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Correlating technical and tactical, and kinematic elements: An in-depth analysis of game-related metrics and running activities in sub-elite senior male rugby union players

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Abstract

To comprehend the complexity of rugby union performance, it is crucial to correlate technical and tactical, and kinematic elements specifically for playing roles. Hence, this study investigated the relationship between game-related metrics and running activities in sub-elite senior males. Technical and tactical performance and running activity of 36 sub-elite senior players (age mean = 25 years; total performances = 200) were assessed in relation to 17 key performance indicators (KPIs). A series of general linear mixed models were performed to evaluate the relationship between KPIs according to roles (backs, forwards and scrum halves), including subjects and games as random effect. The main finding was that the tactical context relates distinctly running activities, and this effect varies between backs and forwards. Tackling mainly involves impacts and deceleration, whereas carrying the ball is associated with impacts and accelerations. Furthermore, the percentage of missed tackles is related to higher occurrences of acceleration events. These findings offer a more profound understanding of the physiological requirements in sub-elite rugby performance, especially given the limited evidence on the interaction between technical and tactical performance and running activities in sub-elite rugby union games. As a result, coaches and physical practitioners should design and execute diverse training sessions that consider both the tactical context and the players' positions.

Keywords

Acceleration, global positioning system, tackling, key performance indicators, time-motion analysis

Introduction

Rugby union is an invasion sport that relies on contact skills, featuring intermittent and high-intensity running demands. It includes phases of static exertion, collisions and running, interspersed with varying periods of lower-intensity activity and rest.[1–3] Matches consist of two 40-min halves and the primary aim of a team is to score more points than the opposition. A rugby union team comprises 23 players (i.e. 15 players on the pitch and eight substitutions) that are categorized into two positional groups, known as 'backs' (i.e. the scrum-halves, the fly-half, the centres, the fullbacks and the wings) and 'forwards' (i.e. including props, hookers, the second row, the flankers and the number eight). In particular, backs are more involved in running activities, while forwards experience higher levels of physical contact and collision, such as scrums, tackles, rucks and mauls.[4] Additionally, within the back's category, scrum halves often stand out,

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particularly in terms of their passing frequency and movement patterns. For instance, they cover the greatest distance at medium and high speeds but cover less distance at maximal speed compared to other backs.[4] In fact, they are often analysed separately from the other backs in terms of movement profiles and technical and tactical performance.[4–6]

From the performance analysis (PA) perspective, both notational (NA) and time-motion analysis (TMA) aim to quantify dynamic and complex technical and tactical situations and movement patterns respectively, in a systematic and reliable manner by the means of several technologies, such as video footage, accelerometers, and global navigation satellite systems (GNSS).[7,8]

Specifically, NA is mainly employed to quantify specific variables in relation to contextual constraints such as strength of the opposition, field position, player roles and match outcome.[9] In particular, NA investigates individual and collective performance by assessing one or a combination of defensive and offensive key performance indicators (KPIs) like tackles, turnovers, breakdowns, penalties, line breaks, rucks, mauls, scrums, lineouts and passes. It places a strong emphasis on understanding their correlation with match outcomes (e.g. winning vs losing), age groups (e.g. youth and senior) and competition levels (e.g. professional vs amateur).[10–12] This approach allowed to highlight differences in playing styles between Northern and Southern hemispheres, home and away location, and positional roles.[4,13–15] However, NA was also used to provide valid and reliable information on players' movement patterns although this approach is notably time-consuming and inefficient since human analysts must focus on one player at a time.[16] Therefore, the trend in quantifying players' movement patterns has shifted towards utilizing newer and increasingly accessible automated tools known as wearable microtechnology (e.g. GNSS, accelerometers, gyroscopes and magnetometers), which are managed by software capable of integrating various sources of information.[17,18]

As a result, NA and TMA differentiated from each other and pursued distinct aims. In particular, TMA primarily focuses on recording movement patterns and providing kinematic data such as speed, distance, acceleration and deceleration during matches or training sessions.[19,20] However, it should be noted that TMA can be affected by significant variations between and within GNSS devices,[21] so careful selection of the most reliable variables, such as distance, speed and peaks in acceleration, is crucial when conducting TMA.[22]

