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Quantification of Training and Competition Load Across a Season in an Elite Australian Football Club.

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Quantification of training and competition load across a season in an elite Australian Football Club

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Abstract

Purpose: Load monitoring in Australian Football (AF) has been widely adopted, yet team sport periodization strategies are relatively unknown. Here we have aimed to quantify training and competition load across a season in an elite AF team, using rating of perceived exertion (RPE) and GPS. tracking. **Methods:** Weekly totals for RPE and GPS loads (including accelerometer data; Playerload) were obtained for 44 players across a full season for each training modality and for competition. General linear mixed models compared mean weekly load between 3x pre-season and 4x in-season blocks. Effects were assessed with inferences about magnitudes standardized with between-player SD. **Results**: Total RPE load was most likely greater during pre-season, where the majority of load was obtained via skills and conditioning. There was a large reduction in RPE load in the last pre-season block. During in-season, half the total load came from games and the remaining half from training, predominantly skills and upper-body weights. Total distance, high-intensity running, and Playerload showed large to very large reductions from pre-season to in-season, whereas changes in mean speed were trivial across all blocks. All these effects were clear at the 99% level. **Conclusions**: These data provide useful information about targeted periods of loading and unloading across different stages of a season. Our study also provides a framework for further investigation of training periodization in AF teams.

Key Words: Training organisation, training distribution, team sports

Introduction

Australian Football (AF) is a multicyclical competition containing a pre-season phase and an in-season phase, requiring athletes to go through a weekly round of competition, recovery, training and subsequent competition.[1] With AF being an intermittent contact sport it requires a wide range of physical attributes such as muscular strength, speed, power, repeated sprint ability, endurance, acceleration, and sport specific skills.[2, 3] Indeed, players cover anything between 9.5-17 km total distance and in excess of 3 km high-speed (> 14.4 km/h) distance per game.[4] As such, AF requires careful planning and monitoring of training so as to maintain athlete fitness whilst maximising performance.

The emergence of training load (TL) monitoring in team sports has exponentially grown owing to the need to monitor individual responses to training. Indeed, the adoption of a coach's own training philosophy that is usually based on years of experience and team needs[5] demonstrates the requirement for daily TL evaluation. The use of global positioning systems (GPS) and accelerometers in team sports is now an important monitoring tool for collecting objective information pertaining to drills, sessions and games. For example, in-depth information on the activity profiles of athletes such as total distance travelled, amount of high-intensity running completed, and average movement speed [6, 7] can all be obtained. In addition, the use of the self-perceived session rating (s-RPE) method, known more as a subjective tool, has proved useful in determining the internal load of athletes such that the physiological stress to the external load, can effectively be captured.[8-10] This approach has now been adopted by a number of teams as part of their training monitoring system.[8]

The ability to obtain both objective and subjective measures of TL allows for a more effective prescription of training. Training periodization requires the careful manipulation of training volume and intensity so as to result in an increase in performance.[11] Accordingly, the balance between training stress, competition and recovery is of significant importance so

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as to protect against underperformance [12] and increased injury risk [13]. Recent research in soccer and rugby has quantified aspects of weekly[14, 15], monthly[8, 16, 17] and seasonal[5] TL. Despite recent advancements in AF,[18] whereby TL and training duration is higher during pre-season compared to in-season, data are limited such that the training and competition load was only quantified using the s-RPE method. The context in which TL is obtained is important as it will allow coaches to better plan and prescribe training at both a team and individual player level. As such, information on the external load (alongside that of the perceived load) associated with the training practises in AF is required. Moreover, where the majority of literature compares pre-season to in-season, it is unknown, within these two major training and competition phases how load is manipulated.

The aim of the current study was to quantify training and competition load of a team of Australian Footballers across various stages of a season using both s-RPE and GPS.

Methods:

Subjects

Forty-four full-time professional elite AF athletes (mean ± SD: age, 24.1 ± 3.8 years; height, 187.7 ± 7.2 cm; body mass, 87.3 ± 8.2 kg) from the same Australian Football League (AFL) club participated in this single full season study. The participating athletes competed in the AFL and the Victorian Football League (VFL) and each provided written informed consent and the research was approved by the institutions human research ethics committee. This team achieved a final ranking on the ladder of 14th out of 18 and won 7 and lost 15 games. In the event that players suffered an injury, defined as pain resulting in modified load, data was excluded from the point of injury to the point of full return to training.

