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# Effect of perceived crowding on risk perception in leisure sports: an analysis based on Edward T Hall's concept of 'proxemics'

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This study investigates the social distancing measures necessary for participants to safely engage in leisure sports activities and comply with social distancing requirements during epidemics. Based on crowding and risk perception in public spaces in this context of an epidemic, this investigation was conducted in terms of distance in Edward T. Hall's concept of 'proxemics'. The participants were males aged 20–65 who used spaces for leisure sports during COVID-19 in South Korea. An online survey was conducted from September 20 to October 20, 2021, and data from 391 participants were used for the final analysis. Measures of perceived crowding, risk perception, and Hall's proxemics were used as tools after they were modified and validated. The results show that perceived crowding according to space for leisure sports activities during COVID-19 affected individual risk perception in indoor leisure sports and social risk perception in outdoor leisure activities. Perceived crowding, according to proxemics, influenced (1) personal, social, and public distances in individual risk perception and (2) public and social distances in social risk perception. Therefore, it is necessary to re-examine the scope of social distance in developing risk perception and reducing the perceived crowding of participants in leisure sports to prevent the spread of infectious diseases such as COVID-19. Moreover, individuals must make efforts to maintain a minimum distance from one another. Further, media education and warning messages must be disseminated to reduce crowding and prevent infection spread.

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The COVID-19 pandemic prompted various national governments, including South Korea, to implement comprehensive social distancing measures, which significantly affected people's daily lives and leisure activities (Carter et al., 2020). Globally, leisure sports spaces, which are intricately connected with other environments, experienced profound changes due to unique social distancing policies, resulting in a 41% reduction in physical activities (Wilke et al., 2021). Paradoxically, while leisure sports offer stress relief and enhance overall well-being, these spaces pose a high risk for COVID-19 transmission, which leads to social challenges such as economic downturns and community disintegration. Consequently, individuals have transitioned from indoor workouts to outdoor activities, seeking secluded spaces to engage in leisure sports (Cheng et al., 2020; Patrick et al., 2020; Shim, 2020; United Nations, 2020; Vazirani & Bhattacharjee, 2022). However, individuals are vulnerable to infection in popular spots like sports facilities and community centers and are therefore advised to avoid crowded environments, which presents a conundrum.

## Introduction

The evolving perception of well-being has transformed personal spaces into organized leisure sports areas, reflecting society's changing norms. Despite concerns, physical activities have proven beneficial for individuals' physical and mental health during the pandemic (Matias et al., 2020). However, individuals tend to avoid indoor sports spaces owing to high population density and potential threats of droplet-borne infection (Jang, 2020; Noh et al., 2020). While outdoor activities are perceived as safer, recent mass COVID-19 outbreaks at outdoor gatherings highlight the need to address overcrowding, even in open spaces. While social distancing guidelines vary globally, they necessitate meticulous planning for leisure sports, both indoors and outdoors. Striking a balance between physical activities and safety requires adherence to specific distance recommendations, often complicated by differing views on safe distances and mask usage.

Concerns about aerosol transmission are prevalent in indoor environments, especially when occupants remain seated for extended periods, emphasizing the need for social interactions to be brief, regardless of social distancing norms. Evaluating adherence to existing guidelines in various leisure activities is essential to gauge their impact on crowding and infectious disease risk perception.

This study, grounded in Edward T. Hall's concept of "proxemics," explores the perceived crowding and risk perception of individuals within particular spaces. It proposes measures for social distancing and infectious disease prevention tailored for leisure sports participants, emphasizing the necessity of reevaluating social distance parameters. The research focuses exclusively on male participants aged 20–65 in South Korea, given the pandemic's differential impact on gender-specific immune responses (Bwire, 2020; Scully et al., 2020). The methodology included convenience sampling, utilizing online surveys to gather data from 391 participants, and meticulous analysis after excluding redundant or incomplete responses (9 participants). The study delves into the impact of the COVID-19 pandemic on perceived crowding and risk perception in diverse indoor and outdoor leisure sports settings.

