SARS-CoV-2 transmission during rugby league matches: Do players become infected after participating with SARS-CoV-2 positive players?

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ABSTRACT

Objectives To examine the interactions between SARS-CoV-2 positive players and other players during rugby league matches and determine within-match SARS-CoV-2 transmission risk.

Methods Four Super League matches in which SARS-CoV-2 positive players were subsequently found to have participated were analysed. Players were identified as increased-risk contacts, and player interactions and proximities were analysed by video footage and Global Positioning System (GPS) data. The primary outcome was new positive cases of SARS-CoV-2 within 14 days of the match in increased-risk contacts and other players participating in the matches.

Results Out of 136 total participants, there were eight SARS-CoV-2 positive participants, 28 players identified as increased-risk contacts, and 100 other players in the matches. Increased-risk contacts and other players were involved in 11.4 ± 9.0 (maximum 32) and 4.0 ± 5.2 (maximum 23) tackles, respectively. From GPS data, increased-risk contacts and other players were within 2 m of SARS-CoV-2 positive players for 65.7 ± 137.7 (maximum 689) and 89.5 ± 169.4 (maximum 1003) seconds, on 10.4 ± 18.0 (maximum 88) and 12.5 ± 20.7 (maximum 121) occasions, respectively. Within 14 days of the match, one increased-risk contact and five players returned positive SARS-CoV-2 RT-PCR tests, and 27 increased-risk contacts and 95 other participants returned negative SARS-CoV-2 RT-PCR tests. Positive cases were most likely traced to social interactions, car sharing, and wider-community transmission and not linked to in-match transmission.

Conclusion Despite tackle involvements and close proximity interactions with SARS-CoV-2 positive players, in-match SARS-CoV-2 transmission was not confirmed. Whilst larger datasets are needed, these findings suggest rugby presents a lower risk of viral transmission than previously predicted.

What are the new findings?

- Based on four Super League rugby league matches in which eight SARS-CoV-2 positive players were subsequently found to have participated, the transmission risk of SARS-CoV-2 during outdoor team rugby appears low, despite a high number of close interactions.

- Match officials who refereed games involving SARS-CoV-2 positive players did not test positive for SARS-CoV-2 in the 14-day period after a match, suggesting a low risk of viral exposure.

How might it impact on clinical practice in the near future?

- The classification of rugby as a “high risk” sport for SARS-CoV-2 transmission should be re-evaluated.

- Within professional and community sport, contact tracing protocols might be adjusted to avoid the need to isolate all players exposed to SARS-CoV-2 during rugby.

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic caused team sports around the world to be postponed.[1] COVID-19 is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)[2] and transmitted from human-to-human by multiple means (i.e., respiratory droplets, aerosols, and fomites).[3,4] Even without considering the risk of crowds,[5] the close proximity of participants and increased respiration rate due to the demands of exercise[6] poses a potential risk for human-to-human transmission during team sports.

The implementation of 'Test and Trace' programmes reduces the risk of wider community spread.[7] If a participant of a team sport tests positive for SARS-CoV-2, close contacts with a high risk of exposure should isolate for 10-14 days.[8,9] The mental, physical, economic and societal impact of a 10-14 day isolation period should not be underestimated.[10–12] Therefore, contact tracing should be precise to limit the potential adverse effects of unnecessary isolation. The return of community sport requires protocols regarding who needs to isolate, should a participant test positive for SARS-CoV-2. Whilst the development of these protocols should aim to minimise community transmission, limited data are available from the sports community to formulate evidence-based recommendations.

Rugby league includes repeated contacts (e.g., tackles)[13] and close proximity interactions between players, similar to other rugby and football codes.[14] The repeated close contact interactions between participants during a match represent theoretical opportunities for transmission of SARS-CoV-2, via droplets, aerosols and fomites.[3]

Super League restarted with a number of risk mitigation factors implemented.[15] These included rule modifications (e.g., removal of scrum), routine weekly reverse transcriptase polymerase chain reaction (RT-PCR) screening for the presence of SARS-CoV-2,[16] daily self-reporting of potential COVID-19 symptoms, and other policies relating to the biosafety of training and match venues.[17]

Since the start of the Super League, a number of players have tested positive for SARS-CoV-2 following a match. Consequently, *'Increased-risk contacts'* have been identified using predetermined criteria.[15] Thus, rugby league provides an opportunity to understand the risk of SARS-CoV-2 transmission which may help to inform test and trace activities in rugby and possibly other outdoor contact sports. This study aims to i) evaluate the interactions of players who tested positive for SARS-CoV-2 with other players, and ii) determine within-match SARS-CoV-2 transmission risk by examining the testing and monitoring of identified close contacts.