Design

TL data were collected over a 41 week period during the 2013-2014 season. In order to obtain relevant information on training and competition loading strategies the season was

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divided into distinctive periods. Pre-season was sub-divided into pre-season 1, pre-season 2 (divided by the Christmas break)[19] and pre-season 3. This latter pre-season period incorporated three practise games. Subsequently, the competition phase was divided into four periods where in-season 1, 3 and 4 contained a similar number of games in each with in-season 2 containing no game (bye weekend). Week 26 (in-season 2) was included as its own separate period as it shows how TL is managed during an in-season period when no game is played. The TL presented in each block represents the average weekly total within the given season block so as to account for differences in number of weeks within blocks. Individual training sessions, recovery and extras (i.e. individual skill development) were not included in the analysis. In order to analyse the distribution of TL by mode, training was categorised into skills (AF specific training), running (field-based conditioning), upper-body weights (UB weights), lower-body weights (LB weights), games and “other” (boxing, cycling, swimming and cross-training).

Methodology

Internal TL data were obtained through the RPE-based method [20] at 10-30 minutes following every field-based and indoor training session and games as well as all strength training and cross training conditioning sessions in the gym. In order to obtain a TL value, the RPE is multiplied by session duration, providing a s-RPE for all training and games.[20] For all field-based training sessions and games, athletes wore GPS devices (MinimaxX S4, Catapult Innovations, Australia). TL parameters obtained from GPS include total distance (m), high-intensity running (>14.4 km/h (m)) (HIR),[21] PlayerLoad [22] (where the unit of measurement represents the square root of the sum of the squared instantaneous rate of change in acceleration in the X, Y and Z axes divided by 100), and average movement speed (m/min). Each athlete wore the same device across the season which was worn inside a custom made vest supplied by the manufacturer across the upper back between the left and

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right scapula. All devices were activated 30-minutes prior to data collection to allow acquisition of satellite signals (>8 satellites). The GPS units have a sampling rate of 10 Hz and accelerometer sampling rate of 100 Hz. The accuracy of GPS units sampling at 10 Hz has been shown recently.[23] Following every training session and game, all GPS and accelerometer derived data were downloaded and analysed by a specialist GPS software package (Sprint 5.1.3, Catapult Innovations, Australia). A total of 25900 individual training observations and a total of 932 individual game observations were obtained. Substitutes in games (N=2 per game) were excluded from the final analysis. Due to the closed roof of the home stadium for 13 of the 26 AFL games full GPS couldn't be monitored. However, PlayerLoad was still able to be collected for all games as this was obtained from the accelerometer. All VFL games (N=21) were monitored with both GPS and PlayerLoad, therefore, increasing GPS game sample to N=34. AFL listed players only were included in the analysis.

Statistical analysis:

We developed general linear mixed models that estimated training and game loads of players in their uninjured state by including their injury status (total of 41 injuries) as covariates in the model. Covariates were also included to adjust block effects to playing position and number of AFL years of experience. Random effects in the model were specified to allow for different between-player standard deviations between blocks (with an unstructured covariance matrix to allow for correlations between blocks) and different within-player standard deviations between blocks (a different residual variance for each block). Effects were assessed with non-clinical magnitude-based inferences, using standardisation to define magnitude thresholds (lower or equal to 0.20 trivial, lower or equal to 0.60 small, lower or equal to 1.20 moderate, lower or equal to 2.0 large, lower or equal to 4.0 very large and >4.0 extremely large).[25] Uncertainty in each effect was expressed as 90%

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confidence limits (CL) and as probabilities that the true effect was substantially positive or negative.[24] To account for an inflation of error associated with a large number of inferences in the current study, effects were declared clear at the 99% level.

Results:

Total RPE Load was most likely greater in pre-season 1 and 2 than in-season (Table 1, Figure 1). During pre-season 1 and 2 the majority of load most likely came from skills, "other" and running in comparison to pre-season 3 and in-season blocks. In contrast, half of the in-season load came from games with the remaining half predominantly from skills training and UB weights (Table 1, Figure 1). LB weights were most likely reduced during in-season as was running and "other" conditioning components.

