Peak movement and technical demands of professional Australian Football competition

Johnston, Rich D., Murray, Nick B., Austin, Damien J. and Duthie, Grant

Accepted manuscript. Johnston, Rich D., Murray, Nick B., Austin, Damien J. and Duthie, Grant. (2021). Peak movement and technical demands of professional Australian Football competition. *The Journal of Strength and Conditioning Research*, 35(10), 2818-2823. https://doi.org/10.1519/JSC.0000000000003241

ORIGINAL INVESTIGATION

TITLE: **Peak movement and technical demands of professional Australian football competition**

RUNNING HEAD: **Peak demands of Australian football**

Rich D. Johnston,[a] Nick B. Murray,[b] Damien J. Austin,[b] and Grant Duthie[c]

[a]School of Behavioural and Health Sciences, Australian Catholic University, Brisbane, Australia

[b]Brisbane Lions Australian Football Club, Brisbane, Australia

[c]School of Behavioural and Health Sciences, Australian Catholic University, Sydney, Australia

Address for correspondence:

Rich Johnston

School of Exercise Science,

Australian Catholic University,

Brisbane, Queensland, Australia, 4014

E: richard.johnston@acu.edu.au

P: +61 7 3623 7726

Word count = 2867 Abstract word count = 246

Figures = 1

Tables = 2

ORIGINAL INVESTIGATION

TITLE: **Peak movement and technical demands of professional Australian football competition**

RUNNING HEAD: **Peak demands of Australian football**

Word Count:
Abstract = 243
Manuscript = 2953
Number of Tables = 2
Number of Figures = 1

Abstract

The aim of this study was to determine the average peak movement and technical demands of professional Australian football (AF) across a number of period durations using an observational cohort design. This information will be able to guide duration specific intensities for training drills. Microtechnology and technical performance data were recorded across 22 games of the 2017 AFL (Australian Football League) season. The peak 1-, 3-, 5-, 7-, and 10-min rolling periods were determined from each game for each player for each frequency of skill involvements. Average speed ($m \cdot min^{-1}$) and accelerometer load (PlayerLoad™; $PL \cdot min^{-1}$) were used as measures of physical output and any disposal of the football or tackle was used as a technical involvement. Linear mixed models and Cohen's effect size statistic were used to determine the impact technical involvements had on movement profiles. There were substantial reductions in average speed across each duration as the number of technical involvements increased, other than for the 10-min period. The reductions in speed were greatest during the 1-min period for one (effect size [ES] = -0.59 ± 0.13), two (ES = -1.96 ± 0.17) and three (ES = -2.39 ± 0.27) involvements. Similarly, less pronounced reductions were seen for accelerometer load, other than during the 7- and 10-min periods where there were small to moderate increases in load for periods with technical involvements. Players may have to perform as many as 3 technical involvements a minute whilst covering 150-160 $m \cdot min^{-1}$. This information provides coaches with the peak speed, accelerometer load, and technical demands of competition. There are reductions in movement profiles as the number of technical involvements increases.

Key Words

Team sport; microtechnology; activity profile; intensity; performance; GNSS

Introduction

Australian football (AF) is an intermittent team sport that is characterised by periods of high intensity activity, such as sprinting, accelerating and high-speed running, interspersed with periods of low intensity activity such as walking and jogging. The average demands of AFL competition have been widely researched, with a systematic review showing players cover 12897 ± 1601 m per game, with an average speed of 129 ± 13 m.min^{-1}, and 27± 13 m.min^{-1} at high-speeds (13). In addition to the physical demands of the game, players are required to perform a number of technical actions in order to maintain or regain possession of the ball to prevent or create goal scoring opportunities. Over the duration of a game, players perform 0.33-0.42 involvements per minute (5), with nomadic players having more possessions per minute (0.17 ± 0.06 n·min^{-1}) compared to fixed position players (0.11 ± 0.04 n·min^{-1}) (10). Whilst this information provides information on the workloads of players during competition, due to the intermittent nature of AF, the average demands do little to inform training practice as they fail to quantify the most intense passages of play (22, 23).

