



COVID-19 outbreak and risk factors for infection in a taekwondo gym in the Republic of Korea

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ABSTRACT

Objectives: Relatively few studies have assessed risk factors for coronavirus disease 2019 (COVID-19) in public facilities used by children and adolescents. This study presents an analysis of a COVID-19 outbreak that occurred in a taekwondo gym in Korea, predominantly among children and adolescents, with the aim of providing insights on managing COVID-19 outbreaks in similar facilities.

Methods: All 108 taekwondo gym students and staff received COVID-19 tests. A survey and closed-circuit television analyses were used to identify risk factors. A univariate analysis was conducted, followed by multivariate logistic regression analysis with backward elimination for variables with a significance level < 0.10 in the univariate analysis.

Results: COVID-19 was confirmed in 30 of 108 subjects at the taekwondo gym (attack rate, 27.8%). The outbreak started in an adult class student. This student transmitted the virus to the staff, who consequently transmitted the virus to adolescent students. In the univariate analysis, the relative risk for younger age (≤ 9 years) was 2.14 (95% confidence interval [CI], 1.01–4.54; $p = 0.054$), and that for food consumption inside the gym was 2.12 (95% CI, 1.04–4.30; $p = 0.048$). In the multivariate logistic regression analysis, the odds ratio for younger age was 2.96 (95% CI, 1.07–8.20; $p = 0.036$), and that for food consumption inside the gym was 3.00 (95% CI, 1.10–8.17; $p = 0.032$).

Conclusion: Food consumption inside the facility and young age were significant risk factors for COVID-19 transmission in this taekwondo gym. Food consumption should be prohibited in sports facilities, and infection prevention education for young students is also required.

Keywords: COVID-19; Gyms; Outbreaks; Severe acute respiratory syndrome coronavirus 2

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Introduction

Coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first became known in December 2019, when a case of pneumonia of unknown cause that occurred in Wuhan, Hubei Province, China was notified to the World Health Organization (WHO) Country Office in China [1]. The WHO then declared a public health emergency of international concern on January 30, 2020 owing to the international spread of COVID-19 and declared it a pandemic on March 11, 2020. As of July 21, 2021, there were more than 190 million confirmed cases of COVID-19 worldwide and more than 4 million deaths (fatality rate, 2.15%). The United States has the highest number of COVID-19 cases, followed by India, Brazil, Russia, and France [2].

The main symptoms of COVID-19 include fever, cough, shortness of breath, chills, myalgia, headache, sore throat, loss of smell and taste, and pneumonia [3]. COVID-19 severity varies with age, and its fatality rate is higher in older individuals [4]. Following research findings that children are less likely to become infected and have a lower transmission rate [5], a recent study found that children's immune systems fight SARS-CoV-2 faster and more aggressively than those of adults [6]. Several vaccines effective against COVID-19 have been developed, and vaccination is being conducted mainly in developed countries [7]. All people are eligible for COVID-19 vaccination, except pregnant women and children aged under 18 years, who were not included in the clinical trials during the vaccine development process. However, this may change depending on additional clinical results (e.g., for the Pfizer-BioNTech COVID-19 vaccines, approval has been granted for children aged 16 years or younger) [8].

Since the first case on January 20, 2020, the Republic of Korea (Korea) has been stably managing the COVID-19 pandemic with the 3T strategy (tracing, testing, and treating) and social distancing [9]. As of July 21, 2021, there were 182,265 domestic COVID-19 patients and 2,060 cumulative deaths, with a fatality rate of 1.13% [10]. The main route of COVID-19 transmission is known to be via respiratory droplets of an infected individual. Several major domestic COVID-19 outbreaks occurred in enclosed spaces. Not wearing a mask (or insufficient use of masks), drinking or eating after exercise, basement floors, airtight structures, vigorous movements, and shouting have been pointed out as risk factors, particularly in indoor sports facilities; however, these factors have not been confirmed through targeted research in Korea [11,12].