Total distance in training was most likely greater during pre-season 1 and 2 compared with in-season. In contrast, total distance covered in games was most likely greater during in-season compared with games in pre-season 3 (Table 2).

Similar to total distance, there were likely reductions in HIR in training during in-season compared to pre-season 1 and 2 whilst there was a likely increase in HIR during in-season 3 compared to in-season 1 and 4. Even though HIR was most likely lower in games during pre-season 3, there was no change in HIR during games across in-season blocks (Table 2).

Differences in mean speed were most likely trivial for all pre-season and in-season blocks for both training and games (Table 2). In contrast, Playerload was most likely higher in training during pre-season 1 and 2 compared to in-season and likely increased during in-season 3 compared with in-season 1 and 4. Playerload in games during pre-season 3 was most likely lower than games during in-season (Table 2).

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Discussion:

The aim of the current study was to quantify training and competition load in AF using a combination of s-RPE and GPS load monitoring across specific blocks of a season. We show that load during pre-season was obtained predominantly from conditioning and skills training whereas in-season load was obtained by competition, skills and upper-body weights. At a global level, this is consistent with existing knowledge, where TL is greater during pre-season, whilst in-season there is a concomitant decrease and increase in training and competition load, respectively.

This study is in agreement with existing literature where pre-season TL is greater than in-season TL,[15, 18, 25] however, we provide new information in the way in which external load is obtained during the course of a season. Indeed, field-based GPS training load was higher in the pre-season compared with in-season, an effect that is likely due to the specific conditioning focus of preparing physically for the in-season competition demands. It is well known that pre-season is a crucial period for team sports yet it was unclear as to the proportion of work in terms of conditioning and skills they do in the pre-season. Moreover, during the in-season, approximately 50% of external load was obtained by games, whereas the remaining 50% was obtained by training (Figure 2b). In contrast to pre-season load distribution though, this in-season training load was actually obtained by more skills training and UB weights (Figure 3), whereas in pre-season the training load consisted of high amounts of skills training and all aspects of conditioning. Presumably due to the high-intensity nature and increased load of games (~900 RPE load units per game), the difference in in-season training load and the distribution of training mode (i.e. reduction in lower-body load) was likely served to support the recovery process (see below for further information on lower-body load). Whilst the current study did not examine the within-week loading between games, it can be speculated that the reduction in overall training load from pre-season to in-season would also result in a reduction in training load within week, i.e. between games. This periodization strategy is supported by recent work where high training load between both AFL and Rugby League games (separated by 1-week) impairs sprint capacity and explosive actions typical of intermittent activity [12] and increases injury risk [13]. Together, these data provide important information for practitioners when considering the overall load and mode of training that is prescribed to team sport athletes at varying times within a season.

As noted previously, training distribution transitioned from pre-season (predominantly running, skills and "other" conditioning) to in-season (skills and UB weights). LB weights load was also greater during the pre-season compared to in-season. Although there may have been a reduction in the frequency of lower body weight sessions during the in-season, it may also be suggested that this reduction in LB weights load was due to an increase in high-intensity running during competition. However, there was a simultaneous decrease in high-intensity running during training in all in-season periods suggesting the reduction in LB weight load is primarily due to the adoption of a recovery focussed training week. Unfortunately, this study is unable to describe whether this dose of LB weights load is capable of maintaining or developing strength. Some evidence suggests up to two weekly sessions of strength based training is required for maintenance of muscular strength,[26] however, there is limited evidence as to the required dose for elite AF players. Future research should aim to uncover the minimal weekly dose required for AF players to maintain a strength and/or hypertrophic stimulus during the in-season period.

Unsurprisingly and consistent with the shift in training focus, field-based weekly TL was similar across all in-season blocks. Due to the 1-game per week schedule in AFL, coaches may be able to plan effective in-season training programmes that facilitate the preparation for and recovery from competition.[12] Interestingly though, there were only trivial differences in mean speed for training across the duration of both pre-season and in-season.