Nevertheless, even though NA and TMA are typically investigated separately to describe performance in rugby union, they are inherently dependent on the 'game model'. Specifically, it was suggested that rugby requires a combination of technical and psycho-physical capacities within a so-called 'tactical context', where players must make appropriate decisions based on different game situations.[23] In fact, according to previous studies,[24,25] rugby union performance is characterized by four main game situations occurring during a match: (i) transition into attack, (ii) attacking organization, (iii) transition into defence and (iv) defensive organization. As a consequence, training has been progressively planned according to skill-based conditioning games (20 m sprint = 3.07 ± 0.02; 30 m sprint = 5.47 ± 0.03), which reported better post-training session speed performances with respect to not-game related training (20 m sprint = 3.12 ± 0.02; 30 m sprint = 5.59 ± 0.03), as well as an improved cardiorespiratory endurance over 9 weeks in elite rugby players.[26] Consequently, players are trained to develop physical abilities (e.g. strength, speed, acceleration and deceleration, endurance, high-intensity repeated sprints) and to transfer them on the pitch according to the game model and the tactical context.[23]

Hence, it is essential to investigate PA from a comprehensive perspective, considering the relationship between technical and tactical (e.g. passes, tackles, breaks, penalties), and kinematic aspects of performance (e.g. speed, distance, acceleration and deceleration, impacts), according to the playing roles. While this approach has been examined in the context of soccer,[27–30] it remains an unexplored area in rugby union.[5] Therefore, the aim of this study was to analyse the relationship between specific game-related technical and tactical KPIs (e.g. pass, carriers, breaks, defenders beaten, turnovers, tackles, penalties) and running activities (e.g. distance covered at a certain speed, accelerations, decelerations, impacts) in sub-elite senior males, specifically for the backs, forwards and scrum halves.

Materials and methods

Participants

Thirty-six senior sub-elite players involved in the major Italian rugby union league (i.e. Top10), including 16 forwards (mean age: 24 years; mean height: 188.5 cm; mean weight: 102.5 kg), and 20 backs (mean age: 25 years; mean height: 175 cm; mean weight: 80 kg) participated in this study. All 36 players were recruited from the same team and had at least 8 years of experience in rugby competitions and training, at the national or international level. A total of 11 (wins: 3; loses: 8) closed (0–9 points) and balanced (10–26 points) games[31] performed during the 2022–2023 Top10 National Championship was considered for the study. Informed consent was obtained from recruited players, and the Club management approved the study. The local institutional review board approved this study (ID25831).

Design and procedures

Data from technical and tactical, and time-motion KPIs were recorded from 11 games. According to expert coaches' feedbacks and suggestions, as well as to previous research,[32] only player performances exceeding 20 min (n = 200) were included in the analysis to ensure database consistency. Due to the different performance profiles,[4,33,34] all the analysis was separately performed for forwards (game performances n = 107), backs (game performances n = 73) and scrum halves (game performances n = 20). Although scrum-half players are commonly considered as backs, their data was treated separately since they usually represent an outlier performance, especially because their high specialization in passing and playmaking.

Games were recorded by an expert match and performance analyst (experience > 2 years) and stored as a mp4 file on a MacBook Pro 15© (Apple Inc). According to previous studies, the same analyst coded the players' events at the end of each game using Longomatch software (Longomatch, version 1.3.7, Barcelona, Spain).[4,5,35] Video analysis was based on eight technical and tactical KPIs reported in Table 1. In line to previous studies on situational sports,[36–38] a single experienced observer (who already performed the notational analysis of more than 200 rugby games) analysed the entire games. However, to provide a reliable single analysis, either the intra- or inter-observer reliability was established. Three observers (i.e. the observer of the analysis reported for this study, and two additional rugby coaches) were involved to score twice (i.e. the observations were separated by 7 days) the technical and tactical KPIs of some random phases of the considered games, for each tactical role. For each KPI, the ICC was calculated between the analyses of the same observer (ICC range = 0.95–1.00) and of all four observers (ICC range = 0.95–1.00) to guarantee satisfactory intra- and inter-observer reliabilities, respectively.