After a COVID-19 case was confirmed in a student at a

taekwondo gym located in North Gyeongsang Province on January 26, 2021, an outbreak centered around the students at the taekwondo gym occurred. In Korea, taekwondo gyms, which are indoor facilities where COVID-19 can spread effectively, are mainly visited by children and adolescents. In addition, this outbreak occurred before a full-fledged vaccination drive was implemented in Korea; therefore, vaccination did not influence the spread of COVID-19 at this time. This study was conducted to identify risk factors for COVID-19 transmission and provide insights on how to manage COVID-19 risk in taekwondo gyms and similar facilities.

Materials and Methods

Ethical Approval

The data were collected as part of the public health response to the COVID-19 pandemic. This paper was submitted to the Institutional Review Board of Korea Disease Control and Prevention Agency (IRB no. 2021-10-02-PE-A) for a bioethics examination, and it was approved (2021-10-18).

Subjects

The people present in the taekwondo gym included 103 students (5 adults and 98 high school or lower grades) and 5 staff members. The index case was confirmed on January 26, 2021 after being tested at a Public Health Center screening clinic on January 25, 2021. After the index case was reported, reverse-transcription (RT) polymerase chain reaction (PCR) diagnostic tests for SARS-CoV-2 were administered to all taekwondo gym students and staff members, regardless of symptoms. Confirmed COVID-19 cases were defined as those with a positive real-time RT-PCR result. In this outbreak, the virus was introduced into gyms during an adult class and then spread within the gym through the staff. Therefore, all students and faculty who entered the taekwondo studio were considered as exposed and selected as subjects for research. We conducted a retrospective cohort study of 98 students in high school or lower grades to confirm the process of transmission from the staff to students.

Management of COVID-19 Transmission

The Gyeongbuk Regional Disease Response Center of the Korea Disease Control and Prevention Agency (KDCA) cooperated with the North Gyeongsang Province Provincial Government and Public Health Center to control the outbreak by managing the confirmed cases and exposed individuals. The confirmed cases were transferred to a hospital or a community treatment center depending

on severity. According to Korea's COVID-19 management guidelines, the exposure range was set to 2 days before the symptom onset (2 days before the sample collection date for cases without symptoms) [13]. Close contacts were classified based on an evaluation of risk levels such as exposure range (time, place, etc.) with confirmed patients and whether or not a person wore a mask [13]. If an individual was classified as exposed, self-quarantine and active monitoring were implemented for 14 days [14]. If symptoms occurred during the quarantine period, SARS-CoV-2 testing was performed, and all exposed individuals were tested 1 day before being released from quarantine. The building in which the taekwondo gym was located also operated 6 other facilities, leading to a possibility that COVID-19 could have spread through communal restrooms or stairs. Therefore, SARS-CoV-2 testing was conducted for all staff members of all 6 facilities, and measures were taken to ensure that those who visited the building were tested via an emergency disaster text message sent by North Gyeongsang Province. In addition, the entire building in which the taekwondo gym was located was temporarily closed and disinfected.

Data Collection

Using the Basic Epidemiological Survey of the 9-5 edition of the Korean COVID-19 Response Guidelines (for local governments), data on demographic characteristics, exposure history, presence of symptoms, and date of symptom onset were obtained via interviews [13]. In addition, to confirm the presence of symptoms and the date of symptom onset, subjects' history of medical institution visits and credit card usage were checked using the epidemiological information support system and the exposure history and date of symptom onset were reconfirmed through re-interviews based on the identified information. On February 3, 2021, a questionnaire was prepared to retrospectively identify risk factors related to COVID-19 transmission within the taekwondo gym based on site visits and analyses of closed-circuit television (CCTV) analyses. The survey was conducted on February 4, 2021 for students, and the questionnaire items included risk factors, such as conversations within the gym, physical contact during class, consumption of food, and preventive measures, such as wearing masks in the gym or using hand sanitizer upon entry.

Laboratory Test Method

The taekwondo gym students visited the local Public Health Center screening clinic to provide upper respiratory tract samples. According to the management guidelines, lower respiratory tract samples were also collected when symptoms such as sputum were present [13]. The collected

specimens were tested at the North Gyeongsang Province Institute of Health and Environment and a diagnostic test consignment agency (Seegene, Seoul, Korea) certified in Korea [14]. The diagnosis was conducted by detecting a specific gene of SARS-CoV-2 using RT-PCR. For this diagnostic method, it is recommended to proceed with E gene PCR as a screening test and use PCR for the RdRp region of the orf1b gene as a confirmatory test in order to judge the result as positive [15].