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This intensity was a lot lower than that of games, highlighting the magnitude of stimulus that games provide. Indeed, the concept of 'train as you play' is highly impractical in this sense owing to the high game demands and increased injury risk. As such, it may actually demonstrate that coaches knowingly prescribe an in-season 'maintenance' dose so as to preserve the physical capacities developed during pre-season[32] but also to ensure optimal preparedness for competition. Furthermore, it may also relate to the reduction in lower-body weights load, such that, more emphasis is placed on maintaining an aerobic fitness stimulus, resulting in a decreased lower-body weights load. It should also be noted that mean speed may be particularly dependent on the coach's philosophy, where drills that develop a particular game style may be repeated regularly throughout the season. In keeping with this concept of a coach's philosophy, the increase in training duration during in-season 3 may have been a coach driven decision targeted to developing game style. Concomitantly, there was also an increase in training HIR and PlayerLoad during in-season 3; a likely result of the increase in duration. These data demonstrate the challenges associated with training design in team sports and may present important questions for coaches and practitioners when planning training during the competitive stage of the season.

Consistent with previous findings,[18, 27] we report reductions in load obtained during pre-season practise games compared to in-season games. This appears to be a direct result of the reduction (approx. 30%) in game time as total distance, HIR and PlayerLoad were also reduced by ~30% suggesting that if game time was standardised between pre-season and in-season games, load would have been similar. It may be speculated that coaches adopt a pre-competition reduction in load so as to protect against injury, such as that shown in rugby league where reductions in load in the pre-season reduce risk of injury and result in greater improvements in physical fitness [28]. In addition, rules on player rotations are also different during practice games compared to AFL competition such that during competitive AFL

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games, teams are limited to 3 players rolling on and off the ground for a total of 120 rotations per team per game. However, during practice games this is unrestricted, where ~6 players rotate at any one time with upwards of a total of 160-180 rotations. To this end, both training load compared to pre-season 1 and 2 and game load during pre-season 3 compared to in-season is lower. Collectively, these data suggest that training and game load is periodically managed prior to competition, possibly in an attempt to reduce risk of injury.

Practical applications:

The combination of internal (s-RPE) and external (GPS) load monitoring is important for practitioners in understanding all load obtained during the course of a season. Indeed, the integration of both internal:external load measures may be a viable and feasible monitoring strategy so as to accurately determine loading at various points in the season. Moreover, load distribution is largely affected according to the time of the season, with pre-season containing the highest amounts of conditioning and skills whilst in-season is characterised by a focus on competition and recovery.

Despite these novel findings, it is acknowledged that this is effectively a case study of one team competing in the AFL. The authors recognize that the findings are likely specific to this group of players and the specific style and philosophy of the coaching staff. As such, further research is required that depicts a broader overview of the TL, intensity and distribution of training in AF. In addition, the training practices presented in the current study are likely to be different at the individual level. That said, load associated with individual skill development sessions and recovery should be examined so as to provide an overview of what additional loading these provide to the athletes. Furthermore, information on position and years of experience in the AF system as well as the link between performance and injury would provide greater understanding as to the organisation of training and competition load during a season and allow for improved athlete conditioning.

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Conclusion:

This is the first study to systematically quantify the training periodization strategies across a season in Australian Football using both perceived exertion (RPE) and GPS-derived monitoring markers. The data from this study revealed that pre-season contains higher training loads, whereas in-season, there is a shift in load distribution such that ~50% of load is obtained via competition. Combined with 'in house' analyses, this distribution of load may aid practitioners in planning and structuring future training plans, as well as to compare and contrast to other practices in Australian Football. As this is an analysis of a single team, the distribution and variation of load across the season may vary between clubs. Future research incorporating other modes of load monitoring as well as examining differences in position, AF years of experience and individual responses will help our understanding of changes in various components of fitness in response to load.

