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Original Article

# Incidence of respiratory infections and SARS-CoV-2 is higher during contact phases in student rugby players – Lessons learnt from COVID-19 risk mitigation strategies–AWARE V

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ABSTRACT

The incidence of acute respiratory infections (ARinf), including SARS-CoV-2, in unvaccinated student rugby players during phases from complete lockdown during the COVID-19 pandemic to returning to competition is unknown. The aim of the study was to determine the incidence of ARinf (including SARS-CoV-2) during non-contact and contact phases during the COVID-19 pandemic to evaluate risk mitigation strategies. In this retrospective cohort study, 319 top tier rugby players from 17 universities completed an online questionnaire. ARinf was reported during 4 phases over 14 months (April 2020–May 2021): phase 1 (individual training), phase 2 (non-contact team training), phase 3 (contact team training) and phase 4 (competition). Incidence (per 1 000 player days) and Incidence Ratio (IR) for 'All ARinf', and subgroups (SARS-CoV-2; 'Other ARinf') are reported. Selected factors associated with ARinf were also explored. The incidence of 'All ARinf' (0.31) was significantly higher for SARS-CoV-2 (0.23) vs. 'Other ARinf' (0.08) ($p < 0.01$). The incidence of 'All ARinf' (IR = 3.6; $p < 0.01$) and SARS-CoV-2 (IR = 4.2; $p < 0.01$) infection was significantly higher during contact (phases 3 + 4) compared with non-contact (phases 1 + 2). Demographics, level of sport, co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits were not associated with ARinf incidence. In student rugby, contact phases are associated with a 3–4 times higher incidence of ARinf/SARS-CoV-2 compared to non-contact phases. Infection risk mitigation strategies in the contact sport setting are important. Data from this study serve as a platform to which future research on incidence of ARinf in athletes within contact team sports, can be compared.

## 1. Introduction

In most countries, including South Africa, sports were suspended in the early phases of the COVID-19 pandemic, with a gradual return to training and competition over months as public health and specific sporting code regulations and risk mitigation changed. With the re-opening of team sport, the impact of re-introducing training or competitions on the spread of SARS-CoV-2 among players was unclear.

The incidence of SARS-CoV-2 in athletic populations during the early period after sport commenced, has only been reported in a few studies, such as in elite football[1–4] and only during specified times of tournaments and competitions[3] or during a football season.[1] Most of these studies were conducted under specified conditions, i.e. team followed specific protocols to mitigate risks of infection,[4] specific testing regimes,[1,3,4] or during a period of preparing and competing in tournaments.[3,4] These studies reported the illnesses over a specified time as a percentage. The difference in the reporting of the results and the study periods, makes true comparisons between data difficult. In order to enhance the comparability of results, a consensus statement by the International

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**Abbreviations**

| | |
|---|---|
| ARinf | Acute respiratory infections |
| AWARE | Athletes With Acute Respiratory InfEctions |
| BMI | Body mass index |
| C | Competition |
| CT | Contact team training |
| IOC | International Olympic Committee |
| IR | Incidence ratio |
| ISEM | Institute of Sport and Exercise Medicine |
| IT | Individual training |
| NCT | Non-contact team training |
| PCR | Polymerase chain reaction |
| REDCap | Research Electronic Data Capture |
| SARS-CoV-2 | Severe Acute Respiratory Syndrome Coronavirus 2 |
| *SD* | Standard deviation |
| SEMLI | Sport, Exercise Medicine and Lifestyle Institute |

Olympic Committee (IOC) Consensus group on the reporting of injuries and illnesses in athletes,[5] suggested the number of illnesses to be reported as incidence per 1 000 player days.

Data on the incidence of SARS-CoV-2 in rugby are limited. In two studies, transmission of SARS-CoV-2 in professional rugby players during periods of return to training or competition following lockdown was reported.[6,7] However, the incidence of acute respiratory infections (ARinf), including SARS-CoV-2 infection, in student rugby players during different risk mitigation strategies in various phases from complete lockdown to return to full competition is not known. Risk factors associated with ARinf in this group of athletes have not been reported.

The primary aim of the study was to determine the incidence (per 1 000 player days) of acute respiratory infection (ARinf), including SARS-CoV-2, in student rugby players as restriction measurements eased and they returned to competitive sport following complete lockdown during the COVID-19 pandemic. Due to the phased roll out of COVID-19 vaccines, these players were unvaccinated against SARS-CoV-2. An additional aim was to determine if selected factors (demographics, level of sport participation, history of co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits) were associated with ARinf, including SARS-CoV-2, in this cohort of rugby players. This study's findings on the incidence of respiratory infections during particularly contact phases, can have practical implications with respect to risk mitigation strategies in order to prevent the spread of infection within contact sports.