Statistical Analysis

Statistical analysis was performed using IBM SPSS ver. 22.0 (IBM Corp., Armonk, NY, USA). To identify potential risk factors for transmission and evaluate their associations, relative risks (RRs) and 95% confidence intervals (CIs) were calculated; additionally, the Fisher exact test was performed in the univariate analysis. Multivariate logistic regression analysis with backward elimination was performed for variables with a significance $p < 0.10$ in the univariate analysis to calculate odds ratios and 95% CIs. The statistical significance was set to $p < 0.05$.

Results

Occurrence

The index case was a student at the taekwondo gym who experienced mild fever (37.3°C) and headache on January 22, 2021 and subsequently developed a fever of 39.0°C on January 23, 2021. The symptoms persisted despite the administration of antipyretics, and the student tested positive for COVID-19 on January 26, 2021. An epidemiological investigation confirmed that the student had visited the taekwondo gym 2 days before symptom onset. Therefore, all staff members and students of the taekwondo gym, family members and acquaintances of the first confirmed case, and instructors and students using the same building were tested for COVID-19 regardless of their symptoms. Fifty-six individuals (2.1%) out of a total of 2,631 individuals tested positive for COVID-19. The confirmed cases consisted of 30 individuals (27.8%) among the 108 taekwondo gym students and staff members, 23 (23.7%) of the 97 family members of the confirmed case, and 3 (0.8%) of the 383 acquaintances of the first confirmed case. There were no additional cases among the instructors and students using the same building.

General Characteristics of the Taekwondo Gym Cases

Among the 30 cases identified among the taekwondo gym students and staff members, 19 (63.3%) were observed in male subjects. The age group of ≤ 9 years was the most common, with 15 cases (50.0%). Two out of the 5 staff

members (40.0%), 5 out of the 5 adult students (100.0%), and 23 out of the 98 adolescent students (23.5%) tested positive for COVID-19. The attack rate was the highest for the participants in the adult classes, as they gathered for tea time before class and were shown not to be wearing masks upon CCTV analysis. Fever (40.0%) was the most common symptom among the 23 cases who showed symptoms as of the confirmed date, followed by sore throat (26.7%), cough (20.0%), and rhinorrhea (20.0%). As of the confirmed date, 7 cases (23.3%) did not have symptoms (Table 1). There were no fatal cases among the taekwondo gym students and staff members.

First Case and Epi-Curve of the Taekwondo Gym

Based on the first day of symptom onset, the first confirmed case in the taekwondo gym was an attendee of an adult class who experienced rhinorrhea and a stuffy nose on

Table 1. General characteristics of coronavirus disease 2019 cases in a taekwondo gym ($n = 30$)

Characteristic	n (%)
Age (y)	
0–9	15 (50.0)
10–19	8 (26.7)
20–29	2 (6.7)
≥ 30	5 (16.7)
Sex	
Male	19 (63.3)
Female	11 (36.7)
Occupation	
Staff	2 (6.7)
Student	28 (93.3)
Class (student, $n = 28$)	
High school or lower grades	23 (82.1)
Adult students	5 (17.9)
Clinical symptoms	
Cases with symptoms at confirmed dates	23 (76.7)
Fever	12 (40.0)
Cough	6 (20.0)
Sputum	2 (6.7)
Sore throat	8 (26.7)
Dyspnea	0
Rhinorrhea	6 (20.0)
Myalgia	4 (13.3)
Headache	4 (13.3)
Loss of taste	1 (3.3)
Loss of smell	2 (6.7)
Diarrhea	0
Abdominal pain	1 (3.3)
Vomiting	0
Cases without symptoms on the confirmed date	7 (23.3)

January 18, 2021 and started experiencing a slight loss of smell and taste thereafter without fever. The first case participated in the adult class at 8 PM on January 19–21, 2021. Six (excluding the index case) adult class students and staff members were classified as secondary cases (date of occurrence or confirmation: January 20–27). The classes for students (i.e., children and adolescents) were operated from 1 PM to 7 PM, and the virus was suspected of having spread between the adult and student classes via the staff members. The COVID-19 cases in the student class were classified as tertiary cases (the date of occurrence or confirmation: January 21–February 2, 2021) (Figure 1).

