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Research article

Impact of Sudden Rule Changes on Player Injuries and Performance: Insights from Australian Football

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Abstract

This study investigated the effects of reduced quarter time due to COVID-19 pandemic rule changes, on running performance and injuries in Australian Football. Microsensor data for eight matches performed by the same 17 players were compared between the 2019 (standard) and 2020 (COVID-19) seasons using linear and generalised mixed models. Injury rates were assessed in 34 players across the full 2019 season, and 32 players across the full 2020 season. The total distance (ES = 1.28 [0.55 to 2.02]), high-speed (>18 km/h) (ES = 0.44 [-0.24 to 1.12]) and very high-speed (>24 km/h) (ES = 0.27 [-0.41 to 0.94]) distances, PlayerLoad™ (ES = 0.96 [0.25 to 1.67]), high-intensity efforts (ES = 0.48 [-0.20 to 1.16]), and accelerations (ES = 0.33 [-0.34 to 1.01]) were smaller ($p \leq 0.01$) for the 2020 than the 2019 season. Expressed relative to playing time, distance (ES=-0.38 [-1.06 to 0.30]), PlayerLoad™ (ES = -0.27 [-0.94 to 0.41]), and acceleration efforts (ES = -0.50 [-1.18 to 0.18]) were greater ($p < 0.05$) for the 2020 than the 2019 season. No significant differences in maximum ball-in-play periods nor the difference between the 1st and 4th quarters were evident. Injury rates remained similar between 2019 (3.36 per game) and 2020 (3.55 per game). However, the proportion of injuries that led to lost time (missed games) was greater for the 2020 (38%) than 2019 season (24%). The changes in the rules had a profound impact on player performance and increased the likelihood of time loss injuries.

Key words: COVID-19 pandemic, playing rules, athletic performance, global positioning systems, locomotion, match analysis.

Introduction

Rules of sporting competitions define and shape the way in which athletes play competitive matches in a season. Any changes to the rules of any sports may have a profound effect on player performance and injury. The outbreak of novel coronavirus SARS-CoV-2 (COVID-19) in Western Australia during February 2020 (Robertson, 2020), resulted in the suspension of all football activities within the state and forced players to train in isolation. Some changes in the rules (i.e., Laws of Australian Football) to the 2020 West Australian Football League (WAFL) season, were introduced in May and implemented in the matches that started from July, three months after the planned start to the season. The WAFL season typically includes 18 regular season games followed by a final's series. However, due to the loss of time caused by the COVID-19 pandemic, and to enable teams to complete some training and conditioning, the 2020 season was reduced by 55% to an 8-game regular season plus finals. Additionally, match quarters were shortened by 20%, from 20 minutes plus time-on (i.e., period of added time to account for stoppages in play) to 16 minutes plus time-on. This provides a unique opportunity for us to investigate the impact of sudden rule changes on performance and injuries of high-level players.

The main reason for the reduced playing time was to reduce fatigue, allowing for the potential for teams to play multiple games in a single week (in normal season, only one match in a week). However, due to the reduction in preparation time afforded post-lockdown, as well as reduced access to strength and conditioning and physiotherapy staff and training facilities during the lockdown period, it is likely that players would be underprepared for the demands of competition, potentially leading to an increase in injuries (Mannino et al., 2021; Platt et al., 2021). The reduction in playing time may also have a significant impact on the physical demands of a game, however this has not been systematically evaluated. It is important that practitioners, coaches, and players are cognisant of the differences that may exist when sudden rule changes are implemented or required, so that player's physical preparation and performance benchmarking can be appropriately adapted, if a similar situation occurs in future seasons, and adjusted load management practices can be considered if rates of injuries consequentially increase. Although this research focuses on Australian Football (AF) players, it can be considered as a model for other similar sports (e.g., soccer), should governing bodies consider changes to the structure of their competitions. For example, should soccer matches be reduced by a similar duration, the findings of this study may help guide practitioners as to the changes in running performance that may be experience by their players.

Accordingly, the aims of this study were to investigate the effects of the reduced playing time on match running performance (e.g., distance travelled), and injury rates within a group of AF players. It was hypothesised that reduced match duration would result in reduced absolute running performance (e.g., total distance ran), but would result in an increase in these values relative to playing time (e.g., total distance ran per minute) for the matches played in the 2020 compared to the 2019 season. Additionally, the decrement in relative measures between the 1st quarter and 4th quarter would be greater in games in the 2019 than 2020 season, where greater playing times would be present, and

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fatigue would be postulated to play a more prominent role. Maximum ball-in-play (BiP) period, which is a marker of maximum match intensities (Pollard et al., 2018; Wass et al., 2020; Wing et al., 2022), would be greater during the 2020 than 2019 season. For injuries, it was hypothesised that injury rates and severity would increase during the 2020 season.

