In-match physical performance fluctuations in international rugby sevens competition

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Research article

In-Match Physical Performance Fluctuations in International Rugby Sevens Competition

Alexis Peeters [1], Christopher Carling [1,2]✉, Julien Piscione [1] and Mathieu Lacome [3]
[1] Performance Department, Fédération Française de Rugby, Marcoussis, France; [2] Institute of Coaching & Performance, University of Central Lancashire, Preston, UK; [3] Performance Department, Paris Saint-Germain FC, France

Abstract

It is widely recognised that the physical demands in rugby sevens are high especially in comparison to the 15-aside version. The aim of this study was to assess fluctuations in physical performance (running and contact loads) in international rugby sevens competition. Altogether, 32 matches played by an international team in the HSBC World Sevens Series were analyzed (63 match-observations). Players wore a validated GPS device (SensorEverywhere, France) sampling at 16Hz while an operator coded every contact action (tackles, collisions, mauls, scrums) using video analysis software (SportsCode, USA). Running load was assessed using total distance travelled (m), individually determined high-speed distance (covered at velocities > maximal aerobic speed, m) and very-high speed distance (covered at velocities > 85% maximal sprinting speed, m). The frequency of accelerations (actions > 2.5 $m \cdot s^{-2}$) and high-intensity actions (HIA, sum of high-velocity runs, accelerations and contact-related actions, n) were also calculated. A magnitude-based inferential approach to statistics was adopted and effect sizes quantified. Findings showed: 1) a *small* decrease in high-speed distance and number of accelerations performed during the second- versus the first-half of play suggesting a decline in running performance. (2) a *moderately* higher total distance and high-speed distance covered during the first and final 1-min period compared to the average for other 1-min periods, suggesting a specific reverse 'J-shape' pacing profile 3) a *most likely* decrease in total distance, high-speed running, and to a lesser extent the number of accelerations declined following the peak 1-min period of the game. These findings provide pertinent information on changes in running performance over the course of international sevens and have implications for physical conditioning strategies.

Key words: Rugby, workload, gps, fatigue, pacing.

Introduction

Rugby sevens is a field-based team sport and a derivative of 15-a-side rugby union. Its inclusion in the 2016 Olympic Games has furthered scientific interest in the development and performance of elite players (Henderson et al., 2018). As such, a substantial body of research has quantified the external load demands in Sevens' match-play particularly at elite levels. Studies demonstrate an intermittent high-intensity profile requiring players to recurrently perform bouts of high-speed running and hard acceleration and deceleration actions combined with repeated collisions notably during tackle events (Couderc et al., 2019). This external load varies, albeit not substantially, according to positional group - backs and forwards (Suarez-Arrones et al., 2014). In-match demands are considered intense with a unique interplay of physical, technical, and tactical capacities necessary to play rugby sevens (Ross et al., 2015b). Indeed, research shows that the relative running demands of elite rugby sevens (total distance covered and that travelled at high-speeds per minute of play) are substantially greater than those observed in the elite 15-a-side format: +45% and +135% respectively (Higham et al., 2012). Work has also reported substantially greater high-intensity running demands in international versus lower standard sevens teams (Ross et al., 2015b).

These intense demands can generate fatigue represented by fluctuations in running activity across the course of match-play. Indeed, *small* to *large* reductions in locomotor activity (e.g., frequency of intense actions, distances travelled) have generally been observed between the first and second halves (Furlan et al., 2015; Granatelli et al., 2014; Higham et al., 2012; Murray and Varley, 2015; Suarez-Arrones et al., 2014; Couderc et al., 2018). While declines occurred irrespective of score line or opponent ranking (Murray and Varley, 2015), to our knowledge no studies have adjusted data according to effective game time thereby removing the potentially confounding impact of half-to-half differences in stoppage time (for example due to injury or substitutions). Similarly, no studies have tailored competitive running data according to players' individual physical characteristics (e.g., maximal aerobic speed and maximal running speed). If these characteristics are accounted for, a substantial shift in actual external load demands can occur (Reardon et al., 2015).

Finally, to our knowledge, no studies have examined whether there is an accumulation of fatigue over the course of competition represented by a decline in external load metrics towards the end of match-play (e.g., final minute). Similarly, only limited information exists (Furlan et al., 2015) on transient changes in metrics notably collision events following peak periods of activity in rugby sevens and additional research is necessary. The aim of this study therefore was to assess in-match physical performance fluctuations represented by external load in elite rugby sevens players.