Based on these shortfalls, studies have attempted to quantify the peak periods of the game by partitioning the game into shorter time periods. One study that used 3-minute rolling periods identified the peak was greater than the 3-minute match average although they failed to report the precise values of these periods and how this changed as the period duration increased or decreased (2). As such, 1- to 10-minute periods have been quantified to determine the most intense passages of play across these durations (8). The peak 1-min period ranged from 199-223 m.min^{-1} depending on playing position, with an exponential decrease in intensity to the 10-min period (131-141 m.min^{-1}) which is still above match average. Another method has also been reported in the literature, where fixed period durations are not used, rather a *change point* determines the duration of the period depending on the mean and variance of the physical and, or skill output (7). Whilst this approach has the strength of not partitioning continuous time series data, it potentially has less practical application due to the complex analysis involved. These data clearly demonstrate that there are periods in a game where the movement intensities are elevated well above average match intensity, which may persist for a number of minutes.

This information can help practitioners prescribe conditioning drills to reflect the duration specific worst case demands of competition.

The technical component of the game appears to be more closely linked to match success than the physical profiles (18, 20). High calibre players have more disposals per minute than low calibre players (0.20 ± 0.53 vs. 0.13 ± 0.51 n·min^{-1}; effect size [ES] = 01.09), and also covered less distance per involvement (ES = 0.69) (16). However, other studies have shown increased physical output is associated with improved technical performance and match success (9, 10, 17). Specifically, one study has shown match speed shared a negative association with involvements, but high-speed running has a positive influence (6). Although the average number of involvements has been documented (16, 19), little is known about the peak skill demands of competition. One study showed that during the 3-minute peak running period, players performed an average of only 2 skill actions over the 3 minutes (2). Using conditional inference trees, the movement demands leading to peak player involvements were identified, with the analysis showing a weak relationship between physical movements and skilled performance (6). This would suggest that physical performance does not have a direct impact on technical involvements, and other factors are at play. Despite this, accelerometer load was not investigated, nor were the peak intensities of match-play documented. Accelerometer load has been shown to be strongly correlated to total distance in AF (1), but this is likely not the case during high-intensity work where accelerometer load is sensitive to changes in direction, that would cause reductions in speed (12). Given the importance of both the technical and physical components of the game, research that documents the combined peak movement and skill periods across a number of playing durations is warranted.

Based on this information, the aim of this study was to determine the peak movement and technical periods across a number of period durations using rolling averages during professional AF games. Such information will provide practitioners with a framework with which they can develop training drills that reflect the worst case demands of the game, both physically and technically.

Methods

Experimental Approach to the Problem

To determine the peak physical and technical periods of professional AF competition, microtechnology data and technical performance data were recorded across 22 games of the 2017 AFL season using an observational cohort design study. Players were divided into three positional groups, midfielders (n = 12) small defenders and forwards (Smalls: n = 13), or fixed position players (Fixed: n = 11). Due to their unique position and small sample size (n = 2), rucks were removed from the analysis, resulting in a total of 450 match files being used for analysis.

Subjects

Thirty-eight professional male AF players took part in this study (age = 23.6 ± 4.5 years; mass = 89.7 ± 7.5 kg; height = 187.0 ± 17.1 cm). Each player was a contracted player to a single club competing in the Australian Football League (AFL). All data were collected as part of the standard procedure of the football club and were de-identified prior to analysis. Ethical approval was provided by the Human Research Ethics Committee (2017-7N).

Procedures

To assess the physical demands of competition, players were fitted with a global navigation satellite system (GNSS) microtechnology device. The devices contained a 10 Hz GNSS chip and a 100 Hz tri-axial accelerometer and gyroscope (Optimeye S5, Catapult Innovations, Melbourne, Australia). Players were allocated a unit at the start of the season which remained consistent across all matches. Units were turned on approximately 20 minutes prior to the start of each match warm-up and placed within a specifically designed pouch on the playing jerseys so that it lay between the scapula at the top of the back. After each match, the GNSS files were downloaded to a computer using proprietary software (Openfield v1.15.0, Catapult Innovations, Melbourne, Australia). Only active playing time was used, with time on the bench being omitted from the analysis. Each file was then divided into 1-minute periods with average speed ($m{\cdot}min^{-1}$) and accelerometer load (PlayerLoad™; $AU{\cdot}min^{-1}$) recorded as the dependent variables. The microtechnology units utilised in this study have been shown to have acceptable accuracy for reporting total distances and high-speed distances in team sport players (21).

To determine the frequency of technical involvements, a timeline of technical skills was imported from Champion Data into SportsCode 11 (Hudl, Agile Sports Technologies, Iowa). Subsequently the skill and corresponding timestamp for any free kick, handball, kick or tackle, as outlined previously (13), were exported in a .csv file. The periods of the GNSS data were captured in real-time, with the period starting when the umpire commenced the game; providing match-time. For the SportsCode data, timestamps were provided for each involvement coded which relates to the time into the video. Following this, the two data sources were synced in Excel. As with the GNSS files, involvements were grouped into one-minute intervals with the total number of involvements performed per minute recorded before the technical time series data was matched to the GNSS time series based on the kick-off time of each match.

