Brief Report

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Cross-infection risks of SARS-CoV-2 while playing catch using a baseball: Creating a safe sporting environment during the COVID-19 pandemic

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SUMMARY Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative agent of the coronavirus disease (COVID-19), is found primarily in the respiratory tract secretions of infected individuals with one of the main routes of transmission being direct or indirect contact. In this study, using fluorescent paint, we evaluated the spread of contaminants while playing catch with a baseball. Fluorescent paint was applied to the right hand of a right-handed baseball player who then engaged in playing catch with 10 other right-handed players (partners) for 5 min each. The fluorescent paint was detected on the right hands (inside) and gloves (inside) of all the 10 partners as well as on the ball; in some partners it was also detected on the back of the right hands or the back of the gloves. However, except for their right hands, fluorescent paint was not detected on the surface of the bodies of the partners. These observations indicated that the fluorescent paint (mimicking virus-containing contaminants) on the hand spreads very efficiently from person to person during the throwing and catching of a baseball, suggesting that a thorough and frequent disinfection of the hands and equipment is important in the prevention of infections that may occur while playing baseball.

Keywords Cross-infection, playing catch, baseball, fluorescent paint, SARS-CoV-2

1. Introduction

The coronavirus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first reported in Wuhan, China in December 2019 (*1*) and has resulted in a global pandemic. Since SARS-CoV-2 is contained primarily in the airway secretions of infected persons, the main route of transmission is considered to be through droplets derived from the infected persons. In an enclosed environment, moreover, an aerosol infection may occur when aerosols derived from the infected persons float in the air for extended periods of time (*2*). Transmission may also occur through surfaces contaminated by direct or indirect contact with mucous membranes in the eyes, mouth, or nose of infected persons(*3*). SARS-CoV-2 has been reported to exist as an aerosol form for several hours and may be present on environmental surfaces for several days (*2*).

The measures taken to prevent SARS-CoV-2 infection include the use of appropriate preventive measures (such as personal protective equipment, and disinfectants) to contain the spread of the pathogen effectively (*4*). It has been recommended that contaminated environmental surfaces be treated with disinfectants and chemical agents, such as alcohol, which is considered to be highly effective (*5*). In the medical field, fluorescent paints and black light are used widely to visualize the effect of infection control measures for the purposes of research and to raise awareness (*6,7*). In this study, we investigated spread of a contaminant (source of infection) during a baseball game using fluorescent paint to visualize the process. In addition, we developed countermeasures to reduce the spread of the disease.

2. Materials and Methods

2.1. Study participants

The participants in this study were 11 right-handed male baseball players, with a mean age of 19.5 years,

who belonged to a university baseball team and who had been playing baseball for at least 10 years. The participants were informed in advance of the purpose and the method of the study, and the management of their personal information. All the participants provided written informed consent, prior to their participation in the study. This study was approved by the Ethics Committee of Chubu University (approval number 20200039). This study was conducted in accordance with the principles of the Declaration of Helsinki.

2.2. Evaluation methods

The study was conducted with one baseball player (regarded as a hypothetically infected person) and 10 other players (partners). With the assumption that the right hand of the hypothetically infected player would be covered with the infectious disease pathogen, fluorescent paint (Spectro-Pro Plus, Morain Cooperation Co., Ltd., Tokyo, Japan), which mimicked virus-containing contaminant, was applied to the right hand of the hypothetically infected player which could be detected using a black light illuminator (Stand Type Hand Wash Checker BLB Set, Saraya Co., Ltd., Osaka, Japan) (Figure 1A). The hypothetically infected player performed playing catch, with 10 different partners for 5 min each (Figure 1B). For every partner, the hypothetically infected player was applied with the fluorescent paint on the right hand and used a new ball. The partners were examined under black light and before and after playing catch.

3. Results and Discussion

In this study, we applied fluorescent paint, which mimicked virus-containing contaminant, to the hand of a baseball player (regarded as a hypothetically infected person), who then played catch with 10 partners for 5 min each. We next visualized the fluorescent paint on the surfaces attributable to contamination by using black light. Table 1 summarizes the results of the fluorescent paint detection on the surface areas (Figure 2) of the 10 partners. The fluorescent paint was detected on the inside of the right hands of all 10 of the partners ([1] and [2]), while it was not detected on the inside of the left hands of the partners ([3] and [4]). Interestingly, the fluorescent paint was detected on the back of the right hands ([5]and [6]) and gloves ([12] and [13]). On the other hand, the fluorescent paint was not detected on any surface area of the bodies of the partners (not shown in Table 1). These findings suggest that contaminant on the infected person's hand can spread to other person *via* a ball during playing catch.

