Activity Profiles by Position in Youth Elite Soccer Players in Official Matches

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ABSTRACT

In order to investigate activity profiles and external load patterns in elite youth soccer players, we studied high-intensity activity patterns, maximum running speed, and temporary and end-of-match decline in external load in 54 U17 players (96 match observations) over a full season of official match play. Wide midfielders covered most high-intensity running (HIR) distance (1044.2 m), most sprinting distance (224.4 m), and the highest number of accelerations (185.2); center defenders had the lowest values for these activities (508.3 m, 85.1 m, and 119.0), respectively. Wide midfielders had the highest and center defenders had the lowest maximum speed ($30.3\,km\cdot h^{-1}$ and $28.6\,km\cdot h^{-1}$), respectively. During the matches, players in all playing positions displayed a significant drop in HIR distance, sprinting distance, and number of accelerations. This was especially pronounced in the 5 min following the 5-min peak period and in the last 5-min period for sprinting distance.
There are substantial differences in activity profiles by positions, but all players show temporary and end-of-match drop in external load. The variation in activity profiles by playing position in this study may aid in the design of training programs. The considerable end-of-match drop in external load observed raises the question of the favorability of 90 min match times for U17 players.

Introduction

Results from time-motion studies are useful for assessing the physiological demands of training and match play in soccer. They allow quantification of player running activities and indirect verification of the energetics of match play [10]. Despite the use of various tracking systems, there is a general consensus that adult players cover a distance of 10–12 km per match [28]. A study of English Premier League players showed that the mean distance covered during a 90-min match was 10 714 m, of which 936 m were high-intensity running (HIR) (19.8–$25.1\,km\cdot h^{-1}$) and 251 m were sprinting ($>25.1\,km\cdot h^{-1}$) [7]. HIR and sprint-type activities are consid-

ered to be crucial determinants for successful performance and discriminate high- and low-level adult players [21]. Recently, HIR (19.8–$25.2\,km\cdot h^{-1}$) distance and sprinting ($>25.2\,km\cdot h^{-1}$) distance were measured at 668 m and 143 m, respectively, in a Danish Superliga club, with no significant differences between U17 and adult players [31].

Although there are limited data on match play in youth elite players, the data that do exist show that the total distance covered during match play increases with age to approximately 10 km in 18-year-old players [8, 16, 20, 25, 27]. When adjusted for match time, differences still exist but are less apparent, especially at older

ages [8]. On the other hand, total distance is only slightly greater in top-class players compared to moderate-class players, indicating that total distance does not distinguish between players at various levels [21]. Less is known about distance covered at various speeds by youth elite soccer players during match play. One report showed that U16 players covered more distance at all speeds than U12–U15 players [16], and when adjusted for match time, U18 players covered more sprinting (>19.1 km·h^{-1}) distance than U13–U17 players [9].

In accordance with adult elite soccer players [5, 6, 13] running performance is influenced by playing position in elite youth players. In 263 male elite soccer players aged 8–18 years from three professional academies, center backs covered the shortest and wide midfielders the longest HIR and sprinting distances [27]. In 52 international cup matches (380 players, mean age 16.0 years), center defenders covered the shortest very high-speed (≥19.8 km·h^{-1}) and sprint (≥25.2 km·h^{-1}) distances, whereas wide players and center forwards covered the longest distances in these speed zones [30], which is in line with other studies [9, 20].

In adult elite soccer players, acceleration profiles differ by playing position, but we found no studies on the U17 population. Running and acceleration profiles could be important to successfully tailor position-specific physical training programs that mimic and surpass the physiological demands of a match, and they may also play a role in the development of relevant physiological tests [11].

Few studies have addressed temporary and end-of-match drop in external load in youth elite players. In two friendly games with players aged 17.6 years on average, significantly lower activity was found for HIR (≥19.8 km·h^{-1}), sprinting (≥25.2 km·h^{-1}), and acceleration (2 m·s^{-2}) after the 5-min peak period. However, only acceleration was significantly lower in the last 5 min of the match [25]. Understanding the peaks and drops in external load could help coaches in prescribing position-specific training load.

