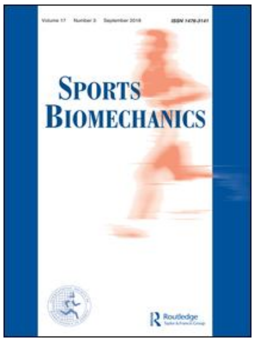

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Influence of opponent ranking on the physical demands encountered during Ultimate Frisbee match-play

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ABSTRACT

There is a lack of evidence regarding the match demands encountered in elite Ultimate Frisbee (UF) overall and dependent upon opponent ranking. These data may be useful to elite UF coaches to implement optimal training loads and recovery strategies. Therefore, this study quantified the physical demands of elite UF match-play and analysed differences in demands according to opponent ranking. Twelve UF players from the same national team participated in the study. An observational design was used to compare the physical demands encountered by players between opponents carrying different rankings (1st, 3rd, 4th, and 5th) during four official matches in a 5-team competition. No significant differences ($p > 0.05$) in sprinting and repeated-sprinting activity were evident across UF matches between opponents. In contrast, a higher (*moderate-large*) quantity and greater intensities of body impacts were observed in UF matches played against higher-ranked (1st) compared to lower-ranked teams (3rd, 4th, and 5th). Additionally, greater (*moderate-large*) PL and metabolic power were observed in matches played against higher-ranked (1st) compared to lower-ranked teams (3rd and 4th). These findings suggest coaches may need to reduce the training loads in the next days after the matches played against higher-ranked opponents compared to when facing lower-ranked opponents.

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KEYWORDS
External loads; sprints; impacts; metabolic power; player load

Introduction

Ultimate Frisbee (UF) is considered an alternative, hybrid, non-contact sport as it contains rules, movements, and physical demands indicative of more common team sports such as rugby, basketball, netball, and football (Scanlan et al., 2015). The popularity and professionalism of UF has grown since its development in 1967 (Marfleet, 1991), with many competitions now held at regional, national, and international levels (Griggs, 2009). This team sport is played by millions of people in approximately 50 countries around the world (Scanlan et al., 2015). Official matches are administered on a soccer-sized pitch between two teams of seven players (Krustrup & Mohr, 2015) aiming to score goals by passing a flying disc (or Frisbee™) and catching it in the attacking end-zone (Madueno et al., 2017). Matches are completed when the first team reaches 15 goals

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with at least a two-goal advantage or when a pre-defined playing duration is met (i.e., 60 min) (WFDF, 2016). Therefore, the duration of UF matches can vary depending on the score (e.g., from 53 min to 75 min), which may dictate the physical demands encountered by players.

In team sports, when quantifying the physical demands encountered during match-play, high-intensity actions are particularly useful to measure given they can occur in critical match situations such as creating passing options to facilitate goal opportunity (Faude et al., 2014). During a UF match, players undertake intermittent activity involving sprints, accelerations, decelerations, changes–of-direction, jumps, and lateral displacements (Krustrup & Mohr, 2015; Scanlan et al., 2015). In fact, collegiate, male UF players cover 4.7 ± 0.5 km, including ~600 m of high-intensity running (14–22 km/h) and ~200 m moving above 22 km/h during match-play (Krustrup & Mohr, 2015). Furthermore, recreational, male and female players undergo high physical loading across all movement planes covering ~3 km during match-play estimated with accelerometery (Madueno et al., 2017). Although the physical demands regarding the distance covered at different speeds and loading experienced by players has been examined during collegiate (Krustrup & Mohr, 2015) and recreational (Madueno et al., 2017) UF matches, reporting a wider range of variables in higher competitions, such as at the national level, is necessary to understand the precise physical demands imposed in elite UF players to maximise their on-field performance.