METHODS

Study Overview and Ethics

Rugby league matches returned on the 2nd August 2020 following the COVID-19 enforced shutdown. Participants were male professional rugby league players. Thirty-six matches were played during this observational period (1st July [start of RT-PCR screening] to 4th October 2020). Each match directly involves 34 players (17 on each team; 13 starting and 4 as interchange), one on-field match official and two touch judges. All participants were within a ≤7-day RT-PCR screening cycle and returned a negative test within the seven days prior to the match. Players subsequently testing positive for SARS-CoV-2 were deemed at risk of shedding infectious virus during a match when the symptom onset or the test occurred within 48 hours of a match. Ethics approval (Reference; 73648) was obtained from Leeds Beckett University ethics committee.

Identification of COVID-19 Positive Players

Players undertook weekly SARS-CoV-2 RT-PCR testing and daily COVID-19 symptom monitoring. Swabs were taken from the nasopharynx and oropharynx by trained health care professionals and RT-PCR conducted by nationally accredited laboratories. Target genes were N, S, and ORF1ab. If a player returned a positive test, their respective cycle threshold (Ct) values (where available) for each gene (N, S, and ORF1ab) and clinical presentations were reviewed by an independent consultant virologist to ensure this was a *'true positive'*. Players' symptoms were monitored by their team physician. The monitoring covered all typical COVID-19 symptoms (e.g., cough, fever, smell and taste disturbances, difficulties breathing).[18]

Identification of Increased-Risk Contacts

If a player returned a positive SARS-CoV-2 screening test or developed symptoms consistent with COVID-19 within 48 hours of a match and had a subsequent positive SARS-CoV-2 test, it was presumed the player was potentially shedding infectious virus during the match[19] and increased-risk contacts were then identified.[15] This included players on the same and opposing team.

Increased-risk contacts were defined based on definitions agreed upon by experts in public health and sports medicine.[15] Between kick-off and full-time, any player from the match who was within 1 m, face-to-face for ≥3 secs was deemed an increased-risk contact and consequently required to isolate for 14 days in accordance with Public Health England guidance at that time. This definition was used as other broader public health definitions (e.g., <2 m for >15 min,[20]) were not deemed to capture the face-to-face and fleeting encounters that occur during team contact and collision sports.

Match statistics for SARS-CoV-2 positive players (tackle involvements, as either a ball carrier [i.e., attacker] or tackler [i.e., defender]) were provided by a commercial match statistics provider (Opta, Leeds, United Kingdom) who analysed the match video footage. Video footage of the match was then analysed by an experienced performance analyst to identify tackles involving SARS-CoV-2 positive players. Tackles and ball-carries were reviewed numerous times in slow motion to determine which tackles involved a <1 m, face-to-face interaction for ≥3 secs with another player. Any interactions that were thought to be '*possible*' increased-risk contacts were included. Clips were then reviewed by a second reviewer (BJ) to confirm or reject the identified increased-risk contacts. A number of increased-risk contacts were rejected, but both reviewers discussed until agreement was reached on the classification of each interaction.

Identification of Tackle Involvements and Player Proximity

To determine the total number of tackle involvements (i.e., in addition and inclusive of increased-risk contact tackles), a matrix was produced using the match statistics to determine how many times SARS-CoV-2 positive players were involved in tackles with

other players (opposition and same team, as some tackles involve more than one defender).

Super League operates a league-wide microtechnology project, whereby all teams are supplied with the same devices (Optimeye S5, Catapult Sports, Melbourne, Australia).[21] When both teams wore microtechnology devices (matches 1, 3 and 4), raw longitude and latitude global positioning system (GPS) data were analysed to determine the number of occasions and the duration of time SARS-CoV-2 positive players were ≤2 m of other players.[22] Different dwell times (i.e., duration of encounters; 1, 3, 5, 7, 10, 15, 20 and 30 secs, respectively) were used to calculate the number of occasions and the duration of time within ≤2 m, and to establish the nature of these interactions. The validity of the GPS for determining player proximity interaction is ± 1 m.[22] One team did not wear their microtechnology units during match-play, thus player proximity for that team was not determined for match 2.

RESULTS

Of the 36 rugby league matches, there were four matches in which eight players (CoV1-CoV8) from four teams subsequently tested positive for SARS-CoV-2 either during routine RT-PCR screening or following the development of symptoms within 48 hours of a match. Consequently, contact tracing was carried out on four Super League matches, identifying 28 players (C1-C28) as increased-risk contacts that were required to isolate for 14 days from exposure. Positive cases and identified increased-risk contacts varied: 5 positive cases and 12 increased-risk contacts (match 1), 1 positive case and 3 increased-risk contacts (match 2), 1 positive case and 9 increased-risk contacts (match 3), and 1 positive case and 4 increased-risk contacts (match 4).

SARS-CoV-2 Positive Player Test Characteristics and Symptoms

The positive RT-PCR test characteristics (where available) and the timing of development of symptoms in relation to the match are shown in Figure 1. Players developed COVID-19 symptoms prior to (reported to the team physician; *n* = 2; CoV6, CoV8), on the day of (*n* = 3; CoV4, CoV5, CoV7) or following (*n* = 2; CoV1, CoV3) their positive SARS-CoV-2 RT-PCR test. One player did not develop COVID-19 symptoms (CoV2). All Ct values collected were <30 consistent with a higher viral load and risk of transmission.

