean young adults, including university students.

MATERIALS AND METHODS

Data collection

A cross-sectional survey was conducted using Google Forms

because in-person data collection was not feasible during the COVID-19 outbreak. We recruited participants who were enrolled at a university in Seoul, South Korea. To recruit participants, an email was sent to all registered undergraduate students (n = 21,163), containing a survey link and specific information on the research, including research objectives, questionnaire information and data collection procedures. Participants (73 and 77 males and females, respectively) were then given access to the URL and the questionnaire. Eighty participants were selected by drawing lots to receive a gift. Survey data were collected for 2 weeks in May 2021 to avoid extremely cold or hot weather in South Korea that might restrict students from participating in the PA.

Measurement tools

The dependent variable of this study was the time spent in PA participation per week. We analyzed moderate PA (MPA) and vigorous PA (VPA) separately in an attempt to identify different aspects of PA participation according to the type of PA under COVID-19 conditions. To measure PA participation time, the Recreation, Sport, and Leisure-Time Physical Activity questionnaire of the International Physical Activity Questionnaire (IPAQ) long version was used (Craig *et al*, 2003). Participants were asked to respond to both open-ended questions, such as "How many days do you participate in MPA/VPA?" and "How much time do you participate in MPA/VPA on that day on average?". These two types of PA participation have been predicted by HBM constructs. To measure EHBM constructs, instruments were applied from previous studies; specifically, we adopted the questionnaire of Champion (1984) to measure perceived susceptibility and severity, the Tergerson and King (2002) instrument for perceived benefits and barriers, and the self-efficacy questions of Garcia and King (1991).

To measure perceived

susceptibility to COVID-19, we asked study participants how they perceived the possibility of contracting COVID-19 (*eg*, "My chances of getting COVID-19 are great"). However, due to the low reliability of the measurement for perceived susceptibility in both male (α = 0.55) and female (α = 0.63) students, we analyzed three questions independently for male students and two questions for female students. The perceived severity of COVID-19 was measured using five items, with an α of 0.83 and 0.74 for males and females respectively (*eg*, "The thought of COVID-19 scares me"). The perceived benefits of the PA participation scale consisted of six items (*eg*, "PA reduces my stress") with an α of 0.82 and 0.78 for males and females respectively. The perceived barriers to PA participation were measured *via* five questions (*eg*, "PA is time-consuming.") with an internal reliability α of 0.77 and 0.71 for males and females respectively. Finally, self-efficacy of PA participation consisted of seven items (*eg*, "I can engage in PA when tired") with an internal reliability coefficient α of 0.85 and 0.87 for males and females respectively. All EHBM items were evaluated using a six-point bipolar Likert-type scale from -3 (strongly disagree) to 3 (strongly agree), excluding a midpoint.

Statistical analysis

All analyses were performed separately for male and female data to identify any sex differences. A multiple regression analysis method was used to analyze answers to the research questions. There were no missing values within the collected data. The amount of PA participation per week, the dependent variable, was calculated using the Metabolic Equivalent of Task (MET) level to measure PA intensity (Sjostrom *et al*, 2005), as follows:

Amount of MPA participation per week = 4.0 × minutes of MPA per day × days per week

Amount of VPA participation per week = 8.0 × minutes of VPA per day × days per week

The internal consistency of measurements of independent variables was assessed using Cronbach's α. Descriptive and frequency analyses were used to produce a statistical summary of the demographic properties and theoretical components. Pearson's correlation analysis was applied to investigate the potential correlations among the main variables and to assess the discriminant validity of the questionnaire. All processes were performed using SAS version 9.4 (SAS Institute Inc, Cary, NC).

Ethical considerations

The study protocol was approved by the Institutional Review Board of Seoul National University, South Korea (IRB No. 2104/002-020).

RESULTS

Male students spent less time on VPA but more on MPA compared to female students (Table 1). Among the EHBM items, perceived benefits of PA participation showed the highest average scores for both males (1.7 ± 0.9) and females (1.4 ± 1.1). In contrast, perceived possibility of contracting COVID-19 in current health status received the lowest average scores for both male (-1.5 ± 1.5) and female students (-1.3 ± 1.6). While self-efficacy of PA participation had positive values for both sexes, perceived susceptibility of COVID-19 and perceived barriers of PA participation had negative values. Perceived severity was also rated negatively by male students (-0.2 ± 1.5), while was not in female students (0 ± 1.2).