Once the GNSS and SportsCode exports were time matched in excel in one-minute intervals, rolling 1-, 3-, 5-, 7-, and 10-minute periods were calculated for match speed ($m{\cdot}min^{-1}$), accelerometer load ($AU{\cdot}min^{-1}$), and involvements ($n{\cdot}min^{-1}$). This allowed the peak periods for each involvement frequency to be determined across each rolling period. For example, each player would have a 1-min period with 0 involvements, they could also record a peak 1-min period for 1, 2, 3 involvements.

Statistical Analyses

Data were assessed for normal distribution using a Shapiro-Wilk test to determine whether parametric testing was appropriate. Subsequently, linear mixed models with fixed effects (technical involvements, period duration and time) and random effects (player identity and match) included to assess differences between duration periods and technical involvements by position. Separate models were built for each duration for match speed, and accelerometer load. The least squares mean test provided pairwise comparisons that were described using Cohen's standardised ES and 90% confidence limits (CL), categorized using the thresholds of; <0.2 trivial, 0.21 – 0.60 small, 0.61 – 1.20 moderate, 1.21 – 2.0 large and >2.0 very large. Differences were considered real if there was a >75% likelihood of the observed effect exceeding the smallest worthwhile difference (0.20), and are described as; 75-95%, likely; 95-99.5% very likely and >99.5%, most likely (11). All statistical analysis was performed in RStudio (Version 1.1.383; Boston, MA, USA). All raw data are reported as means ± SD, while differences are reported as standardised effect sizes ± 95% confidence limits.

Results

The average match demands were 124 ± 4 m.min^{-1} and 12.3 ± 5.2 PL.min^{-1}. In addition, players were involved in an average of 0.2 ± 0.5 involvements per min over the course of a match. Over all matches and positions, a total of 10045 peak periods were recorded over all durations and skill involvement frequencies.

The mean peak speed (m·min^{-1}) over all periods durations for each absolute number of technical involvements frequencies in each positional group are shown in Table 1. There was only a substantial main effect of position across the 1-min period between fixed position players and midfielders and small position players. As such, Figure 1A demonstrates the effect size difference in average speed compared to no involvements for all positions for the 3- to 10-min periods. There were *small* to *large* reductions in speed that became progressively larger as the frequency of involvements increased over the 1-min (ES range = -0.59 to -2.39), 3-min (ES range = -0.10 to -2.32) and 5-min (ES range = 0.21 to -1.80) periods. Over the 7-min period, there were *small* increases for 0.1 (ES = 0.38 ± 0.13) and 0.3 (ES = 0.29 ± 0.13) involvements per min, with a gradual *trivial* to *large* decline in speed as the frequency of involvements increased (ES range = -0.02 to -1.45). Over the 10-min period, there are *moderate* increases in speed, when players perform 0.1 (ES = 0.63 ± 0.13), 0.2 (ES = 0.72 ± 0.14), and 0.3 (ES = 0.62 ± 0.14) involvements per min. *Small* increases for 0.4 (ES = 0.46 ± 0.14) and 0.5 (ES = 0.27 ± 0.16) involvements per min, and *trivial* changes for 0.6 (ES = 0.12 ± 0.19), 0.7 (ES = 0.00 ± 0.27), and 0.8 (ES = -0.10 ± 0.36) involvements per min.

TABLE 1 NEAR HERE

FIGURE 1 NEAR HERE

The average peak accelerometer load (AU·min^{-1}) over all periods durations for each absolute number of technical involvements frequencies in each positional group are shown in Table 2. There was a main effect of technical involvements over each period duration. There were no main effects of position across any durations other than during the 1-min period, with greater accelerometer load for the midfielders and small position players compared to fixed. As such, Figure 1B demonstrates the effect size difference in average accelerometer load compared to no involvements across 3- to 10-min periods for all positions. Similar to peak average speed, there were progressive reductions in accelerometer load over the 1- (ES = -0.33 to -1.76), 3- (ES = 0.03 to -1.16), and 5-min (ES = 0.23 to -0.62). However, over the 7-min period, there were *small* increases for 0.1 and 0.3 involvements per min (ES = 0.36-0.38), and only *trivial* reductions for further increases in involvements. For the 10-min period, all periods where involvements were recorded, there *small* to *moderate* (ES = 0.46 to 0.75) increases in accelerometer load compared to periods with no involvements.

