Influence of physical characteristics and match outcome on technical errors during rugby league match-play

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Abstract

Purpose: To explore the relationship between technical errors during rugby league games, match success and physical characteristics. *Methods:* Twenty-seven semi-professional rugby league players participated in this study (24.8 ± 2.5 years; 183.5 ± 5.3 cm; 97.1 ± 11.6 kg). Aerobic fitness, strength, and power were assessed prior to the start of the competitive season before technical performance was tracked during 22 competitive fixtures. Attacking errors were determined as any error that occurred in possession of the ball that resulted in a handover to the opposition. Defensive errors included linebreaks, penalties and missed or ineffective tackles. Match outcome, the zone on the field each error occurred, and the number of errors in an error chain (≤ 60 seconds between each error) were assessed. *Results:* During a loss, there were more defensive errors in the 0-40 m zone compared to when a match was won (ES = 0.99 [0.04-1.94]). Error chains were a predictor of conceding a try ($p = 0.0001$; $r^2 = 0.22$), with the odds ratio increasing to 2.33 when there were 7 errors per chain. High lower body strength was associated with fewer defensive errors for backs (Bayes Factor [*BF*] = 3.67), and forwards (*BF* = 19.31), relative bench press was also important for backs (*BF* = 3.21). Conclusions: Fewer defensive errors occur 0-40 m zone during winning matches; lower body strength is strongly associated with fewer defensive errors in rugby league players.

KEY WORDS: team sports; skill; strength; power; physical fitness; Bayesian

Introduction

Rugby league is a collision sport that requires players to successfully execute technical skills whilst completing external load such as high-speed running, accelerations, and contact efforts.[1] During competition, players typically cover 90-100 $m \cdot min^{-1}$ and a collision frequency of 0.4-0.8 $n \cdot min^{-1}$, however intensities can be as high as 160 $m \cdot min^{-1}$ and two collisions per minute during certain points of the game.[2, 3] As such, players require the capacity to perform these physical activities whilst effectively executing technical actions to score a try, or prevent a try from being scored.

Defensive skills involve the tackle contest, with offensive skills including catching, passing, and in some positions, kicking the ball. Previous research has highlighted that technical performance is linked to success in matches, with winning teams committing fewer technical errors in attack and defence.[4] High standard players possess better passing and tackling skills compared to their sub-elite counterparts.[5] Well-developed tackle technique is associated with better tackle outcomes in competition.[6] As such, being able to perform effective technical actions and minimising errors over the course of a game is likely to be vital for success.

Whilst the execution of effective skills is associated with success,[4] and strength and power related to good tackle technique,[7] the impact technical errors have on match outcome and the role physical characteristics play in error rates are currently unknown. Previously, fatigue has been shown to impede technical skills,[8-10] with aerobic fitness[8] and lower body strength[9] protecting against fatigue-induced decrements in tackling technique. In addition, following the most intense 5-minute period of match-play reductions in skill actions are seen.[11] However, whilst these studies suggest fatigue impacts technical performance and strength and aerobic fitness may protect against it, the ramifications of reductions in skill involvements or efficiency was not explored. An increase in errors such as missed tackles, forward passes and knock-ons are likely to be linked to conceding a try, but this has yet to be explored. As such, the aim of this study was to (1) determine the influence technical errors have on match outcome and (2) whether any physical characteristics are associated with technical errors. It was hypothesised that technical errors in both attack and defence would be greater when a game is lost; lower error rates would be associated with better playing experience and more well-developed physical qualities.

Methods

Design

To determine the impact of errors on match success and the relationship between technical errors and physical characteristics an observational cohort study design was used. Physical qualities were assessed in a group of semi-professional rugby league players at the end of the

12-week preseason period before technical performance was tracked during 22 competitive matches during the 2017 season (9 wins, 13 losses; points for = 501; points against = 530).

