The Team Sport Risk Exposure Framework-2 to Support the Identification of Increased Risk Contacts in Sport; TS-REF-2

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Background

During the COVID-19 pandemic professional sports have continued to run competitive leagues whilst aiming to reduce potential SARS-CoV-2 transmission. Delivering competitions becomes a challenge when matches are cancelled, postponed or forfeited due to COVID-19 outbreaks. Sports are managing this, whilst prioritising player and support staff health through the implementation of intensive risk mitigation strategies (e.g. SARS-CoV-2 screening, strict social distancing and hygiene practices, monitored social distance breaches during sporting activities), along with the identification and isolation of close or 'increased risk' contacts.[1]

The identification and isolation of players and staff in elite sport, should be undertaken with appropriate precision to both prevent infected individuals remaining in the environment (e.g. resulting in potential virus transmission), and preventing low-risk contacts having to isolate (e.g. potentially increasing the risk of injury when returning, in addition to the negative effect on mental health[2,3]), causing wider disruption to competitions.

The Team Sports Risk Exposure Framework (TS-REF) was proposed in July 2020, when potentially higher risk sports (e.g. rugby) were returning.[1] Since then, it has been adopted by both elite and community sports, to both determine the risk of SARS-CoV-2 transmission during specific sporting activities (e.g. rugby tackle),[1] and to identify and isolate increased risk contacts during sport.[4] The TS-REF classified increased risk contacts as player to player interactions *'within 1 m, directly face-to-face, for 3 or more seconds'*. Increased risk contacts, identified using the TS-REF were determined in rugby league, following interactions with 8 infectious players across 4 matches.[4] Increased risk contacts were monitored for 14-days during their isolation period, to determine if they tested positive for SARS-CoV-2. Of the 28 identified increased risk contacts from the matches, only 1 player subsequently tested positive for SARS-CoV-2, which was linked to an internal club outbreak. The risk of outdoor transmission appears lower than first thought,[4,5] and consequently the TS-REF may require players to isolate who are not at an increased risk of infection.

The TS-REF was designed primarily for outdoor activities, although the increased risk of transmission indoors was acknowledged.[1] Team sports engage in both indoor and outdoor training, thus the development of a framework that accounts for indoor activities is required.

Team Sport Risk Exposure Framework 2 (TS-REF-2)

The SARS-CoV-2 virus can be transmitted both by exhaled large 'ballistic' respiratory (>100 μm diameter), and aerosol (<100 μm diameter) droplets. Aerosol droplets are higher risk, as they rapidly evaporate to become small aerosol particles (<50 μm diameter[6]) that can be easily inhaled.[7] Indoors (e.g. spaces with poor ventilation) these smaller aerosol droplets can form clouds of aerosol particles, increasing the risk of transmission to those in close proximity. Outdoors, due to typically greater air velocities, exhaled aerosol particles are dispersed more rapidly, although this will become less pronounced at close proximities and when directly face to face. It is also important to note that asymptomatic transmission occurs and may account for a substantial proportion of cases. Since the design and implementation of the TS-REF, new variants of the SARS-CoV-2 virus have been identified. Whilst initially the new variants were thought to be more transmissible, this has been debated more recently.[8] Therefore the TS-REF-2 has not been modified to account for the new SARS-CoV-2 variants.

To address the differing risks of indoor and outdoor transmission, an updated TS-REF is proposed; Team Sport Risk Exposure Framework 2 (TS-REF-2; Figure 1). Five additions have been made to the TS-REF (Supplementary Figure 1), to address the greater risk of transmission indoors and observed lower risk of transmission outdoors during sport.[4,5] A detailed explanation of changes are presented in Supplementary Table 1. The TS-REF-2 can be adopted by both elite and community sports, to identify individuals who are required to isolate, if identified as increased risk contacts. The TS-REF-2 can be used during training and match activities, and serve as a supplementation to broader public health definitions in other contexts (e.g. changing room, team meeting, car share).