Methods

Participants

This study was conducted over two seasons in male elite players (n = 15, age: 25.8 ± 3.6 years; height: 1.82 ± 0.10 m; body mass: 88.9 ± 13.5 kg) belonging to the French national rugby sevens team participating in the HSBC World

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Sevens Series (seasons 2012-2013 and 2013-2014). The reference team was ranked 9 and 10th at the end of the 2012-2013 and 2013-2014 World Sevens Series respectively.

Altogether, 32 matches were analyzed for a total of 63 match-observations (players x matches). Only players who completed the entire match were included in the analysis. In order to conduct inter-positional comparisons, players were subdivided into forwards (positions 1 to 3; match observations: n = 29) and backs (positions 4 to 7; n = 34).

To ensure player confidentiality, all performance data were anonymized before the analysis. Prior to participation, all the players received comprehensive verbal and written explanations of the study and gave their written informed consent to participate in conformity with the recommendations of the Declaration of Helsinki. These data arose as a condition of selection for their national team in which player performance was routinely measured over the course of the competitive season (Winter and Maughan, 2009). The Fédération Française de Rugby granted permission to publish the present data at the end of the 2016/2017 competitive season.

Data collection procedures

Running load: During each match, players wore a portable GPS device (SensorEverywhere, Digital Simulation, France), sampling at 16Hz. This system tracked the movements of the player over the entire course of the match. The GPS system was placed in a customized pocket in their playing shirt and located between the scapulae. To limit potential inter-unit variability, each player wore the same unit for the entire duration of the season. Fifteen minutes prior to the start of each match, the GPS units were activated to ensure clear satellite reception. The data were captured and computed using propriety SensorEverywhere Analyser software (Digital Simulation, France). Data were excluded if one of the following criteria was not met: number of satellites < 6, horizontal dilution of precision (HDOP) > 2 and visual inspection of raw traces of velocity report irregularities (Malone et al., 2017). The mean number of satellites and HDOP during match play were 8 ± 1 and 1.35 ± 0.34 respectively. Research conducted to compare the quality of data derived from the present GPS devices in comparison to a gold standard system (radar) has demonstrated a trivial difference for typical error of measurement and small for maximal sprinting speed (0.5, ±0.1%) and maximal acceleration (3.9, ±0.6%) respectively (Lacome et al., 2019).

Contact load: An operator coded each contact related action (tackles, collisions, mauls, scrums) using video analysis software (SportsCode, Hudl, USA) to provide a sum for contact events. Active participation in a scrum was judged to be from the front row engagement to break up or when the player was seen to be detached following the release of the ball (Roberts et al., 2008). Active participation in periods of rucking and mauling was timed from when the player's shoulder entered into contact with the ruck or maul to their detachment from the event (Lacome et al., 2014). Tackles were considered actions when a player physically attempted to stop a ball carrier whilst on their feet (Lacome et al., 2014) and collisions were events when physical contact was made between an attacker with a player in the defensive line (Gabbett et al., 2011). The same analysis software was also used to quantify effective playing time (total time the ball was in play) as this contextual factor can strongly influence time-related changes in running and skill-related performance in team sports (Carling and Dupont, 2011).

To verify the reliability of match coding, an intra-user reliability study was conducted. For effective playing time a trivial Typical Error (i.e. TE) was observed (Standardized TE: 0.10 ± 0.07 (2.0 ± 1.4%)), while for contact related actions a small TE was obtained (Standardized TE: 0.37 ± 0.26 (12.2 ± 9.6%)).

Data processing: To synchronize running and contact load data, a timestamp marker was created both in the GPS and video analysis software at match kick-off (when the ball hit the ground). This synchronization enabled importation of contact-related data derived from the Sportscode software into the propriety GPS software. Data collected during stoppage time were not included in the analysis to facilitate in- (halves) and between-match comparisons.

Individual values for maximal aerobic speed (MAS) and maximal sprinting speed (MSS) were used to adjust data for high and very-high speed running thresholds. MAS was determined using an intermittent progressive running test adapted from the test described by (Leger and Boucher, 1980) consisting of bouts of 3-min running interspersed with 1-min of passive rest on a tartan outdoor track. Speed was increased by 2 $km \cdot h^{-1}$ from 8 to 12 $km \cdot h^{-1}$ and subsequently by 1 $km \cdot h^{-1}$ until voluntary exhaustion. The speed at the final completed stage was considered MAS. The mean value for MAS across all players was 4.72 ± 0.25 $m \cdot s^{-2}$.