Subjects

Twenty-seven semi-professional rugby league players (forwards n = 15; backs n = 12) participated in this study (24.8 ± 2.5 years; 183.5 ± 5.3 cm; 97.1 ± 11.6 kg). All players were from the same rugby league club and all testing procedures and analysis was conducted as part of the clubs monitoring protocol. In accordance with the World Medical Association (Declaration of Helsinki), players were provided with a full description of the testing procedures and signed written informed consent. The study received ethical approval from the university's ethical review board for human research.

Methodology

During the final 10 days of the preseason period, players underwent a battery of physical tests. All players were free from injury at the time of testing, with testing occurring between 17:30 and 18:30 hrs on each day, with a minimum of 48 hours between each test. All tests were performed in normal training attire, with trainers and football boots worn for all indoor and outdoor tests, respectively.

Aerobic fitness, was assessed via a 1200-m time trial, 10 days prior to the start of the season. Players performed the test on a grassed rugby league field following a 7-minute dynamic warm-up. Within two minutes of the cessation of the warm up, players performed five self-paced repetitions of 20 m, 40 m and 60 m shuttles. The time taken to complete the test was recorded with the average velocity being calculated as the marker of aerobic fitness. In addition, running momentum was also calculated by multiplying their average velocity by body mass as this has shown to be a more sensitive measure of running performance in rugby league players.[12] Previous research has highlighted the 1200-m time trial is a reliable and valid test to measure aerobic fitness in rugby league players.[13, 14] All players were familiar with this assessment protocol.

Eight days prior to the start of the season, a one repetition maximum (1RM) bench press and back squat were used to test upper-body and lower-body strength respectively. Players performed increasingly heavier loads using a standard 20 kg Olympic barbell, with a minimum of three minutes rest between sets, until they attempted a load that they could lift only once with appropriate form and technique. For the back squat, players were required to perform the movement to a below parallel thigh position and for the bench press it was essential for the bar to touch the chest before the concentric phase. Expressed as a coefficient of variation, the typical error of measurement (TEM) for the bench press and back squat were 2.8% and 3.0%, respectively.

The assessment of lower-body muscular force and power was conducted 5 days prior to the first game of the season following a period of 72 hours of no training. Players performed countermovement jumps (CMJ) on a force platform (400 Series Force Plate, Fitness Technology, Adelaide, Australia) connected to a laptop running proprietary software (Ballistic Measurement System). Following a dynamic warm-up, and one to two practice jumps, players performed two jumps each with approximately 30 seconds rest between each jump. Players were familiar with the protocol and were instructed to have their hands positioned on their hips and squat to a self-selected depth before jumping as high as possible. Data were downloaded into a spreadsheet to determine the peak concentric force and power recorded. The TEM for peak power and peak force were 3.1% and 6.2%, respectively.

Match errors were coded from 22 matches (290 player appearances) over the 2017 season by a trained analyst using SportsCode (Version 11.2.11, Agile Sports Technologies, Australia). Each match was coded for the events highlighted in Table 1 along with the intra-rater test re-test reliability expressed as a TEM for each variable. To assess the reliability, the same rater coded three games, three months apart. The definitions outlined for each variable were discussed with the coaching staff of the club and in-line with previous studies.[6] In addition, the zone on the field (defensive: 0-40 m; middle: 40-60 m; attacking 60-100 m), the phase of play (attack or defence), match time and proximity to conceding a try were also recorded for each error. Error chains were calculated when there was less than 60 seconds between each error, with the total number of errors per chain being recorded. The epoch of sixty seconds was selected as this is the average time a set of six tackles will take. Following coding, to establish absolute error counts, all errors were summed and then broken down into defensive and attacking errors. Defensive errors were any error that occurred whilst not in possession of the ball and included any missed tackle, ineffective tackle, line break, penalty, or a knock on (e.g. if a defensive player touched the ball and knocked it forward resulting in a scrum). Attacking errors were any error that occurred whilst in possession of the ball and included any knock on, forward pass, intercepted pass, or an ineffective kick. To account for differences in attacking and defensive involvements between players, error rates were calculated and expressed as the number of errors per 100 involvements.