Correlation coefficients were calculated to identify the strength and direction of the relationships among the variables for male and female students (Tables 2 and 3). In both groups, perceived susceptibility, perceived severity, and perceived barriers were negatively associated with both VPA and MPA participation, whereas perceived benefits and self-efficacy were positively associated with PA. Overall, the magnitudes of the correlations for perceived benefits, barriers, and self-efficacy were stronger than those for perceived susceptibility and perceived severity.

Table 1

Time spent on PA and perceptions of PA during COVID-19 outbreak among male and female undergraduate students, Seoul, South Korea, May 2021

Parameter	Average mean ± SD	Range
Male (n = 73)		
Weekly PA participation[a]		
VPA (minutes per week)	77 ± 128	0 - 510
MPA (minutes per week)	98 ± 132	0 - 720
Average scores based on the Expanded Health Belief Model itemb		
Perceived possibility of contracting COVID-19	-0.7 ± 1.3	-3.0 - 3.0
Perceived possibility of contracting COVID-19 in current health status	-1.5 ± 1.5	-3.0 - 3.0
Worries about COVID-19 contagion	-0.6 ± 1.8	-3.0 - 3.0
Perceived severity of COVID-19	-0.2 ± 1.5	-2.8 - 3.0
Perceived benefits of participation in PA	1.7 ± 0.9	-0.7 - 3.0
Perceived barriers to participation in PA	-0.4 ± 1.3	-3.0 - 2.6
Self-efficacy of participation in PA	0.5 ± 1.2	-2.7 - 3.0

Table 1 (cont)

Parameter	Average mean ± SD	Range
Female (n = 77)		
Weekly PA participationa		
VPA (minutes per week)	88 ± 177	0 - 840
MPA (minutes per week)	81 ± 112	0 - 720
Average scores based on the Expanded Health Belief Model itemb		
Perceived possibility and worries of contracting COVID-19	-0.6 ± 1.2	-3.0 - 1.7
Perceived possibility of contracting COVID-19 in current health status	-1.3 ± 1.6	-3.0 - 2.0
Perceived severity of COVID-19	0 ± 1.2	-2.4 - 2.6
Perceived benefits of participation in PA	1.4 ± 1.1	-2.0 - 3.0
Perceived barriers to participation in PA	-0.6 ± 1.2	-2.6 - 2.0
Self-efficacy of participation in PA	0.5 ± 1.3	-3.0 - 2.6

[a]Craig et al (2003); bSix-point bipolar Likert-type scale from -3 (strongly disagree) to 3 (strongly agree)

COVID-19: coronavirus disease 2019; MPA: moderate physical activity; PA: physical activity; SD: standard deviation; VPA: vigorous physical activity

Table 2

Correlations between variables among male participants (n = 73)

Variable	1	2	3	4	5	6	7	8	9
1. VPA	1.000	0.354‡	0.080	-0.202*	-0.032	-0.072	0.404‡	-0.568‡	0.647‡
2. MPA		1.000	0.094	-0.244†	0.001	-0.069	0.195*	-0.436‡	0.329‡
3. Perceived possibility of contracting COVID-19			1.000	0.237†	0.263†	0.260†	0.139	-0.003	-0.038
4. Perceived possibility of contracting COVID-19 in current health status				1.000	0.039	0.209*	-0.139	0.379‡	-0.334‡
5. Worries about COVID-19 contagion					1.000	0.567‡	0.174	0.023	-0.160
6. Perceived severity of COVID-19						1.000	0.057	0.146	-0.180
7. Perceived benefits of participation in PA							1.000	-0.480‡	0.549‡
8. Perceived barriers to participation in PA								1.000	-0.760‡
9. Self-efficacy of participation in PA									1.000

*p-value <0.10; †p-value <0.05; ‡p-value <0.01

COVID-19: coronavirus disease 2019; MPA: moderate physical activity; PA: physical activity; VPA: vigorous physical activity

