A comparison across playing position of generic and individualized speed thresholds within the most demanding phases of match-play in the English Premier League.

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ABSTRACT

Objectives: To compare across playing position, the distances covered above generic and individualized speed thresholds within the most demanding phases of match-play. **Methods**: Categorized by position, 17 English Premier League players match data were analyzed over two consecutive seasons (2019/20 and 2020/21). The most demanding phases of play were determined using a rolling average across four time periods of 1-, 3-, 5- and 10-minutes. Distance covered in the time above the standard speed of 5.5m/s was analyzed, with individualized metrics based on the Maximal Aerobic Speed (MAS) test data. **Results**: CD displayed lower values for high-intensity periods when compared to FB, M and WM for both generic and individualized metrics. MAS during 1-minute periods was significantly higher for F when compared to CD (82.9 ± 18.9 vs 67.5 ± 14.8 for maximum HSR and 96.0 ± 15.9 vs 75.7 ± 13.8 HSR for max MAS activity). The maximum ES difference between the CM, WM and FB positions for HSR and MAS measures under the maximum HSR criterion are 0.28 and 0.18 for the 1-minute period, 0.36 and 0.19 for the 3-minute period, 0.46 and 0.31 for the 5-minute period and 0.49 and 0.315 for the 10-minute period. **Conclusions**: Individualized speed metrics may provide a more precise and comparable measure than generic values. Data appear to be consistent across playing positions except for CD. This information may allow practitioners to directly compare individualized physical outputs of non-CD players during the most demanding phases of play regardless of the players positional group. This may provide

coaches with important information regarding session design, training load and fatigue monitoring.

Keywords: English Premier League, football, match performance, individualized, most demanding passages of play, maximal intensity periods, performance analysis, soccer.

INTRODUCTION

Quantification of intensity and volume of match-play running are essential to allow an appropriate prescription of training to optimally prepare players for the ever-evolving demands [1]. Historically, generic speed thresholds have been applied to all squad athletes to facilitate the comparison of physical performance between players within and across teams and leagues [2]. However, these thresholds do not account for individual physical differences and the relative exertion imposed on the player to attain generic speed thresholds. Additionally, information surrounding match pace and distances covered (e.g. running meters per minute) may be a more significant method of analyzing players that did not participate in the entire match [3]. Such information may allow a more precise prescription of the running based exercises required for each player [4]. Accordingly, it has been well established that the selection of running tasks based solely on average match demands can lead to athletes being under-prepared for subsequent match-play [5,6]. Therefore, it has been argued that the design of specific training activities should pay particular attention to the most demanding phases of match-play [5-7], also recently described as the 'worst-case scenarios' [1].

Numerous authors have attempted to address the worst-case scenario concept by employing various methodological approaches and measures to split the match into consecutive periods ranging from 5- to 15-minutes, with key metrics examined per minute during these time periods [5,8-10]. Recently a systematic review reported an inverse association between the duration of worst-case scenarios and running during competitive match-play [1]. Furthermore, a position dependency, especially when analyzing total distance running performance was observed [1]. The use of rolling time periods with a fixed time period, previously 1- and 5-minute periods, has been employed, where the 1-minute period has been found to be the most demanding period for a specific metric [7]. However, an alternative approach has examined the longest time period that a player exceeds a standardized threshold value [11] and in many systems this has been set at 5.5-m/s or 7-m/s to reflect the standard definitions of high-speed running (HSR) and sprint actions respectively [11].

A multitude of metrics have been previously employed to measure these most demanding phases of play [1,5,10]. The most widely used measures are distance-based metrics including HSR and sprint distances covered [7]. Furthermore, additional measures have recently been examined such as accelerations and decelerations and hybrid-type metrics such as high metabolic load distance (HMLD) that quantify energy expenditure through a combination of speed and acceleration/deceleration values [6,12]. While these standardized thresholds allow for the comparison of physical performance between players, positions and leagues, the relative intensity and exertion imposed on the individual player is not considered [13]. Previously it has been argued that an individualized approach to external load monitoring may also augment practitioner understanding of competition and positional demands [14]. Thus highlighting the importance of applying a measure that characterizes the functional limits of physical capacity for each individual player [14].

