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Peak running speeds in professional male football: influence of division and playing position

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Abstract

Well established physical demands of competitive professional football facilitate prescription and monitoring of training. However, many factors influence these physical demands with implications for efficacious practice. Match-play data were analyzed over two seasons using global positioning systems technology, differentiating English Championship (33 matches) and League One (27 matches) demands. Playing position categorized wide and central defenders and midfielders, and forwards. Peak running speeds defined the outcome measure, assessing the influence of competition level and playing position across 1, 5 and 10-minute rolling average durations using a linear mixed model. Significant effects were detected for competition level ($F_{1,324.5}$ = 5.44, P = 0.02) and playing position ($F_{4,328.3}$ = 89.90, P < 0.001). League One matches demonstrated greater peak running speeds than Championship matches (mean difference = 2.72 m·min^{-1} [95%CI: 0.4, 5.0]). No difference was observed between central and wide midfielders (mean difference = 0.62 m·min^{-1} [95%CI: -3.1, 4.3]). Wide midfielders presented faster peak running speeds than forwards (mean difference = 18 m·min^{-1} [95%CI:14.1, 22.1], P < 0.05), central defenders (mean difference = 25 m·min^{-1} [95%CI: 21.7, 29.8], P < 0.05) and wide defenders (mean difference = 12 m·min^{-1} [95%CI: 8.2, 16.5], P < 0.05). Interaction effects were found for division*position ($F_{4,328.3}$ = 2.57, P = 0.038) demonstrating greater running speeds in League One, except for central defenders. Wide midfielders presented greater peak 1-minute running speeds, whereas 5 and 10-minute peak running speeds were greatest in central midfielders. The sensitivity of peak running speeds to competition level and playing position have implications for training prescription, monitoring particularly when transitioning between competition levels, determining and monitoring positional training intensities, and objective targets for progressive overload during rehabilitation.

Keywords: professional football, peak running speeds, rolling average, training prescription, monitoring

INTRODUCTION

Time motion analysis, and more recently, global positioning systems (GPS) have become effective tools for quantifying movement demands during professional association football matches and monitoring physical training (8,13, 17,44). Activity profiles of out-field players have shown players to cover between 9-12 km during a competitive match (3, 38), representing speeds between 100-133 $m \cdot min^{-1}$ across a 90-minute match. Despite the physical demands of professional association football being well established, coaches and practitioners face the challenge of designing specific training programs that best replicate match-play. Traditionally absolute running demands from matches have been used to monitor training intensities (24, 15) but coaches and practitioners are advised to avoid a 'one-size-fits-all' approach in order to maximize training efficiency whilst targeting individual needs (21, 37).

One of the factors influencing running demands is playing standard (33, 38, 44, 27) and analyses of movement demands across different playing standards have made strong associations to the amount of high-intensity running distance and, by association, match intensity (27, 28, 33). Morgans et al. (35) reported greater total distance covered during an English Premier League season compared with the preceding season in the English Championship, but concluded that total distance provides relatively little practical value in relation to physical preparation and match recovery. English Championship and League One players have demonstrated greater total distances, and distance at higher velocities than Premier League players (12, 20), therefore suggesting that high intensity running might have more specific value in training prescription and injury risk. Another factor influencing running demands is playing position (3, 41) which has been observed to influence total (7, 9, 26) and high-speed distance covered (10, 26, 36). Such factors are important when considering the individualization of training prescription (21, 37).

The temporal pattern of high intensity running during match-play can be influenced by a number of factors including pacing (22), different match scenarios (9, 14), and fatigue (6). Early notational analyses highlighted reductions in high-intensity running in the second half of match-play (2, 33), but contemporary developments facilitate the investigation of within-match fluctuations using predefined time periods, often using 5-minute or 15-minute periods (4, 5, 9, 11, 34, 42, 44). However, the use of these pre-defined time periods may lack sensitivity to detect small fluctuations in running intensity as the most intense period of a match may not fall exactly into these pre-defined periods (20). The rolling average technique has been used to quantify peak running demands ranging from 1-minute to 10-minute periods (16, 17, 18, 23, 43, 44), with pre-defined time periods demonstrating a 20-25% underestimation of peak high velocity running distance compared to rolling averages (43). For the practitioner, the implications of such an underestimation in match-demands would have further implications for physical preparation and injury risk (25). The aim of this study was to investigate the sensitivity of competition level and playing position on the peak running speeds during professional association football, with implications for training prescription and monitoring. To acknowledge the confounding issues in playing position and standard, analysis was extended to compare data from both English Championship League and English League One seasons within the same club.