The external training load was assessed using 20 GPS units equipped with an 18 Hz satellite signal, 120 Hz tri-axial gyroscope, and accelerometer (Gpexe Pro 2, Exelio S.R.L., Udine, Italy). The GPS units were securely attached to the players' torsos beneath their official competitive t-shirts, activated 45 min before kick-off. The analysis focused on nine time-motion KPIs (Table 1) from the start of the game until its conclusion. Briefly, the nine KPIs included data relating to the percentage distance spent at different intensities (i.e. Z1, Z2, Z3, Z4, Z5 and Z6) and the frequency of accelerations, decelerations and impacts per minute performed during the match.

Statistical analysis

Means and standard deviations were computed for each player group (forwards, backs and scrum halves) across all KPIs (Table 1). Each technical and tactical, and time-motion KPI was normalized according to total time in play or total distance, respectively.[39] A series of generalized linear mixed model (GLMM) was performed to evaluate the impact of the technical and, tactical KPIs on time-motion data according to the different roles. Specifically, the eight technical and tactical KPIs and roles entered the model as fixed effects, while the nine time-motion KPIs were dependent variables (Please see Formula (1) as an example of GLMM). When necessary, post-hoc, with Bonferroni correction, were performed to identify difference among Roles. Players and games were included in the model as random effect within the model.

$$\begin{aligned} & \textit{Dependent Variable} \sim \ \beta_0 + \beta_1 \ (\textit{Pass / min}) \\ & \quad + \beta_2(\textit{Carriers / min}) + \beta_3(\textit{Clean Breaks / min}) \\ & \quad + \ \beta_4(\textit{Defenders Beaten / min}) \\ & \quad + \beta_5(\textit{Total Tackles / min}) \\ & \quad + \ \beta_6(\textit{Penalties conceded / min}) \\ & \quad + \beta_7(\textit{Turnovers Conceded / min}) \\ & \quad + \beta_8(\textit{Missed Tackles}) \\ & \quad + \textit{Roles} + (1|\ \textit{athlete}) + (1|\textit{game}) + \varepsilon \end{aligned} \tag{1}$$

Formula 1. Example of the general linear mixed model utilized in this study.

The level of significance was set at $p = 0.05$. Statistical analysis was conducted using the statistical software R (R version 4.1.0, 2021-05-18). For GLMM the following package were used: 'lme4',[40] 'Emmeans',[41] 'effectsize'.[42]

Results

Table 1 contains the descriptive statistics (Mean ± 95%CI) and descriptions of all KPIs, including both technical and tactical indicators and time-motion measurements, for Backs, Forwards and Scrum-halves. Among all individual performances, the analysis included only individual performances that lasted for more than 20 min, resulting in a sample size of $n = 200$.

The total distance run by the athletes was, on the average, 4784 ± 1737 m. Total Tackles/min significantly impact on distance at Z1 (F = 9.6, ES = −0.20, 95%CI [−0.33, −0.07]) and Z3 (F = 6.35, ES = 0.18, 95%CI [0.04, 0.32]) and Z4 (F = 11.71, ES = 0.22, 95%CI [0.09, 0.34]). Moreover, significant differences were observed among roles when considering Z2, Z4, Z5 and Z6. In particular, Backs showed a lower percentage distance spent at Z2 (estimated difference of −5.79%), but a higher one at Z4, Z5 and Z6 compared to the Forwards (estimated difference of 2.19%, 8.51% and 0.91%, respectively) (Figure 1, Table 2).

The Carrier/min and Missed Tackles variables showed a positive association (F = 4.49, ES = 0.18, 95%CI [0.01, 0.34] and F = 4.90, ES = 0.13, 95%CI [0.01, 0.25]) with the Acceleration/min. Additionally, Backs showed a higher value compared to the Forwards (estimated difference of 0.12). Total Tackles/min positively impact Deceleration/min (F = 9.76, ES = 0.21, 95%CI [0.08, 0.35]). Moreover, Backs showed a higher number of

Table 1. Descriptive table of time-motion and technical and tactical KPIs for forwards, backs (except scrum halves) and scrum halves [mean; (95%CI)].