## 2. Method

This study is part of the **A**thletes **W**ith **A**cute **R**espiratory Inf**E**ctions (AWARE) studies, a multi-centre research program conducted by the Sport, Exercise Medicine and Lifestyle Institute (SEMLI) at the University of Pretoria, South Africa, in collaboration with the Institute of Sport and Exercise Medicine (ISEM) at the University of Stellenbosch, and student rugby in South Africa (Varsity Cup and Varsity Shield). The study was conducted according to the ethical guidelines as described in the Declaration of Helsinki.[8] All players consented to the study and ethical clearance was obtained from the Research Ethics Committee of the Faculty of Health Sciences at the University of Pretoria for the AWARE umbrella protocol (REC 409/2020) and this specific study (REC 751/2019) in 2020 and 2019 respectively.

### *2.1. Study design*

This was a retrospective cohort study.

### *2.2. Participants*

Participants were male student rugby players from top (first and second) tier university rugby teams competing in an annual tournament in South Africa (April and May 2021). Managers of these rugby teams were contacted with study information. 17 Universities consented to partake in the study. Recruitment of participants was done during the tournament. Practice contact ('friendly') matches were played by some teams during March 2021. The COVID-19 vaccine was distributed in a phased roll-out from February 2021, and due to the young age of this population, no player was eligible to receive this vaccine during the study period.

### *2.3. Study period and phases of return to competitive sport during the COVID-19 pandemic*

The study period was from April 2020 to May 2021 (14 months). National lockdown measures (restrictions on social interactions, movement of people, trade etc.) commenced in South Africa on March 26, 2020. Rugby players had to comply with both public health restrictions placed by the national government, and restrictions directed by the sports federation (i.e. national rugby governing body). There were four phases from the time of total lockdown restrictions, to return to full competitive sport during the 14-month period. Phases 1 and 2 were characterised by non-contact between players, while phases 3 and 4 allowed full physical contact between players in the team setting. Each team commenced phase 2, 3 and 4 at different time points during the study period, dependant on local university regulations and readiness to open the campuses for access. The phases for each team are described in Table 1.

The definitions for the 4 phases were as follows.

*Phase 1:* Individual training (IT): players were confined to their homes, thereafter, exercise outside their homes was permitted
*Phase 2:* Non-contact team training (NCT): characterised by a gradual decrease in restrictions with opening of university campuses and training facilities where players were allowed to train as a team. Team training included an initial mandatory non-contact training period of 4 weeks to mitigate risk of injury
*Phase 3:* Contact team training (CT): contact training within individual teams was allowed
*Phase 4:* Competition (C): teams from different universities participated in full contact matches. This started with practice contact ('friendly matches') for some teams in March 2021 followed by the tournaments during April and May 2021

### *2.4. Risk mitigation strategies by government and national sport federations during COVID-19 pandemic*

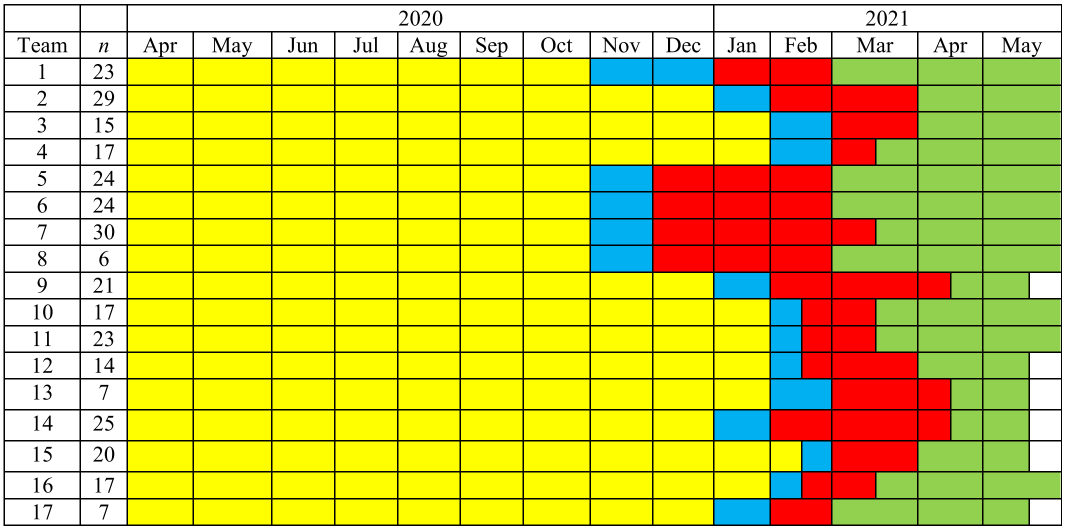
During the COVID-19 pandemic, the South African Government implemented regulations for the public to prevent the spread of SARS-CoV-2. Sport federations had to comply with these rules, but these were not always possible in the sports environment. For example, facial mask wearing and social distancing were not practical during contact training and competition. Risk mitigation strategies implemented by national government and the sport federations were applicable throughout the study period and are outlined in Table 2.

The implementation of these risk mitigation strategies and ARinf testing regimes for each team, were not evaluated in this study.