To assess MSS, players performed two maximal 60-m sprints separated by 5 min of recovery on natural grass. A timing gate system (Smartspeed, Fusion Sport, Australia) was set at 10-m intervals and MSS was defined as the fastest speed reached over any 10-m sector during the sprint. Players began each sprint using the same standing start position with their front foot 0.5-m behind the first timing gate and were instructed to sprint as fast as possible over the 60-m distance. The mean value for MSS across all players was 9.40 ± 0.27 $m \cdot s^{-2}$.

Three running intensity zones were subsequently used to adjust running load data measured in metres (m): total distance (TD), high-speed distance (HSD, velocity > MAS) and very-high speed distance (VHS, velocity > 85% MSS). Running and contact loads were also assessed using the total number of accelerations (actions > 2.5 $m \cdot s^{-2}$) and high-intensity actions (HIA, sum of high-velocity runs, accelerations and contact-related actions, n). These external load outputs were used to assess the following in-match performance fluctuations in running and contact loads in back and forward rugby sevens players:

1) First- vs. second-half external loads,

2) External loads in the first 1-min interval of play versus both the final 1-min interval and the mean for all

other 1-min intervals (excluding the first and final 1-min intervals),

3) Specifically TD and HSD and contact loads in the peak 1-min of activity compared to the following 1-min and the mean of all other 1-min periods (Lacome and al., 2017). The peak 1-min period of running activity was assessed by the mean of a rolling average of 1-min duration and step of 1/16-s, and defined as the peak TD covered by minutes. Peak 1-min periods of activity occurring at the end of a half were excluded.

Statistical analysis

Data are presented as means ± standard deviations (SD). Comparison of first and second half performance and across periods were calculated with 90% confidence limits (90% CL) using specifically-designed Excel spreadsheets. A magnitude-based inferential approach to statistics was adopted (Batterham and Hopkins, 2006; Winter et al., 2014). Effect sizes (ES) were quantified to indicate the practical meaningfulness of the differences in mean values. The ES was classified as trivial (<0.2), small (>0.2–0.6), moderate (>0.6–1.2), large (>1.2–2.0) and very large (>2.0–4.0) (Batterham and Hopkins, 2006). If the 90% CI overlapped positive and negative values, the magnitude was deemed unclear. The chances that the changes in running or technical performance were greater for a group (i.e. greater than the smallest worthwhile change, SWC (0.2 multiplied by the between-subject standard deviation, based on Cohen's d principle)), similar or smaller than the other group, were calculated. Quantitative chances of greater or smaller changes in performance variables were assessed qualitatively as follows: <1%, almost certainly not; 1–5%, very unlikely; 5–25%, probably not; 25–75%, possibly; 75–97.5%, likely; 97.5–99%, very likely; >99%, almost certain (Hopkins et al., 2009).

Results

First- vs second-half performance

Table 1 reports running activity and contact events during first- versus second-half of matches in forwards and backs respectively. Unclear differences in TD covered by forwards and backs were reported in the second- compared to the first-half (-2 ± 7 and -2 ± 5% respectively). A likely small decrease in HSD covered was observed in the second- versus the first-half in forwards (-19 ± 17%) and backs (-16 ± 15%).

In forwards, there was a possibly to likely small decrease in the frequency of both high-intensity actions (-11 ± 13%) and accelerations (-19 ± 17%) whereas a possible small increase in the number of contact events (18 ± 23%) was reported in the second- versus the first-half. In backs, unclear differences in the frequency of high-intensity actions (-6 ± 12%) and a possibly small decrease in accelerations (-16 ± 20%) were reported while a possibly small increase in the number of contact actions (15 ± 22%) occurred.

There were unclear differences (3±6%) and a likely small increase (5±5%) in effective playing time for forwards and backs respectively between the second and first halves.

Accumulated changes in running and contact load

Figure 1 presents the standardized changes for TD, HSD and acceleration and contact event frequency over the course of matches in both positional groups. TD and HS distance covered during the first 1-min period were likely smaller to almost certainly moderately higher compared to the mean of all other periods (24 ± 13 to 131 ± 65%). In comparison to the mean for the other periods, effective playing time during the first 1-min of the game was almost certainly moderately higher (70 ± 17 and 55 ± 17%) for forwards and backs). During the final minute of play [13-14 min], there was a possible small to almost certainly moderate increase in the total distance covered and frequency of high intensity actions performed as well as effective playing time for each positional group compared with the mean for other 1-min match periods.