Interaction between SARS-CoV-2 Positive Players and Other Players during a Match

The SARS-CoV-2 positive players (CoV1-CoV8) and their interactions with other players during the match are shown in Figures 2 and 3.

Identified increased-risk contact tackles (i.e., <1 m, face-to-face for ≥3 secs) were observed between CoV1 and C1, C6, C9, C12 (match 1); CoV2 and C2 (match 1); CoV3 and C6, C8 (match 1); CoV4 and C4, C11 (match 1); CoV5 and C3-C5, C7, C10, C11 (match 1); CoV6 and C13-C15 (match 2); CoV7 and C16-C24 (match 3); CoV8 and C25-C28 (match 4). No player had multiple increased-risk contact tackles with the same player.

Based on the match statistics, increased-risk contacts (C1-C28) and other players were involved in 11.4 ± 9.0 (range 0 – 32) and 4.0 ± 5.2 (range 0 – 23) tackles with SARS-CoV-2 positive players, respectively (Figure 2A, 3A, 3B, 3E). Based on the GPS data analysis, increased-risk contacts (C1-C28) and other players were within 2 m for ≥3 secs with SARS-CoV-2 positive players on 10.4 ± 18.0 (range 0 – 88) and 12.5 ± 20.7 (range 0 – 121) occasions (Figure 2C, 3D, 3G). These interactions within 2 m for ≥3 secs with SARS-CoV-2 positive players totalled 65.7 ± 137.7 (range 0 – 689) seconds for increased-risk contacts (C1-C28) and 89.5 ± 169.4 (range 0 – 1003) seconds for other players (Figure 2B, 3C, 3F).

Figure 4A and 4B shows the cumulative duration of time and number interactions between SARS-CoV-2 players (CoV1-CoV5, CoV7-CoV8) and identified increased-risk contacts (C1-12, C16-C20, C22, C24-C28), for different dwell times (1, 3, 5, 7, 10, 15, 20 and 30 secs, respectively), based on the GPS data analysis. Interactions were typically <5 secs. Sixty-three percent of all interactions were <3 secs. CoV1, CoV2, CoV3, CoV7 and CoV8 all had an interaction with an increased-risk contact for ≥20 secs (Figure 4B).

Testing and Symptom Monitoring of Increased-Risk Contacts

During the 14-day isolation period, increased-risk contacts completed their normal daily self-report screen of potential COVID-19 symptoms and had 1–4 SARS-CoV-2

RT-PCR tests. Increased-risk contacts also had SARS-CoV-2 RT-PCR tests on day 16 or 17 (Figure 5).

During this period of observation, C1 tested positive for SARS-CoV-2 on day 6 of isolation, whereas all other increased-risk contacts (C2-C28) returned negative SARS-CoV-2 RT-PCR tests. Out of the other 100 players participating in the matches with SARS-CoV-2 positive players, five players returned positive SARS-CoV-2 RT-PCR screening results and 95 players returned negative SARS-CoV-2 RT-PCR screening results over the 14 days following the matches (Table 1).

All new cases of SARS-CoV-2 were closely reviewed to assess the potential transmission routes. SARS-CoV-2 positive cases for C1 and P10 (match 1) were part of a larger COVID-19 'outbreak' in the club in which 12 individuals (9 players and 3 staff) tested positive for SARS-CoV-2 within 5 days of match 1. Five of the 9 players did not participate in the match. Players C1 and P10 both reported close contacts outside of training and match 1, including car sharing and social interactions with SARS-CoV-2 positive players within the club environment (Table 1). C1 had the greatest duration and number of close proximity interactions with SARS-CoV-2 positive players during the match in comparison to other identified contacts, whereas P10 was involved in only 1 tackle with a SARS-CoV-2 positive player (CoV1) during the match (Figure 2A). For player C1, whilst match transmission cannot be completely excluded, details of non-match interactions suggests transmission was not related to rugby activities.

P10 and P15 (match 2) were also considered to be part of a COVID-19 outbreak within their club environment (Table 1). In total 6 players (3 players did not play in match 2) tested positive for SARS-CoV-2 at this club within 5 days of match 2. P29 (match 2) was considered to be wider-community transmission, due to the reporting of a community close contact (i.e., social interaction with an individual who tested positive for SARS-CoV-2). P29 also returned a negative SARS-CoV-2 RT-PCR screening test between match 2 and returning a positive SARS-CoV-2 RT-PCR screening test. P17 (match 3) provided no clear explanation for transmission, although lived in an area of high COVID-19 prevalence, and thus was considered to be linked to wider-community transmission.