### *2.5. Data collection*

The main data collection tool consisted of two electronic questionnaires hosted on the Research Electronic Data Capture (REDCap) platform.[9,10] Both questionnaires were distributed to the players at the beginning of the tournaments (April 2021). Players were asked to

**Table 1**
Timelines for the different phases in the study period for each team.




Yellow: Individual training
Blue: Non-contact team training
Red: Contact team training
Green: Competition
n, Number of players in a team

consider the previous 12-month period when answering the questions, which implied that the data were collected retrospectively. The first questionnaire contained sections on demographics (age, height and weight), level of sport participation (professional or amateur), history of any co-morbidities (cardiovascular, respiratory, gastrointestinal, central nervous system, metabolic, immune/blood disorders, renal or cancer), allergies, vaccination (influenza), injuries (acute and chronic) and lifestyle habits (smoking and alcohol consumption). The second questionnaire required the participant to indicate if: 1) *'they experienced symptoms of an acute respiratory infection, including SARS-CoV-2',* or 2) *'had current symptoms of acute respiratory infection, or SARS-CoV-2',* or 3) *'had no symptoms but tested positive for SARS-CoV-2'* or 4) *'had no symptoms of acute respiratory infection',* in the past 12 months. Players reporting current acute symptoms ($n = 3$) during the time of the questionnaire, were excluded from the analysis. Participants were included if: 1) they reported no symptoms of ARinf, 2) they had symptoms of ARinf (with/or without confirmation of causative pathogen), 3) symptoms of SARS-CoV-2, 4) or asymptomatic with confirmed SARS-CoV-2 in the past 12 months.

**Table 2**
Preventative measures from government and sport federations to limit SARS-CoV-2.

| Preventative measures | Phase 1 | Phase 2 | Phase 3 | Phase 4 |
|---|---|---|---|---|
| **National public health policy** | | | | |
| Mandatory mask wearing in public places | + | + | + | + |
| Mandatory social distancing | + | + | + | + |
| Hand sanitiser use | + | + | + | + |
| Curfews | + | + | + | + |
| Restriction on number of persons at gatherings | + | + | + | + |
| Spectators (local sport events) | – | – | – | – |
| **Sport federations policy** | | | | |
| Mask wearing in public places and when not training/competing | + | + | + | + |
| Mask wearing during exercise | + | – | – | – |
| Hand sanitiser use | + | + | + | + |
| Sanitising of sports equipment | + | + | + | + |
| Mandatory SARS-CoV-2 testing (from March 2021) | – | – | – | + |

+Preventative measure was mostly implemented.
-Preventative measure was not always implemented.

### 2.6. Sub-groups of acute respiratory infections

For the analysis, players were divided into 3 subgroups based on their response to the questions on ARinf in the past 12 months: 1) Control subgroup (players reported no symptoms or diagnosis of ARinf/SARS-CoV-2), 2) SARS-CoV-2 subgroup (infection confirmed by polymerase chain reaction [PCR] or antigen testing), including asymptomatic players and 3) 'Other ARinf' subgroup (symptoms of ARinf but pathogen was not identified). Subgroups for 'Other ARinf' and SARS-CoV-2 were combined to form an 'All ARinf' group. The causative pathogen was not investigated in all the infections and therefore the 'Other ARinf' group may contain players with undiagnosed SARS-CoV-2.

### 2.7. Calculation of player days in each team during the four phases of the study

Team managers provided the dates when their team commenced non-contact and contact training and when matches between teams started. Exposure of players were not calculated using hours of training, but as player days. Player days were calculated for each team during every phase based on the provided dates, so player exposure for each phase varied between teams. Player days were therefore calculated on team level (as a cluster) for phases 1, 2 and 3. All players within a team started and ended these 3 phases at the same time. However, in phase 4, players of the same team started the phase at the same time, but the phase ended when a player completed the questionnaire. Player days for phase 4 were therefore calculated on an individual basis. Details depicted in Table 3.

Testing regimes for SARS-CoV-2 differed among the teams in the months before the tournament commenced. However, for four weeks leading up to the tournament, every team had mandatory weekly testing. Players were also tested 48–72 h before entering the competition