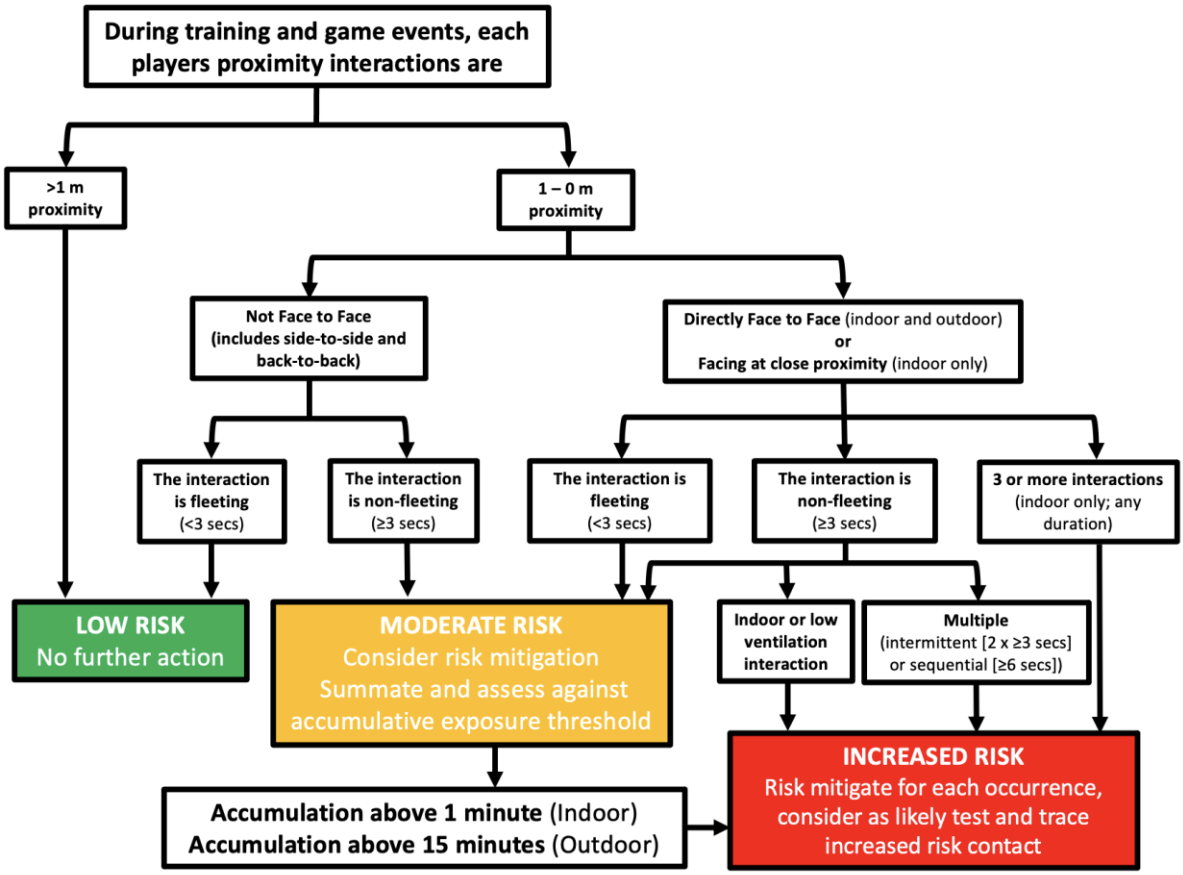

Figure 1. Team Sports Risk Exposure Framework 2 (TS-REF-2), to identify increased risk sporting activities and support the identification of increased risk contacts during indoor and outdoor team sports.

Determining Indoor and Outdoor Activity

Whilst the TS-REF-2 proposes a framework to identify increased risk contacts, differentiating indoors and outdoors spaces in sport can be challenging. For example, consider a stadium with an enclosed roof, or temporary building with no / limited sides. The key considerations for determining an indoor or outdoor environment can be established from Supplementary Table 2, based on the volume, the presence of a roof or ceiling and air velocity characteristics. The indoor TS-REF-2 definitions should be applied when the sporting environments has two or more indoor characteristics. Additional risk factors may also be determined from Supplementary Table 2 (e.g. density of people in space, CO_2 and environmental conditions).

Volume, the presence of a roof or ceiling, air velocity at low levels, density of people, CO_2 and environmental conditions should be considered collectively when determining the SARS-CoV-2 transmission risk, and if the TS-REF-2 should be

applied following the indoor or outdoor definition. For example, a large space may appear ‘outdoors’, yet if air movement at low level is poor (i.e., low air velocities) the formation of clouds of aerosol particles is possible, increasing the risk of transmission.