TABLE 2 NEAR HERE

Discussion

The aim of this study was to assess the peak average speed, accelerometer load and skill periods during professional AF matches over 1, 3, 5, 7, and 10-min durations. This study shows that as the number of technical involvements increases, there is a decrease in average speed, which is greater across the shorter periods. However, over longer periods (7- and 10-min), where players have 0.1-0.3 involvements per min, there are increases in average speed. Accelerometer load showed similar, yet smaller reductions as the number of involvements increased. In fact, over the 10-min period, there were increases in accelerometer load when players performed technical involvements. The information from this study provides practitioners with information to employ training drills that are above, below, or at match speed for both technical and physical aspects of competition.

This is the first study to document the peak average speed across rolling durations whilst also assessing the technical involvements within these periods. As the number of involvements increases, there are reductions in running speed, which are greatest over the 1-min period, highlighted by effect size differences, and gradually become less pronounced. This is most likely due to the fact that when a player has no technical involvement, they are either marking a player in defence, or attempting to find space on the field, which is likely to lead to greater average speed. Whereas, when a player has multiple involvements, they are likely positioned close to the ball, and therefore the affordance to cover large distances (and maintain speed) is reduced. Furthermore, when taking a '*mark*', there may be a stoppage lasting 0-20 seconds, which also reduces running speed. Previous research has suggested that increases in high-speed running are linked to more technical involvements (9, 10, 17). Taken together with the current findings, this would suggest that players are working hard whilst they are not directly involved in the play to create space or close-down opposing players. Having said this, players need to be able to execute technical skills on a consistent basis over the course of a game as they appear more closely link to match outcome compared to physical output (18, 20). This may be explained by the increases in average speed seen over the 10-min period in particular, when multiple technical involvements occurred. During these longer periods, increased average speed may be a result of dominant periods of possession, where players are engaged in long ball-in-play periods and free-flowing bouts of possession.

The similar, yet less pronounced reductions in accelerometer load with the increase in technical involvements is of interest, particularly, the *small* to *moderate* increases in load over the 10-min period for all technical involvements. The accelerometer load variable, PlayerLoad, is heavily influenced by distance covered, as foot strikes contribute heavily to load accumulated in the vertical (z) axis, and the overall load achieved (12). As such due to reductions in speed that accompany increased technical involvements, accelerometer load will naturally be reduced. However, the reason for smaller reductions in accelerometer load compared to those for average speed may due to increased load from anterior-posterior and mediolateral axes. Increases in accelerometer load are seen, in the mediolateral plane in particular, when contact or directional changes are increased (12, 14, 15). As highlighted previously, when a player is performing a number of technical involvements, it is likely that they are in a confined space where changes of direction, acceleration, deceleration, and physical contact is increased. Whilst these increases are not enough to offset the large reductions in speed that contribute to accelerometer load, they likely offset some of the reductions seen. However, during the 10-min periods, when a player performs multiple technical involvements they are likely performing large amounts of accelerations and changes of direction that result in increased load compared to 10-min periods where they have no involvements and are likely having little impact on the game. Future studies should look to quantify the acceleration and deceleration demands of matches alongside technical involvements.

Whilst there was no main effect of position across different periods, the small position players and midfielders recorded more involvements with the ball over their peak periods in comparison to the fixed position players. This is to be expected given the nomadic roles of midfielders, small defenders, and small forwards (10). Despite a higher number of involvements, the influence of involvements on average speed and accelerometer load was similar across positions, which is understandable given the constraints of the game.

The peak average speed of AFL competition reported in this study was similar to that reported previously (8), however, no study has reported the peak accelerometer load using the rolling period method. Match averages reported previously were approximately 15-16 $PL \cdot min^{-1}$ depending on playing position (3), which is much lower than the peaks of 22-24 $PL \cdot min^{-1}$ reported in the current study. Similar to average speed, there are progressive reductions in accelerometer load as the period duration increases. Previous work has shown average involvements are in the region of 0.33-0.42 per minute (4), but the current study shows they can be as high as 3 per minute. Despite the important findings of this research, it was only conducted from one club that finished towards the bottom of the competition ladder, and therefore may not be reflective of the whole league. The games were segmented into periods every 600 Hz, rather than every 1 Hz; therefore, the true peaks may be slightly underestimated. Future research should look to determine how the relationship between running intensity and involvements changes across a game as well as the impact of current score-line and match outcome. Only the total number rather than type of involvements, it would be useful to determine whether there is a difference between the type and outcome of the involvement and running activity. Additionally, breaking down accelerometer load into its constituents of vertical, anterior-posterior, and medio-lateral in response to technical involvements would help in training drill prescription.