**Table 3**
Calculation of player days for each team during the four different phases of the study period.

| University | | Phase 1 Individual training (IT) | | Phase 2 Non-contact team training (NCT) | | Phase 3 Contact team training (CT) | | Phase 4 Competition (C) | |
|---|---|---|---|---|---|---|---|---|---|
| | Team size | Days | Player days* | Days | Player days* | Days | Player days* | Days | Player days# |
| 1 | 23 | 214 | 4 922 | 61 | 1 403 | 66 | 1 518 | # | 651 |
| 2 | 29 | 275 | 7 975 | 31 | 899 | 63 | 1 827 | # | 113 |
| 3 | 15 | 313 | 4 695 | 22 | 330 | 39 | 585 | # | 124 |
| 4 | 17 | 306 | 5 202 | 28 | 476 | 23 | 391 | # | 236 |
| 5 | 24 | 214 | 5 136 | 30 | 720 | 102 | 2 448 | # | 879 |
| 6 | 24 | 214 | 5 136 | 30 | 720 | 102 | 2 448 | # | 704 |
| 7 | 30 | 214 | 6 420 | 30 | 900 | 109 | 3 270 | # | 928 |
| 8 | 6 | 214 | 1 284 | 30 | 180 | 102 | 612 | # | 176 |
| 9 | 21 | 275 | 5 775 | 31 | 651 | 70 | 1 470 | # | 46 |
| 10 | 17 | 306 | 5 202 | 6 | 102 | 40 | 680 | # | 365 |
| 11 | 23 | 307 | 7 061 | 22 | 506 | 28 | 644 | # | 373 |
| 12 | 14 | 313 | 4 382 | 13 | 182 | 49 | 686 | # | 32 |
| 13 | 7 | 306 | 2 142 | 28 | 196 | 45 | 315 | # | 49 |
| 14 | 25 | 275 | 6 875 | 28 | 700 | 73 | 1 825 | # | 27 |
| 15 | 20 | 320 | 6 400 | 13 | 260 | 24 | 480 | # | 394 |
| 16 | 17 | 306 | 5 202 | 20 | 340 | 21 | 357 | # | 340 |
| 17 | 7 | 275 | 1 925 | 31 | 217 | 26 | 182 | # | 486 |
| | **319** | | **85 734** | | **8 782** | | **19 738** | | **5 923** |
| | | | **Non-contact players days = 94 516** | | | | **Contact player days = 25 661** | | |

Two players in 'Other ARinf' group did not specify when they were ill, and thus could not be allocated to a phase.
*Calculated on team level-similar start and end points for players in the same team.
# Calculated from the start of the phase (similar for players in the same team) to the completion of the questionnaire (on an individual player basis). Missing days = 12 196.
ARinf, Acute respiratory infection.

environment ('bio-bubble'). During the tournament, players were only tested (SARS-CoV-2 antigen testing), if they had symptoms of ARinf.

### 2.8. Measures of outcome

The first outcome was to determine the incidence (per 1 000 player days) of ARinf, including SARS-CoV-2, in the cohort for both the overall 14-month study period (120 177 player days), and for the four specific phases: (IT = 85 734 player days, NCT = 8 782 player days, CT = 19 738 player days and C = 5 923 player days) in the months preceding and including the tournament. Additional outcomes were: 1) to determine the period prevalence (%) of ARinf for the entire study period, and 2) to determine if selected factors (demographics, level of sport participation, history of co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits) were associated with ARinf, including SARS-CoV-2.

### 2.9. Statistical analysis

The demographic data, respiratory health data and illness data from the online surveys were analysed in SAS (SASv9.4) for the Control group (no infections), SARS-CoV-2 positive players and players with 'Other ARinf'. All demographic related results were reported as mean (standard deviation). For continuous outcomes comparing two groups a T-test (Satterthwaite or Pooled) was used for parametric data, and the Wilcoxon 2-sample Test for non-parametric data. Categorical outcomes were compared using both the Chi Square Test and Fisher's Exact Test. All incidences (per 1 000 player days) and incidence ratios (IR) were modelled with a generalised linear model with a Poisson distribution and a log link function. All comparisons within the SARS-CoV-2 and within the 'All ARinf' groups were modelled on team level with each team as a separate cluster, and an Exchangeable correlation structure. Due to the small number of infections in the 'Other ARinf' group, comparisons could not be done between this subgroup and the "All ARinf" or SARS-CoV-2 subgroups. Two participants in the 'Other ARinf' subgroup did not indicate the date of infection so these infections could therefore not be included in the incidence per phase, but were included in the overall incidence for "All ARinf'. For all tests, statistical significance was $p = 0.05$.

## 3. Results

There were 319 consenting players in the study population. The demographics, level of sport participation, history of co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits for all participants and subgroups (Control, 'All ARinf', SARS-CoV-2 and 'Other ARinf') are reported in Table 4.

The mean (*SD*) age of the participants was 22 (2.1) years and 52% were professional players. History of any co-morbidity was reported by 18% of participants.

### 3.1. Incidence of acute respiratory infections (ARinf) for the study period

During the 14-month study period, the total number of player days were 120 177. The incidence per 1 000 player days of 'All ARinf' was 0.31 ($n = 37$; 95%*CI*: 0.21–0.41). The incidence of SARS-CoV-2 infection was 0.23 ($n = 28$; 95%*CI*: 0.15–0.32), which was significantly higher than 'Other ARinf' 0.08 ($n = 9$; 95%*CI*: 0.03–0.12) ($p < 0.01$).

The period prevalence during the 14-month study period was 11.6% ($n = 37$) for 'All ARinf', 8.8% ($n = 28$) for SARS-CoV-2, and 2.8% ($n = 9$) for 'Other ARinf'. Due to the small number of 'Other ARinf', this subgroup could not be compared to the other subgroups in further analyses.