KPI	Description	Forwards	Backs	Scrum halves
Distance/sp Z1%	% of distance (in meters) covered at a speed below 5 km/h, relative to the total distance covered	37.9; (36.7, 39.1)	38.1; (37.1, 39.1)	32.7; (30.3, 35.0)
Distance/sp Z2%	% of distance (in meters) covered at a speed between 5 and 10 km/h, relative to the total distance covered	30.5; (29.9, 31.0)	24.3; (23.6, 24.9)	25.8; (24.5, 27.2)
Distance/sp Z3%	% of distance (in meters) covered at a speed between 10 and 15 km/h, relative to the total distance covered	21.7; (21.0, 22.5)	20.2; (19.5, 20.8)	22.3; (20.6, 24.0)
Distance/sp Z4%	% of distance (in meters) covered at a speed between 15 and 18 km/h, relative to the total distance covered	5.80; (5.40, 6.21)	7.84; (7.48, 8.20)	9.06; (8.35, 9.77)
Distance/sp Z5%	% of distance (in meters) covered at a speed between 18 and 25 km/h, relative to the total distance covered	3.93; (3.54, 4.33)	8.42; (7.93, 8.91)	8.95; (7.77, 10.1)
Distance/sp Z6%	% of distance (in meters) covered at a speed above 25 km/h, relative to the total distance covered	0.17; (0.11, 0.24)	1.19; (1.01, 1.38)	1.18; (0.71, 1.66)
Acc events/min	Total accelerations (>2.5 m*s2) relative to the total time spent	0.43; (0.41, 0.46)	0.54; (0.52, 0.58)	0.50; (0.42, 0.58)
Dec events/min	Total decelerations (>2.5 m*s2) relative to the total time spent	0.36; (0.34, 0.39)	0.47; (0.45, 0.51)	0.52; (0.44, 0.60)
Impacts/min	Total impacts relative to the total time spent	0.48; (0.45, 0.52)	0.49; (0.45, 0.54)	0.56; (0.48, 0.64)
Pass/min	Total passes completed by a player, both positive [which centres the target (receiver's hands) and allows receiver to maintain speed and acceleration] and negative (doesn't centres the receiver's hands), relative to the total time played	0.02; (0.01, 0.02)	0.06; (0.04, 0.07)	0.59; (0.48, 0.71)
Carriers/min	Times a player carried the ball in both dominant (gains the collision with the defender and once he is brought to ground, he acts properly to quickly release the ball) and non-dominant manner (loses the ball), relative to the total time played	0.07; (0.06, 0.08)	0.05; (0.04, 0.05)	0.04; (0.02, 0.05)
Clean breaks/min	Times an attacker evades tackles, breaks through defence, creates a scoring opportunity, relative to the total time played	0.01; (0.01, 0.01)	0.001; (0.001–0.002)	0.00; (0.00, 0.00)
Defenders beaten/min	Count of opposing defenders successfully evaded by the attacking player, relative to the total time played	0.03; (0.03, 0.04)	0.02; (0.02, 0.03)	0.02; (0.01, 0.03)
Turnovers conceded/min	Count of instances when a player loses possession to the opposing team due to own mistakes or successful defensive play, relative to the total time played	0.01; (0.01, 0.02)	0.006; (0.003, 0.008)	0.007; (0.001, 0.01)
Total tackles/min	Count a player tackled an opponent (all dominant, non-dominant, missed and assisted/doubled tackles), relative to the total time played	0.11; (0.09, 0.12)	0.06; (0.05, 0.07)	0.04; (0.02, 0.05)
Penalties conceded/min	Count of rule violations by a player, resulting in penalties awarded to the opposing team, relative to the total time played	0.02; (0.01, 0.02)	0.007; (0.004, 0.01)	0.006; (0.002, 0.01)
Missed Tackles (%)	Count of defender player fails to bring down the ball carrier with a tackle attempt, resulting in the attacker continuing their run, relative to all tackles attempts	9.7; (7.4, 12.0)	15.8; (11.3, 20.3)	8.9; (0.0, 17.9)