TABLE 1 NEAR HERE

Statistical Analysis

All statistical analyses were conducted in R (Version 3.4.4, R Foundation for Statistical Computing, 2016) using RStudio (Version 1.1.383, RStudio Inc, Boston, MA, USA). Differences in errors based on match outcome, field position and phase of play were assessed using Cohen’s effect size (ES) statistic and 95% confidence intervals (CI) with thresholds of 0.00-0.19, trivial; 0.20-0.59, small; 0.60-1.19, moderate; and ≥ 1.20, large used.[15]

The likelihood of conceding a try following successive errors was determined using a binary logistic regression, using the *glm* function in R. Try was used as the dependent variable with the number of errors in a chain (1 through to ≥9 errors) used as the explanatory variable. Data were partitioned prior to running the analysis, so that 20% of the data could be used to determine the accuracy of the model by plotting the true positive rate against the false positive rate to determine the area under the curve (AUC). The probability of not conceding a try was calculated for each error chain by dividing the number of times a try was not conceded by the total number of occurrences of that error chain. Odds Ratios (OR) and their 95% CI were calculated to determine the odds of conceding a try for each error chain. A value of greater or less than one implied increased or decreased odds of conceding a try, respectively.

The relationship between player characteristics and defensive and attacking error rates were assessed for normal distribution using the Shapiro-Wilk statistic. Subsequently, Bayesian Linear Regressions were conducted using the *regressionBF* function in the *BayesFactor* package of R. Models were built for both forwards and backs for attacking and defensive errors using all physical characteristics as explanatory variables. All variables were interpreted individually to see if they made a contribution to attacking or defensive error rates. Jeffreys-Zellner-Siow Bayes factors (*BF*) were used to determine the likelihood ratio of each explanatory variable being in favour of the alternative hypothesis (H_1) compared to the null hypothesis (H_0). *BF* greater than 1 were in favour of the alternative hypothesis and interpreted as 1-3, *weak*; 3-20, *positive*; 20-150, *strong*; and >150 *very strong*. Any *BF* less than one were in favour of the null hypothesis and therefore had a detrimental effect on error rates, they were interpreted as 1-0.33, *weak*; 0.33-0.05, *positive*; 0.05-0.0067, *strong*; and >0.0067, *very strong*.[16]

Results

Match Outcome

Figure 1 shows the differences between wins and losses for attacking (Figure 1A) and defensive (Figure 1B) errors across the defensive (0-40 m), middle (40-60 m) and attacking (60-100 m) zones of the field. For attacking errors, the highest frequency occurred in the attacking zone irrespective of match outcome, with *large* differences to the defensive zone during wins (ES = 1.33 [0.23 to 2.43]), and a *moderate* difference during losses (ES = 1.11 [0.24 to 1.98]). There was little difference between wins and losses across each zone of the field for attacking errors other than a *moderate* greater number of errors in the defensive zone during wins (ES = 0.72 [0.22 to 1.32]).

FIGURE 1 NEAR HERE

Defensive errors (Figure 1B) were greatest in the defensive zone during wins and losses compared with both the middle (win ES = 0.77 [-0.28 to 1.83]; loss ES = 2.00 [1.01 to 2.99]) and attacking zones (win ES = 0.95 [-0.10 to 2.00]; loss ES = 2.29 [1.25 to 3.33]) of the field. There was little difference in match outcome for defensive errors, other than a *moderate* greater number of errors during losses in the defensive zone of the field (ES = 0.99 [0.04 to 1.94]).