Methods

Microsensor technology data was collected on 17 male sub-elite AF players (age: 23.2 ± 2.4 y; mass: 85.8 ± 10.1 kg; height: 1.86 ± 0.08 m) from one club competing in the WAFL over the 2019 (normal) and 2020 (COVID-19) seasons. The WAFL is the highest sub-elite league in Western Australia, and sits nationally in the second tier of competition, one step down from the Australian Football League (the top professional competition in the country). Data relating to injuries were based on the entire competitive season, which included 22 matches in 2019, and 11 matches in 2020, with 34 players from the 2019 season, and 32 players from the 2020 season (23 of them played in both seasons). All participants were informed with the study information before providing informed written consent. The study was approved by the Edith Cowan University Human Research Ethics Committee (HREC ID: 2020-01058WING).

To reduce the impact of potential confounding factors, match data was only compared in games, which featured the same opposition, at the same venue, and where the player was in the same playing position (key position, half line or mid-wing). This led to the analysis of eight matches (seven regular season and one finals series). During these eight matches the team recorded seven wins and one loss in the 2019 season, and six wins and two losses in the 2020 season. The distribution of matches was one match per week for both seasons. Additionally, training schedules (three sessions per week) remained the same across both pre and in-season periods for both seasons. Match files (individual player observations) were only removed if a player was injured and unable to complete the match, or if there was failure of the recording device. A total of 136 match files (average observations per player 8.0 ± 4.6; range 2-16) were included within the final analyses.

Microsensor technology data was collected using the Playertek device sampling at 10Hz (Catapult Innovations, Melbourne, Australia). The accuracy of these devices has been confirmed (T. Mooney et al., 2021). To reduce interunit variability, players wore the same device for all games across both seasons, fitted within a pouch sewed into the playing shirt. The Playertek live-feed application was used to mark the start and end of each quarter, which was synced post game to the downloaded microsensor technology data upon the Playertek Cloud. Crops were manually inserted to remove all time spent upon the interchange bench to allow for the analysis of on ground time only. Data was then exported to Microsoft Excel (Microsoft Cooperation, WA, USA) and prepared for analyses.

This included subtracting relative measures of running performance recorded in the 4th quarter from those recorded in the 1st quarter to establish the difference between the two quarters.

Additionally, split times were manually inserted to identify maximum BiP periods, which were extracted from a timeline provided by Champion Data (Champion Data, Melbourne, Australia). Champion Data is a commercial statistical provider to both the WAFL and Australian Football League (AFL) that provide coding of events and associated time stamps during AF matches. These periods started with either an umpire boundary throw or centre bounce, or a player kick-in, until a time when the umpire signals the ball is out of bounds or that a goal or behind has been scored, in line with previous AF research (Wing et al., 2022). Previous research has deemed the identification of these phases as reliable and valid (Rennie et al., 2018). The data were then exported to Microsoft Excel (Microsoft Cooperation, WA, USA) and was appropriately cleaned for analyses. This included removing all BiP periods where a player did not complete the full phase (i.e., a player was rotated off or on in that period) or any plays lasting < 30-s duration as previous research has shown these to give a false indication of intensity (Pollard et al., 2018; Wing et al., 2022). The maximum BiP period for each match, for each of the study metrics was subsequently used for the final analysis. These metrics included total running distance, high-speed distance (HSR: > 18 km·h^{-1}), very-high speed distance (VHSR: > 24 km·h^{-1}), PlayerLoad^{TM} (AU), accelerations (efforts: > 3 m·s^{-2}) and high-intensity efforts (efforts: > 18 km·h^{-1} for > 2 s duration).

Injury data were recorded by the club's medical staff (doctor and physiotherapist) who performed the injury assessment and diagnosis, and included all injury types (contusion, strain, sprain, fracture etc). Injuries were subdivided into upper and lower body and subsequently classified as a 'time loss' injury if a player missed a competitive match as a consequence of the injury. Where a player was injured in the last match of the season, the injury was classified as 'time loss' if the player would have missed a match had there been an additional round of fixtures.