METHODS

EXPERIMENTAL APPROACH TO THE PROBLEM

Data were collected on all outfield players during 2017-18 English Championship (n= 33, 8 wins, 8 draws, 17 losses) and 2019-20 English League One seasons (n=27, 5 wins, 9 draws, 13 losses) using 10Hz GPS units (Catapult Sports^{TM}, OptimEye S5, Firmware 7.4, Leeds, United Kingdom). Only league matches were included in the study design in order to negate the perceived relative importance of knock-out competitions and to maintain the standard of the opposition. The team utilized a 4-2-3-1 formation aiming to play a medium block pressing style. Players were categorized into the following playing positions: central defender (C.Def, *n* = 9), wide defender (W.Def, *n* = 8), central midfielder (C.Mid, *n* = 18), wide midfielder (W.Mid, *n* = 7), or forwards (*n* =10), with technical formation consistent across both seasons.

SUBJECTS

Fifty-seven male outfield professional association football players (25.9 ± 5.2 years [range 18.2-37.7 years], 1.8 ± 0.0m, 79.4 ± 8.6kg) participated in the study. All subjects had been training in a soccer club environment for two years of more prior to the study. Between matches, outfield players completed a consistent training structure (3-4 football-based sessions and 2 gym-based sessions) unless a mid-week fixture was scheduled (2-3 football-based sessions and 1 gym-based sessions). Data were collected as part of routine monitoring and testing carried by the club's medical personnel with written permission provided by the club and players, outlined within their contractual agreements. Study approval was granted from the club and host university ethics committee for the use of anonymised retrospective data. All participants provided written and verbal informed consent in accordance with department and faculty research ethics committees at the host university, and in accordance with the 2013 Helsinki Declaration.

PROCEDURES

Data collection took place during the competitive seasons of 2017-18 and 2019-20. Prior to the competitive season, all subjects completed a pre-season training period consisting of technical football, aerobic conditioning and gym-based sessions in order to ensure an appropriate level of fitness. Prior to each match, all subjects underwent a consistent team based warm up including mobility, co-ordination, sprint, technical, possession and position-specific exercises. During each match, all subjects wore a GPS located between scapula in a custom-made vest underneath their playing shirt. Following each match, data was downloaded (Catapult Sports™, Openfield Software, version 2.3.3) and preliminary analyzed to delimit playing time for each player. Each data set was screened for satellite coverage and horizontal dilution of precision (HDOP) using an inclusion criterion of >6 satellites and ≤1.0 respectively, which are in accordance to previous guidelines for acceptable GPS coverage (32). Raw speed data files were exported and further analyzed using a customized software (R, v1.2.503) which removed data points with speed $\geq 10\ m \cdot s^{-1}$ and/or accelerations $\geq \pm\ 6\ m \cdot s^{-2}$. A total number of 2058 observations were recorded for analysis across both seasons (2017-18 season n = 1191, 2019-20 season n = 867; C.Def n = 396, W.Def n = 333, C.Mid n = 600, W.Mid n = 321, Forwards n = 408).

STATISTICAL ANALYSES

The dependent variable was defined as the peak average running speed, quantified as distance per minute sustained during match-play, calculated using the rolling average technique (17, 18) with durations of 1-minute, 5-minutes and 10-minutes, similar to those previously reported (16, 17, 43, 44), by playing position, and division. A Linear Mixed Model (LMM) was performed to test for the effects of competition level and playing position on average peak running speed, and interactions between competition level and position. Within the mixed-model framework both fixed-factors and random-factors can be modelled. While systematic variability between conditions for fixed factors is explicitly estimated, the variability of random factors is used to: (1) estimate the extent to which mean responses vary across units of the random factor; (2) allow inferences about whether fixed effects generalize beyond the units sampled in the random factor; and (3) remove variability in responses that are associated with the random factor rather than the conditions of experimental interest (i.e, reduce Type I error rate) (31). In the LMM peak running speed was entered as the dependent variable. The variables: duration (i.e. 1-minute, 5-minute, and 10-minute), competition level (i.e. League 1 and Championship) and playing position were entered in the model as fixed factors along with the interaction terms, division*position and duration*position. Participant was entered into the model as a random factor. Post-hoc pairwise comparisons were performed to test for differences in grouping conditions for duration, division and position. All statistical analyses were performed using a specialist software (IBM SPSS Statistics 20, Chicago, IL, USA). Data are presented as mean difference, 95% confidence intervals, and an alpha level of 0.05 was used to determine statistical significance.

RESULTS

Figures 1-3 summarizes the influence of rolling average duration on peak running speeds by playing position and competition level.