Regarding study rigor, we focused specifically on the male population for scientific reasons related to COVID-19. Previous studies have indicated that men are more vulnerable to COVID-19 than women due to differences in immune responses (Bwire, 2020). Accordingly, we concentrated our research on males to explore the specific challenges and perceptions they face during the pandemic.

We recognize the importance of broadening our study's scope in future research endeavors. To address this, we plan to conduct further studies that include diverse gender and demographic groups, allowing for a more comprehensive and representative analysis of the topic. This approach will enhance the robustness of our study findings and allow for a more nuanced understanding of the effects of the COVID-19 pandemic on leisure sports activities across various populations.

## Material and methods

### Setting

*Social distancing guidelines in Korea*. During the research period from September 20th to October 20th, which included the major Korean holiday "Chuseok," strict social distancing measures were enforced in response to the high COVID-19 transmission risk. Distinct differences in these measures were observed between the metropolitan (Seoul area) and non-metropolitan regions. Until 6 p.m., gatherings were limited to groups of four or fewer for individuals who had been fully vaccinated. After 6 p.m., gatherings were further restricted to a maximum of two individuals. Restaurants, cafes, and indoor sports facilities were allowed to operate until 10 p.m.; the latter was also required to register all visitors, recording their entrance and departure times. The Korea Disease Control and Prevention Agency (KCDC) implemented further protocols for indoor sports facilities, including limited occupant capacities (one person per 8 $m^2$ of space; one person per 6 $m^2$ for group exercise (GX) classes), required partitions around exercise equipment, mandatory frequent ventilation, and open windows, regular disinfection of equipment, the provision of hand sanitizer, and the maintenance of cleaning logs. Patrons had to undergo body temperature and symptom checks upon entry, were prohibited from consuming food or showering (except before swimming), and were limited to 2-h visits. Treadmill users could not exceed speeds of 6 km/h. Mask-wearing was required for everyone, patrons had to remain separated by a safe distance when using equipment, and direct contact sports and activities were prohibited (Kwon, 2021).

*Participants*. All the participants in this study were males aged 20–65 who used spaces for leisure sports during COVID-19 in South Korea. According to Scully et al. (2020), biological sex impacts immune responses, and therefore, we can assume it affects COVID-19 outcomes. Using convenience sampling, 400 participants were contacted through an online survey. A self-report questionnaire was distributed among the participants in leisure sports. Finally, an analysis was conducted with 391 participants (nine participants were excluded as they provided unreliable data due to redundancy or non-responses). Participants' characteristics are shown in Table 1.

According to Comrey and Lee (2013), sample sizes for each grade have been classified as 100 = poor; 200 = moderate; 300 = good; and 500 = very good. Our sample consisted of 391 participants and was, therefore, considered adequate.

*Measures*. This study used perceived crowding and risk perception as measures to determine the extent of crowdedness and risk perceived in spaces for leisure sports by people under COVID-19 restrictions. Particularly, various leisure sports activities were subdivided based on the standard for proxemics by Edward T. Hall to verify the impact of COVID-19 on perceived crowding and risk perception in indoor and outdoor spaces and the minimum distance required in leisure sports activities.

**Perceived crowding**. For the perceived crowding of leisure sports participants, we used items of perceived crowding developed by