There are scarce data examining the peak running speed in elite youth soccer players despite the substantial practical applications such data may have on training prescription. In English Premier League academy players with a mean age of 19.9 years, the highest mean maximum speed was 31.0 km·h^{-1}, which was observed among wide attackers [1]. Al Haddad, Simpson, Buchheit, et al. [3] observed a peak match speed of 26.8 km·h^{-1} in 60 elite U17 players, and when merging U13–U17 players in one pool, center forwards (n=52) were the fastest position at 27.0 km·h^{-1}. During the last several decades, soccer players have become faster, and youth soccer players with high maximum speed may be identified as potential professional players [18, 22]. Thus there is a need for results on the maximum speed required in different positions in elite youth players.

To our knowledge, there is no study reporting activity profiles and external load patterns by playing position and match time period in youth elite soccer players on both home and away teams. In order to investigate these aspects, we studied high-intensity activity patterns, maximum running speed, and temporary and end-of-match external load in U17 players over a full season of official match play.

Materials and Methods

The study comprised data from 54 players collected during eight matches played on a single playing field (110 × 68 m outdoor arti-

ficial grass field) during the full 2016 season (6 months) of official match play. Included players came from six teams: five of the highest-ranked U17 teams in the Norwegian National League (1 home and 4 away teams) and one of the cup finalist clubs (U17 National Cup, away team). Players were categorized into the following playing positions: center defenders, wide defenders, center midfielders, wide midfielders, or center forwards. Only players who completed a full match (90 min) in the same playing position were included in the analysis. Some players in the sample were used in different playing positions across matches. Altogether, 14 players from the home team played between one and eight matches, generating 58 match observations. 38 players from the five away teams were also tracked during these same matches, generating 38 match observations. Thus the total number of match observations was 96. This study conformed to the IJSM`s ethical standards document [17], was approved by the Norwegian Data Inspectorate, and received institutional approval from UiT The Arctic University of Norway Institutional Review Board.

Data collection

A stationary radio-based tracking system (ZXY Sport Tracking System, ZXY Sport Tracking AS, Trondheim, Norway, http://chyronhego.com/sports-data/zxy) (Bendiksen et al., 2013) was used to monitor players' activity. Each player wore a specially designed belt wrapped tightly around the waist with a small sensor located at the lumbar spine, and data were transferred by microwave radio channel to 6 RadioEye™ sensors (ZXY Sport Tracking AS). The ZXY Sport Tracking System provides information regarding distance traveled in different speed zones and the number of accelerations, both positive and negative.

Distance covered was measured as HIR for speeds between 19.8 and 25.2 km·h^{-1}, and as sprinting for speeds of 25.2 km·h^{-1} or more. Accelerations were defined by 4 event markers: 1) the player reached a minimum of (1 m·s^{-2}) to mark the start of the acceleration, 2) the player reached and exceeded the acceleration limit (2 m·s^{-2}), 3) the player remained above this limit for at least half a second, and 4) the acceleration event ended when the player fell below the minimum acceleration speed. Maximum speed was measured as the highest speed, offensive or defensive, reached during the match. The accuracy and reliability of the ZXY Sport Tracking System in measuring player movements in match-play have been described in previous studies [19, 24]).

To assess temporary and end-of-match external load, activity profiles were generated by match period for each playing position, separating matches into six 15-min periods and into 18 non-overlapping 5-min periods. Within the 5-min periods, we identified the most intense (peak) 5-min period, the 5 min following the peak 5-min period, the average of all 5-min periods, and the last 5-min period.

Statistical analysis

Data were analyzed as total match activity profiles in order to describe playing position-specific game demands by using a one-way ANOVA with Bonferroni as the multiple comparison procedure. When testing each player's change in performance over time, a repeated-measures ANOVA with possible adjustments according to Mauchly's test of sphericity was used. Thereby each playing position and time effects, including their interactions, were assessed." Contrasts were

used to test the last 15-min period versus the mean of the other five 15-min periods, and to test the peak 5-min period versus the 5 min following the peak 5-min period, the 5 min following the peak 5-min period versus the average of all 5-min periods, and the average of all 5-min periods versus the last 5-min period. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA).

Results

There were significant differences between playing positions for total running distance, HIR distance, and sprinting distance. The main pattern was that center defenders were less active than players at other playing positions. This was especially pronounced for HIR distance (508.3 m for center defenders versus 748.8 m for wide defenders, who were the second least active) and sprinting distance (85.1 m for center defenders, versus 105.4 m for center midfielders, who were second least active). Wide midfielders had the longest HIR distance (1044.2 m), followed by center forwards (854.8 m); and wide midfielders also had the longest sprinting distance (224.4 m), again followed by center forwards (143.3 m). The standard deviation within each playing position was considerable, illustrating a large difference in activity among players in the same playing position (▶ **Table 1**).