Error Chains

Across the 22 games, a total of 208 isolated errors were identified, 106 error chains of two, 61 error chains of three, 35 error chains of four, 21 error chains of five, 11 error chains of six, and 10 instances for error chains of seven, eight and ≥ nine. The binary logistic regression showed the number of errors per chain was a significant predictor of conceding a try ($p = 0.0001$; $r^2 = 0.22$). The odds of conceding a try increases with the number of errors per chain (Figure 2). In particular, when errors per chain are greater than six, there are large increases in the odds of conceding a try (OR = 2.33 [2.24-2.42]) for seven, eight (OR = 4.00 [3.84-4.16]) and ≥ nine (OR = 9.00 [4.8-13.2]) errors per chain. The model correctly predicted 97.0% of no try events, 74.2% of try events, with an overall model accuracy of 92.3%; the AUC was 0.77 showing a high level of predictive accuracy.

FIGURE 2 NEAR HERE

Errors and physical characteristics

It was hypothesised that lower error rates would be associated with better playing experience and more well-developed physical qualities. Table 2 shows that for attacking errors, no *BF* were in favour of the alternative hypothesis for backs, all variables showed *weak* support in favour of the null hypothesis (*BF* = 0.69-0.47). For forwards, there was *positive* support of the alternative hypothesis over the null hypothesis for relative squat, and body mass, and *weak* support for bench press 1RM, and time trial momentum. All other variables showed *weak* support in favour of the null hypothesis (*BF* = 0.82-0.44).

TABLE 2 NEAR HERE

For defensive error rates, there was *positive* support for the alternative hypothesis in favour of the null hypothesis for squat 1RM, relative bench press 1RM, and relative squat (*weak*) for backs. All other physical characteristics showed *weak* support in favour of the null hypothesis (Table 2). For forwards, there was positive support in favour of the alternative hypothesis over the null hypothesis for relative squat, and *weak* support for absolute squat. All other variables showed *weak* association in support of the null hypothesis.

Discussion

The aim of this study was to assess the importance of technical errors on match outcome in rugby league and the relationship between error rates and physical characteristics. The results of this study show that there are a greater number of defensive errors in matches that are lost, with an increase in the 0-40 m zone. In addition, as the number of errors in succession increases, so does the odds of conceding a try, particularly when there are more than 6 errors per chain. Fewer defensive errors were associated with greater lower body strength in both forwards and backs, with upper body strength having a small benefit for backs. Collectively these results show that defensive error rates influence match outcome and players with high lower body strength commit fewer errors when defending.

The greater defensive errors seen during a loss is unsurprising given the importance executing successful tackles to prevent the opposing team gaining metres in attack or having successful line breaks. Previous evidence has highlighted that successful teams have better defensive performance,[4] conceding less territory when defending.[17] Unlike previous research, this is the first study to show that the increased defensive errors seen during a loss occur when defending in the 0-40 m zone. Clearly this suggests that the ability to tackle is vital, but given that the highest error rates occurred when defending the goal line, where the opposition is likely to be more expansive in their play, a decision-making component is also central to successful defensive performance. As such, developing tackle technique alone is unlikely to be sufficient; players must be exposed to match-like scenarios where they are required to defend for multiple attacking sets in various parts of the field, to develop the decision-making aspect and cohesion between players to maximise defensive performance.

The lack of difference in attacking error rates between match outcome in the current study is in contrast to one previous study,[4] but supports another study between successful and less successful semi-professional teams.[17] In the current study, there was a greater number of errors in the defensive zone of the field during matches won. This finding is somewhat surprising, given that the highest number of try's are scored following a turnover, and the likelihood of conceding points increases the closer to the goal line the turnover occurs.[18] However successful teams have a slightly lower completion rate, compared with less successful teams in their defensive zone.[17] These results may reflect that when a team is winning a game, and there is less 'scoreboard pressure', they may be more expansive with the ball, which whilst may lead to more points being scored, it may also result in a greater number of attacking errors. As such, this study highlights that the number of attacking errors is not negatively associated to match outcome.