Statistical analyses were performed in either Microsoft Excel or R Studio (R, v4.0.4, The R Foundation of Statistical Computing, Vienna, Austria). Match running performance was compared between the 2019 and 2020 seasons (fixed effects) for whole game data, maximum BiP periods and for the difference between the 1st and 4th quarter, using linear and generalised mixed models (lmerTest package (Kuznetsova et al., 2017)), with playing position included as a fixed effect and player identification as a random effect. Where significant effects were highlighted within the models, Tukey's post-hoc test (emmeans package (Lenth et al., 2022)) were utilized for pairwise comparisons. A separate model was constructed for each measure of running performance. The significance level was set at $p<0.05$, with the results being further explained using Cohen's d effect sizes (ES) and associated 95% confidence intervals, where ≤0.2, 0.21 to 0.6, 0.61 to 1.2, 1.21 to 2.0 and >2.0 were classified as trivial, small, moderate, large and very large, respectively (Hopkins et al., 2009), calculated using a customised spreadsheet in Microsoft Excel.

Due to non-independence within the data, effect size confidence intervals were calculated with n=17. This is a conservative estimate, with the true confidence interval very likely narrower. Normality of the data was assessed with visual inspection of the residual plots.

Injury data were recorded as counts of occurrences, with injury rates calculated as number of injuries divided by the number of games in the season. Additionally, time loss injuries were calculated as a percentage of total injuries. These calculations were performed for both total injuries and within injury sub-categories of upper and lower body.

Results

All absolute (total recorded volume) measures of activity including playing time were significantly less during the 2020 than 2019 season. As shown in Table 1, duration (p < 0.001, ES: 1.73 [0.94 to 2.51]), distance (p < 0.001, ES: 1.28 [0.55 to 2.02]), high-speed running (p < 0.001, ES:

0.44 [-0.24 to 1.12]), high-intensity efforts (p < 0.001, ES: 0.48 [-0.20 to 1.16]), PlayerLoad^{TM} (p < 0.001, ES: 0.96 [0.25 to 1.67]), very-high speed running (p = 0.011, ES: 0.27 [-0.41 to 0.94]), and accelerations (p < 0.001, ES: 0.33 [-0.34 to 1.01]) were smaller in the 2020 than 2019 season. However, when looking at the metrics expressed per minute of playing time, distance (p < 0.001, ES: -0.38 [-1.06 to 0.30]), PlayerLoad^{TM} (p < 0.001, ES: -0.27 [-0.94 to 0.41]), and accelerations (p = 0.044 ES: -0.50 [-1.18 to 0.18]) were greater in the 2020 than 2019 season. No significant differences (p > 0.05) between seasons were evident for the maximum BiP periods and the difference between the 1st and 4th quarter.

A total of 74 match related injuries were recorded in the 2019 season (3.36 injuries per match), with 22 upper body (1 per match), and 52 lower body (2.36 per match) injuries. Of the 74 injuries, 18 led to time loss (24%), with 5 of these located at the upper body (23%), and 13 the lower body (25%). In 2020, a total of 39 match related injuries were recorded (3.55 injuries per match), with 8 upper body (0.73 per match), and 31 lower body (2.82 per match) injuries. Of the 39 injuries, 15 led to time loss (38%), with 4 of these located at the upper body (50%), and 11 at the lower body (35%). A detailed list of match injuries can be seen in Table 2.

Discussion

This study examined the impact of sudden rule changes (a reduction of season length by 55% [from 18 games to eight games] and reduction in quarter time by 20% [from 20-min to 16-min plus time-on]) on running performance and injury rates in AF. It was found that shorter match quarters significantly reduced running volume compared to standard quarter times including reductions in distance (12,139 vs 10,908 m), high-speed distance (1,812 vs 1,585 m), high-intensity efforts (52 vs 46 efforts), PlayerLoad^{TM} (529 vs 476 AU), very-high-speed distance (269 vs 229 m), and acceleration efforts (70 vs 64 efforts).

Table 1. Average (±SD) and comparisons between the 2019 (No COVID-19) and 2020 (COVID-19) season of 8 matches played by 17 players for measured metrics (distance, high and very-high speed distance, PlayerLoadTM, high-intensity and acceleration efforts) for whole game (WG) for absolute: total recorded volume, and relative: total volume per minute of playing time, the maximum ball in play period (BiP) and the difference between the 1st (Q1) and 4th quarter (Q4).