In recent years, advances in match analysis technology have provided valid and reliable methods to assess activity profiles and mechanical load in team sport players during matches (Malone et al., 2017). Although video based-tracking technology and local positioning systems (i.e., indoor global positioning systems (GPS)) are available to use, their high cost for installation and operation, as well as the potential time-consuming requirements for data acquisition and/or system setup make them practically challenging to use in quantifying the physical demands during match-play (Beato et al., 2018; Fox et al., 2017). Thus, the integration of accelerometers with GPS technology in micro-sensors have allowed the physical demands encountered in team sport match-play to be readily and comprehensively quantified using a suite of variables such as speed, acceleration, collisions, and repeated high-intensity efforts (Gabbett et al., 2012). In this regard, technology quantifies the sum of the individual tri-axial accelerometer vectors registered during player movement to derive body impacts (Malone et al., 2017). In addition, other variables such as player load (PL), equivalent distance index (EDI), and metabolic power can be determined using micro-sensor technology (Dalen et al., 2016). Therefore, quantifying a wide range of variables indicative of the physical demands encountered during match-play may provide more detailed evidence for coaching staff to periodise the weekly microcycle and optimise player performance (Mujika, 2013). While monitoring players using micro-sensor technology permits quantification of player demands during matches, it is also essential to determine the impact of contextual factors on player demands.

In team sports, physical match demands may be influenced by various contextual factors such as match location (Lago-Peñas & Lago-Ballesteros, 2011), playing style (Castellano et al., 2011), and opponent ranking (Castillo et al., 2018). In UF, given the duration of matches, and thus opportunity to perform activity, can vary depending on the score-line, opponent ranking may exert a pronounced influence on the demands encountered by players. Indeed, research in other team sports, such as soccer (Hulka et al., 2015) and rugby union (Murray & Varley, 2015) have shown match-play competed against higher-ranked teams elicits higher ($p < 0.05$) physical demands than match-play against lower-ranked teams. Insight regarding the impact of opponent ranking on match demands in UF may be useful to implement optimal training loads and recovery strategies dependent on the team faced. Thus, the aim of this study was twofold: 1) to describe the physical demands of elite UF match-play and 2) to compare the physical demands encountered during UF matches according to opponent ranking. It was hypothesised that matches played against higher-ranked teams would elicit higher physical demands.

Methods

Participants

Twelve male (n = 8) and female (n = 4) UF players (age = 28.1 ± 5.3 years, height = 173.1 ± 7.2 cm, body mass = 71.1 ± 12.0 kg, body mass index (BMI) = 23.4 ± 2.6 kg/m^2, training experience = 10.4 ± 5.1 years), from the same national team participated in the study. These players participated in at least 80% (50.2 ± 11.1 min) of total match time across all matches and were consequently selected for further analysis. All players trained at least three times a week and were competing in an official, national-level match every two weeks for two months.

The criteria for allocating opponent ranking was based on each team's final position in the competition (Castillo et al., 2018). The team in this study was ranked 2nd in the five-team competition, while the order of matches was as follows: match one = 5th-ranked team; match two = 4th-ranked team; match three = 3rd-ranked team; and match four = 1st-ranked team. All official matches were played at the same time (12:00 h) on the same UF pitch. All players participated voluntarily in the study and provided written consent prior to testing. The study was approved by the Isabel I University Research Ethics Committee before commencement in accordance with the Declaration of Helsinki.

Experimental design

An observational design was used whereby four matches of an official UF competition were monitored. Each match consisted of two 30-min halves with a 5-min rest period between halves. Match rules state when the clock reaches full-time, play continues until one of the teams scores. The match was considered finished when a team scored 15 goals with a two-goal advantage (Krustrup & Mohr, 2015). The final durations were: 1st-ranked team = 75 min, 3rd-ranked team = 74 min, 4th-ranked team = 53 min, and 5th-ranked team = 71 min. The field was comprised of an outdoor, natural grass floor, spanning 100 m in length (including two 15-m end zones) and 60 m in width. An official referee was presented to tabulate the score and ensure match rules were followed. Prior to each match, players undertook a 20-min standardised warm-up consisting of slow jogging, strolling locomotion, dynamic stretching, UF-specific exercises (e.g., different passes in groups), and brief progressive sprints.