The analysis of distance covered above Maximal Aerobic Speed (MAS) and Maximal Sprint Speed (MSS) is regarded as a reliable method to provide appropriate contextual training prescription and allows the identification of an individual players' aerobic and anaerobic capacity [15]. Time spent above MAS has also been shown to correlate with improvements in aerobic fitness with a strong positive relationship ($r = 0.9$) between MAS and the velocity at which maximal oxygen uptake (vVO2max) occurs [16]. Furthermore, the importance of peak speed exposure has previously been outlined [17,18], while the number of exposures above 90% of an athletes' peak speed has been described as a "speed vaccine" [19]. Notably, the difference between MAS and MSS has been previously quantified as the Anaerobic Speed Reserve (ASR) [20] and has been used to provide a transition to sprinting [2,20].

Therefore, the aim of this study was to compare across playing positions, the distances covered above individualised and generic thresholds within the most demanding periods of match-play employing in male English Premier League (EPL) soccer players across two consecutive seasons. To the authors knowledge, this is the 1st study to examine distance covered above individualised speed thresholds within the most demanding phases of match-play. Our hypothesis was that playing position will influence the quantity of distance covered above generic and individualized speed thresholds. The authors also hypothesized that individual thresholds may allow for comparison of workload between positions.

METHODS

DESIGN

A retrospective study was conducted analyzing EPL match data from the 2019-20 and 2020-21 seasons for a cohort of 17 male professional soccer players. Data was collected via an Optical Tracking System from twenty EPL stadiums. The most demanding phases of match-play were categorized into a range of rolling time periods including 1-, 3-, 5- and 10-minutes, examining the maximal physical performance measures and continuous activity above specific speed thresholds. Individualized HSR thresholds were employed based on MAS test data and were derived from the 1200-m shuttle test [21]. Individualized MSS values were determined from Second Spectrum match data.

PARTICIPANTS

Seventeen male professional outfield soccer players (Mean ± *SD*, age at start of 2019-20 season 27.8 ± 3.5 years, height 183.7 ± 5.4 cm; weight 83.9 ± 7.1 kg) from an EPL team participated in the present study. The sample group consisted of outfield players classified into the following positions: fullbacks (FB, n = 4), central defenders (CD, n = 4), central midfielders (CM, n = 3), wide midfielders (WM, n = 3) and forwards (F, n = 3). Second Spectrum data were collated from 76 official league matches during the 2019-20 and 2020-21 EPL seasons. Only official league match data were collected for analysis, where 38 were gathered at the study team's home stadium, while the remaining matches were performed at other EPL stadiums. Data were analyzed for the full match duration including any stoppage time as determined by the official match referee. All data evolved as a result of employment where players were routinely monitored over the course of the competitive season. Nevertheless, the study was approved by the club [22] and ethics was granted by the committee of the host university (BAHSS 646 dated 17/04/2019). In addition, the study was conducted in accordance with the Helsinki Declaration. To ensure confidentiality, all data were anonymized prior to analysis.

PROCEDURE

League match data across the 2019-20 and 2020-21 seasons were recorded and analyzed via the Optical Tracking System (OTS) Second Spectrum (Second Spectrum®, Los Angeles, USA) to report physical performance data. Second Spectrum has been validated by the FIFA program to meet industry standards [23]. Data was collected via semi-automated HD cameras positioned around the stadium with a sampling frequency of 25-Hz. As previously reported, there is no scientific literature available reporting the reliability and validity of the Second Spectrum system, most likely due to the system being adopted by the EPL for the 2019-20 season [24].

A total of 814 individual match data points were examined with a median of 47 data points per player (range = 3 to 74). To ensure the most demanding phases of match-play were examined players were only considered for analysis when time spent on the field exceeded 75-minutes of the entire match [25]. This resulted in 633 full or nearly full match data points for all players with a median of 39 per player (range = 3 to 74). These criteria excluded only one player (CD) with the remaining 16 players having a median of 40.5 data points per player (range = 8 to 74).