**Table 1 Sociodemographic background.**

| Variable | | *n* (%) |
|---|---|---|
| Gender | Male | 391 |
| | Total | 391 (100) |
| Age | 20 s | 35 (9.0) |
| | 30 s | 52 (13.3) |
| | 40 s | 100 (25.6) |
| | 50 s | 100 (25.6) |
| | 60 s | 104 (26.6) |
| | Total | 391 (100) |
| Average monthly income | 1 million KRW or less | 24 (6.1) |
| | 1.01 million KRW to less than 2 million KRW | 23 (5.9) |
| | 2.01 million KRW to less than 4 million KRW | 155 (39.6) |
| | 4.01 million KRW to less than 6 million KRW | 111 (28.4) |
| | 6.01 million KRW or more | 78 (19.9) |
| | Total | 391 (100) |
| Proxemics | Intimate distance, where there is physical contact (0.45 m) | 14 (3.6) |
| | Personal distance, where there is no physical contact (1.2 m) | 92 (23.5) |
| | Social distance, where there is personal space on both sides (3.5 m) | 172 (44.0) |
| | Public distance, where one does not interact with other people (7.5 m) | 113 (28.9) |
| | Total | 391 (100) |
| Space for leisure activities | Indoor | 112 (28.6) |
| | Outdoor | 279 (71.4) |
| | Total | 391 (100) |
| Principal leisure activity | Fitness exercise (indoor) | 47 (12.0) |
| | Walking (outdoor) | 104 (26.6) |
| | Golf (outdoor) | 57 (14.6) |
| | Mounting (outdoor) | 60 (15.3) |
| | Jogging (outdoor) | 58 (14.8) |
| | Other indoor activities | 65 (16.6) |
| | Total | 391 (100) |
| Vaccination | First dose of vaccination completed (Pfizer, Moderna, AstraZeneca, etc.) | 117 (29.9) |
| | First dose of vaccination completed (Johnson & Johnson) | 25 (6.4) |
| | Second dose of vaccination completed | 217 (55.5) |
| | Not vaccinated | 32 (8.2) |
| | Total | 391 (100) |

*KRW* Korean won.

Heberlein and Vaske (1977) and those of user density expectation by Graefe, Fedler (1986) and Hall and McArthur (1993). The latter were modified and supplemented and then used after construct validation by experts (two professors of sociology of sport and leisure studies and three doctors of leisure studies). Four items were rated on a 5-point Likert scale: "Did you expect crowdedness to keep you from having fun before visiting the space for leisure sports activities?" "Did you expect crowdedness to restrict activities before visiting the space for leisure sports activities?" "Did crowdedness in the space for leisure sports activities keep you from having fun?" and "How did crowdedness in the space for leisure sports activities affect activities?"

**Risk perception**. Risk perception is a concept involving individuals' cognitive processes that affect their behavior. Further, risk perception affects constant participation in relevant activities (Yoon et al., 2007). It is a subjective concept that varies among individuals and has a great impact on individual decision-making (Gronhaug & Stone, 1995). Thus, this concept requires attention while considering the behaviors of participants in sports activities. Risk perception comprises both subjective and objective aspects (McComas, 2006), and experts perceive risks based on objective data or facts, whereas the general public makes judgments based on the severity of risk outcomes (Jacobs & Worthley, 1999; Kellens et al., 2011). Risk perception is generally formed by various factors and based on individual experiences and interactions with others (Slovic, 2000). In particular, the risk is perceived through media in many cases, thus indicating that media use is closely related to risk perception, which has also been shown in studies of infectious diseases such as Middle East Respiratory Syndrome (MERS) before COVID-19 (Hong & Jun, 2020). Therefore, this study subdivided risk perception into individual risk perception and media or social perception of risk based on measurement items used in Kim's (2020) study of novel swine flu.

For risk factors, the items used were adopted from a survey developed by Knowles et al. (1973), and factors of risk perception were adopted from those used by Park (2016) and adventure sports by Kim et al. (2019). They were employed after construct validation by a group of experts comprising two professors of the sociology of sports and leisure studies and three doctors of leisure studies. Eight survey items were rated on a 5-point Likert scale: four items on individual risk perception and four items on social risk perception. To verify that the data were normally distributed and suitable for factor analysis, this study used Bartlett's and Kaiser–Meyer–Olkin (KMO) tests; the latter gave a result of 0.792, indicating sampling adequacy. The total cumulative variance explained was 72.186%. Bartlett's test of sphericity was significant ($\chi^2 = 1884.735$, $p < 0.001$). See Table 2 for the factor analysis.