A novel aspect of this study was quantifying chains of errors and assessing the relationship to conceding a try. Whilst all errors (both attacking and defensive) were grouped together, the results clearly show that as the number of errors in succession increases, so too does the odds of conceding a try. In particular, once a chain of seven errors occurs, the odds of conceding a try increases from 0.57 to 2.33. As such, it is vital that once an error occurs, the team must make attempts to limit any subsequent errors, this may mean kicking earlier in the tackle count or being more cautious in possession. On the other hand, if attacking against a team who has conceded multiple errors, it is likely to be advantageous to run the ball rather than attempting a penalty goal if the opportunity presents itself. These results may differ at a professional level due to superior physical and technical attributes. As such, further studies should be conducted at different levels of rugby league competition to determine whether the trends reported here differ.

Lower body strength was positively linked to reduced defensive error rates across all players, but was greater in the forwards. The difference in these results is likely due to the difference in tackle demands between forwards and backs, with forwards performing more frequent collisions.[19, 20] Interestingly however, relative strength was more important for forwards than absolute strength, which highlights that whilst high body mass is important,[1] if it is to increase, it must be concomitant with changes in strength. Lower body strength has been previously shown to be associated with greater tackle technique in rugby league players,[7, 21] with good technique resulting in more dominant and fewer missed tackles during competition.[6, 19] The high support of strength being associated with reduced defensive errors seen in the present study add further evidence to the importance of muscular strength in rugby league players. Due to the physical nature of the tackle contest,[22] players with greater levels of strength will use a lower proportion of their maximum compared to weaker players, developing less fatigue,[9] and therefore fewer errors. Developing strength leads to improvements in tackle technique;[23] which is likely to lead to reductions in defensive error rates. Despite this, whilst the physical skill of effecting a tackle may be underpinned by physical capacities, there is a large cognitive component to successful defensive performance during match-play. The *weak* evidence of lower body power being in favour of the null hypothesis with regards defensive errors, is in accordance with others.[7] This may be reflective of the CMJ being performed at body weight and therefore the force profile is much lower than of a tackle, where a large force component is required to be produced in a horizontal and vertical direction to halt the momentum of the attacker. As such, future research should look to assess the relationship between tackle technique and exercises across the entire force-velocity spectrum in both horizontal and vertical planes.

No physical characteristics were associated with reduced attacking error rates (e.g. knock on, forward pass) in the backs, with all physical characteristics showing weak association with increased error rates. In the forwards however, body mass and relative squat showed positive association in the forwards, with weak associations also from time-trial momentum and bench press 1RM. The difference in results here is likely due to the different responsibilities of the forwards. Forwards are involved in more collisions, and more collisions where there are multiple defenders making the tackle.[20] As such, being heavier and stronger is likely to be advantageous to the attacker in order to maintain possession of the ball and 'win' the tackle contest. Whereas for the backs, the higher percentage of one-on-one tackles from the side, and fewer front-on tackles with multiple defenders is likely to lower the force of the tackle and reduce the likelihood of an error. Practitioners should look to increase body mass in forwards, but not at the expense of relative strength.

There was *weak* support of the alternative hypothesis of reduced error rates with well-developed aerobic fitness. This is in accordance with other studies, showing a relationship with skills under fatigue.[5] Additionally, reductions in skill efficiency are seen following the greatest five minutes of high-speed running in rugby league players,[11] and following repeat-effort activity,[10] suggesting that there is some link to aerobic fitness. Whilst it has been shown previously that running fitness is important in rugby league players,[1] it becomes less important when the contact demands increase.[24] Due to the frequent and violent collisions of rugby league match-play, it could be expected that a measure of running fitness does not reflect the repeat contact, wrestle, and skill demands of match-play.[1] The relationship between error rates and aerobic fitness may have increased using a test more specific to the demands of the game, such as one involving tackles and running efforts.[22] Furthermore, the lack of association with physical characteristics, suggests that attacking skills, such as passing and catching ability, are likely to be more related to technical skills.

Practical Applications

Developing lower body strength may reduce the number of defensive error rates should be a training focus. Increases in body mass should not come at the cost of relative strength. Forwards are likely to benefit more from strength training due to their role within the game. Improving defensive performance through drills aimed at improving tackle technique and exposure to match-like scenarios where players are required to work as a team and make complex decisions is likely to be beneficial. Minimising errors in succession is also pivotal to success and should be emphasised to players.