Individualized thresholds employed to determine key metrics utilized both the player's MAS and MSS values. During the pre-season period MAS values were collected from the 1200-m maximum effort shuttle test. The 1200-m shuttle test has previously shown a strong correlation with other MAS tests [21,26]. Briefly, the test protocol started with poles set at the start point, 20-m, 40-m and 60-m. Players were instructed to run from the start point to the 20m pole and return to the start point, then to 40-m pole and returned to the start point before running to the 60-m pole and returning to the start point (see Figure 1 for test protocol). This sequence was repeated as quickly as possible five consecutive times until the distance of 1200-m had been completed [21]. Players were informed how much time was remaining at 1-minute intervals until test completion to ensure players were performing maximally [27]. This verbal encouragement has been shown to be a motivational requirement for laboratory assessments of time to exhaustion and central fatigue [28]. Due to the change of direction within the test, a corrective equation was used: 1200/(Time - 20.3-s (0.7-s for each turn) = MAS (m/s) [26]. The mean (± *SD*) MAS value was 4.65 ± 0.20-m/s. This MAS test was repeated in January. Maximum sprint speed values were extrapolated directly from Second Spectrum match data.

The ASR measure, employed a weighted MAS value and the MSS for each player using 70% and 30% respectively as previous reported [2,14]. The mean (± *SD*) MSS and related ASR values were 9.09 ± 0.31m/s and 5.98 ± 0.17m/s respectively. In this paper, we shall term this the ASR30 metric to reflect the weightings identified in the above-mentioned calculation.

The Second Spectrum match data was processed directly using the python programming language (Python 2.7) through the Spyder scientific development environment (https://www.spyder-ide.org/). Although, match data can be imported and filtered through several commercially available systems including Sonra (Statsports, Ireland) and OpenField (Catapult Innovations, Melbourne, Australia), processing the data directly via programmes such as Python 2.7 allows more detailed analysis of the most demanding phases. Publishing the exact algorithms used to determine the examined measures was not possible due to the technological commercial entities keen to protect their intellectual property rights. Thus, it is understandable that the full detail of the conversion and filtering algorithms utilized in these systems were not provided.

For all matches, data was analyzed for the full match duration including any stoppage time. Generic player locomotive variables analyzed included total distance, distance covered above 5.5-m/s (the HSR threshold) and the distance covered above 7-m/s (the sprint threshold). Two individualized measures that included distance covered above MAS and ASR30 were also employed. The most demanding phases (or maximal intensity periods) were first computed by applying a moving average approach across each match for every player using four different time durations of 1-, 3-, 5- and 10-minutes. The maximum value for each time period was recorded. Therefore, for each match, maximum values using five variables were calculated for each of the four time periods. The timing of these maximal periods was also recorded. Previously, it has been argued that these time periods correspond to normal training duration and have been previously applied by other researchers [7,29]. The most demanding phases of match-play or maximal intensity periods were also examined based on the maximum duration that a player was continually above a specific speed threshold. In this case, two threshold values were selected, a generic value of 5.5-m/s and an individualized MAS value.

Statistical Analyses

The analyzes were conducted with the software R version 4.2.0 (R Foundation for Statistical Computing, Vienna, Austria), with the lme4 package. All variables are shown as mean ± *SD*. A linear mixed model with random intercept for individual players was developed for each measure under each of the criteria and time periods. This was used to compare the examined physical performance variables across playing positions; (CD), (FB), (CM), (WM) and (F). When there was a significant ($p<0.05$) effect for playing position, Tukey's tests were used to examine which positions differed. The estimated differences were standardized by the estimated between-subject *SD* to determine the effect size (ES), and were interpreted as <0.2, trivial; 0.2-0.5, small; 0.5-0.8, moderate; >0.8, large [30].

RESULTS

Table 1 shows the mean ± *SD* values for the different measures for each position where the most demanding phases of play have been identified based on the total distance covered in the specified time periods of 1-, 3-, 5- and 10-minutes. Table 1 also shows the fixed effect estimates for the models (with CD as a default position) and the associated significance levels for each fixed effect estimate with the intercept values. The interclass correlation coefficients for each model (ICC) and the p-value for the fixed effects (position) and random effects (player) are presented.