**Edward T. Hall's concept of proxemics**. Edward T. Hall's (1966) theory of "proxemics" describes human territory and is

**Table 2 Factor analysis of risk perception.**

| Item | Factor | | $h^2$ |
|---|---|---|---|
| | Social | Individual | |
| People around me think they are likely to be infected with COVID-19 when using a space for leisure sports activities. | 0.856 | 0.187 | 0.767 |
| People around me think they are likely to be infected with COVID-19 in a space used for leisure sports activities. | 0.880 | 0.132 | 0.792 |
| I think I am likely to be infected with COVID-19 in a space used for leisure sports activities. | 0.888 | 0.124 | 0.803 |
| I think I am likely to be infected with COVID-19 when participating in leisure sports activities. | 0.884 | 0.132 | 0.799 |
| I think COVID-19 can completely stop the social functions in my country. | 0.118 | 0.722 | 0.535 |
| I think the COVID-19 pandemic may cause chaos. | 0.167 | 0.667 | 0.473 |
| I think COVID-19 is a fatal disease that puts my life at risk. | 0.114 | 0.898 | 0.819 |
| I think being infected with COVID-19 would lead to economic loss. | 0.110 | 0.880 | 0.787 |
| Confidence | 0.911 | 0.819 | 0.837 |
| Eigenvalue | 3.143 | 2.632 | |
| Variance (%) | 39.288 | 24.398 | |
| Cumulative variance (%) | 47.787 | 72.186 | |

KMO = 0.792, $\chi^2 = 1884.735$, $df = 28$, $p < 0.001$.

commonly used to explain human relations. The concept of proxemics presents four zones of interpersonal distance: intimate distance, personal distance, social distance, and public distance. Intimate distance (less than 50 cm) is described as a distance so close that one can feel the other's breath; it is commonly referred to as the distance between family or lovers. Personal distance (50–120 cm) is a distance reachable at arm's length, referring to the distance maintained between friends or associates. Social distance (2–4 m) is a distance where communication is possible by voice; this distance between people is recommended worldwide owing to COVID-19. Public distance is a separation of 4 m or more, in which communication is possible only when speaking in a loud voice, generally requiring an amplifier such as a microphone (Kim & Kang, 2021). Therefore, this study classified the distance required for leisure sports activities based on the idea of distance in proxemics.

We used the following specific survey items: (1) leisure sports activities that require intimate distance (0.45 m) include jiu-jitsu, personal training, and swimming lessons; (2) leisure sports activities that require personal distance (1.2 m) include yoga, Pilates, and squash; (3) leisure sports activities that require social distance (2–4 m) between individuals on both sides include golf, cycling, and hiking; and (4) leisure sports activities that require public distance (7.5 m) that keep a significant distance from other people include jogging, at-home workouts, and personal exercises.

*Data analysis*. The collected data were analyzed through coding and data cleaning, followed by statistical analysis using SPSS (Ver 26.0). The specific data analysis method was as follows. First, descriptive and frequency analyses were conducted to identify participants' individual characteristics. Exploratory factor analysis was conducted to validate the items of perceived crowding in the space for leisure activities and those of risk perception. Cronbach's $\alpha$ coefficients were calculated to verify the internal consistency among items and test the reliability. Moreover, correlation analysis and regression analysis were conducted to analyze the impact of perceived crowding on risk perception. All items were tested at the statistical significance level of $\alpha = 0.05$.

Chung-Ang University Research Ethics Committee reviewed and approved the protocol of this study (approval number: 1041078-202103-HRSB-090-01). The information collected and the procedure followed adhered to the Declaration of Helsinki and the policies concerning human participants stipulated by the authors' institution. Written informed consent was obtained from the participants before the study. The participants were informed of their right to withdraw at any time without incurring any penalty and were given a chance to ask for clarifications regarding the study.

**Table 3 Correlation coefficient values for perceived crowding and risk perception.**

| | 1 | 2 | 3 |
|---|---|---|---|
| Perceived crowding | 1 | | |
| Risk perception—individual | 0.252* | 1 | |
| Risk perception—social | 0.212* | 0.314* | 1 |

*$p < 0.001$.

## Results

**Correlation analysis of perceived crowding and risk perception**. Table 3 presents the results of correlation analysis among subvariables of perceived crowding and risk perception. The results showed that the correlation between perceived crowding and subfactors of risk perception, such as individual and social risk perception was significant ($p < 0.05$).