Table 3

Correlations between variables among female participants (n = 77)

Variable	1	2	3	4	5	6	7	8
1. VPA	1.000	0.129	-0.239†	-0.273†	-0.092	0.308‡	0.383‡	0.469‡
2. MPA		1.000	-0.160	-0.344‡	-0.057	0.291†	–0.198*	0.247†
3. Perceived possibility and worries of contracting COVID-19			1.000	0.254†	0.475‡	-0.175	0.457‡	-0.288†
4. Perceived possibility of contracting COVID-19 in current health status				1.000	0.135	-0.409‡	0.496‡	-0.431‡
5. Perceived severity of COVID-19					1.000	0.025	0.322‡	-0.106
6. Perceived benefits of participation in PA						1.000	-0.421‡	0.627‡
7. Perceived barriers to participation in PA							1.000	-0.664‡
8. Self-efficacy of participation in PA								1.000

*p-value <0.10; †p-value <0.05; ‡p-value <0.01

COVID-19: coronavirus disease 2019; MPA: moderate physical activity; PA: physical activity; VPA: vigorous physical activity

To examine the influence of EHBM constructs on VPA and MPA participation in each group, multiple regression analyses were conducted. Among the six EHBM items, male students were more likely to participate in VPA when they had a higher self-efficacy in PA participation (β = 433, p-value <0.01), and more likely to engage in MPA when they confronted fewer barriers to PA (β = -161, p-value <0.05) (Table 4). Among a similar set of EHBM items, female students were more likely to participate in VPA when they had higher self-efficacy in PA participation (β = 396, p-value <0.05), similar to male students. However, female students were more likely to take part in MPA when they believed that they would not be infected with COVID-19 (β = -76, p-value <0.05) (Table 5).

DISCUSSION

We investigated how perceptions regarding COVID-19 and PA influenced participation in PA among South Korean university students using the EHBM. EHBM is a well-known, useful framework for predicting behavior and has been used by many researchers to examine PA participation among various populations (Asril *et al*, 2020; Kaushal *et al*, 2021; Orji *et al*, 2012). It is a particularly useful tool for examining the impact of individuals' perceptions on preventive behavior in risky situations, such as the threat to health during the COVID-19 pandemic. Unlike other diseases studied using EHBM, COVID-19 is an aerosol-borne communicable disease and can lead to mortality (Buonanno *et al*, 2020; Tang *et al*, 2020). Therefore, health authorities in many affected countries have advocated a policy of self-isolation, ie, a "lockdown" (Atalan, 2020; Onyeaka *et al*, 2021). Students have to rely on the online/remote mode of teaching. Those attending colleges/universities become more inactive, as many of their normal activities involving gatherings of any kind (*eg*, classes, sports, clubs, and other such activities) are prohibited during the COVID-19 outbreak. In this context, their PA

Table 4

Influences of EHBM constructs on PA participation among male students (n = 73)

Variable	VPA		MPA	
	β	SE	β	SE
Perceived possibility of contracting COVID-19	64	80	50	49
Perceived possibility of contracting COVID-19 in current health status	10	74	-47	45
Worries about COVID-19 contagion	17	69	1	42
Perceived severity of COVID-19	8	82	0	50
Perceived benefits of participation in PA	28	139	-18	85
Perceived barriers to participation in PA	-128	117	-161†	71
Self-efficacy on participation in PA	433‡	134	-1	82
R^2	0.443		0.213	
ΔR^2	0.382		0.127	
F	7.26‡		2.47†	

$^{\dagger}p$-value <0.05; $^{\ddagger}p$-value <0.01

β: beta coefficient; COVID-19: coronavirus disease 2019; EHBM: extended health belief model; MPA: moderate physical activity; PA: physical activity; SE: standard error; VPA: vigorous physical activity; F: overall model test; R^2: coefficient of determination; ΔR^2: change in R^2

Table 5

Influences of EHBM constructs on PA participation among female students (n = 77)