This study shows that as the number of involvements increases, there is a reduction in both peak average speed and (to a lesser extent) peak accelerometer load; reductions are less pronounced over the longer periods. Indeed, in the 10-min period, there are increases in average speed (with up to 5 involvements, 0.5 per min) and accelerometer load (for all involvement frequencies). This information can be used to guide the prescription and monitor the intensity of technical and conditioning drills used in training to prepare players for the peak demands of competition. Depending on the aim of the session or drill, coaches could either overload or underload specific components of the drill (physical, and technical) as well as incorporating a decision-making component that is associated with team sport match-play. During and following training, the intensities of each drill can be reviewed to determine whether changes need to occur to the drill to increase or decrease physical or technical intensities. Future studies should look at the interaction of contextual factors such as opposition strength, match outcome and stint duration on the peak demands of match-play for AF players.

Practical Applications

This information can be used to guide training prescription. Coaches can now design drills that reflect the most intense passages of play from both a physical and technical standpoint. Increases in technical involvements will result in a reduction in running speed, as such, using GPS as a measure of 'performance' is not good practice. Although running speed may decline with increased involvements, there may be increases in accelerometer load, particularly in the anteroposterior and mediolateral planes. A technical drill lasting 5-min that is 100% of match pace should involve 130 $m \cdot min^{-1}$ and include 6 or more technical involvements

Acknowledgements

The authors would like to thank the players and staff of the club for participation in this study. No funding was used for this research; the authors have no conflicts of interest to declare.

References

1. Aughey RJ. Applications of GPS technologies to field sports. *Int J Sports Physiol Perform* 6: 295-310, 2011.
2. Black GM, Gabbett TJ, Naughton GA, and McLean BD. The effect of intense exercise periods on physical and technical performance during elite Australian Football match-play: A comparison of experienced and less experienced players. *J Sci Med Sport*, 2015.
3. Boyd LJ, Ball K, and Aughey RJ. Quantifying external load in Australian football matches and training using accelerometers. *Int J Sports Physiol Perform* 8: 44-51, 2013.
4. Burgess D, Naughton G, and Norton K. Quantifying the gap between under 18 and senior AFL football: 2003-2009. *Int J Sports Physiol Perform* 7: 53-58, 2012.
5. Burgess D, Naughton G, and Norton K. Quantifying the Gap Between Under 18 and Senior AFL Football: 2003 and 2009. *Int J Sports Physiol Perform* 7: 53-58, 2012.
6. Corbett DM, Sweeting AJ, and Robertson S. Weak Relationships between Stint Duration, Physical and Skilled Match Performance in Australian Football. 8, 2017.
7. Corbett DM, Sweeting AJ, and Robertson S. A change point approach to analysing the match activity profiles of team-sport athletes. *Journal of Sports Sciences*: 1-9, 2019.
8. Delaney JA, Thornton HR, Burgess DJ, Dascombe BJ, and Duthie GM. Duration-specific running intensities of Australian football match-play. *J Sci Med Sport*, 2017.
9. Dillon PA, Kempton T, Ryan S, Hocking J, and Coutts AJ. Interchange rotation factors and player characteristics influence physical and technical performance in professional Australian rules football. *J Sci Med Sport*, 2017.
10. Hiscock D, Dawson B, Heasman J, and Peeling P. Game movements and player performance in the Australian Football League. *Int J Perform Anal Sport* 12: 531-545, 2012.
11. Hopkins WG, Marshall SW, Batterham AM, and Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc* 41: 3-13, 2009.
12. Hulin BT, Gabbett TJ, Johnston RD, and Jenkins DG. Playerload Variables are Sensitive to Changes in Direction and Not Related to Collision Workloads in Rugby League Match-Play. *Int J Sports Physiol Perform*: 1-21, 2018.
13. Johnston RD, Black GM, Harrison PW, Murray NB, and Austin DJ. Applied Sport Science of Australian Football: A Systematic Review. *Sports Med*, 2018.
14. Johnston RD, Gabbett TJ, and Jenkins DG. Influence of Number of Contact Efforts on Running Performance During Game-Based Activities. *Int J Sports Physiol Perform* 10: 740-745, 2015.
15. Johnston RD, Gabbett TJ, Walker S, Walker B, and Jenkins DG. Are three contact efforts really reflective of a repeated high-intensity effort bout? *J Strength Cond Res* 29: 816-821, 2015.
16. Johnston RJ, Watsford ML, Pine MJ, Spurrs RW, Murphy A, and Pruyn EC. Movement demands and match performance in professional Australian football. *Int J Sports Med* 33: 89-93, 2012.
17. Mooney M, O'Brien B, Cormack S, Coutts A, Berry J, and Young W. The relationship between physical capacity and match performance in elite Australian football: A mediation approach. *J Sci Med Sport* 14: 447-452, 2011.
18. Robertson S, Back N, and Bartlett JD. Explaining match outcome in elite Australian rules football using team performance indicators. *J Sports Sci* 34: 637-644, 2016.
19. Sullivan C, Bilsborough JC, Cianciosi M, Hocking J, Cordy J, and Coutts AJ. Match score affects activity profile and skill performance in professional Australian football players. *J Sci Med Sport* 17: 326-331, 2014.