### 3.2. Incidence of ARinf during the four phases of risk mitigation strategies and return to competitive sport

The incidence per 1 000 player days of 'All ARinf' ($n = 37$) and SARS-CoV-2 ($n = 28$) in the four different phases from complete lockdown to return to competitive sport are depicted in Fig. 1. Phases 1 and 2 were characterised by non-contact between players and phases 3 and 4 by physical contact between players.

**Table 4**
Demographics, level of sport participation, history of co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits for all participants and sub-groups (Control, All ARinf, SARS-CoV-2 and Other ARinf).

| Variables | All participants $n = 319$ | Control $n = 282$ | All ARinf and subgroups | | |
|---|---|---|---|---|---|
| | | | All ARinf $n = 37$ | SARS-CoV-2 $n = 28$ | Other ARinf $n = 9$ |
| **Demographics** | | | | | |
| Age (years) (mean) (*SD*) | 22.0 (2.1) | 22.1 (2.1) | 21.8 (1.5) | 21.9 (1.5) | 21.4 (1.6) |
| BMI (mean) (*SD*) | 28.6 (4.0)[a] | 28.7 (4.0)[a] | 28.1 (3.9) | 27.4 (3.2) | 30.2 (5.2) |
| **Level of sport participation** | | | | | |
| Professional, *n* (%) | 165 (52) | 149 (53.0) | 16 (43.2) | 12 (42.9) | 4 (44.4) |
| Amateur, *n* (%) | 153 (48) | 132 (47.0) | 21 (56.8) | 16 (57.1) | 5 (55.7) |
| **History** | | | | | |
| Co-morbidities (any) *n* (%) | 56 (17.6) | 47 (16.7) | 9 (24.3) | 8 (28.6) | 1 (11.1) |
| Allergies *n* (%) | 19 (6.0) | 17 (6.0) | 2 (5.4) | 2 (7.1) | 0 |
| Influenza vaccination *n* (%) | 65 (20.4) | 56 (19.9) | 9 (24.3) | 8 (28.6) | 1 (11.1) |
| Injuries (acute and chronic) in past 12 months *n* (%)[b] | 82 (30.8)[b] | 68 (28.9)[c] | 14 (45.2)[d] | 10 (40.0)[e] | 4 (66.7)[e] |
| **Lifestyle habits** | | | | | |
| Alcohol consumption (yes) *n* (%) | 168 (62.9)[f] | 148 (62.7)[g] | 20 (64.5)[d] | 17 (68.0)[e] | 3 (50.0)[e] |
| Smoking history (current/ previous) (yes) *n* (%) | 53 (19.9)[f] | 46 (19.5)[g] | 7 (22.6)[d] | 6 (24.0)[e] | 1 (16.7)[e] |

% has been adjusted for missing values in denominator.
Number of missing participants: a = 5 b = 53, c = 47, d = 6, e = 3, f = 52, g = 46.
*n*, Number of participants; *SD*, Standard deviation; BMI, Body mass index.

The main observation was that the incidence of ‘All ARinf’ and SARS-CoV-2 progressively increased from phases 1 to 4. The incidence ratio (IR) of ‘All ARinf’ (IR = 3.7 [95%*CI*: 1.4–9.9]) and SARS-CoV-2 infection (IR = 5.0 [95%*CI*: 1.4–17.6]) were significantly higher in phases 3 compared with phase 1 (both $p = 0.01$). There was also a significant increase from phase 1 to phase 4 for ‘All ARinf’ (IR = 7.2 [95%*CI*: 3.8–14.0] [$p < 0.01$]) and SARS-CoV-2 (IR = 11.7 [95%*CI*: 5.0–27.6] [$p < 0.01$]). Overall, the incidence of ‘All ARinf’ (IR = 3.6 [95%*CI*: 1.4–9.1]) and SARS-CoV-2 (IR = 4.2 [95%*CI*: 1.6–11.2]) during contact (phase 3 + 4) were significantly higher compared to non-contact (phase 1 + 2) (both $p < 0.01$). Therefore, the incidence of both ‘All ARinf’ and SARS-CoV-2 was approximately 3–4 times higher during contact compared to non-contact phases.

### 3.3. Incidence of SARS-CoV-2 in the general population during the study period

The incidence SARS-CoV-2 cases per 100 000 populations is depicted in Fig. 2.

The incidence of SARS-CoV-2 in the general population[11] peaked on two occasions (‘waves’) during the study period. The first wave was in July/August 2020 and the second in January 2021. During the first wave, all the study participants were in phase 1 (individual training) and we note that the incidence for SARS-CoV-2 in our study population was the lowest during this first wave in the general population (Fig. 2). There was an increase in the incidence of SARS-CoV-2 in our cohort during the second wave, but the highest incidence of SARS-CoV-2 in our study population was during phase 4, at a time when the incidence in the general population was low. The two peaks in the incidence of SARS-CoV-2 in the general population did not coincide with the highest peak during phase 4 in the study cohort i.e. there is a dissociation in the peak incidences in the general population and the study cohort.