** Insert Figures 1-3 near here **

Results from the LMM showed a significant effect for competition level ($F_{1,324.5}$ = 5.439, P = 0.02) and playing position ($F_{4,328.3}$ = 89.897, P < 0.001). Pairwise comparisons revealed that matches in League One elicited a peak speed of 2.7 m·min^{-1} faster than those in the Championship (mean difference = 2.7 m·min^{-1}, 95%CI: 0.43, 5.02, P = 0.02).

Pairwise comparisons revealed significant differences between all positions ($P < 0.05$) except C.Mid and W.Mid where no significant difference was observed (mean difference = 0.6 m·min^{-} 95%CI: -3.09, 4.32). Central midfielders and W.Mid presented with the fastest peak running speeds, running faster than W.Def, C.Def and Forwards. Specifically, C.Mid ran faster than W.Def (mean difference = 13.0 m·min^{-1}, 95%CI: 9.82,16.27, $P < 0.001$), C.Def (mean difference = 26.4 m·min^{-1}, 95%CI: 23.25, 29.53, $P < 0.001$), and Forwards (mean difference = 18.6 m·min^{-1}, 95%CI: 15.67, 21.83, $P < 0.001$). Wide midfielders ran faster than W.Def (mean difference = 12.4 m·min^{-1}, 95%CI: 8.28, 16.57, $P < 0.001$), C.Def (mean difference = 25.8 m·min^{-1}, 95%CI: 21.7,29, $P < 0.001$), and Forwards (mean difference = 18.1 m·min^{-1}, 95%CI: 14.11,22.16, $P < 0.001$). Wide defenders ran faster than both C.Def (mean difference = 13 m·min^{-1}, 95%CI: 9.7,16.99, $P < 0.001$) and Forwards (mean difference = 5.7 m·min^{-1}, 95%CI: 2.12,9.3, P = 0.002), while Forwards ran faster than C.Def (mean difference = 7.6 m·min^{-1}, 95%CI: 4.12,11.15, $P < 0.001$).

The LMM also revealed significant results for the interaction term division*position ($F_{4,328.3}$ =2.573, P = 0.038). Matches in League One were faster than those in the Championship when playing as W.Def (142.0 vs. 138.4 m·min^{-1}), C.Mid (153.5 vs. 153.0 m·min^{-1}) and W.Mid (157.9 vs. 147.4 m·min^{-1}). Only a marginal difference was observed between League One and Championship for the Forwards position (135 vs. 134 m·min^{-1}), while matches in the Championship were faster than League One for C.Def (i.e. 127 vs. 126 m·min^{-1}).

DISCUSSION

The aim of the current study was to quantify peak running speeds during professional football association match-play whilst acknowledging the influence of competition level and playing position, with implications for the practitioner in exercise prescription and monitoring.

Our findings show that League One matches elicit greater peak running speeds Championship matches, with similar magnitudes to those reported between professional and semi-professional rugby league players (27). Peak running speeds were 2.7 $m \cdot min^{-1}$ higher in League One which is equivalent to 0.2 kilometres per hour. This may be of little practical significance, suggesting that no fundamental changes are required for a club or player transitioning between these divisions. The current study failed to determine the frequency to which players are exposed to these peak running speeds, which may be an important when comparing differences between competition levels. Bradley et al, (12) reported greater speeds in League One players compared to Championship and Premier League players. However, technical indicators were superior in higher competition standards. A recent study demonstrated greater peak running speeds during negative transitions in comparison to positive transitions, counter attacks and high pressing (9). This may explain the current findings, as potentially greater technical indicators may exist in the Championship, suggesting that players in competing in League One may require to physically exert themselves more as a consequence to turnovers in possession and end to end activity.

Despite trivial differences between competition levels, peak running speeds reported here were higher than average running demands (100-133 $m \cdot min^{-1}$) reported over 90-minutes across various domestic leagues (41). The context of these findings is important providing an appropriate guide for practitioners to prescribe and monitor football-specific drills, for example peak running speeds can be used to determine progressive intensities during possession drills and small sided games to physically prepare players for the level of competition, but are not advised as a guide for traditional conditioning. It should also be acknowledged that differences in running performance may be of little practical concern given the potential influence of technical and tactical factors on running performance (35). Future research may wish to consider the relationships between technical and tactical factors on peak running speeds at different competition levels.