Table 1. Comparisons of running- and contact-related performance for back and forward sevens players across the first- and second-halves of match play. Data are means±SD.

Performance for positions 1-3 (n=29)			Comparison 1st Half vs 2nd Half		
	Half 1	Half 2	Diff. (%)	Effect size	Chances (%)
Total distance (m)	685.9±97.3	675.2±114.9	-2±7	-0.1±0.43	13/52/35
High Speed dist. (m)	138.8±50.1	112.6±56.7	-19±17	-0.48 ±0.43	1/13/86
% HS dist.	0.2±0.1	0.2±0.1	-19 ±15	-0.54±0.43	0/9/91
Acceleration (n)	6.8±2.6	5.6±2.7	-19 ±17	-0.47±0.43	1/14/86
Contact actions (n)	5.3±2.8	6.3±2.9	18±23	0.34±0.43	70/27/2
High intensity action (n)	21±6.3	18.6±6.5	-11±13	-0.36±0.43	2/25/74
Ball in play (s)	205.7±28.3	211.1±33.2	3±6	0.17±0.43	46/46/8
Performance for positions 4-7 (n=34)			**Comparison 1st Half vs 2nd Half**		
	Half 1	**Half 2**	**Diff. (%)**	**Effect size**	**Chances (%)**
Total distance (m)	737.7±85.7	721.1±100.4	-2±5	-0.18±0.4	6/48/46
High Speed dist. (m)	155±64.2	130.6±54.1	-16±15	-0.41±0.4	1/19/81
% HS dist.	0.2±0.1	0.2±0.1	-14±14	-0.41±0.4	1/18/82
Acceleration (n)	6.1±3.3	5.1±2.8	-16±20	-0.3±0.4	2/31/67
Contact actions (n)	5.3±3	6.1±2.7	15±22	0.27±0.4	62/35/3
High intensity action (n)	19.8±6.4	18.7±5.5	-6±12	-0.18±0.4	6/47/47
Ball in play (s)	200.6±26.9	210.9±24.9	5±5	0.39±0.4	79/20/1