Metric	Phase	2019	2020	P value	Cohen's d effect size (95% CI)
Time on ground (min)	WG	99.2 ± 8	85.9 ± 7.4	< 0.001	1.73 (0.94 to 2.51)
Distance (m)	WG absolute	12,138.8 ± 1099.6	10,907.5 ± 793.9	< 0.001	1.28 (0.55 to 2.02)
	WG relative	123.0 ± 13.0	127.5 ± 10.5	< 0.001	-0.38 (-1.06 to 0.30)
	BiP	229.3 ± 32.3	224.5 ± 28.5	0.326	0.16 (-0.52 to 0.83)
	Difference Q1 vs Q4	12.5 ± 13.0	12.3 ± 14.4	0.926	0.01 (-0.66 to 0.69)
High-speed running (m) (>18km·h-1)	WG absolute	1812 ± 581	1584.6 ± 452.7	< 0.001	0.44 (-0.24 to 1.12)
	WG relative	18.5 ± 6.4	18.7 ± 5.9	0.707	-0.03 (-0.70 to 0.64)
	BiP	113.8 ± 39	105.7 ± 45.4	0.225	0.19 (-0.48 to 0.87)
	Difference Q1 vs Q4	4.2 ± 5.8	4.0 ± 6.5	0.873	0.03 (-0.64 to 0.70)
High intensity efforts (efforts) (> 18km·h-1 for >2s)	WG absolute	52.2 ± 15.2	45.7 ± 11.8	< 0.001	0.48 (-0.20 to 1.16)
	WG relative	0.5 ± 0.2	0.5 ± 0.2	0.671	0.00 (-0.67 to 0.67)
	BiP	3.1 ± 0.9	2.8 ± 0.9	0.102	0.33 (-0.34 to 1.01)
	Difference Q1 vs Q4	0.1 ± 0.2	0.1 ± 0.2	0.474	0.00 (-0.67 to 0.67)
PlayerLoadTM (AU)	WG absolute	529.3 ± 59.7	475.5 ± 51.7	< 0.001	0.96 (0.25 to 1.67)
	WG relative	5.4 ± 0.8	5.6 ± 0.7	< 0.001	-0.27 (-0.94 to 0.41)
	BiP	9.7 ± 1.5	9.4 ± 1.3	0.124	0.21 (-0.46 to 0.89)
	Difference Q1 vs Q4	0.6 ± 0.7	0.7 ± 0.6	0.642	-0.15 (-0.83 to 0.52)
Very-high-speed running (m) (>24km·h-1)	WG absolute	269.1 ± 156.9	228.8 ± 144.5	0.011	0.27 (-0.41 to 0.94)
	WG relative	2.7 ± 1.6	2.7 ± 1.8	0.736	0.00 (-0.67 to 0.67)
	BiP	44.9 ± 25.7	40.4 ± 28.6	0.275	0.17 (-0.51 to 0.84)
	Difference Q1 vs Q4	0.7 ± 2.1	0.1 ± 2.8	0.158	0.24 (-0.43 to 0.92)
Accelerations (efforts) (>3m·s-2)	WG absolute	69.9 ± 15.9	64.4 ± 17	0.001	0.33 (-0.34 to 1.01)
	WG relative	0.7 ± 0.2	0.8 ± 0.2	0.044	-0.50 (-1.18 to 0.18)
	BiP	4.1 ± 1.0	4.1 ± 1.3	0.892	0.00 (-0.67 to 0.67)
	Difference Q1 vs Q4	0.1 ± 0.2	0.1 ± 0.3	0.084	0.00 (-0.67 to 0.67)

Model p values and effect sizes (≤0.2: trivial, 0.21 - 0.6: small, 0.61- 1.2: moderate, 1.21 - 2.0: large, >2.0: very-large).

Table 2. An overview of the match related injuries.