20. Sullivan C, Bilsborough JC, Cianciosi M, Hocking J, Cordy JT, and Coutts AJ. Factors affecting match performance in professional Australian football. *Int J Sports Physiol Perform* 9: 561-566, 2014.
21. Varley MC, Fairweather IH, and Aughey RJ. Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion. *J Sports Sci* 30: 121-127, 2012.
22. Whitehead S, Till K, Weaving D, and Jones B. The Use of Microtechnology to Quantify the Peak Match Demands of the Football Codes: A Systematic Review. *Sports Med* 48: 2549-2575, 2018.
23. Whitehead S, Till K, Weaving D, and Jones B. Authors' Reply to Carling et al: Comment on: "The Use of Microtechnology to Quantify the Peak Match Demands of the Football Codes: A Systematic Review". *Sports Med* 49: 347-348, 2019.

Figure Legends

Figure 1. Effect size difference of (A) peak average speed and (B) accelerometer load compared to no technical involvements over 3-, 5-, 7-, and 10-min period duration. The grey area represents a trivial effect size difference (± 0.20).

Table 1. Average peak speed ($m \cdot min^{-1}$) across each period duration and number of technical involvements.

Inv.	1-min	3-min	5-min	7-min	10-min
			Midfielders		
0	226.4 ± 26.4	176.8 ± 16.2	157.7 ± 15.6	144.3 ± 17.0	126.8 ± 25.8
1	214.2 ± 23.1	178.0 ± 18.2	161.9 ± 16.8	152.2 ± 16.7	141.6 ± 16.8
2	168.8 ± 32.8	166.4 ± 18.9	160.4 ± 17.5	153.7 ± 17.7	145.2 ± 16.7
3	150.7 ± 35.2	150.1 ± 19.3	151.1 ± 14.6	149.6 ± 14.3	145.6 ± 15.1
4	-	139.8 ± 19.3	143.2 ± 17.9	142.6 ± 17.7	142.5 ± 13.9
5	-	126.3 ± 19.1	134.3 ± 18.7	137.5 ± 15.9	138.3 ± 15.9
6	-	-	132.7 ± 15.9	130.5 ± 17.5	132.4 ± 13.4
7	-	-	-	126.9 ± 9.4	129.4 ± 13.3
8	-	-	-	-	127.0 ± 9.9
			Small Positions		
Inv.	1-min	3-min	5-min	7-min	10-min
0	221.6 ± 18.2	174 ± 14.2	156.4 ± 13.8	146.4 ± 12.9	132.1 ± 19.7
1	211.4 ± 21.2	172.6 ± 14.8	159.3 ± 13.2	151.4 ± 12.8	143.9 ± 13.3
2	171.1 ± 33.1	163.5 ± 18.4	155.8 ± 13.5	150.7 ± 11.5	145.6 ± 11.8
3	149.4 ± 44.1	148.0 ± 18.5	14.07 ± 13.7	144.9 ± 13.3	142.5 ± 11.9
4	-	144.4 ± 24.3	140.9 ± 17.3	140.8 ± 13.0	138.7 ± 13.7
5	-	145.1 ± 17.0	143.4 ± 17.9	139.2 ± 15.7	134.5 ± 13.5
6	-	-	128.7 ± 9.3	134.3 ± 14.3	134.0 ± 13.9
7	-	-	-	130.6 ± 9.7	132.7 ± 14.3
8	-	-	-	-	134.5 ± 15.3
			Fixed Positions		
Inv.	1-min	3-min	5-min	7-min	10-min
0	214.2 ± 24.1	169.3 ± 12.8	152.7 ± 9.5	144.1 ± 10.8	134.0 ± 12.9
1	192.2 ± 22.1	163.8 ± 14.5	153.9 ± 12.2	146.6 ± 11	139.4 ± 11
2	153.6 ± 29.5	145.8 ± 18.2	143.1 ± 14.3	141.1 ± 12.4	137.5 ± 10.7
3	159.0 ± 35.2	140.2 ± 20.3	138.0 ± 15.3	136.9 ± 12	134.4 ± 12.5
4	-	130.6 ± 12.1	130.1 ± 13.2	132.9 ± 12.8	131.4 ± 12.6
5	-	-	126.8 ± 0.3	128.1 ± 8.5	128.3 ± 9.2
6	-	-	-	124.4 ± 10.7	128.8 ± 5.8
7	-	-	-	-	-
8	-	-	-	-	-