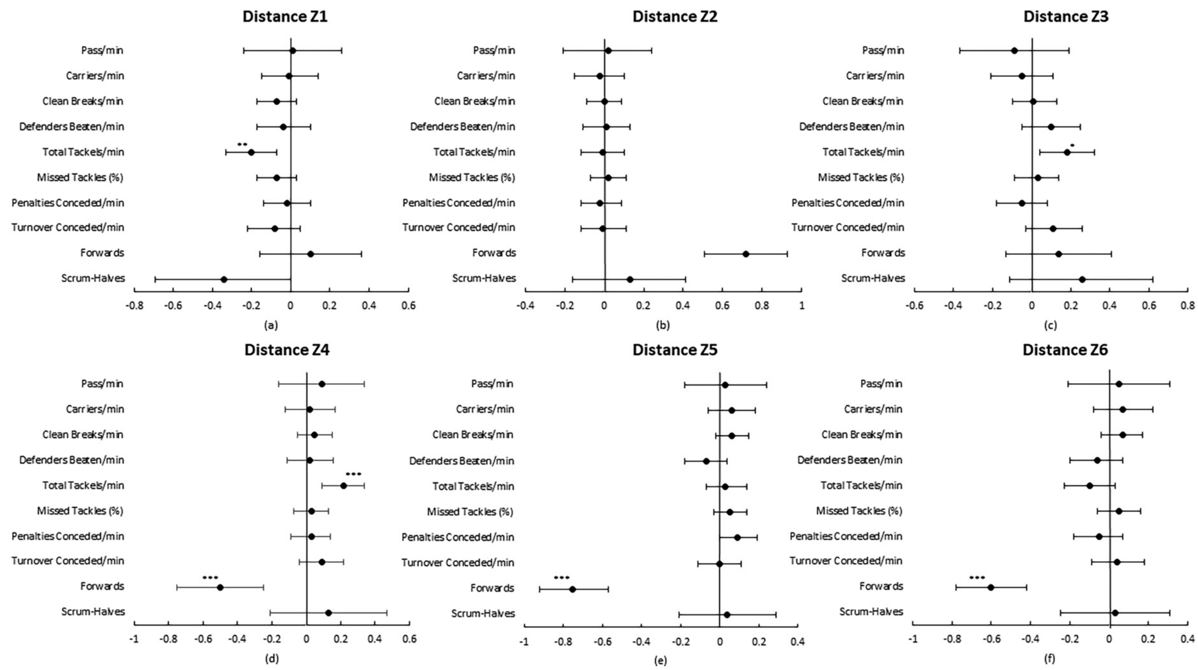

Figure 1. General linear mixed models (GLMM) outcomes for percentage distance at different zones.

deceleration/min compared to the Forwards (estimated difference of 0.15). Finally, Carrier/min (F = 12.13, ES = 0.25, 95%CI [0.11, 0.39]), Total Tackles/min (F = 34.91, ES = 0.36, 95%CI [0.24, 0.48]) and Turnover Conceded/min (F = 12.61, ES = 0.23, 95%CI [0.10, 0.36]) positive influenced Impact/min (Figure 2, Table 3).

Discussion

This study investigated the relationship between technical and tactical (i.e. pass, carriers, breaks, defenders beaten, turnovers, tackles, penalties) and running activities (i.e. distance covered at a certain speed, accelerations, decelerations, impacts) in relation to different tactical roles (i.e. Backs, Forwards, Scrum-halves). The main finding was that the tactical role significantly affects running activities, highlighting differences especially between backs and forwards. Tackling mainly involves impacts and deceleration, whereas carrying the ball is associated with impacts and accelerations. Furthermore, the percentage of missed tackles is related to higher occurrences of acceleration events. Nevertheless, only the minor part of the relationship between either distances/speed (3 over 48) or acceleration/deceleration/impacts (6 over 24) with the tactical variables reported the significance. Also, for the positional differences, only 5 over 18 significant relationships emerged (all for forwards, and no one for scrum-halves), thus highlighting the complexity of the rugby union players' performances, and the need of promoting additional match analyses.