**Simple-regression analysis of risk perception due to perceived crowding in spaces for leisure sports**. A simple regression analysis (see Table 4) was conducted to examine the correlation between perceived crowding and risk perception depending on space for leisure sports activities. Table 4 presents the regression analysis that determined the effect of perceived crowding on risk perception. These results revealed that the regression for individual risk perception due to perceived crowding was significant ($F = 26.340$, $p < 0.001$) and explained 6.1% of response variation. The regression for social risk perception was also significant ($F = 18.218$, $p < 0.001$) and explained 4.2% of response variation. Specifically, perceived crowding affected both individual risk perception ($\beta = 0.252$) and social risk perception ($\beta = 0.212$). The tolerance limit was greater than 0.10, and the variance inflation factor (VIF) was less than 10, thus indicating that collinearity was not a problem.

According to Table 5, among spaces for leisure sports activities, the regression for individual risk perception predicted in indoor spaces was significant ($F = 8.713$, $p < 0.001$) and explained 6.8% of response variation, but that for social risk perception predicted in indoor spaces was not significant ($F = 2.275$, $p > 0.05$). The regression for risk perception predicted in outdoor spaces was significant ($F = 17.019$, $p < 0.001$) and explained 5.4% of response

**Table 4 Regression analysis of risk perception due to perceived crowding.**

| Dependent variable | Independent variable | Unstandardized coefficient | | Standardized coefficient | t | Collinearity statistics | | $R^2$ | F |
|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | β | | Tolerance | VIF | | |
| Individual risk perception | (Constant) | 2.657 | 0.144 | | 18.507* | | | 0.061 | 26.340* |
| | Perceived crowding | 0.221 | 0.043 | 0.252 | 5.132* | 1.000 | 1.000 | | |
| Social risk perception | (Constant) | 2.995 | 0.145 | | 20.706* | | | 0.042 | 18.218* |
| | Perceived crowding | 0.185 | 0.043 | 0.212 | 4.268* | 1.000 | 1.000 | | |

*VIF* variance inflation factor, *$p < 0.001$

**Table 5 Regression analysis of perceived crowding and risk perception depending on space for leisure sports.**

| Dependent variable | Group variable | Independent variable | Unstandardized coefficient | | Standardized coefficient | t | Collinearity statistics | | $R^2$ | F |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | B | Std. Error | β | | Tolerance | VIF | | |
| Individual risk perception | Indoor | (Constant) | 2.637 | 0.281 | | 9.391* | | | 0.068 | 8.713* |
| | | Perceived crowding | 0.243 | 0.082 | 0.271 | 2.952* | 1.000 | 1.000 | | |
| | Outdoor | (Constant) | 2.672 | 0.168 | | 15.927* | | | 0.054 | 17.019* |
| | | Efficacy | 0.210 | 0.051 | 0.241 | 4.125* | 1.000 | 1.000 | | |
| Social risk perception | Indoor | (Constant) | 3.046 | 0.302 | | 10.069* | | | 0.011 | 2.275 |
| | | Efficacy | 0.134 | 0.089 | 0.142 | 1.508 | 1.000 | 1.000 | | |
| | Outdoor | (Constant) | 2.958 | 0.163 | | 18.116* | | | 0.059 | 18.116* |
| | | Efficacy | 0.212 | 0.049 | 0.249 | 4.279* | 1.000 | 1.000 | | |

*VIF* variance inflation factor, *$p < 0.001$.

variation. The regression for social risk perception was significant ($F = 18.116$, $p < 0.001$), thereby indicating a significant effect of perceived crowding. The tolerance value was greater than 0.10, and VIF was less than 10, suggesting that collinearity was not a problem.

As shown in Table 6, among spaces for leisure sports activities, the regression for individual risk perception—predicted according to distance in Hall's proxemics—was significant ($F = 10.586$, $p < 0.001$) for personal distance (within 1.5 m), and it explained 9.5% of response variance. The regressions were also significant for social distance (within 3.5 m; $F = 7.712$, $p < 0.001$; $R^2 = 0.038$) and for public distance (more than 7.5 m; $F = 8.472$, $p < 0.001$; $R^2 = 0.063$). The regression for social risk perception—also predicted according to distance in proxemics—was significant for public distance (more than 7.5 m; $F = 10.065$, $p < 0.001$; $R^2 = 0.075$) and for social distance (within 3.5 m; $F = 6.102$, $p < 0.05$; $R^2 = 0.029$). The tolerance limit was greater than 0.10, and VIF was lower than 10; thus, collinearity was not a problem.