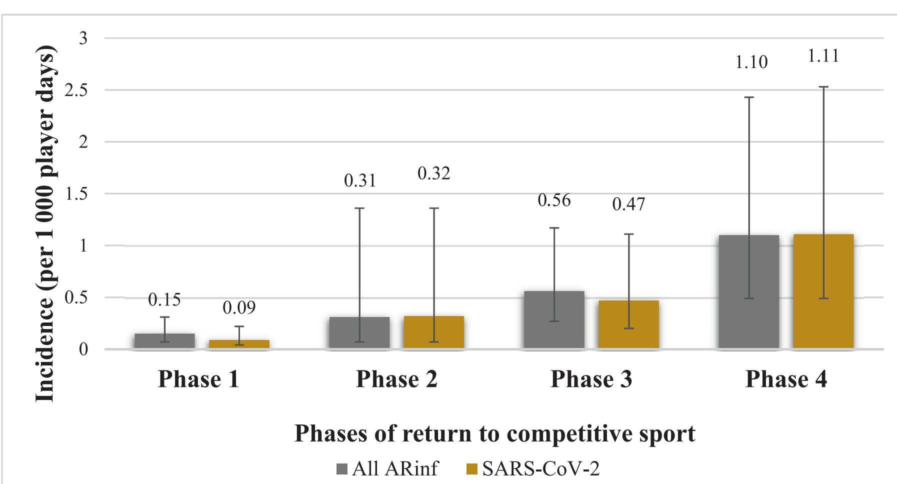
### 3.4. Factors associated with the incidence of acute respiratory infections

The demographics, level of sport participation, history of co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits associated with ARinf are reported in Table 5.

There was no significant difference between either the Control vs. ’All ARinf’ or the Control vs. SARS-CoV-2 for any of the selected factors ($p > 0.05$).

## 4. Discussion

The main findings of this study were: 1) the incidence of ‘All ARinf’ in a cohort of student rugby players over a 14-month period during the COVID-19 pandemic, was 0.31 per 1 000 player days with a period prevalence of 11.6%; 2) the incidence of ‘All ARinf’ and SARS-CoV-2




| Infection | Phase 1 | Phase 2 | Phase 3 | Phase 4 |
|---|---|---|---|---|
| All ARinf | $n = 13$ | $n = 3$ | $n = 12$ | $n = 7$ |
| SARS-COV-2 | $n = 8$ | $n = 3$ | $n = 10$ | $n = 7$ |

**Fig. 1.** Incidence per 1 000 player days of All ARinf and SARS-CoV-2 in the four different phases of return to competitive sport
The whiskers represent the 95% confidence intervals and the numbers on top of the whiskers are the incidence (per 1 000 player days)
Two players in ‘All ARinf’ group did not specify when they were ill, and thus could not be allocated to a phase
*n*, Number of participants; ARinf, Acute respiratory infections.

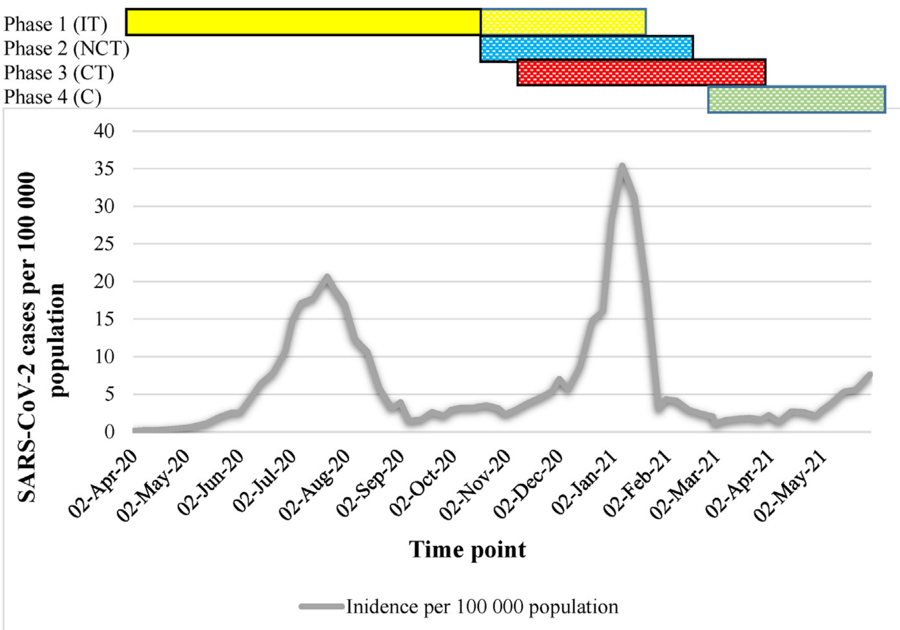



**Fig. 2.** Incidence of SARS-CoV-2 cases per 100 000 in the general South African population in relation to the four phases of return to competitive sport
Bar graph represent the four phases during the study period. The solid colour represents all teams in the same phase (phase 1). Shaded colours represent the different start and end points for each team in a phase. IT, Individual training; NCT, Non-contact team training; CT, Contact team training; C, Competition.