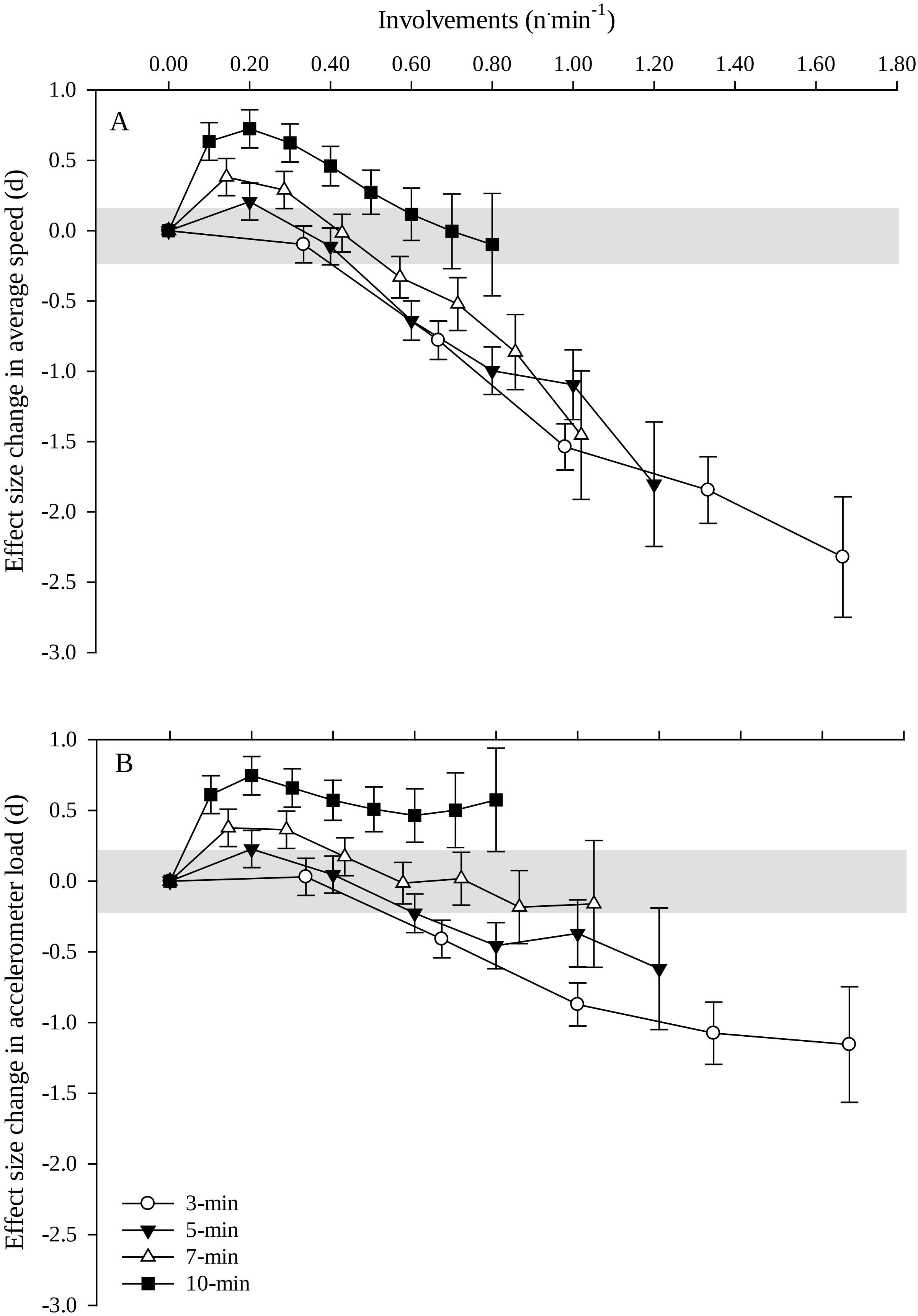
Inv. = Absolute number of technical involvements in a period, e.g. 5 in 3 min = 1.7 $n \cdot min^{-1}$; Small Positions = small defenders and forwards; Fixed Positions = tall defenders and forwards