This scenario, in accordance with other studies,[43,44] highlights a defensive gameplay model where the rate of tackles occurs more when in motion, running between 10 and 18 km/h, but not when accelerating. This reasonably emphasizes a type of defence where the tactical aspect is mainly based on speed. Specifically, it was suggested that defensive structures should limit the space of attackers by preventing them from breaking the line, and in order to achieve this goal, defensive speed is the main characteristic that enhances the probability of a successful defensive play.[43] Furthermore, these results align with previous findings on speed, ranging from 3.9 to 6.4 m/s (i.e. from 14 to 23 km/h) in both front-on and side-on tackles, with no significant difference between competitive levels (i.e. junior, national and international levels).[44]

On the contrary, the only instance where tackles are associated with acceleration is in the case of missed tackles. The interpretation of this phenomenon can be ambiguous, as more acceleration events could result from both a pre-tackle or a post-tackle situation. On one hand, it has been reported that the contribution of high pre-tackle velocity is relatively low compared to other factors, such as tackling technique.[45–47] Consequently, well-trained players tend to prioritize good technique over high speed in tackling.[47,48] Conversely, it is reasonable to assume that situations with more missed tackle events could be caused by a preference for high speed and accelerations with poor technique before impacts. On the other hand, missed tackles could be related to higher acceleration events due to a post-tackle situation. Specifically, a missed tackle could force players to recover from a compromised defensive situation, prompting them to modify the defensive structure by moving quickly and involving a greater

Table 2. General linear mixed models (GLMM) results [ES (95%CI); F-value / t-value for Bonferroni post-hoc test] for percentage distance at different zones (*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$).

	Distance Z1	Distance Z2	Distance Z3	Distance Z4	Distance Z5	Distance Z6
Pass/min	0.01 (−0.24, 0.26) F = 0.005	0.02 (−0.21, 0.24) F = 0.020	−0.09 (−0.37, 0.19) F = 0.394	0.09 (−0.16, 0.34) F = 0.477	0.03 (−0.18, 0.24) F = 0.085	0.05 (−0.21, 0.31) F = 0.139
Carriers/min	−0.01 (−0.15, 0.14) F = 0.008	−0.02 (−0.15, 0.10) F = 0.132	−0.05 (−0.21, 0.11) F = 0.343	0.02 (−0.12, 0.17) F = 0.109	0.06 (−0.06, 0.18) F = 0.950	0.07 (−0.08, 0.22) F = 0.858
Clean breaks/min	−0.07 (−0.17, 0.03) F = 1.866	0.01(−0.09, 0.09) F = 0.003	0.01 (−0.10, 0.13) F = 0.067	0.05 (−0.05, 0.15) F = 0.926	0.06 (−0.02, 0.15) F = 2.290	0.07 (−0.04, 0.17) F = 1.601
Defenders beaten/min	−0.04 (−0.17, 0.1) F = 0.274	0.01 (−0.11, 0.13) F = 0.034	0.10 (−0.05, 0.25) F = 1.790	0.02 (−0.11, 0.16) F = 0.127	−0.07 (−0.18, 0.04) F = 1.460	−0.06 (−0.20, 0.07) F = 0.831
Total tackles/min	−0.2 (−0.33, −0.07)** F = 9.615	−0.01 (−0.12, 0.10) F = 0.027	0.18 (0.04, 0.32)* F = 6.355	0.22 (0.09, 0.34)*** F = 11.717	0.03 (−0.07, 0.14) F = 0.346	−0.10 (−0.23, 0.03) F = 2.255
Missed tackles (%)	−0.07 (−0.17, 0.03) F = 1.740	0.02 (−0.07, 0.11) F = 0.162	0.03 (−0.09, 0.14) F = 0.193	0.03 (−0.07, 0.13) F = 0.336	0.05 (−0.03, 0.14) F = 1.450	0.05 (−0.06, 0.16) F = 0.876
Penalties conceded/min	−0.02 (−0.14, 0.1) F = 0.120	−0.02 (−0.12, 0.09) F = 0.131	−0.05 (−0.18, 0.08) F = 0.496	0.03 (−0.09, 0.14) F = 0.181	0.09 (0.00, 0.19) F = 3.645	−0.05 (−0.18, 0.07) F = 0.721
Turnover conceded/min	−0.08 (−0.22, 0.05) F = 1.611	−0.01 (−0.12, 0.11) F = 0.025	0.11 (−0.03, 0.26) F = 2.290	0.09 (−0.04, 0.22) F = 1.705	−0.01 (−0.11, 0.11) F = 0.002	0.04 (−0.09, 0.18) F = 0.393
Forwards	0.10 (−0.16, 0.36) t = −1.09	0.72 (0.51, 0.93) t = −5.79	0.14 (−0.13, 0.41) t = -0.98	−0.50 (−0.75, −0.25)*** t = 2.19	−0.75 (−0.92, −0.57)*** t = 4.61	−0.6 (−0.78, −0.42)*** t = 0.90
Scrum halves	−0.34 (−0.69, 0) t = 7.11	0.13 (−0.16, 0.41) t = −1.88	0.26 (−0.11, 0.62) t = −3.30	0.13 (−0.21, 0.47) t = −1.04	0.04 (−0.21, 0.29) t = −0.46	0.03 (−0.25, 0.31) t = −0.08