Transmission Risk Factors in the Student Classes of the Taekwondo Gym

In the classes at the taekwondo gym, a total of 6 sessions were held per day only on weekdays, and each class was separated into the first and second floors. The body temperature was checked at the entrance before class, and hand sanitizer was provided for use. A CCTV analysis revealed that the staff members were wearing masks during class but failed to keep them on properly throughout the entire class owing to the need to give instructions and physical contact. The windows were closed during class, and ventilation was conducted for approximately 5 minutes after a 50-minute class. Among the staff members, 1 person conducting the class and 1 person operating the gym vehicle tested positive for COVID-19. A total of 92 of the 98 students (93.9%) participated in the survey that was conducted to identify risk factors related to the transmission of tertiary cases, which are presumed to have been transmitted via the staff members. The univariate analysis showed that the RR of the younger age group (≤ 9 years of age) was 2.14 (95% CI, 1.01–4.54; $p = 0.054$). In addition, people who consumed food in the gym (38.0% of subjects) had a RR of 2.12 (95% CI, 1.04–4.30; $p = 0.048$). The proportions of people who sanitized their hands at the entrance and always wore a mask were 95.6% and 79.3%, respectively. The RRs of hand sanitization at the entrance (RR, 0.48; 95% CI, 0.17–1.36) and always wearing a mask (RR, 0.59; 95% CI, 0.29–1.24) were low but not statistically significant (Table 2). In the multivariate logistic regression analysis for younger age and food consumption in the gym, both of which had a significance level < 0.1 , the odds ratio for younger age was 2.96 (95% CI, 1.07–8.20; $p = 0.036$), reflecting a statistically significant risk increase. Likewise, a statistically significant risk elevation was found for food consumption in the gym, which had an odds ratio of 3.00 (95% CI, 1.10–8.17, $p = 0.032$) (Table 3).