Physical demands

The physical demands of players were monitored using micro-sensor units containing a 10-Hz GPS (Wimu Pro^{TM}, RealTrack Systems, Almería, Spain) (Bastida-Castillo, Gómez-Carmona, De la Cruz-Sánchez & Pino-Ortega, 2018). Micro-sensor units were affixed between the scapulae of each player in a fitted vest worn during the entirety of each match. The micro-sensor units were activated 15 min before the start of each match in accordance with manufacturer recommendations. Data were downloaded post-match to a computer and analysed using a customised software package (WIMU SPRO, version 1.0, Almería, Spain). The validity and reliability of the WIMU microsensor units for the measurement of sprints, body impacts, and load variables are supported elsewhere (Bastida-Castillo et al., 2018). A number of physical measures were recorded and taken as outcome variables across each match. Sprinting variables included the quantity of sprints (>22 km/h) performed, maximum velocity (Vel_{max}) reached, and the quantity of repeated-sprinting bouts (sprints completed within 30 s after finishing the previous sprint [RSA_{30}] and sprints completed within 20 s after finishing the previous sprint [RSA_{20}]). Body impacts were detected from accelerometer data provided in 'g' force. An impact was identified by the system if the force applied was greater than 5 g. The total impact count from collisions, intensity of each impact, and the time in the match where the impact occurred were recorded. A scaling system between 5 and 10 + g for grading the impacts was used as follows: I5-6 g: light impact (hard acceleration/deceleration/change-of-direction); I6-6.5 g: light to moderate impact (player collision, contact with the ground); I6.5–7 g: moderate to heavy impact; I7-8 g: heavy impact; I8-10 g: very heavy impact; and I10 + g: severe impact/collision (Abade et al., 2014). Various loading variables were also taken using the accelerometer, including PL, maximum EDI (EDI_{max}), mean EDI (EDI_{mean}), and metabolic power. Player load was computed as the vector magnitude representing the sum of accelerations recorded in the anteroposterior, mediolateral, and vertical planes of movement, measured with 100-Hz triaxial piezo-electric linear accelerometers in the micro-sensors (Dalen et al., 2016). Equivalent distance index represents the relation between the distance a player would have covered at a steady pace on grass using the same total energy spent over the match and the actual distance covered during the match (Osgnach et al., 2010). From these data, EDI_{max} and EDI_{mean} were determined for each match. Finally, metabolic power was derived using the mathematical model proposed by Di Prampero et al. (2005) to estimate overall metabolic cost across each match (Gaudino et al., 2014).

Statistical analyses

All variables are reported as mean ± standard deviation (SD). Normal distribution and homogeneity of variances was confirmed with the Kolmogorov–Smirnov and Levene tests. The repeated measures analysis of variance (ANOVA) with the Bonferroni post hoc test was used to compare the physical demands of players among each match. Effect sizes (ES) with uncertainty of the estimates shown as 90% confidence limits (CL) were used to quantify the magnitude of the difference between the four matches against varied opponents. Effect sizes were classified as *trivial* (<0.2), *small* (0.2–0.59), *moderate* (0.6–1.19), *large* (1.2–1.99), *very large* (2.0–3.99), and *extremely large* (≥4.0) (Hopkins et al., 2009).

Statistical analysis was performed using the Statistical Package for Social Sciences (version 25.0 for Windows, SPSS Inc, Chicago, IL, USA). The level of significance was set at $p < 0.05$.

Results

Mean ± SD sprinting variables against each opponent are shown in Table 1. No significant differences ($p > 0.05$, *trivial-small*) in sprinting variables were observed across UF matches against differently ranked opponents.

Table 1. Mean ± standard deviation sprinting variables during Ultimate Frisbee matches played against differently ranked opponents.

	Opponent (ranking)					
Variable	1st	3rd	4th	5th	Total	Statistical differences
Sprints (bouts)	9.3 ± 8.4	6.8 ± 5.6	9.8 ± 5.4	8.3 ± 6.5	8.5 ± 6.4	No significant differences (p > 0.05).
Vel_{max} (km/h)	25.4 ± 4.1	25.9 ± 3.4	27.3 ± 3.8	25.5 ± 3.0	26.0 ± 3.5	No significant differences (p > 0.05).
RSA_{30} (bouts)	2.1 ± 2.3	1.2 ± 1.4	2.0 ± 1.6	2.2 ± 2.7	1.8 ± 2.1	No significant differences (p > 0.05).
RSA_{20} (bouts)	0.8 ± 1.4	0.8 ± 0.9	1.1 ± 1.0	0.7 ± 0.9	0.8 ± 1.0	No significant differences (p > 0.05).