Variable	VPA		MPA	
	β	SE	β	SE
Perceived possibility and worries of contracting COVID-19	-117	155	-31	52
Perceived possibility of contracting COVID-19 in current health status	-49	111	-6†	37
Perceived severity of COVID-19	27	139	-2	46
Perceived benefits of participation in PA	10	176	67	59
Perceived barriers to participation in PA	-89	196	32	65
Self-efficacy of participation in PA	396†	176	19	59
R^2	0.238		0.152	
ΔR^2	0.173		0.080	
F	3.64‡		2.10*	

*p-value <0.10; $^{\dagger}p$-value <0.05; $^{\ddagger}p$-value <0.01

β: beta coefficient; COVID-19: Coronavirus disease 2019; EHBM: extended health belief model; MPA: moderate physical activity; PA: physical activity; SE: standard error; VPA: vigorous physical activity; F: overall model test; R^2: coefficient of determination; ΔR^2: change in R^2

participation or lack thereof could ultimately lead to the development of lifelong habits, both good and bad, with potential impacts on their physical and mental health.

Our results indicated differences in the perceptions of COVID-19 and PA, and how they influence male and female students' involvement in MPA and VPA. Among both sexes, self-efficacy played a key role in VPA participation. When faced with disturbing factors or environmental barriers to PA participation, people with confidence tend to overcome them. Previous studies on predicting PA behavior using EHBM reported similar results, namely a significant influence of self-efficacy on PA among healthy and sick populations (von Ah *et al*, 2004; Gammage *et al*, 2012; Garza *et al*, 2013; Sas-Nowosielski *et al*, 2013; Saghafi-Asl *et al*, 2020). In particular, self-efficacy is the strongest predictor of young adults' PA behavior (von Ah *et al*, 2004). Some of the popular sporting activities for Korean university students, such as badminton, basketball and soccer, are included among the categories VPA. The COVID-19 epidemic presents additional barriers to participating in these VPAs as compared to activities considered MPAs. During the COVID-19 outbreak, university students were prohibited from participating in sporting activities with friends or clubs at their schools by the social distancing rules mandated by the South Korean authorities (Chen *et al*, 2021; Lee Ludvigsen *et al*, 2023). In this constrained situation, students who had stronger confidence and trust in their own ability to undertake PA would be able to participate in VPA regardless of perceived obstacles.

Regarding MPA and perceptions, male students had lower perceived barriers resulting in greater MPA participation; whereas female students were more likely to engage in MPA when they perceived that they would not become infected with COVID-19. These results are similar to those from a previous study showing that female students' PA is influenced by their perceived susceptibility to a disease, while that

of male students is predicated by their perceived barriers (Gammage *et al*, 2012).

Considering that Korean male students enjoy team sports and fitness training, the COVID-19 outbreak in itself would present a considerable barrier to PA participation. Ashton *et al* (2017) noted that young men are generally motivated to participate in PA for their physical health, sport performance and appearance of participating in PA, a behavior subject to peer influence, financial status and time constraint. On the other hand, young females' involvement in MPA may be governed by their personal health concerns, as they tend to worry about health risks and are motivated by the perceived benefits for preventing negative health outcomes (Egli *et al*, 2011; McQueen *et al*, 2008). This suggests that the concern of contracting COVID-19 would be a predictor of female students' MPA participation.

Originally, EHBM hypothesizes that individuals with a higher perceived susceptibility are more receptive to health behaviors (Brug *et al*, 2009; Durham *et al*, 2012; Park *et al*, 2010). However, PA behavior during the COVID-19 pandemic differs in that this virus is a potentially fatal communicable disease easily spread by air through inhalation from unsuspected nearby sources (Anonymous, 2020; Ram *et al*, 2021). Korean female students may feel vulnerable during or even before PA among other individuals, despite PA being a preventive measure against COVID-19 (Clemente-Suárez *et al*, 2022; Jakobsson *et al*, 2020). Considering that women are more than twice as likely to be cautious about risks than men (Galasso *et al*, 2020; Pawlowski *et al*, 2008), it is reasonable to expect that female students would consider their health status and susceptibility before participating in PA during the COVID-19 pandemic.