The areas of the partners in which no fluorescent paint was detected were considered to be free from direct contact with the ball. However, fluorescent paint was detected in two locations on the back of the glove and two locations on the back of the right hand that were not in direct contact with the ball on some, though not all, partners (Table 1: [5], [6], [7], [8]). First, with regard to the back of the right hand; it is possible that the fluorescent paint adhering to the front of the glove may have been transmitted when the player gripped the ball in the glove. It is also expected that the act of hitting the front of the glove with the fist with the ungloved hand, which baseball players often do between ball catches, may have caused this secondary transmission. In addition, the detection of fluorescent paint at the back of the glove may be considered to be due to contact between the back of the glove and the right palm, which was covered with fluorescent paint. In brief, the contaminants were expected to be transferred from the hands of the hypothetically infected person to the ball, followed by the glove, palm, or fist of the partners, and subsequently to anything that came into contact with the infected body parts or surfaces, causing secondary or tertiary transmission.

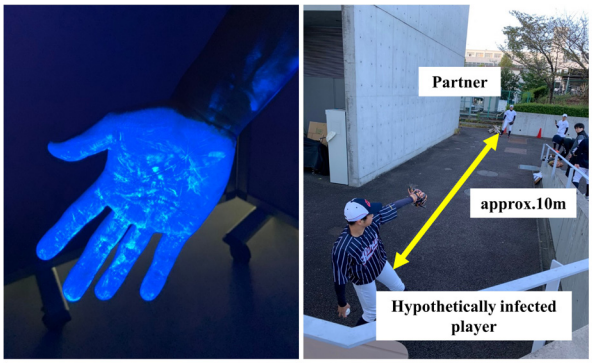

Figure 1. Evaluation method. (A) Fluorescent paint was applied to the right hand of the hypothetically infected player. The paint on the hand could be visualized as blue emissions under the black light. **(B)** The distance between the hypothetically infected player and his partner was approximately 10 m.

In the present study, no fluorescent paint was detected on the body; however, the body may not have been touched with the palm of the right hand because the exercise was continuous, *i.e.*, playing catch for 5 min. However, in a normal baseball practice or game, exercise is often interrupted; therefore, the contaminated hands may have been brought into contact with the eyes, nose, and mouth. The U.S. Centers for Disease Control and Prevention (CDC) have pointed out that people should be aware of contact transmission and should not touch their own eyes or nose to prevent new coronavirus infection. For example, if an infected person sneezes or coughs while covering the nose or mouth with his or her hand and then touches something around with that hand, the virus is transmitted *via* that hand, and then, if another person touches the same item the virus will stick to his or her hand. Now, if this person touches his or her eyes, nose, or mouth with the contaminated hand, the virus may then be transmitted

Table 1. Detection of fluorescent paint on the bodies and equipment

Evaluation areas	Partners										Positive rate (%)
	A	B	C	D	E	F	G	H	I	J	
Hand (inside) right											
[1]	+	+	+	+	+	+	+	+	+	+	100
[2]	+	+	+	+	+	+	+	+	+	+	100
Hand (inside) left											
[3]	-	-	-	-	-	-	-	-	-	-	0
[4]	-	-	-	-	-	-	-	-	-	-	0
Hand (back) right											
[5]	-	+	-	+	-	-	+	+	+	+	60
[6]	+	-	-	-	-	-	-	+	-	+	30
Hand (back) left											
[7]	-	-	-	-	-	-	-	-	-	-	0
[8]	-	-	-	-	-	-	-	-	-	-	0
Glove (inside)											
[9]	+	+	+	+	+	+	+	+	+	+	100
[10]	+	+	+	+	+	+	+	+	+	+	100
[11]	+	+	+	+	+	+	+	+	+	+	100
Glove (back)											
[12]	-	-	-	-	-	-	-	-	+	+	20
[13]	-	-	-	-	-	-	-	-	-	+	10
[14]	-	-	-	-	-	-	-	-	-	-	0

The 'catch' surface of the grove was defined as "inside" while the opposite side as "back." The evaluation of paint detection was performed by tat least three evaluators, and all the agreed-upon fluorescence-positive were marked with '+,' otherwise were marked '-.' The evaluation areas [1]-[14] correspond to those shown in Figure 2.