Table 2. Average peak accelerometer load (AU·min^{-1}) across each period duration and number of technical involvements.

Inv.	1-min	3-min	5-min	7-min	10-min
			Midfielders		
0	23.8 ± 2.4	18.3 ± 1.9	16.2 ± 1.7	14.7 ± 1.9	12.7 ± 2.6
1	23.2 ± 2.5	18.7 ± 2.2	16.8 ± 1.9	15.6 ± 1.9	14.4 ± 1.9
2	18.8 ± 3.9	17.8 ± 2.4	16.8 ± 2.0	16.0 ± 2.0	15.0 ± 1.9
3	16.9 ± 3.9	16.2 ± 2.8	16.1 ± 2.2	15.7 ± 1.8	15.0 ± 1.7
4	-	15.3 ± 2.6	15.4 ± 2.3	15.1 ± 2.2	14.8 ± 1.7
5	-	14.3 ± 2.4	14.6 ± 2.5	14.6 ± 2	14.5 ± 2.1
6	-	-	14.8 ± 2.3	14.2 ± 2.4	14.0 ± 2
7	-	-	-	14.4 ± 1.4	14.0 ± 2.1
8	-	-	-	-	14.2 ± 1.9
			Small Positions		
Inv.	1-min	3-min	5-min	7-min	10-min
0	23.8 ± 2.4	18.2 ± 2.2	16.1 ± 2.1	14.9 ± 1.9	13.3 ± 2.4
1	23.3 ± 2.5	18.4 ± 2.1	16.6 ± 1.9	15.7 ± 1.9	14.7 ± 1.8
2	19.3 ± 4.3	17.5 ± 2.5	16.4 ± 2.1	15.7 ± 1.8	15.0 ± 1.8
3	16.9 ± 5.6	16.0 ± 2.3	15.5 ± 2.0	15.2 ± 1.9	14.7 ± 1.8
4	-	15.5 ± 2.9	15 ± 2.1	14.7 ± 1.7	14.3 ± 1.8
5	-	16.2 ± 3.2	15.6 ± 2.3	14.8 ± 2.2	14.1 ± 1.8
6	-	-	14.1 ± 1.7	14.3 ± 1.9	14.0 ± 1.9
7	-	-	-	14.0 ± 1.7	14.2 ± 2.1
8	-	-	-	-	14.3 ± 2.5
			Fixed Positions		
Inv.	1-min	3-min	5-min	7-min	10-min
0	22.0 ± 2.6	16.6 ± 2	14.8 ± 1.7	13.8 ± 1.7	12.6 ± 1.8
1	20.2 ± 2.8	16.3 ± 1.9	15.0 ± 1.7	14.2 ± 1.6	13.3 ± 1.6
2	16.4 ± 3.6	14.4 ± 2.2	13.9 ± 1.7	13.6 ± 1.6	13.2 ± 1.6
3	17.2 ± 4.2	14.0 ± 2.7	13.6 ± 2.1	13.1 ± 1.8	12.8 ± 1.7
4	-	13.5 ± 1.6	12.6 ± 1.5	12.7 ± 1.8	12.5 ± 1.7
5	-	-	12.6 ± 1.5	12.6 ± 1.2	12.2 ± 1.5
6	-	-	-	11.8 ± 0.4	12.4 ± 0.9
7	-	-	-	-	-
8	-	-	-	-	-

Inv. = Absolute number of technical involvements in a period, e.g. 5 in 3 min = 1.7 n·min^{-1}; Small Positions = small defenders and forwards; Fixed Positions = tall defenders and forwards

Figure 1



Involvements (n·min-1)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
A
Effect size change in average speed (d)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
B
Effect size change in accelerometer load (d)
3-min
5-min
7-min
10-min