CL: confidence limits; RSA_{20}: number of repeated sprints completed within 20 s of the previous sprint; RSA_{30}: number of repeated sprints completed within 30 s of the previous sprint.

Mean ± SD body impacts against each opponent are shown in Table 2. A higher quantity of total body impacts was registered against the 1st-ranked team compared to the 5th- ($p < 0.01$, *moderate*), 4th- ($p < 0.01$, *large*), and 3rd-ranked teams ($p < 0.01$, *moderate*). In addition, higher total body impacts were encountered against the 5th-ranked team compared to the 4th-ranked team ($p < 0.01$, *moderate*) (Table 2). Body impacts at each intensity (e.g., I5-6 g, I6-6.5, 6.5–7 g, I7-8 g, I8–10 g and >I10 + g) were higher ($p < 0.05$, *moderate-large*) against the 1st-ranked team compared to all other opponents.

Mean ± SD loading variables against each opponent are shown in Table 3. PL against the 4th-ranked team was lower ($p < 0.01$, *large*) than against all other opponents. In addition, PL against the 1st-ranked team was higher ($p < 0.01$, *moderate*) than against the 3rd-ranked team. No significant differences ($p > 0.05$) in EDI_{max} and EDI_{mean} were observed across UF matches against differently ranked opponents. A lower metabolic power was evident against the 4th-ranked team ($p < 0.01$, *large*) compared to all other opponents. Additionally, metabolic power against the 1st-ranked team was higher ($p < 0.05$, *moderate*) than against the 3rd-ranked team.

Discussion and implication

The main aim of this study was to quantify and analyse the differences in physical demands registered during national-level UF matches according to opponent ranking. To our knowledge, this is the first study reporting the influence of opponent ranking on match demands in UF. Our results indicate higher volumes and intensities of body impacts, PL, and metabolic power were encountered during matches played against higher-ranked teams than lower-ranked teams.

This study is the first to quantify body impacts during UF matches, showing competition against higher-ranked teams promoted more frequent and intense impacts than

Table 2. Mean ± standard deviation body impacts during Ultimate Frisbee matches played against differently ranked opponents.

Variable	Opponent (ranking) 1st	3rd	4th	5th	Total	Statistical differences (Effect size; ±90% CL)
Impacts	1017.1 ± 456.1	764.0 ± 289.2	605.3 ± 246.0	863.2 ± 352.1	816.0 ± 366.1	Large: 1st vs.4th** (1.95; ±0.85) Moderate: 4th vs.5th** (−0.71; ±0.32); 1st vs.5th** (0.74; ±0.75); 3rd vs.4th** (0.89; ±0.40); 1st vs.3rd** (0.80; ±0.44)
I5–6 g	459.3 ± 202.1	357.1 ± 134.1	251.3 ± 84.0	420.1 ± 118.2	374.1 ± 158.0	Large: 4th vs.5th** (−1.31; ±0.40); 3rd vs.4th** (1.28; ±0.75); 1st vs.4th** (2.47; ±1.23) Moderate: 1st vs.5th* (0.69; ±1.05); 1st vs.3rd** (0.70; ±0.45)
I6–6.5 g	152.4 ± 70.1	115.2 ± 40.2	93.1 ± 39.3	178.2 ± 109.0	124.0 ± 57.1	Large: 1st vs.4th** (1.76; ±0.84) Moderate: 4th vs.5th**(−0.66; ±0.54); 3rd vs.4th** (0.72; ±0.37); 1st vs.3rd** (0.84; ±0.48)
I6.5–7 g	116.4 ± 56.2	90.2 ± 35.0	69.1 ± 38.4	94.1 ± 49.1	93.1 ± 46.3	Large: 1st vs.4th** (1.53; ±0.72) Moderate: 1st vs.5th* (0.77; ±0.79); 3rd vs.4th** (0.83; ±0.29); 1st vs.3rd* (0.94; ±0.48)
I7–8 g	143.3 ± 77.2	107.0 ± 49.1	96.1 ± 56.4	115.0 ± 75.2	116.3 ± 65.1	Large: 1st vs.4th** (1.24; ±0.56) Moderate: 1st vs.5th* (0.68; ±0.57); 1st vs.3rd** (0.67; ±0.43)
I8–10 g	109.0 ± 71.1	74.2 ± 49.1	73.1 ± 42.1	79.1 ± 63.4	84.2 ± 57.0	Large: 1st vs.4th** (1.27; ±0.68) Moderate: 1st vs.5th* (0.61; ±0.45); 1st vs.3rd* (0.65; ±0.37)
I10 + g	39.1 ± 35.1	21.2 ± 19.0	23.2 ± 19.1	19.3 ± 23.1	26.2 ± 26.1	Large: 1st vs.4th** (1.19; ±0.61) Moderate: 1st vs.5th* (0.64; ±0.44); 1st vs.3rd** (0.81; ±0.54)