Location	Type	2019 Season		2020 Season	
		Occurrences	Missed Match	Occurrences	Missed Match
Head	Whiplash/concussion/bruising	7	2	1	1
Scapula/shoulder	Sprain/strain/rupture	5	0	0	0
	Bursitis/tendinopathy	4	0	0	0
	Fracture/break	1	1	0	0
	Contusion	0	0	1	0
Hand/wrist	Sprain/strain/rupture	2	1	0	0
	Fracture/break	1	1	0	0
	Bruising/inflammation	0	0	1	0
Arm	Sprain/strain/rupture	0	0	1	1
Ribs	Sprain/strain/rupture	1	0	1	0
	Fracture/break	0	0	1	1
	Bruising/inflammation	1	0	2	1
Thigh/Hip	Sprain/strain/rupture	4	3	4	4
	Tendinopathy	5	1	5	0
	Contusion	11	2	9	0
	Impingement	1	0	0	0
Knee	Sprain/strain/rupture	9	4	3	2
	Bursitis/tendinopathy	2	0	0	0
Shin	Contusion	2	0	1	0
	Tendinopathy	1	0	0	0
Calf	Contusion	2	0	2	1
	Sprain/strain/rupture	0	0	1	1
Ankle/Achilles	Sprain/strain/rupture	13	3	5	3
Foot	Bruising/inflammation	2	0	0	0
	Sprain/strain/rupture	0	0	1	0
Total		**74**	**18**	**39**	**15**

This is undoubtedly due to the reduced time available to the players to perform locomotor activities, where players spent ~13 minutes less time on ground during the 2020 than 2019 season. As indicated by the effect sizes, the reduced playing time appeared to affect the total running distances (large effect size) greater than the measures of high and very-high speed running, and high-intensity and acceleration efforts (small effect size). It may be possible that the reduction in running volumes enabled players to better manage fatigue, and thus only suffer small reductions in distances travelled at higher velocity, as well as the ability to perform explosive efforts such as accelerations. This has been demonstrated previously in AF, where it was reported that during matches played in the heat, players were able to maintain high-intensity activities due to the reduction in total running volume (Aughey et al., 2014). Therefore, it is reasonable to assume that during games where playing times are shorter, in which the running distances are reduced, the impact of fatigue on high-intensity output is attenuated.

It was hypothesised that players would be able to perform match activities at a higher intensity for a greater proportion of the game. However, this was not the case, where only relative measures of total running distance, PlayerLoad™, and acceleration efforts (small effect size), were significantly greater during the 2020 relative to the 2019 season. This finding may be attributed to a player's physical capacity and the reduced time afforded to the players in order to physically prepare for the shortened 2020 season. Previous research has suggested that those completing greater running distances during pre-season training also complete higher distances during competitive matches (Johnston et al., 2019). Additionally, the relationship between an individual's physical capacity and match running performance has been established (M. Mooney et al., 2011; Stares et al., 2015; Stein et al., 2015). Due to the lockdown period, where players were limited to home training programs for approximately two months, a reduced and interrupted pre-season preparation time was present (2019 season: 17 weeks, 2020 season: eight weeks post lockdown period). This may have led to a decrease in player physical capacity, which may have attenuated the expected increases in relative running measures. Previous research within other football codes (professional soccer) appears to confirm this, where it was suggested that short retraining periods post lockdown may not be sufficient for players to reach optimal levels of conditioning (Cohen et al., 2020; Rampinini et al., 2021). However, it should be noted that comparable measures of physical capacity are unavailable for the 2020 season, somewhat hampering our ability to make this conclusion.

In contrast to our hypothesis, no significant differences were noted between the two seasons concerning maximum BiP phases, indicating that maximum match intensity remained constant irrespective of playing time. This is somewhat supported by previous research involving elite female players (Thornton et al., 2020), where maximal intensities across one minute time durations were reported to be similar to those recorded amongst elite male players, despite the differences in playing time (Delaney et al., 2017; Johnston, Murray, Austin, et al., 2019; Thornton et al., 2020; Wing et al., 2021). Therefore, players should be exposed to similar maximum match intensities during training, irrespective of match duration.

Due to the higher distances travelled during the 2019 season, it had been expected that the reduction in running performance between the 1st and 4th quarter would be greater in the 2019 season. Although there was a reduction in relative measures of running performance from the 1st to the 4th quarter in both seasons, the magnitude of this decrement demonstrated no significant difference between seasons. It is speculated that physical preparation factors may play a role in this finding, where the interrupted pre-season may have reduced the player's ability to tolerate accumulated match running distances. Therefore, the same reduction in relative match running performance was experienced during the 2020 season, despite the players seemingly having to buffer the effects of reduced total running distances.