Differences in peak running speeds showed the following descending order: central midfielders, wide midfielders, wide defenders, forwards, central defenders. In the current study, positional differences in peak running speeds were reported across all playing positions except between central and wide midfielders. Our findings are similar positional trends to Delaney et al, (18) with lower peak running speeds in central defenders compared to all other positions. Although peak 1-minute running speeds in the current study were lower than Delaney et al, (18), peak 5-minute running speeds were similar. However, these findings represent senior teams from different domestic leagues and competition levels and are likely to demonstrate different technical and tactical factors which appear to influence physical output during match-play (12). In the current study, peak 1-minute running speeds were greatest in wide midfielders, however central midfielders elicited greater peak running speeds for 5-minute and 10-minute rolling average durations. This may reflect the technical and tactical responsibilities of these positions as central midfielders tend to cover more total distance across 90-minutes, whereas wide players cover greater distances at higher speeds, working in shorter bouts (9, 10, 26, 36). The differences between playing positions have implications for training prescription and personalized monitoring and do not support the use of 'unit-specific' training classifying defenders, midfielders, forwards for example.

Significant interaction effects were found between competition level and playing position. League One matches elicited greater running speeds for wide defenders, central midfielders, wide midfielders and forwards compared to Championship matches, whereas Championship matches elicit greater running speeds for central defenders. These findings may be the result of superior technical factors at higher competition levels (12, 35); however, this was not established in the current study. Despite significant interactions being detected, differences in peak running speeds for central and wide midfielders across competition levels ranged from 1-10 $m \cdot min^{-1}$, which is of little practical significance. Future research and practitioners should consider the frequency of exposure to peak running speeds across different competition levels in order to prescribe the appropriate volumes of high-intensity training. No significant result was found between competition level and all rolling average durations, with matches in League One being faster than those in the Championship.

Whilst there are clear practical implications in terms of objective prescription and monitoring of position-specific training, caution should be taken when generalizing beyond the specific sample and performance metrics used in the current study. Results from the current study should be applied to football-specific tasks rather than traditional conditioning practices. Practitioners should also consider the influence of technical and tactical factors on peak running speeds during match-play. Similarly, the positional classification used in the current study reflects the technical formation used by the club across these two seasons. These two seasons reflect an opportunity to compare two (of four) divisions within the same domestic structure, but changes in playing and non-playing staff etc. must be acknowledged. The dependent variable in the current study was defined as peak speed, expressed as meters per minute, enabling standardization across competition level and playing position. But additional metrics warrant attention, including high-speed running, sprinting, acceleration and Playerload, in order to better evaluate peak demands and intermittent nature of match-play. Peak 1-minute running speeds in the current study represent a running speed of ~3.5 meters per second, well below the peak running speeds and maximal aerobic speeds observed in professional association football players (45). This reflects the intermittent nature of match-play where sprints are of relatively short distance and therefore duration, interspersed with active recovery and representing clusters of high intensity efforts. The detail of high intensity activities which comprise the peak demands per minute are worthy of attention, particularly given the association with injury mechanisms.

PRACTICAL APPLICATIONS

Peak running speeds appear to have little difference when comparing competition level, however positional differences are more apparent. Data from the current study supports the notion of position-specific prescription and monitoring of training based on peak running speeds during match-play, omitting a one-size fits all approach. As expected, peak running speeds decline within rolling average duration. Practitioners may therefore develop position-specific targets for football-specific training exercises to better prepare and monitor players for the more intense periods of match-play. This may also have implications for training design during end-stage rehabilitation and return to play.

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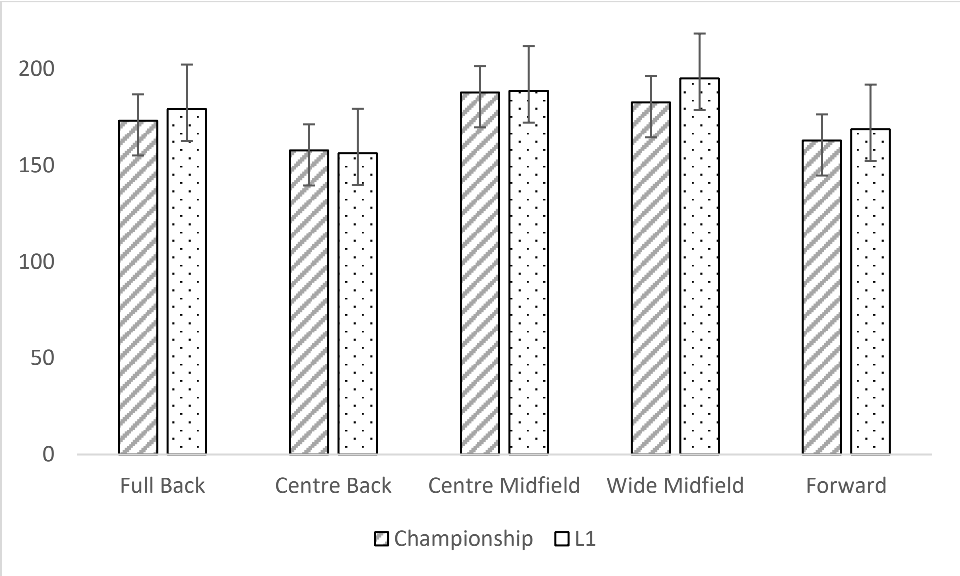