## Discussion

This study subdivided leisure sports activities based on distance according to Edward T. Hall's concept of proxemics and demonstrated the effect of proxemics on the perceived crowding and risk perception in spaces of individuals who participated in various leisure sports activities during COVID-19.

First, perceived crowding affected risk perception depending on the space for leisure sports. Therefore, it is necessary to provide ways to encourage participation in safe and stable leisure sports activities while promoting awareness of the risks of infectious diseases and reducing perceived crowding. Similar results were found for severe acute respiratory syndrome and Middle East Respiratory Syndrome before COVID-19. Additionally, daily life activities were disturbed and obstructed by the symptoms of COVID-19, such as breathing difficulties, fatigue, arthralgia, muscle pain, anxiety, and depression (Carter et al., 2022). Considering that people perceived physical activities outside their homes to be dangerous owing to the spread of COVID-19, methods of online leisure (Zoom dinner parties, over-the-top media services, online PC games, and so forth; Kim, 2020; Park, 2023) and sports activities have been investigated. Here, the level of risk may vary depending on perceived crowding among individuals; further, the social atmosphere also affects leisure sports activities, which indicates that the current social distancing measures do not sufficiently reduce perceived crowding and risk perception in spaces for leisure sports (Mehta, 2020; Ping et al., 2020; White & Van Der Boor (2020)). Studies demonstrate that policies such as social distancing or restrictions on going out because of COVID-19 constrain physical activities. As such, those participating in many physical activities are affected more by COVID-19 (Woods et al., 2020; Yang & Park, 2021). That is, it is necessary to reduce the fear of risk factors and crowdedness felt by people and to increase awareness of risk factors.

Second, perceived crowding influenced individual risk perception in indoor spaces for leisure sports and social risk perception in outdoor spaces. Furthermore, the proportion of participants in outdoor leisure sports activities in this study was twice that in indoor activities. This is consistent with Kim and Kang (2021), who reported that while the proportion of indoor leisure sports activities was high, COVID-19 increased perceived crowdedness and risk perception in indoor activities; thus, people participated more in outdoor activities. Yang et al. (2019) agreed that even after implementing various preventive methods provided in spaces for leisure sports activities, activities in secluded spaces or outdoors away from compact and dense spaces among participants did not reduce perceived crowding or constraints on participants.

**Table 6 Regression analysis of perceived crowding and risk perception depending on space for leisure sports.**

| Dependent variable | Group variable | Independent variable | Unstandardized coefficient | | Standardized coefficient | t | Collinearity statistics | | $R^2$ | F |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | B | Std. Error | β | | Tolerance | VIF | | |
| Individual risk perception | Intimate distance | (Constant) | 2.654 | 0.741 | | 3.582*** | | | −0.025 | 0.685 |
| | | Perceived crowding | 0.182 | 0.219 | 0.232 | 0.828 | 1.000 | 1.000 | | |
| | Personal distance | (Constant) | 2.473 | 0.283 | | 8.735*** | | | 0.095 | 10.586*** |
| | | Perceived crowding | 0.279 | 0.086 | 0.324 | 3.254*** | 1.000 | 1.000 | | |
| | Social distance | (Constant) | 2.804 | 0.212 | | 13.218*** | | | 0.038 | 7.712*** |
| | | Perceived crowding | 0.177 | 0.064 | 0.208 | 2.777*** | 1.000 | 1.000 | | |
| | Public distance | (Constant) | 2.566 | 0.290 | | 8.855*** | | | 0.063 | 8.472*** |
| | | Perceived crowding | 0.251 | 0.086 | 0.266 | 2.911*** | 1.000 | 1.000 | | |
| Social risk perception | Intimate distance | (Constant) | 2.418 | 0.767 | | 3.151** | | | 0.051 | 1.705 |
| | | Perceived crowding | 0.297 | 0.227 | 0.353 | 1.306 | 1.000 | 1.000 | | |
| | Personal distance | (Constant) | 3.117 | 0.318 | | 9.807*** | | | 0.013 | 2.156 |
| | | Perceived crowding | 0.141 | 0.096 | 0.153 | 1.468 | 1.000 | 1.000 | | |
| | Social distance | (Constant) | 3.098 | 0.213 | | 14.524*** | | | 0.029 | 6.102* |
| | | Perceived crowding | 0.158 | 0.064 | 0.186 | 2.470* | 1.000 | 1.000 | | |
| | Public distance | (Constant) | 2.792 | 0.268 | | 10.434*** | | | 0.075 | 10.065*** |
| | | Perceived crowding | 0.253 | 0.080 | 0.288 | 3.173*** | 1.000 | 1.000 | | |