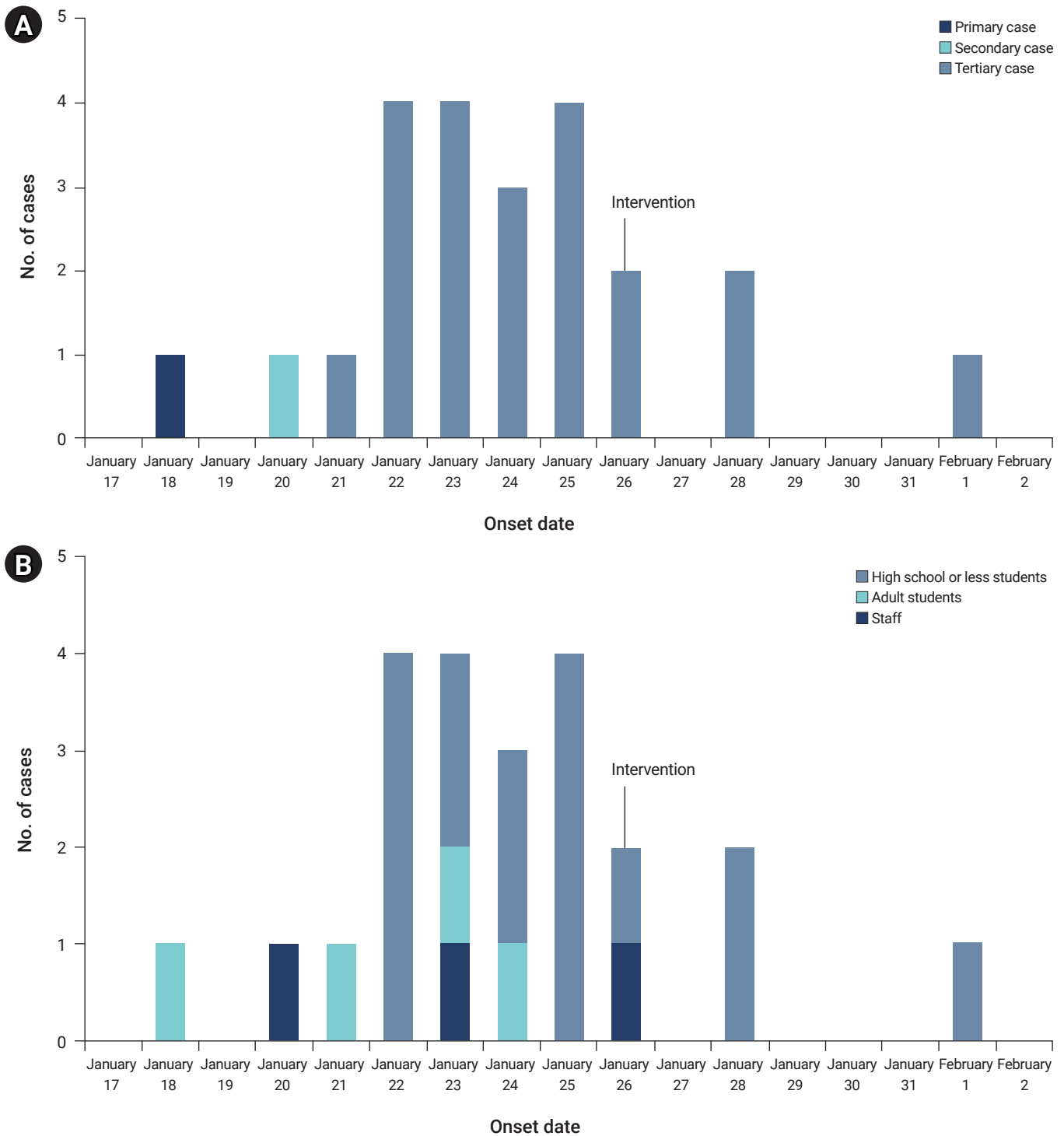


Figure 1. Epidemic curve of an outbreak in a taekwondo gym (symptomatic cases). (A) Transmission in the taekwondo gym. (B) Occupation in the taekwondo gym.

Discussion

In total, 30 of the 108 individuals (27.8%) related to the taekwondo gym were confirmed to have COVID-19, and

the adult class had the highest attack rate at 100.0%. The adult class held a before-class tea time, and the class was conducted without wearing masks. The cases associated with the taekwondo gym were presumed to have been

Table 2. Risk factors for coronavirus disease 2019 transmission among students in high school or lower grades in a taekwondo gym

Characteristic	Category	Tertiary cases/total	AR (%)	Relative risk (95% CI)	<i>p</i> ^{a)}
Sex	Male	19/68	27.9	1.68 (0.63–4.43)	0.411
	Female	4/24	16.7	Reference	
Age (y)	≤ 9	15/43	34.9	2.14 (1.01–4.54)	0.054
	10–19	8/49	16.3	Reference	
Class site	First floor	21/79	26.6	1.73 (0.46–6.51)	0.506
	Second floor	2/13	15.4	Reference	
Use of hand sanitizer at the entrance	Yes	21/88	23.9	0.48 (0.17–1.36)	0.259
	No	2/4	50.0	Reference	
Mask wearing inside the gym (always)	Yes	16/73	21.9	0.59 (0.29–1.24)	0.234
	No	7/19	36.8	Reference	
Conversation inside the gym	Yes	19/70	27.1	1.49 (0.57–3.92)	0.574
	No	4/22	18.2	Reference	
Physical contact during the class	Yes	9/37	24.3	0.96 (0.46–1.98)	1.000
	No	14/55	25.5	Reference	
Food consumption inside the gym	Yes	13/35	37.1	2.12 (1.04–4.30)	0.048
	No	10/57	17.5	Reference	
Use of the changing room	Yes	15/66	22.7	0.74 (0.36–1.53)	0.434
	No	8/26	30.8	Reference	
Use of the toilet	Yes	13/51	25.5	1.05 (0.51–2.14)	1.000
	No	10/41	24.4	Reference	
Use of the gym car	Yes	18/72	25	1.00 (0.42–2.36)	1.000
	No	5/20	25	Reference	

AR, attack rate; CI, confidence interval.