**Table 5**
Demographics, level of sport participation, history of co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits as possible factors associated with acute respiratory infection.

| Variable | Control $n = 282$ | All ARinf $n = 37$ | *p*-value* | SARS-CoV-2 $n = 28$ | *p*-value** |
|---|---|---|---|---|---|
| **Demographics** | | | | | |
| Age (years) (mean) (*SD*) | 22.1 (2.1) | 21.8 (1.5) | 0.402 | 21.9 (1.5) | 0.706 |
| BMI (mean) (*SD*) | 28.7 (4.0)[a] | 28.1 (3.9) | 0.430 | 27.4 (3.2) | 0.116 |
| **Level of sport participation** | | | | | |
| Professional (vs amateur) *n* (%) | 149 (53.0)[b] | 16 (42.9) | 0.263 | 12 (42.9) | 0.304 |
| **History** | | | | | |
| Any co-morbidity (yes) *n* (%) | 47 (16.7) | 9 (24.3) | 0.250 | 8 (28.6) | 0.123 |
| Allergies (yes) *n* (%) | 17 (6.0) | 2 (5.4) | 1.000 | 2 (7.1) | 0.685 |
| Influenza vaccination (yes) *n* (%) | 56 (19.9) | 9 (24.3) | 0.526 | 8 (28.6) | 0.277 |
| Injuries (acute and chronic) in past 12 months (yes) *n* (%) | 68 (28.9)[c] | 14 (45.2)[d] | 0.066 | 10 (40.0)[e] | 0.251 |
| **Lifestyle habits** | | | | | |
| Alcohol consumption (yes) *n* (%) | 148 (62.7)[f] | 20 (64.5)[d] | 0.845 | 17 (68.0)[e] | 0.602 |
| Smoking history (current/ previous) (yes) *n* (%) | 46 (19.5)[f] | 7 (22.6)[d] | 0.685 | 6 (24.0)[e] | 0.601 |

* Difference between Control and 'All ARinf' subgroups.
** Difference between Control and SARS-CoV-2 subgroups.
Other ARinf group was too small to compare to Control.
% has been adjusted for missing values in denominator.
Number of missing participants: a = 5, b = 1, c = 47, d = 6, e = 3, f = 4.
*n*, Number of participants; ARinf, Acute respiratory infections; *SD*, Standard deviation; BMI, Body mass index.

infection progressively increased during the four different phases of return to competitive sport following lockdown, with a significantly higher incidence (3–4 times higher) during contact phases compared with non-contact phases; and 3) factors such as demographics, level of sport participation, history of co-morbidities, allergies, influenza vaccination, injuries and lifestyle habits were not associated with ARinf/SARS-CoV-2.

To date, most studies reported only the period prevalence of SARS-CoV-2 infection. In early studies on professional European football players resuming sport during the COVID-19 pandemic, the period prevalence of SARS-CoV-2 infection (over 9–11 weeks) varied between 0.5 and 2.7%.[2–4] In a study among Brazilian football teams over a 6-month period, weekly PCR testing showed that 11.7% of players tested positive for SARS-CoV-2.[1] In another cohort study among college football players over 3-month period, the period prevalence of SARS-CoV-2 was 11.6%.[12] Our period prevalence of 'All ARinf' was 11.6% and for SARS-CoV-2 infection was 8.8%, but this cannot strictly be compared to the prevalence in the mentioned studies due to study period differences (2–6 months vs. 14 months). However, the period prevalence of SARS-CoV-2 infection during the match phase (4.4%) in one study, was higher compared to entering (1.6%) and exiting (1.2%) periods of quarantine before and after matches.[4] This supports our finding that the risk of infection is higher during competition. Studies also differed considerably in the frequency of SARS-CoV-2 testing (varying from 3/week to weekly). Testing in our population differed for teams during the preparation period, but testing was mandatory in the 4 weeks prior to the tournament, 48–72 h before entering the tournament environment, and when a player was symptomatic during the competition phase. The higher incidence of ARinf (including SARS-CoV-2) during competition in our study, may also indicate the value of mandatory testing, as asymptomatic players will be identified.

We suggest that reporting the incidence of ARinf per 1 000 player days is more appropriate to make comparisons between studies, irrespective of study periods.[13] In a systematic review and meta-analysis for multi-coded sports, the incidence per 1 000 player days of ARinf (suspected/confirmed) was 4.9 during tournaments.[13] Our incidence of 'All ARinf' (0.31) is considerably lower than that reported in this review, that was conducted before the COVID-19 pandemic. The lower incidence of ARinf in our study is likely due to the risk mitigation strategies throughout our study period. Although these strategies were implemented (Table 2), they were not always practical in the contact sport setting.