*VIF* variance inflation factor, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Moreover, the World Health Organization (2020) recommended that people maintain physical distance while carrying out physical activities, suggesting that they wear masks in parks or open public spaces where people are walking or jogging. Meanwhile, Wijngaards et al. (2022) revealed that indoor leisure sports activities increased in winter when outdoor exercising is relatively uncomfortable, and participation in indoor leisure sports activities increased among vaccinated people. Their finding indicates that risk perception of infectious diseases may vary depending on vaccination status. If risk perception can be reduced by vaccination, keeping an adequate distance among participants may be more important for reducing perceived crowding. Therefore, to reduce the risk perceived by individuals due to crowding in indoor spaces for leisure sports, it is necessary to provide hand sanitizers in various parts of sports facilities as preventive measures against infectious diseases, sterilize sports equipment every hour, and ventilate the space for 10–15 min every hour in between classes for group exercises (WHO, 2020; KCDC, 2020).

These procedures must be strictly managed by displaying daily checklists that are visible to all participants. Moreover, in outdoor spaces for leisure activities, all participants must be allowed to engage in leisure sports activities because, regarding COVID-19, it is safer to engage in such activities outdoors than indoors. Furthermore, unnecessary chats, long phone calls, and food and beverage consumption in crowded spaces should be banned.

Finally, according to proxemics, perceived crowding in spaces for leisure sports activities affected personal, social, and public distances in individual risk perception and public and social distances in social risk perception. Many people ignored or forgot about the social distance rules at the beginning of the pandemic and maintained crowding. This result was inconsistent with the findings of previous studies that showed that crowding led to evasive action among users (Kim & Hong, 1998; Manning, 1999) and studies of outdoor sports activities (Andereck & Becker, 1993; Ditton et al., 1983; Donnelly et al., 1986) that revealed individuals perceive higher levels of crowding when they notice higher density than expected during sports activities. That is, participants in leisure sports activities are aware that there will be a high level of infection exposure in enclosed spaces and perceive high crowding due to limited space, but they show low-risk perception, thinking that they will not be infected during leisure sports activities regardless of how many participants there are or how close they are to one another. Thus, it is important to develop more specific and substantial leisure policies for participants, such as creating a safe environment for individuals to engage in leisure sports activities (Kim & Lee, 2020).

Ultimately, it is necessary to establish guidelines for accurate preventive actions and ensure that all participants understand the need to perform social distancing by maintaining a minimum safe distance during leisure sports activities to engage in safe and healthy leisure sports activities while perceiving a certain level of risk of infectious diseases (Morawska & Cao, 2020; Setti et al., 2020). That is, participants should be allowed to maintain a minimum distance from one another during leisure sports activities where they can perceive risk and reduce crowding or maintain low crowdedness by keeping a 10–15 $m^2$ distance between them; it is also necessary to set a particular number of participants who can be accommodated each hour in indoor spaces with high crowdedness.

During the specified period, participants in Korea were generally well-informed about the spread of COVID-19 and prevention measures. The government and health authorities actively communicated guidelines, including the necessity of completing COVID-19 vaccinations to access indoor sports facilities. Additionally, facilities themselves implemented rigorous protocols,

such as temperature checks, verifying vaccination status, and enforcing social distancing measures. These efforts ensured that individuals entering the facilities were aware of COVID-19. risks and were taking necessary precautions to prevent its spread. Overall, participants were expected to have a good understanding of these preventive measures owing to the strict regulations and extensive public awareness campaigns.