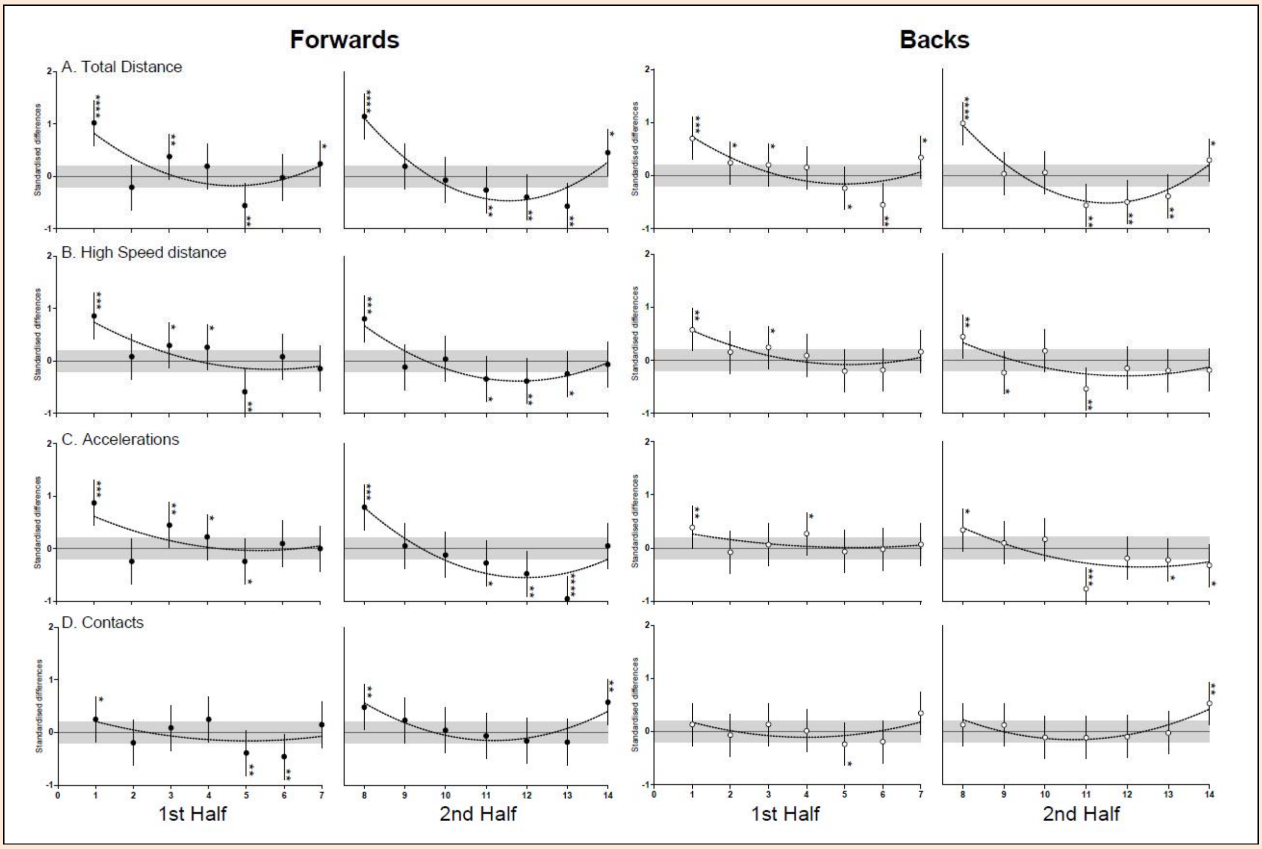

Figure 1. Standard difference of each one- minute period vs mean minute for Forwards and Backs: A. Total Distance, B. High Speed Distance, C. Accelerations and D. Contacts. * : Possibly, ** : Likely, *** : Very Likely, **** : Almost Certainly

Transient changes in running and contact loads

Figure 2 presents standardized differences between loads during the peak period of 1-min and the following 1-min period compared with mean activity across other 1-min periods.

Forwards covered almost certainly more total distance and HSD during the peak 1-min period (176 ± 26 m and 63 ± 26 m vs 82 ± 11 m and 15 ± 6 m, +115 ± 10% and +319 ± 56%, respectively) and almost certainly less during the following 1-min period (47 ± 36 m and 5 ± 10m, -43 ± 14% and -68 ± 24%) compared to the mean for all others periods. Backs covered almost certainly more total distance and HSD in the peak 1-min period (184 ± 23 m and 55 ± 36 m vs 90 ± 11 m and 18 ± 7 m, +104 ± 8% and +212 ± 56% respectively) and almost certainly less during the following 1-min period (53 ± 30m and 4 ± 7m, -42 ± 10% and -78 ± 15%) compared to the mean for all other periods.

Forwards performed likely more accelerations during the peak 1-min period (1.1 ± 0.9 accelerations, +46 ± 38%) and likely less actions during the following 1-min period (0.5 ± 0.8, -32 ± 36%) compared to the mean of all other periods (0.8 ± 0.3). Backs performed likely more contact events during the peak 1-min period (1.1 ± 1.1 acceleration, +62 ± 47%) and possibly less during the following 1-min period (0.4 ± 0.6, -49 ± 29%) compared to the mean for all other periods (0.7 ± 0.3).

During the peak 1-min period (1.3 ± 1.3 contacts, +58 ± 50%) forwards performed likely more contact actions compared to the mean for all other periods (0.8 ± 0.4 contacts), while no clear difference was observed for the following 1-min period (0.8 ± 1, -9 ± 38%). Backs performed likely more contact actions during the peak 1-min period (1.2 ± 1.2 contacts, +52 ± 44%) and possibly less during the following 1-min period (0.8 ± 0.5, -31 ± 41%) compared to the mean for all other periods (0.6 ± 1.1).

Discussion

The aim of this study was to assess fluctuations in physical performance, represented by running activity and contact events, in elite rugby sevens competition. Key findings were: (1) in both forwards and backs, there was a small decrease in high speed distance and number of accelerations performed during the second- versus the first-half of play, (2) a moderately higher TD and HS distance was covered during the first and final 1-min period of play compared to the mean for other 1-min periods, suggesting a specific reverse 'J-shape' pacing profile (3) total and high-speed running distance, and to a lesser extent the number of accelerations were all most likely decreased in the 1-min period following the peak 1-min period of the game.