Figure 1: Average peak 1-minute running speeds by competition level and playing position

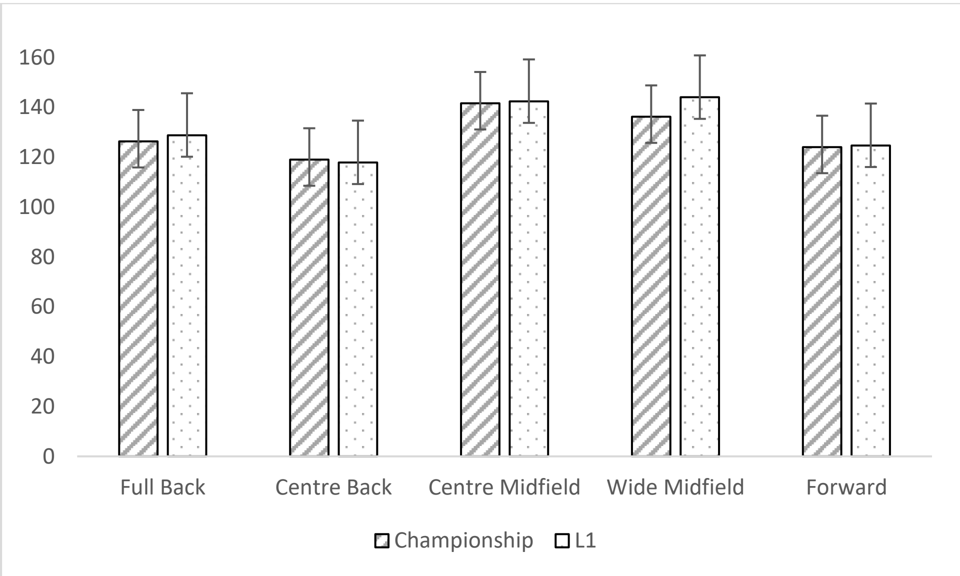

Figure 2: Average peak 5-minute running speeds by competition level and playing position

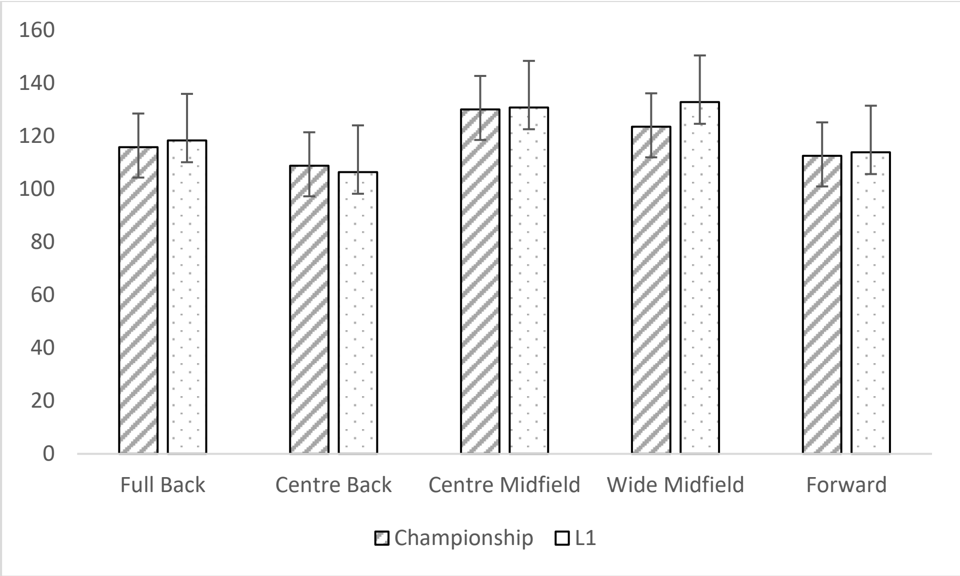

Figure 3: Average peak 10-minute running speeds by competition level and playing position