Conclusions

Overall, this study highlights that defensive errors are linked to match outcome, with increased error rates in the defensive third of the field occurring when a match is lost. When errors occur in succession the odds of conceding a try increases, particularly when there are more than six errors in succession. As such, minimising the number of errors that occur in succession in both attack and defence is vital. Lower defensive error rates are associated with greater lower body strength. As such, developing these qualities should be central to training in rugby league players. It is important to note, that this study was only conducted in players from one semi-professional rugby league team and therefore may not be generalisable to all players. Additionally, physical characteristics were only assessed at the end of preseason and changes may have occurred in technical and physical capacities as the season progressed.

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Figure Legends

Figure 1. Attacking (A) and Defensive (B) errors in different field positions during winning and losing games. *M* = moderate effect size difference; *L* = Large effect size difference; *o* = outcome; *p* = all other field positions; $_m$ = middle, 40-60 m zone.

Figure 2. The relationship between the number of errors per chain and the likelihood of conceding a try. * denotes Odds Ratio > 1. An error chain was calculated as the number of errors in a succession when there were less than 60 seconds between errors.

Table 1. Match variable and their definition

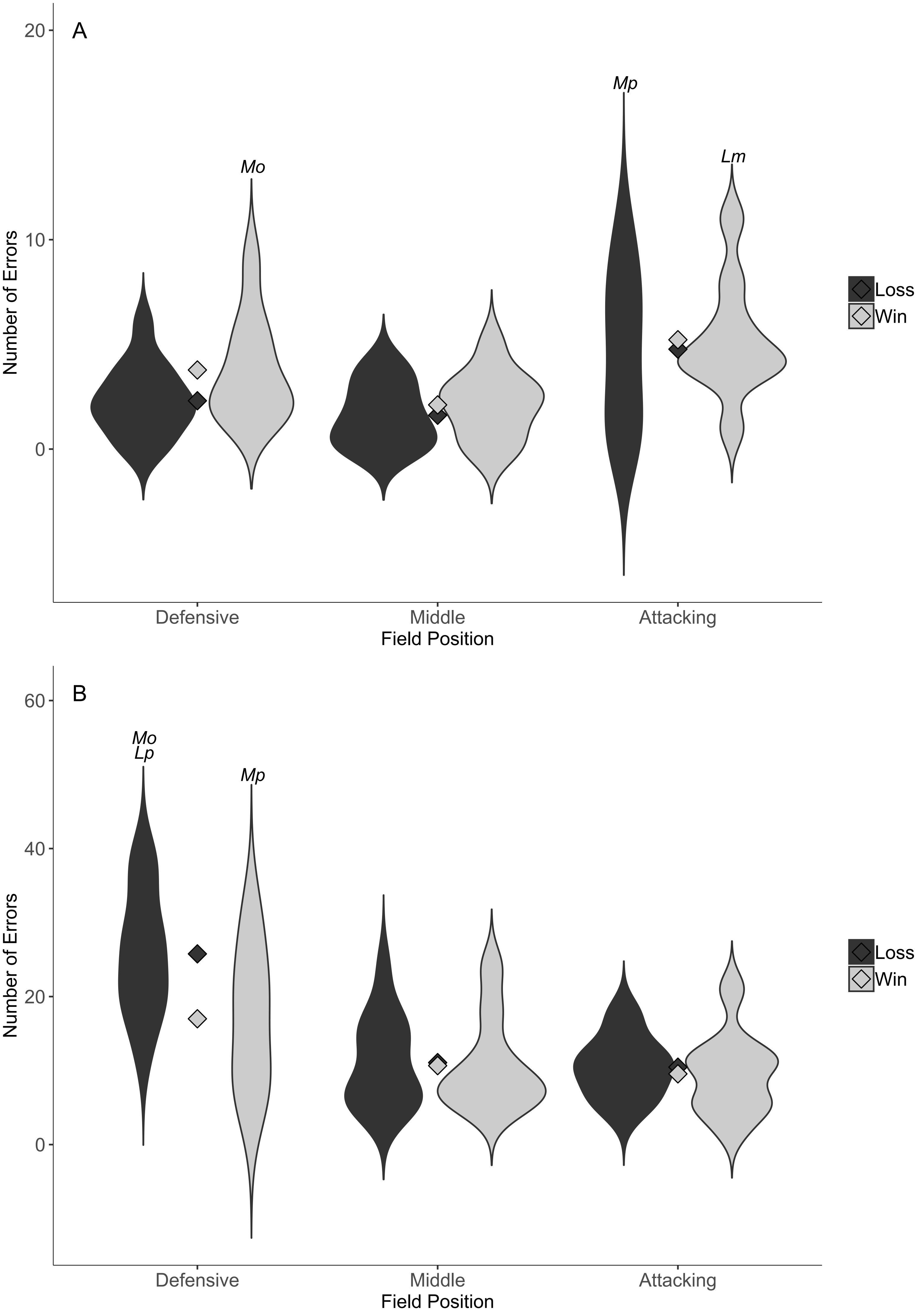
Descriptor	Definition	TEM (%)
Tackle	One or more defenders make contact with the ball carrier and the player is either brought to ground, with the ball carrying arm touching the ground, or forward progress is halted, both outcomes resulting in a completed tackle and play-the-ball or handover	4.5