Contrary to expectation, female students were relatively more likely to participate in VPA than their male counterparts. Female students have healthier habits than

males regarding PA participation, even though they have perceived barriers (Wallace, 2002; Denton *et al*, 2004; Juniper *et al*, 2004; Neils-Strunjas *et al*, 2021). Furthermore, female students' PA may engender relatively lower risk, as most young Korean women enjoy individual types of PA, such as yoga, Pilates and fitness training whereas Korean male students mainly participate in VPA through team sports, such as basketball, futsal, and soccer (MCST, 2020). The emergence of COVID-19 resulted in male students being restricted from using sports facilities/gyms or gathering for sports activities both intra- and extramural. Hence, male students needed to overcome more obstacles to participate in VPA. In addition, differences in socioeconomic, demographic, and psychosocial factors, as well as individual lifestyle, may cause dissimilarities between the sexes in the types of PA (von Bothmer and Fridlund, 2005).

To the best of our knowledge, this is the first theoretical study of the influence of COVID-19-related risk perceptions on PA behaviors. Although EHBM is a widely used tool to predict preventive behaviors against diseases, there is no previous report on the use of EHBM in a pandemic context. COVID-19 is distinct from other diseases that have been investigated by EHBM over the past 70 years, and this requires a new approach to determine the relationship between risk perceptions of COVID-19 and PA behavior. We believe that the application of EHBM will increase in the future to predict behaviors in COVID-19 and other similar pandemics, and in the range of predictors utilized.

However, our study had several limitations. Firstly, this was a cross-sectional study, and causal relationships should be interpreted with caution. A longitudinal study is necessary to clarify the various associations. Secondly, because all data analyzed in this paper were collected through self-reported questionnaires, this might reflect social desirability and biases in recall and/or response. Future studies should consider using

objective measurements to evaluate PA participation. Thirdly, the level of generalizability of this research was limited because the data were collected by students only from two departments of a single university in South Korea. The sample size was not sufficiently large for generalization. We recruited participants through email invitations (n = 21,163) and conducted the survey using a website platform (*ie*, Google Forms), due to COVID-19 restrictions on in-person data collection. In addition, students' limited use of the university email account as a primary communication channel and reduced engagement with campus-related activities during the COVID-19 outbreak may have contributed to the relatively low response rate (0.71%). Nevertheless, the statistically significant findings from this study still offered a meaningful contribution to our understanding of the Korean university students' perceptions of COVID-19 on their PA behavior.

In conclusion, using the Expanded Health Belief Model (EHBM), we found that the COVID-19 situation had psychological and emotional effects on moderate physical activity (MPA) participation among female students; whereas it impacted the physical barriers to male students' engagement in MPA. As regards vigorous physical activity (VPA), only self-efficacy appeared to play a key role in the decision to participate, as VPA required stronger motivation and intention to overcome barriers for participation. Future studies should focus on the roles of risk perceptions on PA participation to assist in designing more effective programs promoting PA participation among Korean university students in an epidemic of a highly contagious disease with a large rate of morbidity and mortality, exemplified by the COVID-19 pandemic.

ACKNOWLEDGEMENTS

The article processing fee for the publication was supported by Seoul National University Institute of Sports Science.

CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflict of interest.

REFERENCES

Abraham C, Sheeran, P. The health belief model. In: Conner M, Norman P, editors. Predicting health behaviour: research and practice with social cognition models. 2nd ed. Maidenhead, UK: Open University Press; 2005. p. 28-80.

Amatriain-Fernández S, Murillo-Rodríguez ES, Gronwald T, Machado S, Budde H. Benefits of physical activity and physical exercise in the time of pandemic. *Psychol Trauma* 2020; 12(S1): S264-6.

Ammar A, Brach M, Trabelsi K, *et al*. Effects of COVID-19 home confinement on eating behaviour and physical activity: results of the ECLB-COVID19 international online survey. *Nutrients* 2020; 12(6): 1583.

Anonymous. COVID-19 transmission - up in the air, 2020 [cited 2024 May 20]. Available from: URL: https://www.thelancet.com/journals/lanres/article/PIIS2213-2600(20)30514-2/fulltext

Ashton LM, Hutchesson MJ, Rollo ME, Morgan PJ, Collins CE. Motivators and barriers to engaging in healthy eating and physical activity. *Am J Mens Health* 2017; 11(2): 330-43.