DISCUSSION

Professional and community team sports have returned during the COVID-19 pandemic, although transmission during these activities is relatively unknown. For the first time, this study presents detailed player-to-player interactions through video analysis and GPS data of eight players who participated in rugby league matches whilst infectious with SARS-CoV-2. Twenty-eight players were identified as increased-risk contacts due to their interactions with SARS-CoV-2 positive players and were required to isolate. Players identified as increased-risk contacts were involved in 11.4 ± 9.0 (range 0 – 32) tackles and were within 2 m of SARS-CoV-2 positive players for 65.7 ± 137.7 (range 0 – 689) seconds. Twenty-seven identified increased-risk contacts returned negative, and one identified increased-risk contact returned a positive RT-PCR SARS-CoV-2 test during their isolation period. Of the other 100 players involved in the matches, in the following 14 days, five returned positive and 95 returned negative RT-PCR SARS-CoV-2 tests during their routine screening. All positive RT-PCR SARS-CoV-2 tests (both in identified increased-risk contacts and other players) were deemed to be due to internal club COVID-19 outbreaks, social interactions, and wider-community transmission, and not linked to in-match transmission. Despite the frequent interactions between SARS-CoV-2 positive players and other players, these data suggest that SARS-CoV-2 transmission is limited during rugby league matches.

Identified increased-risk contacts

The one identified increased-risk contact (C1) who tested positive for SARS-CoV-2 was likely exposed to the virus within the club environment as opposed to the match. This player reported a close contact non-rugby interaction with one of the SARS-CoV-2 positive players from the match, which took place the day after the match (Table 1). Furthermore, other players who did not play in the match and staff from the same club also tested positive at the same time. The transmission appears beyond the field-based training activity, since staff members also tested positive for SARS-CoV-2. During the match, C1 was involved in 30 tackles and accumulated a high duration of close proximity (689 seconds) with all SARS-CoV-2 positive players during match 1 (Table 1, Figure 2B). In the same match, increased-risk contact C3 accumulated a higher number of tackles with SARS-CoV-2 positive players (Figure 3A; 32 tackles), and another player had a greater duration and number of close proximity interactions

(P9, Figure 3B; 1003 seconds, Figure 3C; 121) than C1. Both C2 and P9 returned negative SARS-CoV-2 tests in the 14-days following the match. Furthermore, C4, C6 and C11 had two increased-risk interactions with SARS-CoV-2 positive players (C4 with CoV4 and CoV5, C6 with CoV1 and CoV3, C11 with CoV4 and CoV5). None of these players (C4, C6, C11) tested positive for SARS-CoV-2 in the 14-day period following the match. This analysis therefore supports that viral transmission for C1 was likely not from the match, although this possibility cannot be entirely excluded.

If the tackle was the mechanism of SARS-CoV-2 transmission for C1, other players would have also theoretically tested positive for SARS-CoV-2, given the accumulated high number of tackles with SARS-CoV-2 positive players (CoV1-CoV5) in match 1 (Figure 3A) and individual tackles with CoV7 in match 3 (i.e., CoV7 was involved in 10-14 tackles with C18, C19, C21, P7, P8, P11; Figure 3A). None of these players tested positive for SARS-CoV-2 in the 14-days following the match. Therefore, there appears to be limited transmission of SARS-CoV-2 during a tackle, even when directly face-to-face, as per the increased-risk contact tracing framework.[15] The limited transmission may be due to the good ventilation of an outdoor environment or minimal 'prolonged' face-to-face interactions during the match.

P17 tested positive for SARS-CoV-2 following match 3, although was not identified as an increased-risk contact and was involved in only one tackle and was within 2 m for only 3.8 secs with CoV8 (Figure 3B and 3C). The match is unlikely to be the cause of transmission, given the greater interactions between SARS-CoV-2 positive and other players who did not subsequently test positive within 14 days. Of note, the players not identified as increased-risk contacts in the match were within 2 m of SARS-CoV-2 positive players for more time and more often (89.5 ± 169.4 vs. 65.7 ± 137.7 secs and 12.5 ± 20.7 vs. 10.4 ± 18.0 occasions) than increased-risk contacts. Therefore, this cohort of players were still theoretically exposed to high transmission risk situations, and no within-match transmission was observed. A greater number of increased-risk contacts were with the opposing team (i.e., more likely to result in a face-to-face tackle), whereas players on the same team were within closer proximity of each other.

Other observations

All match officials returned negative SARS-CoV-2 RT-PCR screening tests, after officiating matches with positive SARS-CoV-2 players. Rugby league appears to be more fleeting than first thought, given the limited number of tackles classified as increased-risk during a match (4.0 ± 1.4% of all tackles for SARS-CoV-2 players). Furthermore, it appears that the ball is low risk to facilitate virus transmission given that SARS-CoV-2 players frequently touched the ball.

The strategy used to identify increased-risk contacts results in players requiring to isolate and has implications for community team sport 'Test and Trace' policies and a player's ability to go to work or school. As such, participants who exceed the interactions observed in this study may be at risk of transmission, but based on the observations in this study, the transmission risk of rugby league does appear low, which may also apply to similar outdoor team sports.