* Significant level was set at $p < 0.05$ ** Significant level was set at $p < 0.01$. CL: confidence limits; I5–6 g: light impact; I6–6.5 g: light to moderate impact; I6.5–7 g: moderate to heavy impact; I7–8 g: heavy impact; I8–10 g: very heavy impact, and; I10 + g: severe impact.

Table 3. Mean ± standard deviation player load and metabolic power variables during Ultimate Frisbee matches played against differently ranked opponents.

	Opponent (ranking)					
Variable	1st	3rd	4th	5th	Total	Statistical differences (Effect size; ±90% CL)
PL (AU)	65.6 ± 22.3	53.9 ± 11.6	37.6 ± 6.6	64.7 ± 6.6	55.7 ± 17.3	Large: 4th vs.5th** (−3.54; ±0.67); 3rd vs.4th** (2.69; ±0.74); 1st vs.4th** (4.45; ±1.65); Moderate: 1st vs.3rd** (0.92; ±0.65)
EDI_{max}	1.2 ± 0.2	1.2 ± 0.2	1.3 ± 0.2	1.4 ± 0.3	1.3 ± 0.2	No significant differences.
EDI_{mean}	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	No significant differences.
Metabolic power (W)	18,857.1 ± 5004.0	16,258.0 ± 2547.1	11,455.2 ± 1257.1	19,463.1 ± 2389.2	16,564.1 ± 4368.0	Large: 4th vs.5th** (−2.77; ±0.72); 3rd vs.4th** (4.12; ±1.02); 1st vs.4th** (6.28; ±2.05) Moderate: 1st vs.3rd* (0.93; ±0.76)

* Significant level was set at $p < 0.05$ ** Significant level was set at $p < 0.01$. CL: 90% confidence limits; PL: player load; AU: arbitrary units; EDI_{max}: maximum equivalent distance index; EDI_{mean}: mean equivalent distance index.

when playing against lower-ranked teams. Quantification of body impacts in team sports may provide insight on the fatigue accumulated across competition in players (Arruda et al., 2015). In fact, studies have considered quantification of body impacts during match-play as a useful variable to quantify match and training loads in team sports (Gaudino et al., 2014), compared to other physical measures such as TD and high-running intensity (Abade et al., 2014; Arruda et al., 2015). Considering body impacts do not only refer to collisions, and include actions such as hard accelerations and decelerations, changes-of-direction, or contact with the ground (Moreira et al., 2016), it was unsurprising many impacts were detected in our study examining national-level UF players. Our data revealed similar external loads in terms of volume and intensity of body impacts as previous studies in rugby and soccer players (Arruda et al., 2015; McLellan et al., 2011). While a total of 816.1 ± 366.2 body impacts were encountered by UF players, 830.0 ± 135.1 and ~850 body impacts were found in elite, adult rugby league (McLellan et al., 2011) and international, junior soccer players (Arruda et al., 2015), respectively, during match-play. These data suggest the impact demands encountered during national-level UF are comparable to elite players in more traditional field-based team sports. Furthermore, a higher quantity and intensity of body impacts occurred as opponent ranking increased during UF match-play. These differences could be due to an alteration of tactical behaviours when playing against higher-ranked teams, whereby more frequent high-intensity actions (i.e., accelerations, decelerations, jumps and changes-of-direction) are performed to evade or defend a higher level of opponent in offensive and defensive situations (Folgado et al., 2018).