Conclusion

The TS-REF-2 considers the transmission risk of SARS-CoV-2 during indoor and outdoor activities, building on the previously adopted TS-REF.[4] Using the information provided in this article, policymakers and practitioners can determine if the activity was undertaken in an indoor or outdoor environment and then appropriately apply the TS-REF-2 to identify increased risk contacts in sport. The TS-REF-2 can be applied to training and match activities, for both professional and community sports, when implementation can be achieved with an appropriate level of precision (e.g. video footage available), to supplement broader non-sport contact tracing guidelines. This should be continually reviewed and updated, as the evidence related to the transmission risk of SARS-CoV-2 evolves. Ultimately, sports should aim to undertake as much activity as possible outdoors, given the lower SARS-CoV-2 transmission risk in comparison to indoors.

References

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Supplementary Table 1. Changes to the Team Sport Risk Exposure Framework (TS-REF), shown in the Team Sport Risk Exposure Framework 2 (TS-REF-2).

Key	Explanation of changes
1	By broadening the face to face definition to include *'facing at close proximity (indoor only)'*, this ensures that during indoor interactions, whereby clouds of aerosol particles may form and expose players beyond the 'direct face to face' definition, more increased risk contacts can be identified. (Facing can be defined as directly face to face, ± 1 m laterally).
2	The number of interactions between individuals at close proximity, either face to face or facing at close proximity (indoors only) increases the risk of direct virus transmission between individuals. As such, if an infected individual has *'3 or more interactions (indoor only)'* fleeting or non-fleeting, they would be identified as an increased risk contact due to the risk of aerosol clouds and lower particle dispersion.
3	Given the limited transmission risk of increased risk contacts identified using the TS-REF during rugby in outdoor environments,[4] a contact is now deemed increased risk if *'multiple'* 1 – 0 m, face to face, ≥3 sec interactions are observed. Multiple is defined as either *'intermittent'* encounters (i.e. 2 or more ≥3 secs) or *'sequential'* (i.e. ≥6 secs).
4	The ≥3 sec or more definition, as per the TS-REF remains the threshold for identifying increased risk contacts indoors, or during low ventilation outdoor interactions (e.g. rugby union scrum) due to the greater transmission risk due to lower ventilation and dispersion of expired droplets.
5	Due to the increased transmission risk indoors, an *'accumulation above 1 minute'* of close proximity interactions would result in an increased risk contact being identified, again due to the lower ventilation resulting in a reduced dispersion of expired droplets, accumulation of aerosol clouds and aerosol transportation in thermal plumes (i.e. the natural upward convective air currents that surround the human body).

Supplementary Table 2. A checklist for determining indoor and outdoor environmental spaces and key risk factors during training and matches, to support the identification of increased risk contacts using the Team Sport Risk Exposure Framework 2 (TS-REF-2).

Characteristics	Indoor	Outdoor
Volume	Low (e.g. indoor training area; 500 m^3)	High (e.g. indoor stadium; 1,500,000 m^3)
	If the volume of the space is greater, the concentration of viral particles accumulating in the air and inhaled over time is likely to be less.	
Roof or ceiling	Low (e.g. indoor warm up room at stadium with same ceiling height as normal room [2.6 m])	No / High (e.g. indoor barn; ceiling height 10 m)
	Many aerosol particles that are exhaled become entrained into thermal plumes that rise vertically above the heads of individuals. With (low) ceilings, aerosols tend to accumulate under the ceiling before slowly descending through the breathing zone due to gravitational deposition. Outdoors aerosols would be dispersed upward into the atmosphere.	
Air Velocity at Low Level	Low (e.g. windows / doors shut and no mechanical ventilation within indoor building)	High (e.g. windows, doors or side of marque open on multiple sides, creating high velocity airflow)
	Greater air velocities result in exhaled aerosol particles being dispersed more rapidly.	
Density of people (in enclosed) space	High (e.g. indoor training barn, with high number of people)	Low (e.g. indoor training barn, with low number of people)
	Large indoor sporting facilities (e.g. arenas) containing a high number of people, should be treated as being indoor spaces for COVID-19 risk assessment purposes. Leaving the building empty for a period of time to allow complete air-exchange may be advantageous. The specific risk based on room dimension, duration, ventilation and occupancy can be calculated (https://airborne.cam/).	
Carbon dioxide (CO_2)	High (>1000 ppm)	Low (<1000 ppm)
	It is not always easy to determine room ventilation rates, particularly where natural ventilation is employed. CO_2 monitoring can be used as a surrogate measure for ventilation. This can be done by ensuring that CO_2 levels are maintained below 1000 ppm.[9] If room CO_2 levels exceed this threshold, strategies to increase the ventilation rate should be adopted, thus any airborne viral particles are flushed from the room space.	
Environmental Conditions*	Warm and humid (e.g. > 18°C and >40% relative humidity; heated)	Cold and dry (e.g. < 18°C and <40% relative humidity; not heated)
	The SARS-CoV-2 virus remains viable in aerosols for longer when the air is cool and dry.[10,11] Under such circumstances, even though a room space may be heated, the air can be very dry <40% relative humidity, with the result that the viral load in any droplets inhaled may be greater than when humidity is greater.[11]	