In Table 1 CM and WM consistently covered the greatest distance, followed by FB and F, with all positions significantly higher than CD (ES = 0.6-2.2). Although, FB consistently produced the highest MAS and HSR distances covered during the 1- and 3-minute periods with WM and F reporting the highest during the 5- and 10-minute periods. The significant differences identified across varying time periods showed that CD covered lower HSR (ES = 0.5-1.6) and had lower MAS values (ES = 0.8-1.7) when compared with all other positions. While FB reported higher sprint distances (ES = 0.6-0.8) than CD and CM.

****insert table 1 here****

[a] denotes a significant difference higher than the CD value; [b] denotes higher than the FB value; [c] denotes higher than the M value; [d] denotes higher than the WM value; [e] denotes the value is significantly higher than the F value.

Table 2 presents the most demanding phases of play for HSR distance. High-speed running distance was consistently highest for WM, followed by FB, CM and F positions, while CD were consistently and significantly lower for all time periods (ES = 0.5-1.8). Maximal Aerobic Speed distances showed similar values for FB, CM, WM and F although all were significantly higher than CD (ES = 0.7-1.8).

****insert table 2 here****

[a] denotes a significant difference higher than the CD value; [b] denotes higher than the FB value; [c] denotes higher than the M value; [d] denotes higher than the WM value; [e] denotes the value is significantly higher than the F value.

Table 3 presents the most demanding phases of play for MAS distance. MAS distance was significantly lower for CD than all other positions (ES = 1.0-1.9) with very similar values for FB, CM, WM and F positions. While HSR for CD were significantly lower than all other positions (ES = 0.9-1.7) during 5- and 10-minute periods, F values did not significantly differ compared with CD during 1- and 3- minute periods (ES = 0.3-0.6). Furthermore, there was no significant difference in sprint distance with only significant differences observed in ASR30 distance during 5- and 10-minute periods.

****insert table 3 here****

[a] denotes a significant difference higher than the CD value; [b] denotes higher than the FB value; [c] denotes higher than the M value; [d] denotes higher than the WM value; [e] denotes the value is significantly higher than the F value.

Table 4 presents the most demanding phases of play for sprint distance. Sprint distance was significantly lower during all examined time periods for CD when compared with FB (ES = 0.7-1.0). Furthermore, during the 5- and 10-minute periods, F (ES = 0.8-0.9) and WM (ES = 1.0-1.1) were significantly higher than CD. CM and WM were also consistently higher than CD for sprint distance.

****insert table 4 here****

[a] denotes a significant difference higher than the CD value; [b] denotes higher than the FB value; [c] denotes higher than the M value; [d] denotes higher than the WM value; [e] denotes the value is significantly higher than the F value.

Table 5 presents the most demanding phases of play for ASR30 distance. Anaerobic Speed Reserve30 distance was higher for FB and WM followed by CM and F with the lowest values reported for CD. Maximal Aerobic Speed distance was highest for WM and CM and lowest for CD.

****insert table 5 here****

[a] denotes a significant difference higher than the CD value; [b] denotes higher than the FB value; [c] denotes higher than the M value; [d] denotes higher than the WM value; [e] denotes the value is significantly higher than the F value.

Table 6 shows the number of values in the data set by player and position for distance over a 1-minute period. The table also shows the random effect values for the best fitting model.

****insert table 6 here****

DISCUSSION

The aim of this paper was to compare across playing positions, the distances covered above generic and individualized speed thresholds within the most demanding phases of match-play. Similar methodological approaches have previously been employed to determine specific player position data relating to total distance, HSR and sprint distance [5-7]. To the authors' knowledge this is the first study to examine the most demanding periods utilizing individualized metrics. The results of this study provide the first indication that individualized thresholds for external workload during the most demanding phases in match-play may provide a more robust and comparable measure. The current study findings appear to be consistent across playing positions except CD. This may allow practitioners to employ MAS and/or ASR30 to directly compare the intensity of activity during short periods in training and match-play across different playing positions.