With respect to external load, dividing the 90-min matches into 15-min periods showed a time effect with significantly less activity observed during the last 15 min in all playing positions. This trend was most pronounced for wide midfielders, who were the most active players (▶ **Fig. 1**). A large difference in activity was also displayed when 5-min periods were investigated, with the peak 5-min period having much higher values than all other 5-min periods. The 5 min following the peak 5-min period were somewhat less active than the average of all 5-min periods. Finally, the last 5-min period was less active than the average of all 5-min periods. In terms of percentages, reductions in the last 5-min period relative to the average value of the rest of the 5-min periods were 7.8, 18.0, 48.0, and 22.0 for total distance, HIR distance, sprinting distance, and number of accelerations, respectively. This pattern was fairly similar across all playing positions (▶ **Fig. 2**).

Wide midfielders had the highest maximum speed (mean maximum speed 30.3 km·h^{-1}). The player with the highest maximum speed was also a wide midfielder, who reached a maximum speed of 32.8 km·h^{-1}. The player with the lowest maximum speed was a center defender (24.8 km·h^{-1}) (▶ **Table 2**).
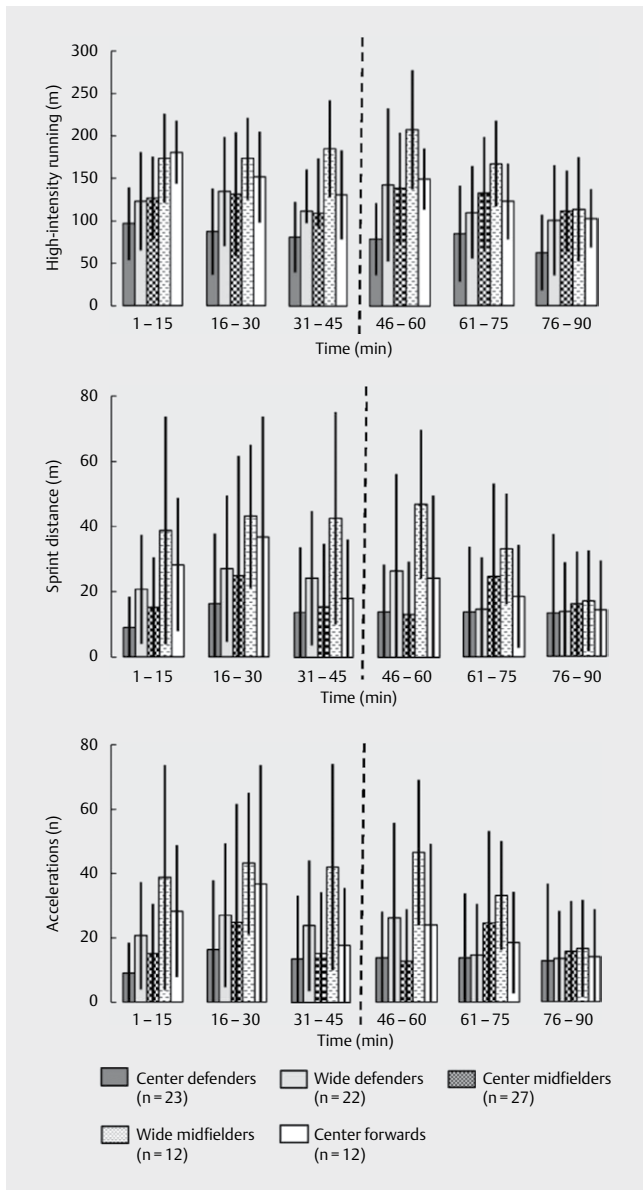
Discussion

This study shows that U17 players have difficulty maintaining the same standard of running and acceleration performance throughout the course of a match. This trend was especially pronounced for sprinting distance. A temporary drop in external load was also demonstrated after the peak 5-min period. Indeed, in the 5 min following the peak 5-min period, players at all playing positions showed a significant drop in all high-intensity activities. Another study found a similar temporary drop in U19 players, but showed that only accelerations dropped the last 5-min period [25]. A more mature pacing strategy and/or superior training status may explain this difference, because the contextual situation with no team controlling the latter stages of the matches was equal. Similarly, tracking 380 U17 players in an international tournament revealed that running performance was reduced in the second half of the match compared with the first half [30].