Study limitations

This study is limited by the small sample, and increased-risk contact tracing and player interactions are limited to only match play (kick off to full time). However, the low Ct values strongly supports that players were shedding infectious virus during match play and had a high number of human-to-human interactions (confirmed by video analysis and GPS data), but without confirmed transmission.

Reported player interaction data during the match provides only a snapshot of the number of interactions that likely took place between SARS-CoV-2 positive players and others. Players on the same team as SARS-CoV-2 positive players may have arrived and departed on a team coach, were in changing rooms pre-, half-time and post-match, and took part in a team warm-up. Social distancing during non-rugby activity (e.g., changing rooms, bus travel) was advised by the governing body but its compliance was beyond the scope of this study. Nevertheless, these findings indicate limited transmission during matches in team sports.

Given the outbreaks observed within two clubs, an assessment of player interactions during rugby training activities would have been valuable if similar video and GPS data was available. This study also would have been strengthened with the application of genomic epidemiology, to further understand and confirm player-to-player

transmission. The limited to absent within-match transmission observed in this study supports that the risk of transmission was during rugby activities is low. Given the number of positive SARS-CoV-2 cases observed, it appears that SARS-CoV-2 transmission amongst players is greater from non-rugby activities such as social interactions and car sharing. Indoor activities associated with team sports (e.g., gym, clubhouse, changing rooms), whereby airflow is lower than outdoors, and fomite transmission is greater, may pose a greater risk than field-based sporting activity *per se*. However, these scenarios were not investigated and delineated in this study. Furthermore, the risks of virus transmission during off-field behaviours (conversations and socialising) warrants investigation, and general public health interventions (physical distancing and mask wearing) should remain a priority for elite and community team sports.[23]

Conclusion

Based on four rugby league matches, where 128 players were exposed to eight SARS-CoV-2 positive players, limited transmission was observed during the match. Positive SARS-CoV-2 observations were linked to internal club COVID-19 outbreaks or wider-community close contact transmission. Furthermore, there was no observed transmission to match officials involved in the matches. Given the return of community team sports during the COVID-19 pandemic, determining the transmission risk during sports is a priority to balance potential human-to-human viral transmission against the wider physical and mental health benefits of sports participation. An accurate assessment of transmission risk during sport also will inform management recommendations for close contacts and prevent unnecessary isolation. These data provide reassurances that the transmission risk during a rugby match is likely to be very low. Further analysis of other close-contact sport settings and exploration of transmission risk in the training environment should be undertaken to better understand the risk of SARS-CoV-2 transmission during sport.

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Table 1. Clinical and Transmission Characteristics in New Positive SARS-CoV-2 Cases

Match	Player ID	Positive SARS-CoV-2 RT-PCR screening test returned (*COVID-19 symptom onset*)	Interactions with SARS-CoV-2 players (i.e., CoV1-CoV8)			Clinical Rationale for Probable Transmission
			Tackles (*n*)	Duration of time within 2 m (secs)	Number of times within 2 m (*n*)	
1	C1	5 days after match (*4 days after match*)	30 (6.0 ± 4.0; 1 – 11)	689.0 (137.8 ± 83.6; 32.7 – 259.9)	88 (17.6 ± 9.5; 5 – 31)	Team experienced a COVID-19 outbreak resulting in a total of 12 individuals testing positive for SARS-CoV-2 within 5 days of match 1. Five individuals did not participate in the match. Both C1 and P10 reported being a close social contact of other SARS-CoV-2 positive players outside of the match.
1	P10	4 days after match (*4 days after match*)	1 (0.2 ± 0.4; 0 – 1)	112.2 (44.1 ± 27.4; 0.0 – 75.2)	14 (6.0 ± 4.6; 0 – 13)	
2	P10	5 days after match (*5 days after match*)	0	-	-	Team experienced a COVID-19 outbreak resulting in 6 individuals testing positive for SARS-CoV-2 within 5 days of match 2. Three individuals did not participate in the match.
2	P15	3 days after match (*No symptoms developed*)	2	-	-	
2	P29	9 days after match (*9 days after match*)	1	-	-	Reported a community close contact with SARS-CoV-2 individual via social (non-sporting) interaction.
3	P17	3 days after match (*No symptoms developed*)	1	3.8	1	No clear explanation. Potential community transmission given high prevalence in area.

Where multiple positive SARS-CoV-2 players participated within a match, interactions reported as sum of all interactions with positive SARS-CoV-2 players (mean ± standard deviation; minimum and maximum). Duration and number of times within 2 m of SARS-CoV-2 players (i.e., CoV1-CoV8) calculated from ≥3 secs interactions.