Asril NM, Tabuchi K, Tsunematsu M, Kobayashi T, Kakehashi M. Predicting healthy lifestyle behaviours among patients with type 2 diabetes in Rural Bali, Indonesia. *Clin Med Insights Endocrinol Diabetes* 2020; 13: 1179551420915856.

Atalan A. Is the lockdown important to prevent the COVID-19 pandemic? Effects on psychology, environment and economy-perspective. *Ann Surg* 2020; 56: 38-42.

Brug J, Aro AR, Richardus JH. Risk perceptions and behaviour: towards pandemic control of emerging infectious diseases: international research on risk perception in the control of emerging infectious diseases. *Int J Behav Med* 2009; 16(1): 3-6.

Buonanno G, Stabile L, Morawska L. Estimation of airborne viral emission: Quanta emission rate

of SARS-CoV-2 for infection risk assessment. *Environ Int* 2020; 141: 105794.

Cao ZJ, Chen Y, Wang SM. Health belief model based evaluation of school health education programme for injury prevention among high school students in the community context. *BMC Public Health* 2014; 14: 26.

Carpenter CJ. A meta-analysis of the effectiveness of health belief model variables in predicting behavior. *Health Commun* 2010; 25(8): 661-9.

Champion VL. Instrument development for health belief model constructs. *ANS Adv Nurs Sci* 1984; 6(3): 73-85.

Chen WL, Song SY, Yap KH. The unintended consequences of the pandemic: the New Normal for college students in South Korea and Taiwan. *Front Public Health* 2021; 9: 598302.

Clemente-Suárez VJ, Beltrán-Velasco AI, Ramos-Campo DJ, *et al*. Physical activity and COVID-19. The basis for an efficient intervention in times of COVID-19 pandemic. *Physiol Behav* 2022; 244: 113667.

Craig CL, Marshall AL, Sjöström M, *et al*. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003; 35(8): 1381-95.

da Silveira MP, da Silva Fagundes KK, Bizuti MR, Starck É, Rossi RC, de Resende E Silva DT. Physical exercise as a tool to help the immune system against COVID-19: Aan integrative review of the current literature. *Clin Exp Med* 2021; 21(1): 15-28.

Denton M, Prus S, Walters V. Gender differences in health: a Canadian study of the psychosocial, structural and behavioural determinants of health. *Soc Sci Med* 2004; 58(12): 2585-600.

Durham DP, Casman EA, Albert SM. Deriving behavior model parameters from survey data: Self-protective behavior adoption during the 2009-2010 influenza a (H1N1) pandemic. *Risk Anal* 2012; 32(12): 2020-31.

Egli T, Bland HW, Melton BF, Czech DR. Influence of age, sex, and race on college students' exercise motivation of physical activity. *J Am Coll Health* 2011; 59: 399-406.

Galasso V, Pons V, Profeta P, Becher M, Brouard S, Foucault M. Gender differences in COVID-19 attitudes

and behavior: panel evidence from eight countries. *Proc Natl Acad Sci USA* 2020; 117(44): 27285-91.

Gammage KL, Gasparotto J, Mack DE, Klentrou P. Gender differences in osteoporosis health beliefs and knowledge and their relation to vigorous physical activity in university students. *J Am Coll Health* 2012; 60(1): 58-64.

Garcia AW, King AC. Predicting long-term adherence to aerobic exercise: a comparison of two models. *J Sport Exerc Psychol* 1991; 13(4): 394-410.

Garza KB, Harris CV, Bolding MS. Examination of value of the future and health beliefs to explain dietary and physical activity behaviors. *Res Social Adm Pharm* 2013; 9(6): 851-62.

Harrison JA, Mullen PD, Green LW. A meta-analysis of studies of the Health Belief Model with adults. *Health Educ Res* 1992; 7(1): 107-16.

Jakobsson J, Malm C, Furberg M, Ekelund U, Svensson M. Physical activity during the coronavirus (COVID-19) pandemic: prevention of a decline in metabolic and immunological functions. *Front Sports Act Living* 2020; 2: 57.

Juniper KC, Oman RF, Hamm RM, Kerby DS. The relationships among constructs in the health belief model and the transtheoretical model among African-American college women for physical activity. *Am J Health Promot* 2004; 18(5): 354-7.