^{a)}The Fisher exact test was used.**Table 3.** Multivariate logistic regression to determine risk factors for coronavirus disease 2019 transmission in a taekwondo gym

Characteristic	Category	Odds ratio (95% CI)	<i>p</i> -value
Age (y)	≤ 9	2.96 (1.07–8.20)	0.036
	10–19	Reference	
Food consumption inside the gym	Yes	3.00 (1.10–8.17)	0.032
	No	Reference	

CI, confidence interval.

transmitted to the staff members through the first case among the adult class members and subsequently to the student class members via the staff members. A survey conducted among the taekwondo gym class members revealed that food consumption in the gym and younger age were significant risk factors according to the multivariate analysis.

In domestic fitness centers where people engage in physical activities similar to those in the taekwondo gym in the current study, COVID-19 outbreaks were detected 7 days after the day of symptom onset of the first case, and the attack rate was 23.2%, which was lower than that of the taekwondo gym in this study (27.8%) [12]. In a call center

in Korea where continuous conversations occurred, a COVID-19 outbreak were detected 16 days after the day of symptom onset of the first case, and the attack rate was 8.5%; however, the attack rate in the same space on the floor where most of the confirmed cases occurred was 43.5% [16]. The attack rate can be affected by the place of contact, the time it takes for an index case to be found, and mask wearing. In the current study, it took only 8 days to recognize the symptoms of the first case, and a high rate of mask wearing was noted; however, it was relatively easy for COVID-19 transmission to occur owing to extensive physical contact, raising of voices, or vigorous exercise.

Even though the taekwondo gym described herein

conducted body temperature measurements, the first case was not detected as the individual did not exhibit fever symptoms. More than 40% of COVID-19 cases may not have a fever [17]; therefore, it may be difficult to detect patients with COVID-19 simply via body temperature monitoring. The most common symptom of the confirmed cases from the taekwondo gym as of the confirmed date was fever, followed by sore throat, cough, and rhinorrhea. In addition to fever, screening for respiratory symptoms, such as sore throat, cough, and rhinorrhea, was thought to be helpful in preventing the spread of the virus early. The rate of asymptomatic presentation of all confirmed cases from the taekwondo gym was 23.3% as of the confirmed date. This rate was higher (26.1%) among those 19 years or younger. In a study investigating the clinical and epidemiological characteristics of 36 children with COVID-19 in China, the rate of asymptomatic cases was 28% on the day of admission, which was similar to that in this study [18].

The multivariate analysis showed that the attack rate was significantly higher among people who consumed food in the gym. There is no evidence that COVID-19 can be transmitted via the ingestion of food. Although it is true that COVID-19 can be transmitted by touching a surface or object that has the virus on it and then touching one's mouth, nose, or eyes, this is not believed to be the primary route of transmission of the virus [19]. Instead, COVID-19 spreads from person to person mainly through respiratory droplets released when coughing, sneezing, and talking [19]. In addition, a study conducted in the United States showed that one can become infected with COVID-19 through close contact with a confirmed case or by eating or drinking in places where confirmed cases of COVID-19 had occurred. The rate of spread may be increased while eating or drinking, as it is impossible to maintain proper mask wearing during these activities [20]. The consumption of food in the gym may have been a significant risk factor because of improper mask wearing while eating rather than the possibility of direct transmission through food.

In this outbreak, the attack rate was significantly higher in the age group of ≤ 9 years than in the age group of 10 to 19 years. According to a report released by the WHO in September 2020, children aged under 18 years accounted for approximately 8.5% of the reported cases, had a relatively low fatality rate compared to other age groups, and mostly showed mild symptoms [21]. However, at the taekwondo gym in this study, the attack rate was higher in younger age groups. The attack rate for the taekwondo gym-related cases may be different from the clinical picture as tests were performed regardless of the presence or absence of symptoms. In other cases of COVID-19 outbreaks, such as in

daycare facilities, the attack rate was also higher in younger age groups [22]. A reason for this may be that younger children find it more difficult to adhere to preventative behaviors, such as mask wearing or not touching their mouth or nose with their hands.