The injury rates remained comparable for the total (3.36 vs 3.55 per game), upper body (1.00 vs 0.73), and lower body (2.36 vs 2.82) injuries between the 2019 and 2020 seasons. This may partly be owed to the reduction in total match running distances brought about by the rule changes. However, in line with our hypothesis, a greater proportion of injuries were classified as time loss injuries (i.e., missed games) during the 2020 season for total (24% vs 38%), upper body (23% vs 50%), and lower body (25% vs 35%) injury. This suggests that although injury occurrence, relative to match exposure, was unchanged, the severity of injury appears to have increased during the 2020 season. This is particularly pertinent, when 11 of the 15-time loss injuries within the 2020 season where due to sprains, strains or ruptures, which are injuries that are more likely due to the interrupted pre-season and subsequent potential deconditioning. This finding is somewhat unsurprising, with increased injury rates post COVID-19 lockdowns also demonstrated in other sports such as baseball (Platt et al., 2021) and soccer (Mannino et al., 2021). This could be due to the potential detraining of the neuromuscular and cardiovascular systems during COVID-19 lockdowns (Cohen et al., 2020; Font et al., 2021), as well as a lack of exposure to relevant training loads (Stokes et al., 2020). This also included reduced access to strength and conditioning facilities, coaches, and medical staff (e.g., physiotherapists) during the lockdown period, and restricted access during the phased return to play. Therefore, both the quantity and quality of training were reduced as a result of the COVID-19 lockdown and subsequent return to play protocols. Furthermore, the large increase in upper body time loss injuries during the COVID-19 impacted season could also potentially be owed to a lack of time afforded to regain tackling and contact scenario familiarisation (Stokes et al., 2020).

Collectively, these findings have important practical implications for training of AF players, and potentially other similar sports, should a similar situation be presented in the future. As athletes are required to travel shorter distances in matches with a reduced duration, it seems reasonable that training loads during the preparation period can be reduced. However, the prescription high-intensity/ high-speed actions (e.g., high-speed running) may be somewhat similar when preparing athletes for shorter duration matches. Importantly, it appears that disrupted preparation periods lead to increase in time loss match related injuries. Therefore, should players be faced with similar disruption to schedules in the future (e.g., COVID-19 isolation), it is important that injury prevention strategies are strictly adhered to, alongside careful load monitoring. These injury prevention strategies should focus primarily upon the ankle, thigh, and knee, as these appear to contribute to the majority of time loss injuries.

Limitations and strengths

This study was not without its limitations, which should be discussed. First, we had a relatively small sample size of both players and matches. This was in part due to the context in which this study was performed (e.g., the 2020 season had a small number of matches). We also only included players for running based metrics who played in the same position in the corresponding fixture across both seasons. Although this further reduced our sample size, it did enable the control for factors such as opposition, venue, and playing position, which can be seen as a strength. However, several other factors have been reported to affect match running performance, including weather, match outcome, number of stoppages, and score margin (Dillon et al., 2018; Esmaeili et al., 2020; Ryan et al., 2017; Sullivan et al., 2014; Wing et al., 2021) which were not accounted for within our analysis. As previously mentioned, this study would have also benefitted from measures of both player physical capacity (e.g., 2-kilometer time trial) and fatigue monitoring (e.g., wellness questionnaire), however, this data was not available to the research team.

Conclusion

The rule changes were introduced with the aim to reduce fatigue, allowing for the potential to play multiple games in a week should it be necessary. Although limited to a small sample size, and by a lack of fatigue monitoring, the predominantly small changes in absolute running based metrics may suggest that reducing playing quarters by four minutes may not have large effects on player fatigue. Previous research has indicated that sprint actions (e.g., sprint distance (> 25 $km \cdot h^{-1}$), accelerations and decelerations) contribute to 48% of post-match creatine kinase activity levels in AF players, suggesting that these actions may also be large contributors to fatigue and muscle damage (Gastin et al., 2019). Similar metrics reported in this study (very-high speed distance, acceleration and high-intensity efforts) only saw a small reduction during shortened games. Therefore, it seems likely that the effects on subsequent fatigue and muscle damage were minor. Additionally, the sudden rule changes may have contributed to more time loss injuries. It is important to understand better how a rule change affects athletes physical demands and injuries. The present study provided an example, which is useful for devising training programs and load management strategies when any rule change is introduced for a sport in the future.

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Key points

- Rule changes had predominantly a small effect on running performance
- Rule changes had no effect upon the decrement of running performance
- Rule changes had no effect on injury rates
- Rule changes increased the severity of injuries

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