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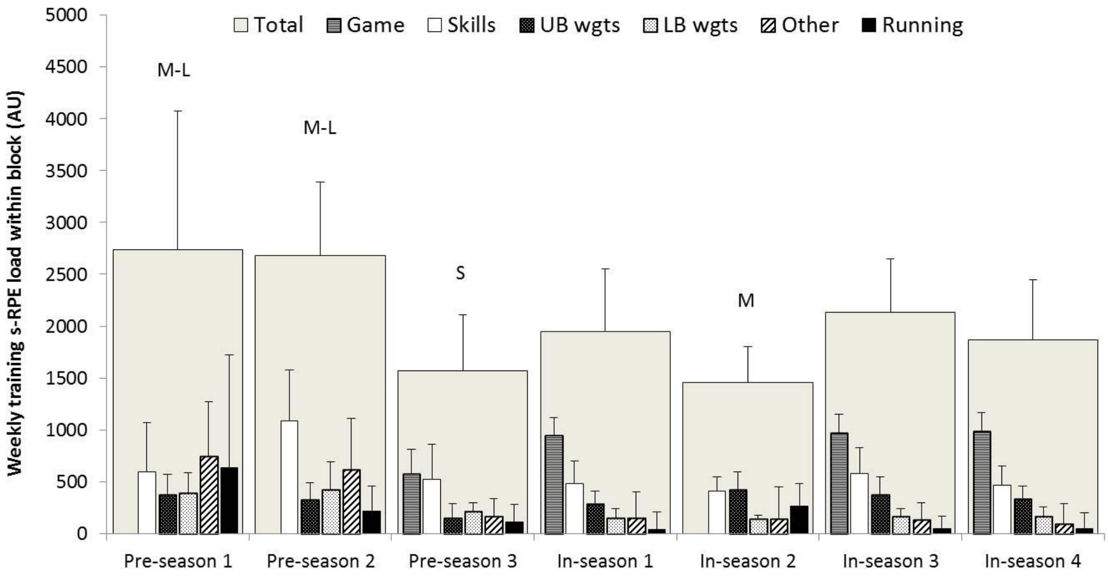

Figure 1. Training distribution expressed by RPE Load per week within block for weekly total load (large bar) and all modes (small bars). Pre-season 1 and pre-season 2; M denotes moderate standardised difference vs in-season 1, 3 and 4; L denotes large standardised difference vs pre-season 3 and in-season 2. Pre-season 3; S denotes small standardised difference vs in-season 1, 3 and 4. In-season 2; M denotes moderate standardised difference vs in-season 1, 3 and 4. Data are shown as mean ± SD.

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TABLE 1. Quantification of weekly training and game load throughout each block during the season for total, games, skills, UB weights, LB weights, other and running load. Standardised differences are denoted by letters and expressed by effect size. Data are shown as mean ± SD.

Block	Total (AU)	Games (AU)	Skills (AU)	UB weights (AU)	LB weights (AU)	Other (AU)	Running (AU)
Pre-Season 1	2740 ± 1330 $^{M, L}$	-	600 ± 470 $^{S, L}$	370 ± 200 $^{S, L}$	390 ± 200 $^{S, M, L}$	740 ± 530 $^{S, L}$	640 ± 1080 $^{M, L}$
Pre-Season 2	2680 ± 710 $^{M, L}$	-	1090 ± 490 ^{L}	320 ± 170 $^{M, L}$	420 ± 270 ^{L}	610 ± 500 ^{L}	220 ± 240 ^{S}
Pre-Season 3	1570 ± 540 $^{S, M}$	570 ± 240 ^{L}	520 ± 340	150 ± 140 ^{M,L}	210 ± 90 ^{S}	160 ± 180	110 ± 170
In-Season 1	1950 ± 600	940 ± 180	480 ± 220	280 ± 130 ^{S,M}	150 ± 90	150 ± 250	40 ± 170
In-Season 2	1460 ± 340 ^{M}	-	410 ± 140 ^{S}	420 ± 180 ^{S,M}	140 ± 40	140 ± 310	270 ± 210 ^{S}
In-Season 3	2130 ± 520 ^{S}	970 ± 180 ^{S}	580 ± 250	370 ± 180 ^{S}	160 ± 80	130 ± 170	50 ± 120
In-Season 4	1870 ± 580	980 ± 190	470 ± 180	330 ± 130	160 ± 100	90 ± 200	50 ± 150

Superscripts indicate small (S), moderate (M), large (L) and very large (V) differences (clear at the 99% level) as follows.

Total:

Pre-season 1 and Pre-season 2; M vs in-season 1, in-season 3 and in-season 4. L vs pre-season 3 and in-season 2.

Pre-season 3; S vs in-season 1 and in-season 4. M vs in-season 3.