Our main findings reported that positional differences in the key absolute metrics of total distance, HSR and sprint distance are in support of existing literature [31,32] . Specifically, similar to Oliva-Lozano, Fortes and Muyor [6], CD produced the lowest physical output for all examined variables across the most demanding phases of match-play . However, although Martín-García, Casamichana, Díaz, Cos and Gabbett [5] reported higher values for FB, CM and WM, values for F and CD were similar to our findings. This may possibly be related to differences between the physical profile of the two teams under investigation and in any tactical variations identified between the two playing systems/styles examined in this paper and in the work by Martín-García, Casamichana, Díaz, Cos and Gabbett [5]. The tactical roles and style of play of each position and player may also have an impact on these values [33].Furthermore, in support of previous research, the drop-off in metres per minute across various time periods is consistent with a negative power curve [31]. Overall, the values for the absolute metrics of total distance, HSR and sprint distance are consistent with the findings of a previous systematic review [1].

MAS and HSR distances for F were found to be lower than CM, WM and FB for the 1-minute periods but evidently there is a trend towards other positions over different time periods suggesting that MAS for F during 10-minute periods may exceed the average for CM, WM and FB positions (see Table 3). This highlights that positional differences are influenced by metrics and by the time period. It is important to note, that when HSR is used to quantify the most demanding phases (see Table 2), F produce consistently lower HSR than all other non-CD positions. This may be due to FB and WM having more opportunities to perform HSR during games due to the positional demands [34]. The maximum ES difference between the CM, WM and FB positions for the HSR and MAS measures are 0.28 and 0.18 for the 1-minute period, 0.36 and 0.19 for the 3-minute period, 0.46 and 0.31 for the 5-minute period and 0.49 and 0.315 for the 10-minute period. This indicates that, in using the MAS measure, there may be less difference between the CM, WM and FB positions as compared with the HSR measure. This may allow practitioners to compare physical outputs of players during the most demanding phases of play regardless of the players positional group. Indeed, practitioners may need to manipulate and periodize drill duration based on player position to ensure each positional group is prepared for the most demanding phases of play. This process may be facilitated by using the MAS measure as opposed to the absolute threshold of HSR.

Despite the previous strengths of this study, there some limitations to list: a) the study was conducted using only one team and thus a limited sample of players were examined, which consequently may restrict a generalization of the results; b) the metrics chosen for this study did not account for the transition between the different speed and intensity zones, usually expressed by accelerometry based variables. The addition of acceleration and metabolic measures may provide practitioners with additional loading information, not provided by high intensity distance metrics. c) contextual factors such match location, score status, and team formation were not considered in this study , this would potentially influence positional demands over the course of the game [1]. Future research should also examine the most demanding phases within training and additional leagues to ensure players are prepared for the most intensity periods of the game.

PRACTICAL APPLICATIONS

Practitioners may look to develop and monitor short-duration high-intensity match-based training activities using targets for non-CD groups based on distances covered above MAS and ASR30. Similar to Martín-García, Casamichana, Díaz, Cos and Gabbett [5] a key finding of this research was that while high-intensity periods are quantified using a single variable, significant differences still exist between positions for other variables. This is important information for practitioners to understand that high-intensity periods differ hugely based on the metric examined, duration and playing position. As a result, isolated conditioning may not be the optimal modality for preparing players for those high-intensity periods. The results of this research may also allow for the comparison of workload between positions which could influence recovery modalities and training prescription.

CONCLUSION

When analysing the most demanding phases using total distance, HSR, sprint distance and ASR30, there were significant differences between positions for other variables where it was found that CD covered the lowest and WM the highest distances regardless of the time-periods. However, when analysing distance covered above MAS the same pattern is not always evident. Failure to monitor the relative intensity placed on the individual athlete may result in the intensity of the most demanding phases being substantially underestimated. This research provides practitioners with individualized positional demands for the most demanding phases of play, with distance above MAS indicating a greater similarity between non-CD positions than the generic HSR measure. Future research should examine high-intensity periods within training to ensure players are prepared for the demands of the game in their respective leagues.

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