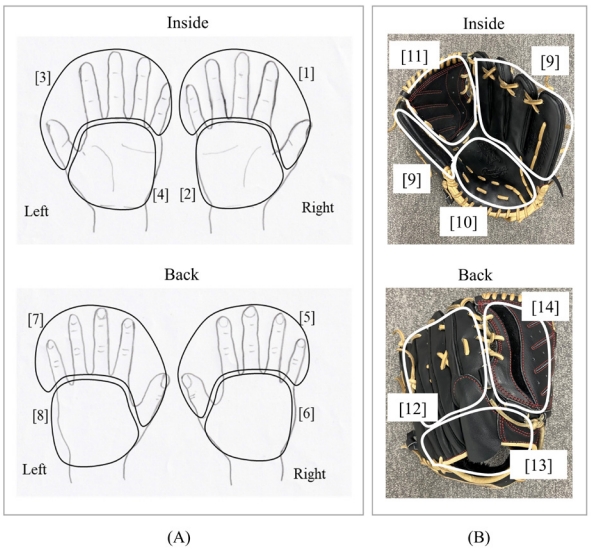

Figure 2. Evaluation areas. Hands (A) and glove (B) of partners.

through this person's mucous membranes. According to previous reports, people unconsciously touch their faces on an average of 23 times per hour, and approximately 44% of all cases touch the mucous membranes of the eyes, nose, and mouth (*8*). Since the results of this study suggest that transmission may occur from the hands of a hypothetically infected person to a hypothetically uninfected person *via* a contaminated ball, caution should be exercised.

The risk of COVID-19 infection has been considered to be low in sports that are conducted outdoors at a sufficient distance (*9*). The baseball game is usually performed outdoors at a sufficient distance. However, this experiment showed that contaminants may be transmitted from the hands of an infected person to the hands and glove of other players *via* the ball.

Although no previous studies on the transmission of contaminants *via* sports equipment have been found, an experiment has been reported, wherein, the SARS-CoV-2 virus was applied to the surfaces of 10 types of balls, including tennis balls; while the virus was not detected on any of the types of balls after 15 min, it was detected on seven of the 10 types after 1 min (*10*). Based on the results of this study, there is a risk of transmission *via* equipment such as balls, immediately after virus adherence. This suggests that the removal of contaminants from hands, balls, and other sports equipment may be an effective measure to prevent infection transmission during game play. Experiments applying high concentrations of SARS-CoV-2 to the surfaces of sports balls, particularly soccer balls (footballs), tennis balls, golf balls, and cricket balls, have shown that no traces of the virus were detected when the balls were wiped with dry or damp wet wipe, or dropped and rolled (*11*). Furthermore, there have been reports that despite the presence of infected participants there has been no evidence of potential surface infections in soccer club facilities where regular cleaning procedures were in place (*12*).

Cleaning and disinfection with alcohol has been reported to be effective in eliminating the microbial contamination of medical devices and other equipment

(*13*). Frequent hand washing with water and soap, and hand disinfection with 70% alcohol base are used as infection control protocols in medical settings (*14*). Therefore, the frequent wiping of balls, gloves, and other equipment, and hand washing during play is required to inhibit or control the spread of viruses and other infectious agents on the sports field. However, because it is impractical to use water and soap to wash hands on the baseball field during practice and games, alcohol disinfection may be effective and is recommended as an infection control measure.

The COVID-19 pandemic disrupted organized sports in communities indirectly by the enforcing of cancellations, drastic schedule alterations, or postponement of sports events. This had a significant impact on the psychosocial and physical development of athletes (*15*). Therefore, it was necessary to examine the infection control measures that may be used to achieve a safe environment for sport play and participation. Therefore, based on the findings of this study it is recommended that frequent hand alcohol disinfection during sporting activities is an effective method of creating a safe sports environment.

However, there were two limitations to this study. First, this study used fluorescent paint and not the actual virus. Second, since the experiment in this study was carried out individually with the 10 partners, we were unable to confirm the extent to which contaminants can be transmitted when playing with a large number of players. During actual games and practices, contaminants may infect other players *via* the balls that were touched by infected players.

We were able to visualize the gradual spread of the fluorescent paint that was applied to one player's hand and observe its transmission to another player's glove and hand *via* the ball while playing catch that occurs in baseball. This indicated the risk of viral transmission and other contaminants through sports equipment. Thus, the frequent disinfection of hands with alcohol during sport play is recommended as a countermeasure.

4. Conclusion

This study suggested the possibility of transmission of contaminants while playing catch that occurs in baseball. During the COVID-19 pandemic, the frequent disinfection of hands with appropriate disinfectants and chemical agents, such as alcohol, while playing sports is, therefore, recommended and may contribute to a safer sports environment.

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