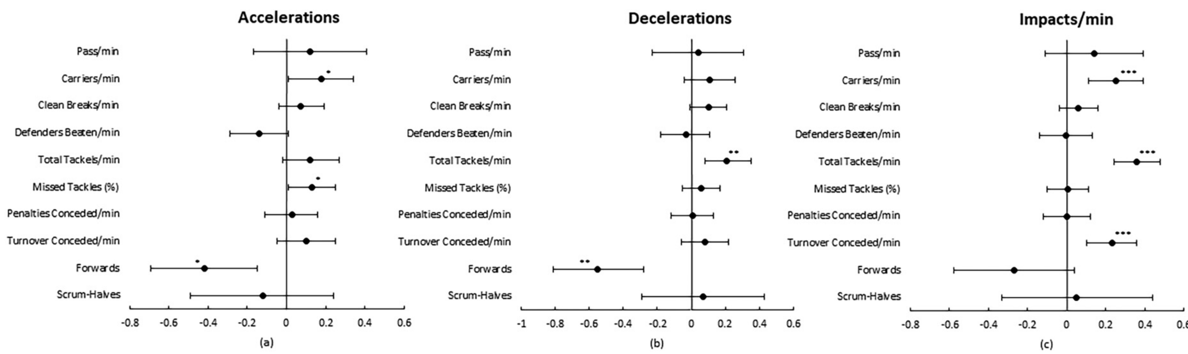

Figure 2. General linear mixed models (GLMM) outcomes acceleration/min, deceleration/min and impacts/min.

Table 3. General linear mixed models (GLMM) results [ES (95%CI); F-value / t-value for Bonferroni post-hoc test] for impacts/min, acceleration/min and deceleration/min (*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$).

	Impact/min	Acceleration/min	Deceleration/min
Pass/min	0.14 (−0.11, 0.39) F = 1.178	0.12 (−0.17, 0.41) F = 0.649	0.04 (−0.23, 0.31) F = 0.088
Carriers/min	0.25 (0.11, 0.39)*** F = 12.129	0.18 (0.01, 0.34)* F = 4.486	0.11 (−0.04, 0.26) F = 2.030
Clean breaks/min	0.06 (−0.04, 0.16) F = 1.376	0.07 (−0.04, 0.19) F = 1.640	0.10 (−0.01, 0.21) F = 3.471
Defenders beaten/min	−0.01 (−0.14, 0.13) F = 0.004	−0.14 (−0.29, 0.01) F = 3.216	−0.03 (−0.18, 0.11) F = 0.194
Total tackles/min	0.36 (0.24, 0.48)*** F = 34.908	0.12 (−0.02, 0.27) F = 2.935	0.21 (0.08, 0.35)** F = 9.755
Missed tackles (%)	0.01 (−0.10, 0.11) F = 0.010	0.13 (0.01, 0.25)* F = 4.899	0.06 (−0.05, 0.17) F = 1.330
Penalties conceded/min	0.01 (−0.12, 0.12) F = 0.0005	0.03 (−0.11, 0.16) F = 0.165	0.01 (−0.12, 0.13) F = 0.019
Turnover conceded/min	0.23 (0.10, 0.36)*** F = 12.617	0.10 (−0.05, 0.25) F = 1.618	0.08 (−0.06, 0.22) F = 1.385
Forwards	−0.27 (−0.58, 0.04) t = 0.09	−0.42 (−0.69, −0.15)* t = 0.121	−0.55 (−0.81, −0.28)** t = 0.151
Scrum halves	0.05 (−0.33, 0.44) t = −0.03	−0.12 (−0.49, 0.24) t = 0.06	0.07 (−0.29, 0.43) t = −0.03