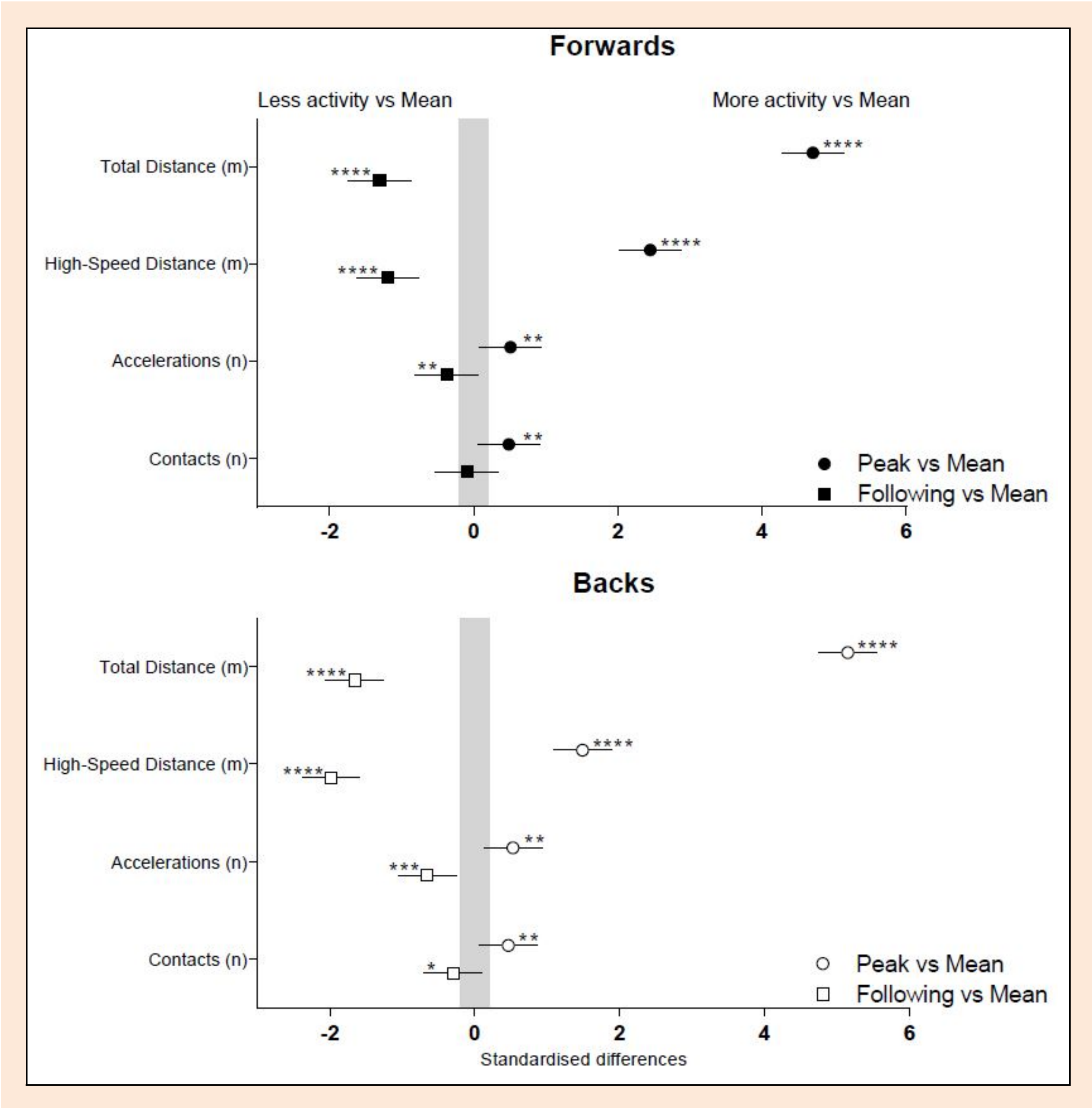

Figure 2. Standardized differences between Peak- vs Mean- minute and Following- vs Mean- minute for forwards and backs, for total distance (m), HS distance (m), accelerations (n), contact events (n). * : Possibly, ** : Likely, *** : Very Likely, **** : Almost Certainly.

First- vs second-half performance

Rugby sevens players must tolerate high running demands and subsequent metabolic perturbations notably in comparison with rugby union players despite a similar contact loading when data are normalised by minute of play (Couderc et al., 2017). As such, accumulation of fatigue represented by a decrease in running performance, particularly during the second-half, is to be expected. Indeed, a drop in overall distance covered has been previously reported (Furlan et al., 2015; Higham et al., 2012) with this linked not only to a need to minimise physiological disturbances but to the desire to maintain the ability to perform high-speed activity and participate in key match actions (Lacome et al., 2017). Here however, total distance was not clearly reduced during the second- versus the first-half in the present forwards and backs respectively. This discrepancy and lack of consensus with other results on changes in running performance might be explained by factors such as differences in playing style across teams and/or fitness levels of players (Ross et al., 2015a). Indeed, running activity profile in rugby sevens is dependent upon a myriad of contextual variables (Murray and Varley, 2015).