Kaushal N, Preissner C, Charles K, Knäuper B. Differences and similarities of physical activity determinants between older adults who have and have not experienced a fall: testing an extended health belief model. *Arch Gerontol Geriatr* 2021; 92: 104247.

Lee Ludvigsen JA, Harrison K, Millward P, Ogden C. Lockdown leisure. *Leis Stud* 2023; 42(1): 1-7.

McArthur LH, Riggs A, Uribe F, Spaulding TJ. Health Belief Model offers opportunities for designing weight management interventions for college students. *J Nutr Educ Behav* 2018; 50(5): 485-93.

McQueen A, Vernon SW, Meissner HI, Rakowski W. Risk perceptions and worry about cancer: Does gender make a difference? *J Health Commun* 2008; 13(1): 56-79.

Ministry of Culture Sports and Tourism (MCST). 2019 National sports

participation survey in Korea, 2019 [cited 2025 Jan 18]. Available from: URL: https://www.mcst.go.kr/site/s_policy/dept/deptView.jsp?pSeq=1297&pDataCD=0417000000# [in Korean]

Ministry of Culture Sports and Tourism (MCST). 2020 National sport participation survey in Korea, 2020 [cited 2025 Feb 19]. Available from: URL: https://www.mcst.go.kr/attachFiles/viewer/skin/doc.html?fn=DEPTDATA_20201230092110031898.pdf&rs=/attachFiles/viewer/result/202601/ [in Korean]

Ministry of Health and Welfare (MOHW). Regular Briefing of Central Disaster and Safety Countermeasure Headquarters on COVID-19, 2020 [cited 2025 Jan 17]. Available from: URL: https://mohw.go.kr/board.es?act=view&bid=0032&list_no=353590&mid=a20401000000&tag=

Neils-Strunjas J, Crandall KJ, Ding X, Gabbard A, Rassi S, Otto S. Facilitators and barriers to attendance in a nursing home exercise program. *J Am Med Dir Assoc* 2021; 22(4): 803-8.

Nigg C, Geller K, Adams P, Hamada M, Hwang P, Chung R. Successful dissemination of Fun 5 - a physical activity and nutrition program for children. *Transl Behav Med* 2012; 2(3): 276-85.

Nigg CR, Jordan PJ. Commentary: It's a difference of opinion that makes a horserace. *Health Educ Res* 2005; 20(3): 291-3.

Noar SM, Benac CN, Harris MS. Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychol Bull* 2007; 133(4): 673-93.

Onyeaka H, Anumudu CK, Al-Sharify ZT, Egele-Godswill E, Mbaegbu P. COVID-19 pandemic: a review of the global lockdown and its far-reaching effects. *Sci Prog* 2021; 104(2): 368504211019854.

Orji R, Vassileva J, Mandryk R. Towards an effective health interventions design: an extension of the health belief model. *Online J Public Health Inform* 2012; 4(3): ojphi.v4i3.4321.

Otto SP, Day T, Arino J, *et al*. The origins and potential future of SARS-CoV-2 variants of concern in the evolving COVID-19 pandemic. *Curr Biol* 2021; 31(14): R918-29.

Park JH, Cheong HK, Son DY, Kim SU, Ha CM. Perceptions

and behaviors related to hand hygiene for the prevention of H1N1 influenza transmission among Korean university students during the peak pandemic period. *BMC Infect Dis* 2010; 10: 222.

Pawlowski B, Atwal R, Dunbar RI. Sex differences in everyday risk-taking behavior in humans. *Evol Psychol* 2008; 6(1): 29-42.

Poobalan AS, Aucott LS, Precious E, Crombie IK, Smith WCS. Weight loss interventions in young people (18 to 25 year olds): a systematic review. *Obes Rev* 2010; 11(8): 580-92.

Ram K, Thakur RC, Singh DK, *et al*. Why airborne transmission hasn't been conclusive in case of COVID-19? An atmospheric science perspective. *Sci Total Environ* 2021; 773: 145525.

Rhodes RE, Mark RS, Temmel CP. Adult sedentary behavior: a systematic review. *Am J Prev Med* 2012; 42(3): e3-28.