Checklist for determining indoor and outdoor environmental spaces presented in grey shaded cells (volume, roof or ceiling, air velocity at low level). *Classification of environmental conditions on virus transmission is challenging. During the winter months the virus will persist for longer in aerosols outdoors than indoors (when the air is heated).

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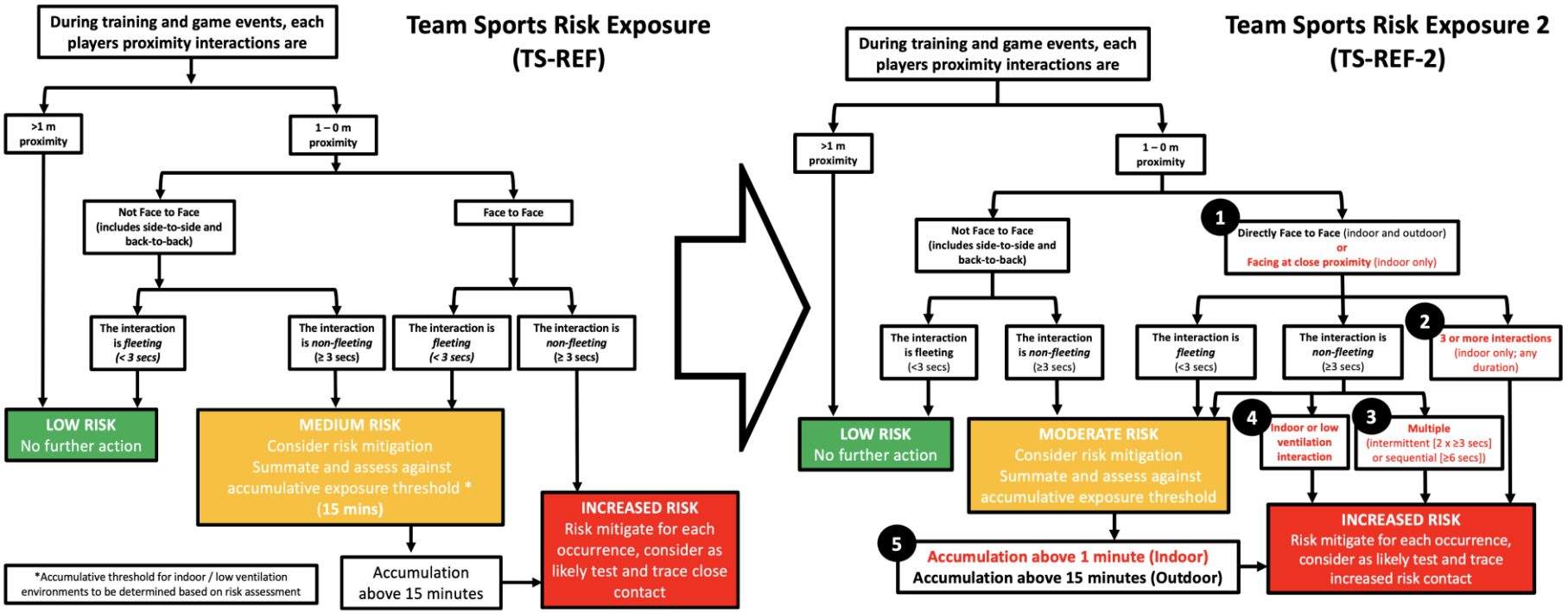

Supplementary Figure 1. Key differences between the Team Sports Risk Exposure Framework (TS-REF) and the Team Sports Risk Exposure Framework 2 (TS-REF-2), to identify increased risk sporting activities and support the identification of increased risk contacts during indoor and outdoor team sports.