Missed tackle	Any unsuccessful attempt to complete a tackle where the defender(s) make contact with the ball carrier, but lose contact before the tackle is completed	6.5
Ineffective tackle	Contact is made with the ball carrier by the defender(s), but the attacker offloads the ball prior to the tackle being completed	3.7
Penalty	Any infringement by a player that causes the play to be stopped by the referee and possession given to the opposing side	12.3
Line break	A player in possession of the ball moves through the defensive line, without a defender making contact with the attacker	5.5
Receipt	A player receives the football from a pass, kick, or play-the-ball	4.5
Knock on	A player in possession of the ball drops the ball forward, making contact with the ground or an opposing player	1.3
Forward pass	When the ball carrier passes the ball forward where it is caught by a teammate	1.9
Pass intercepted	The ball carrier passes or offloads the ball that is intercepted by an opposing player	0.0
Ineffective kick	When the football is kicked out of hand during open play and goes over the touch line without bouncing inside the field of play resulting in a scrum to the opposition from where the kick took place.	0.0

TEM = typical error of measurement as a coefficient of variation.

Table 2. Bayes factors for each explanatory variable from the Bayes linear regression.

	Attacking Errors		Defensive Errors	
Explanatory Variable	Backs	Forwards	Backs	Forwards
Age	0.54	0.55	0.72	0.46
Height	0.54	0.8	0.47	0.47
Body mass	0.54	7.05	0.56	0.99
Experience	0.49	0.44	0.97	0.52
Squat 1RM	0.49	0.50	3.67	1.56
Relative squat	0.48	18.74	2.90	19.31
Bench press 1RM	0.54	1.65	0.63	0.55
Relative bench press	0.48	0.46	3.21	0.46
CMJ force	0.69	0.45	0.80	0.46
CMJ power	0.47	0.46	0.52	0.45
Time-trial momentum	0.47	1.54	0.49	0.45