The building in which the taekwondo gym was located had 4 floors, on which 6 academies were operated, and each floor was observed to have communal restrooms. However, there were no additional cases at any other academies besides the taekwondo gym. This may have been because of the high rate of mask wearing among the students of other academies (79.3%) and the short contact time in the restrooms. In addition, the taekwondo gym had a secondary attack rate of 23.7% in families. This is higher than the rates of 11.8% from the results of a survey conducted among 10,592 domestic contacts [23] and 16.6% from a meta-analysis of 54 studies [24]. The high proportion of cases in the younger age groups in the taekwondo gym indicates that the secondary attack rate may have been higher owing to close contact with family members.

It is known that proper mask wearing can prevent the spread of COVID-19. A study examining the usage patterns in 6 colleges where mask wearing was compulsory during September to November 2020 found that wearing a face mask correctly could limit the spread of COVID-19. Additionally, higher education institutions suggest that masks must be worn indoors and outdoors within 6 feet (1.82 meters) [25]. Although mask wearing lowered the transmission of COVID-19 in this taekwondo gym outbreak, its effect was not statistically significant. This is because the number of students examined was small and there was a possibility of improper mask wearing; additionally, although the classes were conducted with masks, the possibility of high-concentration droplet exposure owing to vigorous and high-energy activities in a dense space was confirmed through CCTV analysis. In addition, hand hygiene is a very important factor in the infection control of COVID-19, and several studies have confirmed that handwashing affects the incidence of respiratory diseases [26]. In this taekwondo gym, the use of hand disinfection at the entrance lowered the attack rate, although not to a statistically significant extent. It is possible that transmission within the taekwondo gym could have been prevented if hand disinfection had been performed during or after class; however, hand disinfection was only performed at the entrance.

This study had the following limitations. First, it was not possible to check the number of times the taekwondo gym students participated in classes conducted by staff members with confirmed COVID-19 infections. Although the class hours and the staff in charge of the class were not

clearly defined, the staff member who tested positive was in charge of 4 out of 6 classes. Second, it was not possible to assess the distance between the students and staff members with confirmed COVID-19 during class, because there was no assigned seating for students, and staff members with confirmed COVID-19 were constantly moving around during class. Third, the route of infection of the first case was not identified. Additional interviews and an analysis of the Epidemic Intelligence Support System of existing COVID-19 cases were conducted over the course of the study, but the details could not be established.

Younger age (≤ 9 years) and food consumption in the gym were found to be significant risk factors in this outbreak. In the adult class, all adult individuals were infected by consuming food together without a mask. In a dense environment where intense exercise takes place, as in a taekwondo gym, it is necessary to follow the principles of infection prevention even more thoroughly, and intensive management is required for younger age groups. In addition, although body temperature monitoring was performed at the entrance of the facility, the first case was detected 8 days after symptom onset, indicating that further transmission within the taekwondo gym could not have been prevented. Therefore, it is necessary to prevent transmission within the group by more thoroughly monitoring respiratory symptoms, such as sore throat and rhinorrhea, in addition to fever. After recognizing the outbreak of COVID-19 in the taekwondo gym, the further outbreak was managed through aggressive measures, such as halting of the operation of the other academies in the same building and testing all contacts. Although various outbreaks are currently occurring and responses to these outbreaks are being prioritized, the data presented herein provide valuable evidence for responding to COVID-19 by conducting an investigation regarding the route of infection and infectivity with an analysis of the source of infection and confirmation of the transmission route.

Notes

Ethics Approval

The study was approved by the KDCA Institutional Review Board (IRB No: 2021-10-02-PE-A).

Conflicts of Interest

The authors have no conflicts of interest to declare.

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None.

Availability of Data

The data used in this study are protected under the Personal Information Protection Act.

Authors' Contributions

Conceptualization: all authors; Data curation: SHS, JHP, TJS; Formal analysis: SHS, JHP; Investigation: all authors; Methodology: all authors; Project administration: TJS; Resources: all authors; Software: all authors; Supervision: TJS; Validation: all authors; Visualization: all authors; Writing—original draft: SHS, JHP, TJS; Writing—review & editing: all authors.

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