In contrast to overall running distance, there was a likely small decrease in high speed activity (-19 ± 17% and -16 ± 15%) and possibly-to-likely small decrease in the number of accelerations (-19 ± 17% and -16 ± 20%) (Table 1). This trend for a decrease in high-speed distance covered in the second-half results is similar to that previously reported (Higham et al., 2012; Murray and Varley, 2015; Pereira et al., 2018). Interestingly, the frequency of accelerations was slightly decreased during the second-half whereas the number of contact events demonstrated a slight increase. We can speculate that a modification in playing style occurred which might explain this increase in the frequency of contact events. As previously demonstrated in rugby union (Lacome et al., 2017), irrespective of scoreline, teams commonly use short passes close to the rucking zone in order to maintain possession notably towards the end of play rather than opting for an expansive running hence physically demanding type of game. This style of play would also partly explain the increase, albeit non-substantial, in second-half effective playing time. To further investigate this suggestion, examination of fluctuations in the occurrence of technical events is warranted. Concomitant analyses of internal-to-external workload ratios (Lacome et al., 2018) would also be pertinent to gain additional insights into the occurrence of second-half fatigue.

Accumulated changes in running- and contact-load

Here, a minute-by-minute analysis of external load showed that TD and HS distance covered were likely small to almost-certainly moderately higher during the first 1-min period compared to the mean of other 1-min periods (44 ± 18% to 131 ± 65% for forwards and 24 ± 13% to 54 ± 37% for backs). Regarding the final 1-min period of play, there was a possible to likely small increase in the total distance covered and frequency of high intensity actions and contact events performed for each positional group compared to the mean for all other 1-min periods (9 ± 13% to 54 ± 40%) (Figure 1). This fluctuation in performance can be associated with an increase in end-match effective playing time offering more opportunities to perform running activity. This activity pattern is different to that previously observed in professional Italian rugby sevens players (Granatelli et al., 2014). One partial explanation for this finding could be the substantially larger sample size used in the present study (63 vs ~30 match observations) potentially enabling clearer patterns to be identified. It is also possible that the present international cohort had higher levels of physical fitness - taken into account in the analysis as running data were adjusted according to maximal aerobic speed and maximal sprinting speed - enabling players to better resist end-match fatigue.

Overall, the aforementioned running activity profile (total and high speed distance covered, and acceleration frequency) seemed to follow the reverse-J-shape pacing strategy (Abbiss and Laursen, 2008) characterized by a 'fast' start, slowing during the middle of the period, but with an increase in activity or speed during the final minutes of the match. In addition to team sports (Black and Gabbett, 2014), these pacing profiles have also been described during middle-distance running races (Abbiss and Laursen, 2008) or rowing events (Garland, 2005) where the total effort duration is comprised between 5 and 15-min. The choice of pacing profile might not solely be related to the occurrence of disturbances in one physiological energy system, but is influenced by a complex system of integrated feedback (prior experience, knowledge of the end of the game) and contextual variables (scoreline, opponent, match importance). In our opinion, exploration of counter-fatigue strategies (e.g., mental training to aid players resist fatigue (e.g., (Inzlicht and Marcora, 2016) is warranted in an attempt to achieve greater regularity in the external workload profile across the course of competition.

It is noteworthy that there was no substantial variation across play in the number of player-to-player contact events performed per minute. This result suggests that minute by minute fluctuations in external load demands are related to the specific type of loading examined (running activity vs contact event). Nevertheless, research investigating the consequences when multiple contact events occur successively and their short and long-term effects on subsequent running performance is merited as greater reductions in running intensity are shown to occur in game-based activities when this is the case (Johnston et al., 2015).