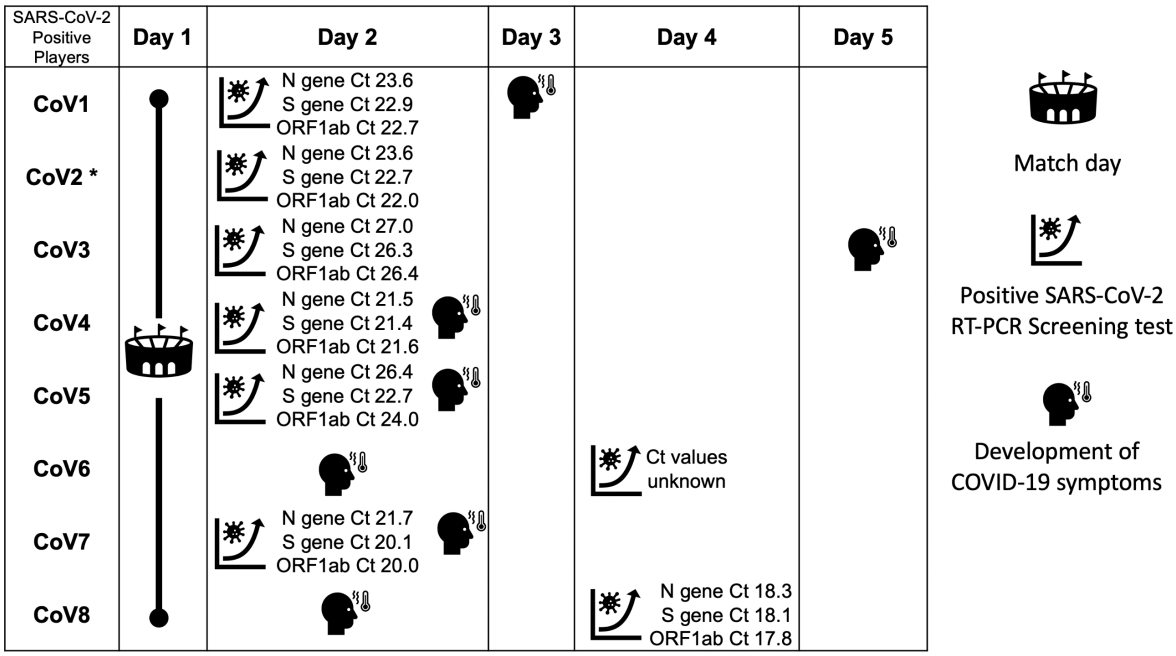

Figure 1. Time course of positive test, test characteristics and development of symptoms for SARS-CoV-2 positive players.

*CoV2 did not develop symptoms. Positive SARS-CoV2 RT-PCR screening depicted on day of test, not day of result.

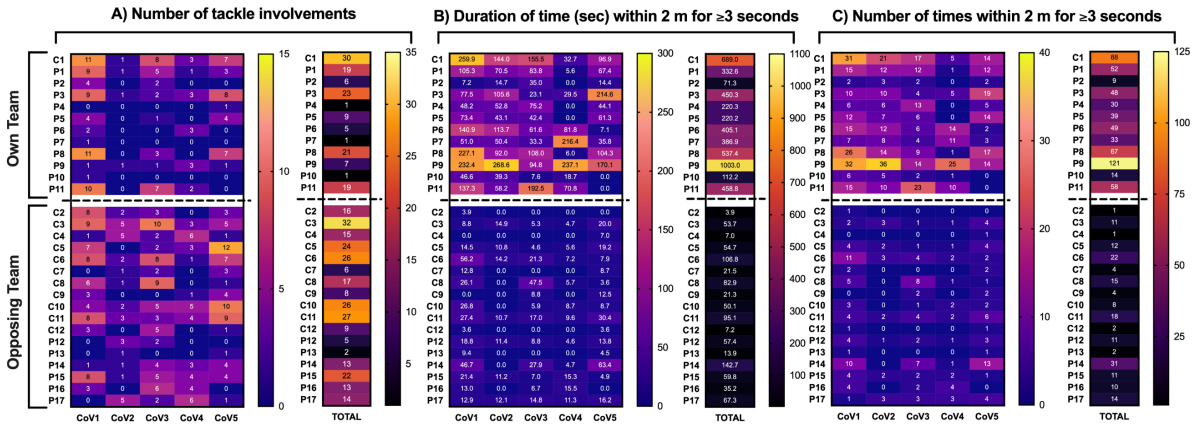

Figure 2. Number of tackle involvements and close proximity (<2 m) interactions identified in increased-risk contacts and other players with SARS-CoV-2 positive players during rugby league match 1.