Rhodes RE, Nigg CR. Advancing physical activity theory: a review and future directions. *Exerc Sport Sci Rev* 2011; 39(3): 113-9.

Rhodes RE, Pfaeffli LA. Mediators of physical activity behaviour change among adult non-clinical populations: a review update. *Int J Behav Nutr Phys Act* 2010; 7: 37.

Robinson E, Boyland E, Chisholm A, *et al*. Obesity, eating behavior and physical activity during COVID-19 lockdown: a study of UK adults. *Appetite* 2021; 156: 104853.

Roh M, Choi Y, Park H. Analysis of issues in fitness centers through news articles before and after the COVID-19 pandemic in South Korea: applying big data analysis. *Sustainability* 2023; 15(3): 2660.

Romero-Blanco C, Rodríguez-Almagro J, Onieva-Zafra MD, Parra-Fernández ML, Prado-Laguna MDC, Hernández-Martínez A. Physical activity and sedentary lifestyle in university students: changes during confinement due to the COVID-19 pandemic. *Int J Environ Res Public Health* 2020; 17(18): 6567.

Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the Health Belief Model. *Health Educ Q* 1988; 15(2): 175-83.

Saag M. Wonder of wonders, miracle of miracles: the unprecedented speed of COVID-19 science. *Physiol Rev* 2022; 102(3): 1569-77.

Saghafi-Asl M, Aliasgharzadeh S,

Asghari-Jafarabadi M. Factors influencing weight management behavior among college students: an application of the Health Belief Model. *PLoS One* 2020; 15(2): e0228058.

Sallis JF, Pratt M. Multiple benefits of physical activity during the coronavirus pandemic. *Rev Bras Ativ Fís Saúde* 2020; 25: e0112.

Sas-Nowosielski K, Grabara M, Hadzik A. Perceived control variables and leisure-time physical activity of adults. *Trends Sport Sci* 2013; 4(20): 197-203.

Sheeran P, Klein WMP, Rothman AJ. Health behavior change: moving from observation to intervention. *Annu Rev Psychol* 2017; 68: 573-600.

Sjostrom M, Ainsworth B, Bauman A, Bull F, Hamilton-Craig C, Sallis J. Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ) - short and long forms, 2005 [cited 2025 Apr 03]. Available from: URL: https://www.researchgate.net/file.PostFileLoader.html?id=5641f4c36143250eac8b-45b7&assetKey=AS%3A294237418606593%401447163075131

Skinner CS, Tiro J, Champion VL. The Health Belief Model. In: Glanz K, Rimer BK, Viswanath K, editors. Health behavior and health education: theory, research, and practice. San Francisco, CA: John Wiley & Sons; 2015. p. 76-94.

Strecher VJ, DeVellis BM, Becker MH, Rosenstock IM. The role of self-efficacy in achieving health behavior change. *Health Educ Q* 1986; 13(1): 73-92.

Tang S, Mao Y, Jones RM, *et al*. Aerosol transmission of SARS-CoV-2? Evidence, prevention and control. *Environ Int* 2020; 144: 106039.

Tergerson JL, King KA. Do perceived cues, benefits, and barriers to physical activity differ between male and female adolescents? *J Sch Health* 2002; 72(9): 374-80.

von Ah D, Ebert S, Ngamvitroj A, Park N, Kang D-H. Predictors of health behaviours in college students. *J Adv Nurs* 2004; 48(5): 463-74.

von Bothmer MIK, Fridlund B. Gender differences in health habits and in motivation for a healthy lifestyle among Swedish university students. *Nurs Health Sci* 2005; 7(2): 107-18.

Wallace LS. Osteoporosis prevention in college women: application of the expanded health belief model. *Am J Health Behav* 2002; 26(3): 163-72.

World Health Organization (WHO). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020, 2020 [cited 2024 Sep 10]. Available from: URL: https://www.who.int/news-room/speeches/item/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

World Health Organization (WHO). COVID-19 remains a persistent public health threat, 2023 [cited 2024 Sep 15]. Available from: URL: https://www.emro.who.int/media/news/covid-19-remains-a-persistent-public-health-threat.html?utm