Transient changes in running- and contact-load

Studies in elite rugby have reported that high-speed running distance decreases over the short-term following the most intense period in competition - both in union and league formats (Kempton et al., 2015; Lacome et al., 2017). Current results confirm that total distance covered and that in high-speed running, and to a lesser extend the number of accelerations were all most likely decreased following the peak 1-min period of the game compared to the mean of all 1-min periods (-32 ± 36% to -78 ± 15%). Several hypotheses can be forwarded to explain these findings. First, it has been demonstrated that rugby sevens players experience blood lactate concentrations up to 16.3 $mmol \cdot l^{-1}$ and associated high levels of acidosis (pH <7.2) (Couderc et al., 2017) due to an important solicitation of the glycolytic pathway in the overall energy production. Muscle acidosis might subsequently impair players' ability to cover distance at high-speeds, probably due to indirect mechanisms such as glycolytic inhibition (Glaister, 2005) or via the stimulation of group III and IV muscle afferents generating central fatigue (Knicker et al., 2011). A second hypothesis could be that as the most-intense periods of the game occur concomitantly with tries scored (Gabbett and Gahan, 2016), the following 1-min period of the game has reduced effective playing time. Unfortunately, a present limitation was that we were unable to record accurately the effective playing time during the peak 1-min and following 1-min periods to confirm this hypothesis. However, the frequency of contact actions recorded was not clearly affected during the 1-min period following the peak 1-min of activity in forward players and only small decreases were observed in backs. We can suggest two explanations for these discrepancies in running and contact loads. First, game-specific 'fatigue' could selectively impair high-speed running-activity through potential large hamstring muscle function impairment as observed in soccer players (Silva et al., 2018). Second, another suggestion might be that teams collectively change their strategy following the most intense period of the game either to recover physically, for example following a try conceded or scored. Although anecdotal, players performed their peak period activity on average around the 7th minute of play (7:13 ± 4:37min) and approximatively one fifth of peak periods of activity occurred during the final 2-mins of the match. These findings suggest that players were able to perform intense periods of high-speed running even at the end of competition, owing to high levels of fitness and/or to adoption of pacing strategies. Further investigations, using measures of physical fitness, would be pertinent to examine the association between these (e.g., aerobic power, glycolytic capacity, repeated sprint ability) and match running activity, pacing profile and end-game 'fatigue'.

Limitations

Although this study investigated performance in international-standard players, larger scale studies including multiple international teams and additional match observations are warranted in an attempt to draw more definitive conclusions. The present analysis focused on physical-related performance fluctuations and additional studies are necessary to determine whether players are able to maintain technical and/or tactical performance across match-play.

Practical applications

As pacing strategies were demonstrated, coaches could implement mental training based on the central governor model of exercise in an attempt to help maintain and/or improve overall running output over the course of play (Inzlicht and Marcora, 2016).

Practitioners could develop conditioning regimens to help improve physical output following peak periods of running activity (periods requiring distances of ~175-180 m.min-1, 30-35% of the total distance covered above individual MAV) as players generally demonstrated a decrease in locomotor output following these intense periods.

Conclusion

In this study, we investigated fluctuations in running- and contact-related activity in international rugby sevens players. We reported small decreases in high speed distance and number of accelerations performance during the second- compared to the first-half of match play. We also found that running activity was most likely decreased following the peak 1-min period of the game compared to the mean of all 1-min periods suggesting that the players experienced fatigue over the course of play. To our knowledge however, this is the first time clear and specific "J shape" pacing profiles have been observed during elite rugby sevens games. Indeed, running performance increased during the final 2-mins of play and around 20% of peak 1-min periods of activity occurred during the final 2-min of the game.

Further studies dedicated to quantifying the most intense period of the game and its influence on additional performance metrics (tactics, technical performance, fatigue) are warranted. Similarly, Rugby sevens differs from other rugby codes due to the repetition of games - up to 6 played in 2 consecutive days. Thus research investigating the accumulative effects of multiple games on running- and technical- performance is required. Finally, analysis of physical performance and its relation with changes in scoreline is merited.

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Key points

- Small decreases occur in high speed distance and number of accelerations in the second- compared to the first-half of match play.
- High-speed running activity was most likely decreased following the peak 1-min period of the game compared to the mean of all 1-min periods.
- High-speed running activity did however increase during the final 2-minutes of play.

AUTHOR BIOGRAPHY

Alexis PEETERS
Employment
Sport Scientist at FFR
Degree
Master Degrees
Research interests
Training load & performance monitoring
E-mail: alexis.peeters@ffr.fr

Christopher CARLING
Employment
Senior Lecturer in elite performance
Degree
PhD
Research interests
Training load & performance monitoring
E-mail: christopher.carling@gmail.com

Julien PISCIONE
Employment
Head of performance department at FFR
Degree
PhD
Research interests
Training load & performance monitoring
E-mail: julien.piscione@ffr.fr

Mathieu LACOME
Employment
Head of Research and Development at PSG
Degree
PhD
Research interests
Training load & performance analysis
E-mail: mlacome@psg.fr

✉ **Christopher Carling, PhD**
Institute of Coaching & Performance, University of Central Lancashire, UK