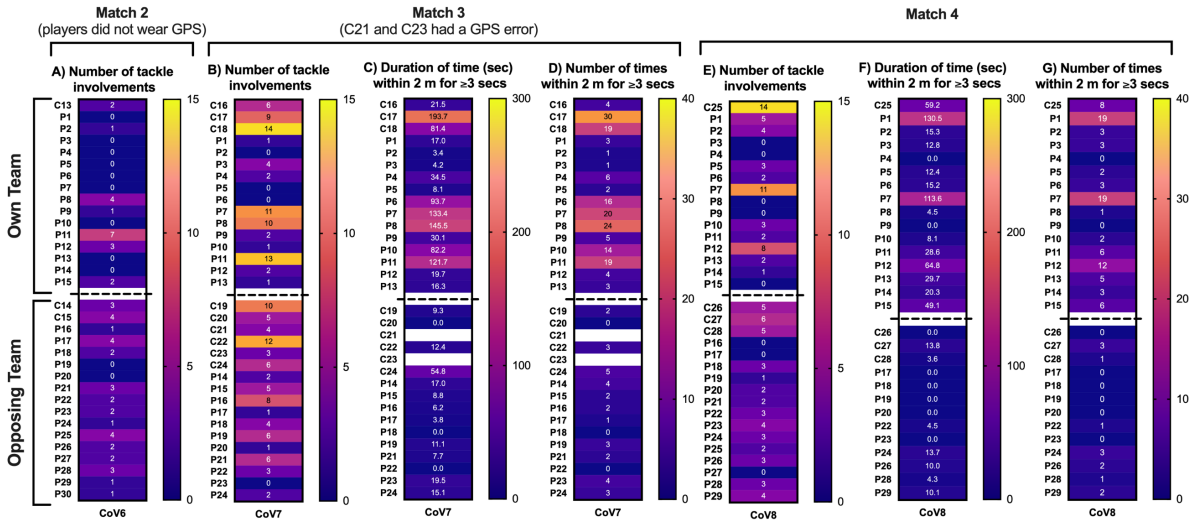

Figure 3. Number of tackle involvements and close proximity (<2 m) interactions identified in increased-risk contacts and other players with SARS-CoV-2 positive players during rugby league matches 2, 3 and 4.