In-season 2; M vs in-season 1, in-season 3 and in-season 4.

In-season 3; S vs in-season 1 and in-season 4

Game:

L vs all in-season blocks and S vs in-season 1.

Skills:

Pre-season 1; S vs in-season 2 and in-season 4. L vs pre-season 2.

Pre-season 2; L vs all in-season blocks

In-season 2; S vs in-season 3

UB weights:

Pre-season 1; S vs pre-season 2, in-season 1, in-season 2 and in-season 4. L vs pre-season 3.

Pre-season 2; M vs pre-season 3 and in-season 3. L vs in-season 2.

Pre-season 3; M vs in-season 1 and in-season 4. L vs in-season 2 and in-season 3.

In-season 1; S vs in-season 3 and in-season 4. M vs in-season 2.

In-season 2; S vs in-season 3. M vs in-season 4.

In-season 3; S vs in-season 4.

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LB weights:
Preseason 1; S vs pre-season 2, M vs pre-season 3 and L vs all in-season blocks.
Pre-season 2; L vs pre-season 3 and all in-season blocks
Pre-season 3; S vs all in-season blocks
Other:
Pre-season 1 and 2; S vs pre-season 2 and L vs pre-season 3 and all in-season blocks.
Running:
Pre-season 1; M vs pre-season 2, pre-season 3 and in-season 2. L vs in-season 1, in-season 3 and in-season 4.
Pre-season 2; S vs pre-season 3, in-season 1, in-season 3 and in-season 4.
In-season 2; S vs pre-season 3, in-season 1, in-season 3 and in-season 4.

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TABLE 2. Quantification of weekly training and game load throughout each block during the season for duration, total distance, high-intensity running, mean speed, and PlayerLoad. Standardised differences are denoted by letters and expressed by effect size. Data are shown as mean ± SD.

Block	**Duration (min)**		**Total Distance (m)**		**HIR (m)**		**Mean Speed (m/min)**		**PlayerLoad (AU)**	
	Training	*Game*	*Training*	*Game*	*Training*	*Game*	*Training*	*Game*	*Training*	*Game*
Pre-Season 1	199 ± 76 L	-	20000 ± 8200 L	-	6680 ± 3540 LV	-	99 ± 201	-	1910 ± 770 L	-
Pre-Season 2	209 ± 72 L	-	21400 ± 7300 L	-	6350 ± 2490 LV	-	101 ± 152	-	2060 ± 720 L	-
Pre-Season 3	103 ± 49	69 ± 21 V	10200 ± 5600	9900 ± 3000 L	2630 ± 2120	2550 ± 840 M	98 ± 149	142 ± 73	1000 ± 500	1010 ± 290 L
In-Season 1	112 ± 41	100 ± 13	9900 ± 3800	13300 ± 1700	2440 ± 1120	3140 ± 820	87 ± 102	132 ± 80	980 ± 380	1310 ± 190
In-Season 2	117 ± 24	-	10500 ± 2500	-	2850 ± 1050	-	88 ± 79	-	970 ± 210	-
In-Season 3	126 ± 52 S	101 ± 13	11800 ± 4400 S	13400 ± 1500	2970 ± 1400 S	3270 ± 670	93 ± 128	132 ± 74	1130 ± 430 S	1320 ± 190
In-Season 4	111 ± 38	102 ± 14	10400 ± 3300	13500 ± 1700	2430 ± 900	3330 ± 810	93 ± 78	133 ± 57	990 ± 320	1320 ± 200

Superscripts indicate small (S), moderate (M), large (L) and very large (V) differences (clear at the 99% level) as follows.
Training Duration: L vs pre-season 3 and all in-season blocks and S vs pre-season 3.
Game Duration: V vs all in-season blocks.
Training Total Distance: L vs pre-season 3 and all in-season blocks and S vs pre-season 3 and in-season 1.
Game Total Distance: L vs all in-season blocks.
Training High-Intensity Running: LV vs pre-season 3 and all in-season blocks and S vs in-season 1 and in-season 4.
Game High-Intensity Running: M vs all in-season blocks.
Training Player Load: L vs pre-season 3 and all in-season periods and S vs in-season 1, in-season 2 and in-season 4.
Game Player Load: L vs all in-season blocks.