number of players. Although this interpretation cannot be resolved only by this study, it remains a fact that missed tackles are significantly related to the external load, specifically in terms of acceleration occurrences.

While this study did not investigate the outcome of offensive actions, from an attacking perspective, carriers are positively related to accelerations but not to the distance covered in any speed zone. In fact, it was reported that the ability of the player carrying the ball in front of the defensive line to side-step and accelerate represents a critical factor in offensive maneuvers.[49] Moreover, carriers tend to keep accelerating before contact with tacklers (i.e. within the last 0.5 s before impact), especially in sub-elite competitions.[44] Although defensive and offensive situations are complex events where strategic, tactical and technical constraints, as well as responses to opponents' behaviour must be taken into account, it is important to highlight that some technical and tactical aspects correspond to specific external training load.

Notably, researchers have encouraged for embracing complexity in analysing GPS data, urging the inclusion of technical and tactical factors, along with other variables (e.g. match location, nutrition, opposition strength and individual characteristics), as potential contextual factors associated with match running.[50] Nonetheless, introducing extra levels in the GLMM involves a delicate balance between sample size and statistical power.[51] Considering the current sample size, the decision was made to focus solely on variations among player positions. For future investigations, a larger sample size should be pursued to conduct a more comprehensive exploration of additional variables associated with performance. Furthermore, to analyse into this phenomenon, we considered that players were repeatedly measured across a series of matches. According to previous recommendations,[52,53] we applied a set of GLMM to address the dependency of observations on repeated measurements. Indeed, it has been proposed that mixed models constitute the most suitable statistical methodology for analysing movement patterns in invasion sports, particularly when dealing with longitudinal datasets.[53]

Finally, these findings offer a more profound understanding of the physiological requirements in sub-elite rugby performance, especially given the limited evidence on the interaction between technical and tactical performance and running activities in sub-elite rugby union games. As a result, coaches and physical practitioners should design and propose training sessions that coherently consider both the tactical context and the players' positions.

Conclusion

In conclusion, this comprehensive study analysed the relationships between technical and tactical, and kinematic aspects of sub-elite performance in rugby union. The findings revealed significant relationships, emphasizing the different impact of the technical and tactical context on running activities, particularly varying between backs and forwards. Tackling mainly involved impacts and decelerations, contrasting with ball-carrying associated with impacts and accelerations. Notably, missed tackles correlated significantly with higher acceleration occurrences, suggesting potential implications for defensive strategies and recovery scenarios. In particular, the defensive gameplay model underscored the importance of speed in defensive manoeuvres, aligning with established literature on tackle rates and defensive structures. Although offensive actions were not directly investigated, the positive association between carriers and accelerations highlighted the significance of agility and acceleration in offensive manoeuvres. The study's integration of technical and tactical, and kinematic factors in analysing GPS data contributes to better understand the dynamic nature of rugby performance.

However, the study acknowledges limitations, particularly the delicate balance between sample size and statistical power in the GLMM. Future research should expand sample sizes for a more comprehensive exploration of additional variables associated with performance. Overall, these insights might offer valuable guidance for coaches and practitioners in designing targeted training sessions that consider both tactical contexts and players' positions in sub-elite rugby union.

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