Despite several significant results, this study has a few limitations. First, it was conducted with participants of leisure sports activities without considering those who could not continue participating in leisure sports owing to COVID-19 restrictions, as well as adolescents and older adults who cannot easily participate in these activities. Second, the percentage of participants involved in outdoor leisure sports was 71.4%, but it was not determined whether these participants engaged in indoor activities before COVID-19 and then switched to outdoor activities afterward or if they switched because of crowdedness and risk factors in indoor spaces. Finally, this study did not reveal that the correlation between depression and perceived crowding or risk perception among participants in leisure sports activities was becoming more serious due to frequently changing social distancing policies and tight constraints. Perceived crowding and risk may vary depending on an individual's level of depression, and thus, different approaches must be taken to resolve it. Therefore, it is necessary to adopt healthy lifestyle management methods and personalized intervention programs for infection prevention based on individual lifestyles and healthcare standards.

This study examined the perceived crowding in spaces for leisure sports activities of individuals under social distancing constraints imposed because of COVID-19 and their risk perception of the pandemic. Various leisure sports activities were analyzed by subdividing the types of distance in sports activities based on Edward T. Hall's concept of proxemics into intimate distance (0.45 m), personal distance (1.2 m), social distance (3.5 m), and public distance (7.5 m).

The major conclusions of this study are as follows. People tended to perceive severe crowding while participating in leisure sports activities owing to COVID-19; many also had a high-risk perception of infection. To resolve this issue, it is necessary to find a way to provide people with personal space for leisure sports and help them feel mentally secure through online and non-face-to-face leisure sports that can increase sociality.

Second, depending on whether indoor or outdoor spaces are used for leisure activities, it was found that individual risk perception was high in indoor spaces, while social risk perception was high in outdoor spaces. Therefore, the capacity of indoor spaces must be limited by reducing density and allowing participants to participate in leisure sports in a secluded space, and preventive actions such as regular ventilation and sterilization should be increased to reduce perceived crowding and risk perception of infection among participants.

Subsequently, by subdividing and analyzing distance among participants in leisure sports activities based on proxemics, we found that individual risk perception influenced participants' high-risk perception of personal distance, while social risk perception affected their high-risk perception of public distance. During indoor sports activities, perceived crowding and risk perception were high among participants, although the capacity in indoor spaces is limited with sufficient distance between individuals as compared to outdoor spaces. Additionally, even when public distance is maintained with sufficient distancing among many people, it is not enough for people to perceive safety when crowding and risk are involved. This indicates that participants believe that they are not free from exposure to infectious diseases during sports activities when others are close to them.

Therefore, it is necessary to re-examine the scope of social distance in perceiving risk perception and reducing the crowding perceived by participants in leisure sports activities. Moreover, individuals must make efforts to maintain a minimum distance from one another. Lastly, there must also be media education and warning messages to prevent infection and reduce crowding.

## Data availability

Data supporting the findings of this study are available from Dryad, but limitations apply to the availability of such data. This data was used under a license for current research and is therefore not publicly available. The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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## Author contributions

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by S.W.K. and Y.J.K. The first draft of the paper was written by S.W.K., and all authors commented on every version of the paper. All authors read and approved the final paper for submission.

## Competing interests

The authors declare no competing interests.

## Ethical approval

Chung-Ang University Research Ethics Committee reviewed and approved the protocol of this study (approval number: 1041078-202103-HRSB-090-01). The information collected and the procedure followed adhered to the Declaration of Helsinki and the policies concerning human participants stipulated by the authors' institution.

## Informed consent

The consent form was distributed and obtained online along with a questionnaire on adults (ages 20–60) who used leisure sports spaces in between September and October 2021 through an online survey by the Korean research company Macromill EMBRAIN. Written informed consent was obtained from participants prior to the study. Participants were informed of their right to withdraw at any time without penalty and were given the opportunity to request an explanation of the study.

## Additional information

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