1RM = 1 repetition maximum; relative scores were divided by body mass;
CMJ = countermovement jump; time-trial = 1.2 km time-trial. *BF* greater than 1 were in favour of the alternative hypothesis:1-3, *weak*; 3-20, *positive*; 20-150, *strong*; and >150 *very strong*. *BF* less than zero were in favour of the null hypothesis: 1.00-0.33, *weak*; 0.33-0.05, *positive*; 0.05-0.0067, *strong*; and >0.0067, *very strong*.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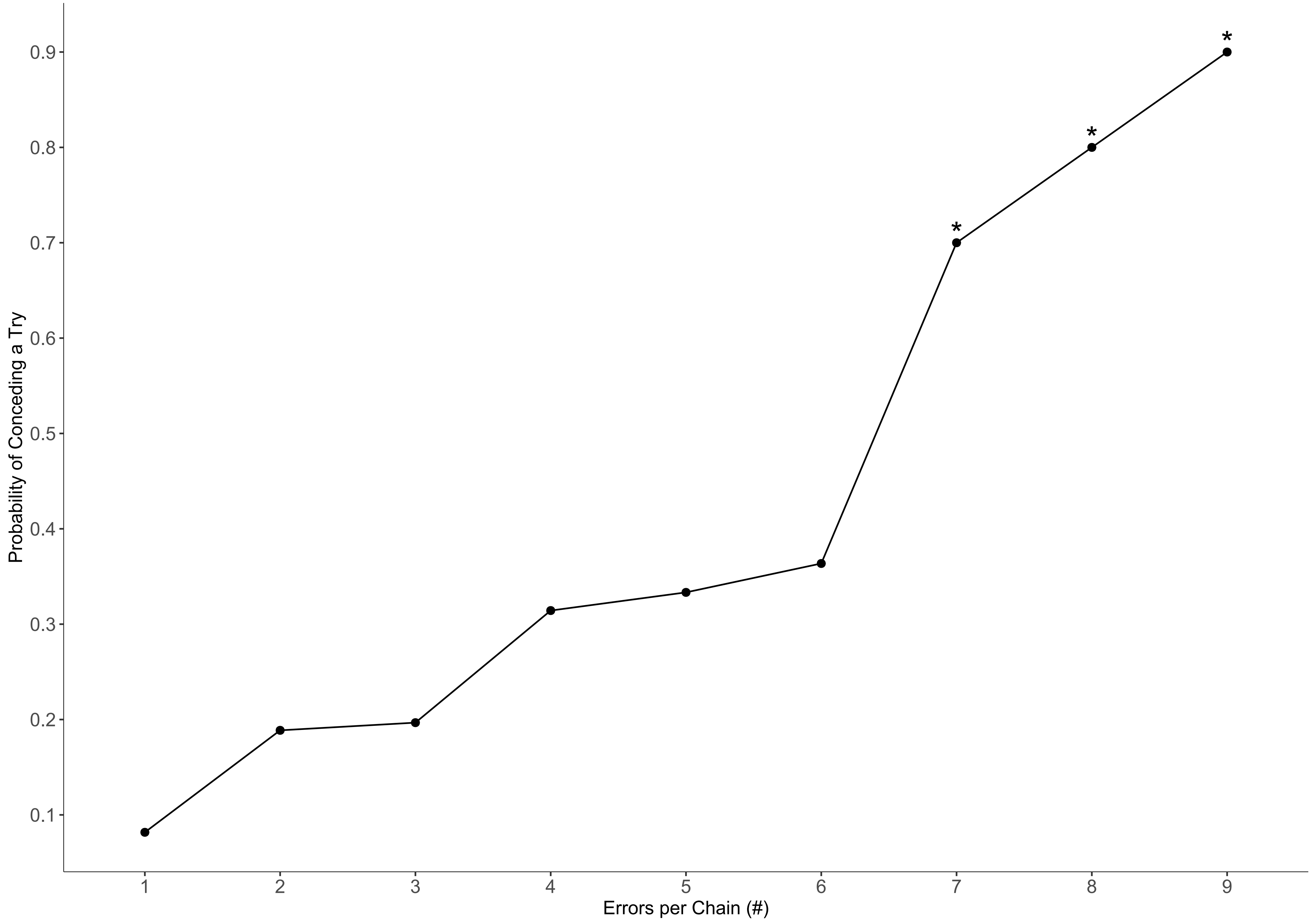
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