Assessment of Airborne Cross-infection Risk Across Various Body Orientations in Indoor Airflow Environments

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SUMMARY

This study aims to evaluate airborne cross-infection risk under different discharge angle (-20°, 0°, and +20°) and supply temperatures (18, 25, and 30 °C) of an air-conditioner, with various body orientations (face-to-face, side-by-side, and back-to-back). Field experiments on particle dispersion were conducted within a full-scale test chamber using a manikin-shaped particle generator and detector with simulated particles (NaCl). Initial trends in particle transmission varied with body orientations. Meanwhile, the cross-infection risk was lower at -20° and higher at +20° under a supply temperature of 25°C for all body orientations. However, discharge angles associated with lower or higher cross-infection risk varied with changes in supply temperatures. The findings indicated that body orientation is a crucial factor influencing cross-infection risk, and careful adjustment of discharge angles and supply temperatures is essential to prevent airborne cross-infection in such airflow environments.

KEYWORDS

Airborne infection; Cross-infection risk; Particle transmission; Air-conditioners; Body orientations

1 INTRODUCTION

Global attention has turned to pandemic planning and preparedness due to frequent infectious disease outbreaks. Recent transmissions have been associated with indoor airflow environments, especially air-conditioned room (Kwon et al., 2020). The particle dispersion can also be influenced by system settings such as supply temperatures (Kang et al., 2011), however; previous studies have mainly evaluated on ventilation strategies to prevent airborne cross-infection. Additionally, the diverse seating arrangements in indoor spaces such as restaurants necessitate evaluation with consideration of various body orientations. Therefore, this study evaluated airborne cross-infection risk under different settings of an air-conditioner considering different body orientations.

2 METHODS

The field experiments of particle dispersion were conducted within a full-scale test chamber, employing two seated manikins to simulate both the source and target individuals in the center of the chamber with a distance of 2 m between them. The source and target manikins continuously emitted and counted simulated particles of NaCl from their circular opening mouths, with a volumetric breathing rate of 2.83 L/min considering speaking activities. The stand-type air conditioner used in this study was installed facing the center of the chamber, with evaluation conditions set for air discharge angles ranging from -20°~+20° vertically and temperatures ranging from 18°C to 30°C. We evaluated intake fraction to assess airborne cross-infection risk based on different body orientations (face-to-face, side-by-side, and back-to-back). Each experiment case consisted of a 5-minute pre-measurement of background concentration with the target manikin, followed by 20 min continuous particle emission.

Table 1: Evaluation cases of particle dispersion experiments

Condition	Air-conditioner		Body orientation
	Supply temperature	**Discharge angle**	
Base	Na.	Na.	FTF, SBS, BTB
Heating	30°C	-20°, 0°, +20°	FTF, SBS, BTB
Moderate heating	25°C	-20°, 0°, +20°	FTF, SBS, BTB
Cooling	18°C	-20°, 0°, +20°	FTF, SBS, BTB

Figure 1: Experiment settings in the test chamber

3 RESULTS AND DISCUSSION

The Initial trends in particle transmission varied with body orientations, showing not only the highest levels in face-to-face but also in side-by-side and back-to-back in certain cases. Meanwhile, the intake fraction remained consistently low at a downward discharge angle (-20°) over time under a supply temperature of 25°C for all body orientations. However, the lowest intake fraction showed at an upward (+20°) discharge angle under a supply temperature of 30°C, and at a straight (0°) discharge a ngle under 18°C. This suggests that cross-infection risk related to body orientation varies with indoor airflow, which is influenced by the operational settings of the air conditioner.

4 CONCLUSIONS

Experimental results showed that body orientations significantly affected cross-infection risk, even with the same distance between individuals. Additionally, careful adjustment of discharge angles and supply temperatures is essential to prevent airborne cross-infection in such airflow environments.

5 ACKNOWLEDGEMENTS

This research was supported by the National IT Industry Promotion Agency (NIPA) under the 'AI-integrated New Infectious Disease Response System' project and the National Research Foundation of Korea (NRF) grant funded by the Ministry of Science and ICT [No.2022R1A2C2011296]

6 REFERENCES

Kwon, K. S., Park, J. I., Park, Y. J., Jung, D. M., Ryu, K. W., Lee, J. H. (2020). Evidence of long-distance droplet transmission of SARS-CoV-2 by direct air flow in a restaurant in Korea. *Journal of Korean Medical Science*, 35(46).

Kang, Y., Wang, Y., Zhong, K. (2011). Effects of supply air temperature and inlet location on particle dispersion in displacement ventilation rooms. *Particuology*, 9(6), 619-625.