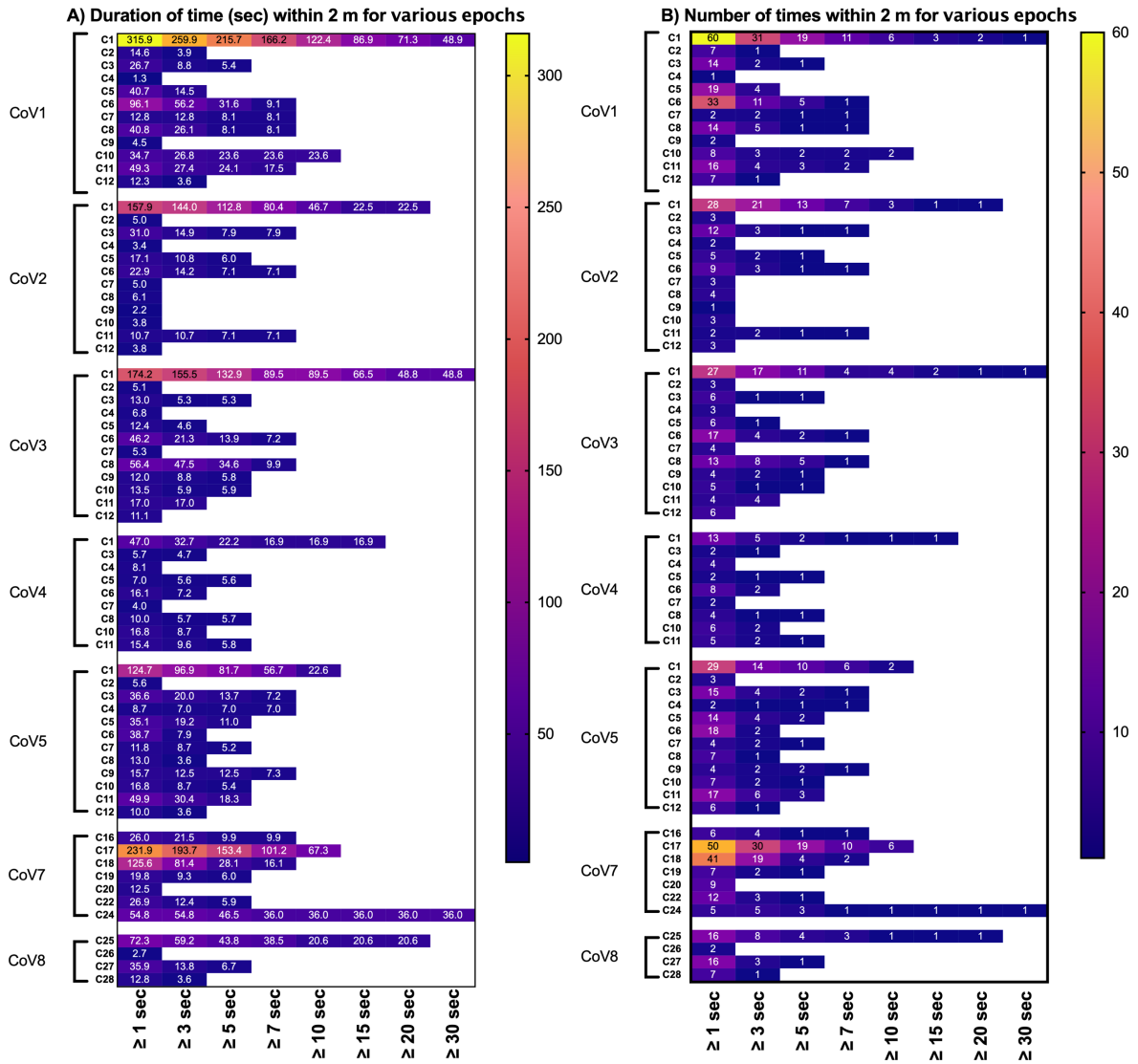

Figure 4. Duration (A) and number (B) of close proximity (<2m) interactions between SARS-CoV-2 positive players and identified increased-risk contacts, for various durations of time.

*C21 and C23 had a GPS unit error therefore data are not included.

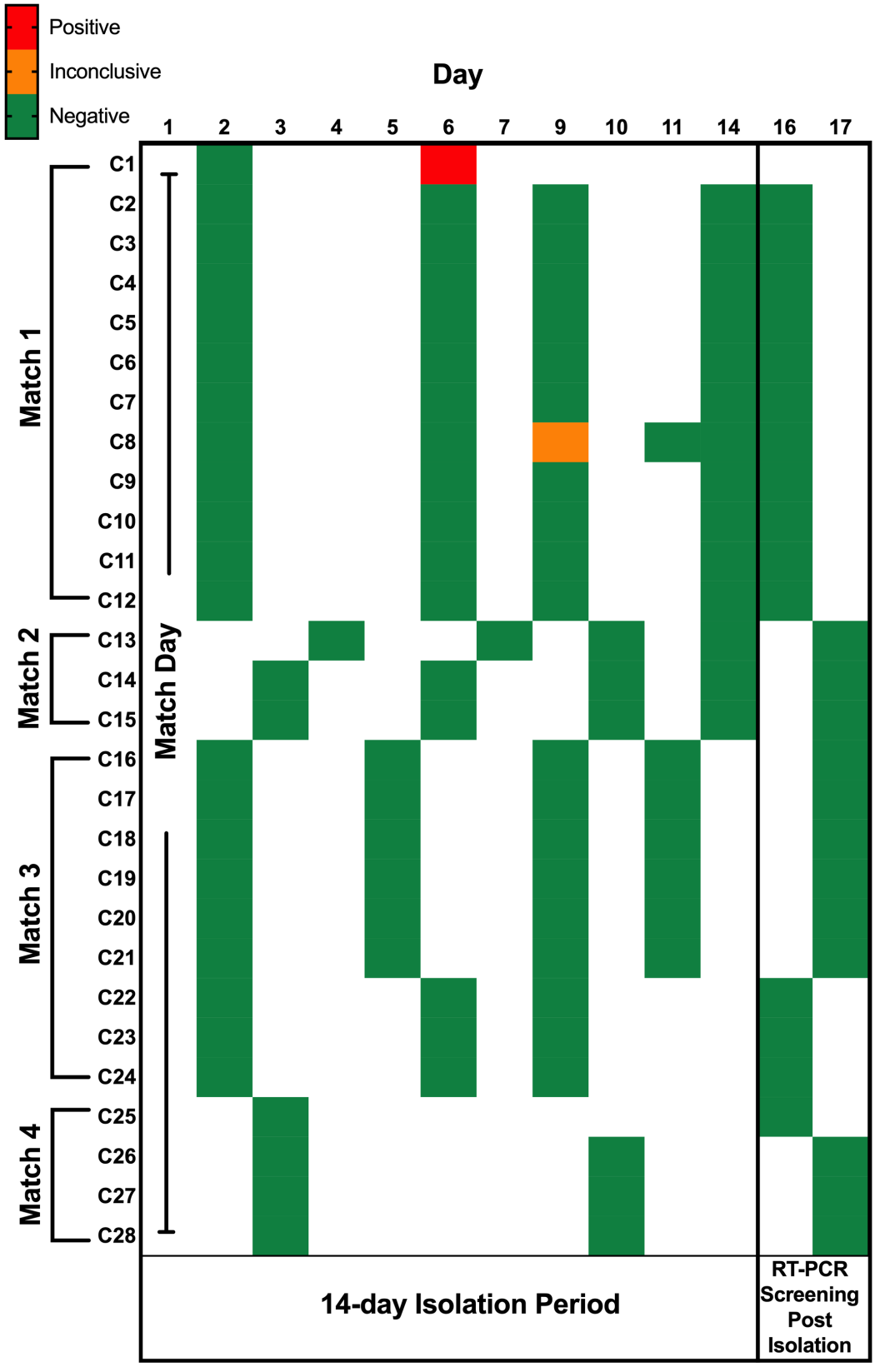

Figure 5. Time course of RT-PCR testing for increased-risk contacts following a match with SARS-CoV-2 positive players.