Further to impact data, PL and metabolic power exhibited significant differences in matches according to opponent ranking. In this regard, PL and metabolic power against the 4th-ranked team ($p < 0.01$, *large*) were lower compared to all other opponents. In addition, PL and metabolic power were *moderately* higher against the 1st-ranked team than the 3rd-ranked team. These load variables are indicative of the volume of activity performed, being determined by the product of movement intensity and duration. In the line with previous studies reporting higher physical loading volumes when competing against higher opponents in soccer (Hulka et al., 2015) and rugby union (Murray & Varley, 2015), our findings may be due to the tactical strategies adopted when facing higher-ranked opponents. Specifically, better teams may manage the tempo of the match by retaining possession of the disc more effectively through passing and catching the disc, creating less unforced turnovers. Consequently, when defending in these situations, the analysed team implemented individual player-to-player marking on defence to increase pressure on the opposition across the pitch. In this sense, defensive formations involving individualised marking evoke higher work intensities than zone formations with less stringent defending (Ngo et al., 2012), which may underpin the greater PL and metabolic power we observed against the 1st-ranked team.

Sprinting actions play a key role during critical scoring periods in team sports, potentially impacting the outcome of matches and physical performance of players (Cochrane & Monaghan, 2018). Our results indicate no significant differences in sprinting activity (<22 km/h) were apparent during matches played against differently ranked opponents in UF. These findings may be due to the same playing structure (i.e., two handlers and five cutters) being used by the team analysed in this study across all matches, promoting similar offensive tactical behaviours and therefore sprinting actions in creating space for passing and catching opportunities. These results concur with those reported by Varley et al. (2018) who observed consistent sprint performance across 3 successive, international soccer matches. However, the lack of differences in sprinting demands we observed between opponents contrasts other research conducted in soccer and rugby union showing greater sprinting distances are encountered during matches played against higher-ranked teams than lower-ranked teams (Hulka et al., 2015; Murray & Varley, 2015). Differences in findings across studies might underline the variations in movement patterns across teams or competitions, as well as relate to the different requirements of soccer and rugby union compared to UF. More precisely, these ball sports may involve more sprinting work when facing better opponents given offensive positioning on the field is dictated by defensive structures (i.e., players can be ruled offside if not in correct positioning) possibly allowing more talented players to make breaks in the defensive line and rapidly move across the pitch, requiring defenders to sprint more readily to prevent scoring (Higham et al., 2014).

While this study provides novel insight regarding the impact of opponent ranking on match demands in national-level UF players, it is not exempt from limitations. The main limitation was the unequal duration of the matches (53 to 75 min), which should be considered when interpreting the provided data given variables were not reported relative to time. In addition, opponent ranking was identified according to the final position at the end of the competition (Castillo et al., 2018). We are aware the ranking of teams may change from match to match in a competition format, depending on the win/loss record of the team. However, final placing in the competition is likely to reflect the longitudinal performance of each team across the entire competition and thus was used to establish criteria to adjudge team ranking in our study. In addition, only four UF matches were examined in the present study. While examination of a wider number of matches would have been ideal, the included matches allowed for an effective comparison between all teams in the competition holding different rankings. Furthermore, only one contextual factor (opponent rank) was considered in this study. Other contextual factors (e.g., match location, playing style) (Castellano et al., 2011) may have affected the physical demands encountered by players and should be considered in future investigations. Finally, we included a range of variables to comprehensively quantify match demands in elite UF. Given the practical advantage in reducing the volume of data needed for interpretation of match demands, future work is encouraged applying appropriate analyses (e.g., principal component analysis) to identify variables that provide unique insight (Weaving et al., 2017).

Conclusions

The current results first emphasise the high physical demands required of players during UF match-play at the national level. Specifically, players undergo extensive intermittent and high-intensity activity involving sprints and repeated-sprinting bouts, with high volumes and intensities of body impacts and loading. Second, the novel analysis of match demands considering the ranking of the opposing team showed coaching staff may need to prepare and manage players differently dependent upon the quality of the opposition faced. Specifically, matches played against higher-ranked teams may imposed greater volumes and intensities of body impacts, PL, and metabolic power than matches played against lower-ranked teams. Consequently, UF coaching staff may reduce the training loads in the next days after the matches played against higher-ranked opponents compared to when facing lower-ranked opponents. Third, greater precision in the planning of player training loads and recovery considering opponent ranking may allow coaches to optimise player performance and minimise overuse injury risk across the season.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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