To date, the comparison of the incidence of SARS-CoV-2 in rugby during non-contact and contact phases, was only reported in one study over a 6-month period in South African elite rugby players.[7] In this study, the overall incidence (per 1 000 player days) of SARS-CoV-2 was 1.23, and this is higher than our overall incidence. A fundamental difference between our study and this study, was that players were tested for SARS-CoV-2 on a weekly basis and therefore included asymptomatic players. This study also reported the incidence of SARS-CoV-2 was higher during contact training 1.04 (95%*CI*: 0.36–1.71) and competition 1.54 (95%*CI*: 1.00–2.10) compared to non-contact training (nil infections). This finding correlates with our data showing an increasing incidence of SARS-CoV-2 infection during contact team training (0.47) and competition (1.11).

Direct comparisons between the incidence of SARS-CoV-2 in the general population, and the phases of return to competitive sports in our study, cannot be made as the timelines for each team differed. Although the incidence of SARS-CoV-2 in our study participants could have been influenced by the spread of infection in the general population, our data show a dissociation in the peak incidences in the general population and the study cohort. We report the highest incidence of SARS-CoV-2 when different teams returned to full contact during competition, and this was at a time when the incidence in the general population declined after the peak of the second wave.

In our study, factors including demographics, history of any co-morbidities, allergies, influenza vaccination, injuries, or lifestyle habits were not associated with the incidence of ARinf. At the time of the study, SARS-CoV-2 infections were predominantly of the Ancestral virus and Beta variant and our study population was unvaccinated for COVID-19. However, in a study on 414 athletes[14] competing in mixed sport and with a SARS-CoV-2 prevalence of 8.5%, age (under 27 years old), smoking history and a team mate with a positive COVID-19 test, were factors associated with potential risk of SARS-CoV-2.

Our study was conducted on a defined cohort of players over a 14-month period, and we compared the incidence of ARinf during different phases of return to competitive sport during the COVID-19 pandemic.

The following limitations of the study are acknowledged. We collected self-reported data from players using questionnaires and this could introduce recall bias. Data for phases 1, 2 and 3 were collected and analysed per team, and not for individual players. There was no regular SARS-CoV-2 PCR/antigen testing during the non-contact phases. Players could only report SARS-CoV-2 infection if the diagnosis was confirmed. However, pathogens for 'Other ARinf' were not identified. Infections during the competition phase, might be underreported as players completed the questionnaire during varying times during the tournament. Exposure days for each player in the competition phase were calculated up to the date of the completion of individual questionnaires. Infections after the completion of the questionnaire were not included. The questionnaire enquired about respiratory infection in the previous 12 months, therefore some infections during the beginning of the study period, might be underreported.

We included a large number of players in our cohort but the number of ARinf was small, particularly the 'Other ARinf' subgroup. Comparisons between subgroups could therefore not be done for all variables. Furthermore, it is possible that symptomatic players in the 'Other ARinf' group may not have been tested for SARS-CoV-2 or had a false negative test. The national public health risk mitigation measures were the same throughout the study period, but individual compliance to these measures could not be determined.

The authors do acknowledge that the incidence of ARinf cannot solely be attributed to the nature of contact sports or risk mitigation strategies, as other factors (e.g. seasonal changes, social interactions off the field of play and spread of infections within the general population) could also influence the incidence of ARinf.

## 5. Conclusion

The incidence of ARinf (including SARS-CoV-2) in a cohort of student rugby players increased progressively during 4 phases from lockdown to full competition. A key finding was that the incidence was 3–4 times higher during contact phases compared to non-contact phases despite similar public health risk mitigation measures for all phases. No demographic factors, level of sport participation or history of co-morbidities and lifestyle habits were associated with incidence of ARinf in this cohort. A higher incidence of ARinf (including SARS-CoV-2) can be expected during close physical contact (contact training and competition).

Data from this study serve as a platform to which future research on incidence of ARinf in athletes, future pandemics or outbreaks of other respiratory infective illnesses within contact sports, can be compared.

### 5.1. Clinical recommendations

Contact training is essential in contact sports such as rugby to prepare for tournaments and competition. Due to the higher incidence of ARinf during this period, sport and exercise clinicians should implement strategies to decrease the effect of these transmissible infections within their teams by reducing the risk of transmission, early identification of infection, isolation of ill players, appropriate clinical assessment and management, and safe return to training (RTT) guidance after infection. Timing of RTT is also important in order not to spread contagious infections in the team. These recommendations will be of clinical relevance for all contagious ARinf, regardless of the pathogen. As ARinf can cause time-loss from training,[15] and negatively impact athlete health[16–18] and performance,[19] all precautions should be implemented to minimise ARinf transmission between players, especially during contact sports.

## Submission statement

All authors have read and agree with the manuscript content. The manuscript has not been published and is not under consideration for publication elsewhere.

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## Authors' contributions

**Carolette Snyders:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Nicola Sewry:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Conceptualization. **Wayne Derman:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Conceptualization. **Maaike Eken:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Conceptualization. **Esme Jordaan:** Writing – review & editing, Formal analysis. **Sonja Swanevelder:** Writing – review & editing, Formal analysis. **Martin Schwellnus:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Conceptualization.

## Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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