The distinct activity profiles we observed by playing position are similar to those seen in other studies of youth elite soccer players [1, 8, 31] and adult professional soccer players [7]. This also applies to wide midfielders and center forwards covering the most distance at high speeds [4, 8, 20]. On the other hand, one study including elite youth soccer players found a somewhat different pattern, with center defenders covering the least HIR and sprinting distances, and wide defenders covering more sprinting distance than wide midfielders [30]. The rather low HIR and sprinting distances observed among wide defenders in the present study may be affected by the wide midfielders being very active and forcing the wide defenders not to leave too much space available while attacking.

Center midfielders cover the most total distance, because this playing position links offence and defense and thus requires continuous movement [20, 30, 31]. Our wide midfielders covered by far the longest HIR and sprinting distances, which may be related to the task these players have to penetrate the opposition's defense. Center forwards covered the second most HIR and sprinting distances, indicating that this ability is important to create scoring opportunities [14].
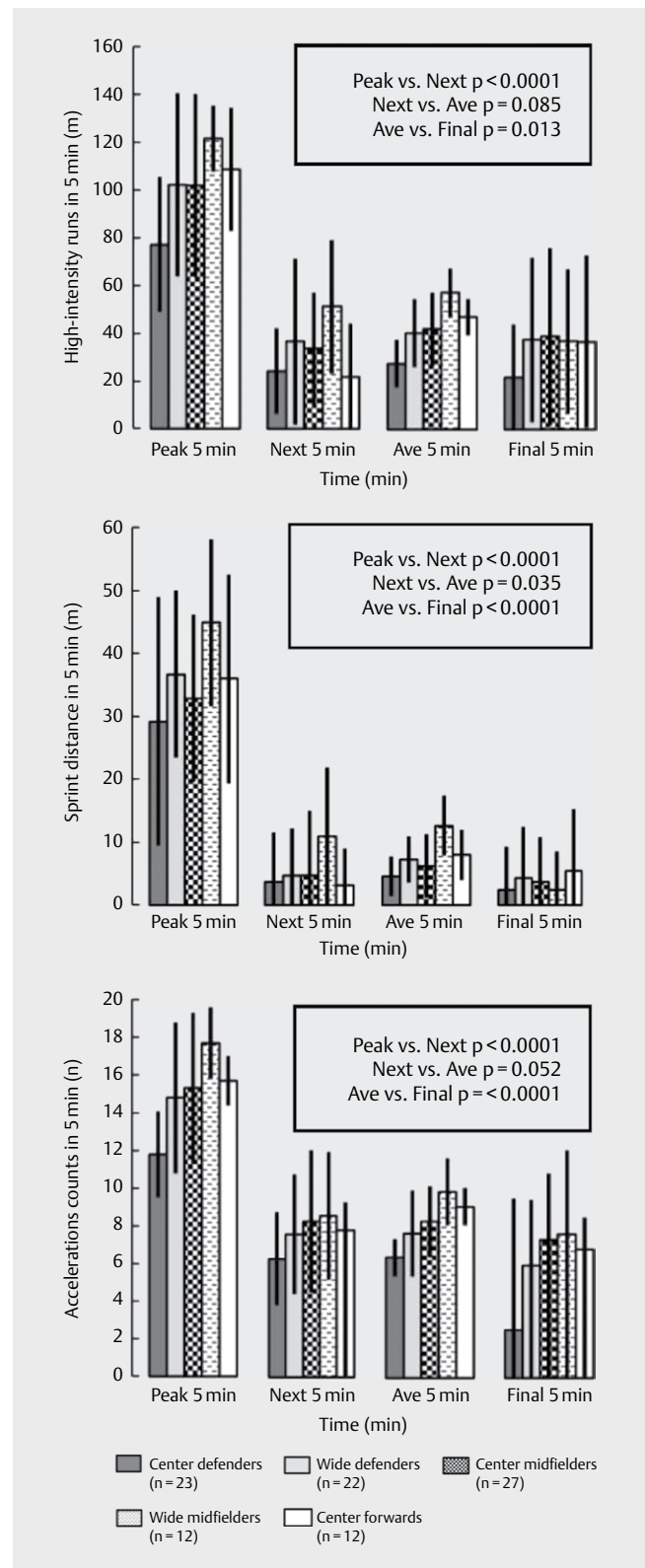
Pacing strategy and/or tactical considerations may have also partly affected the results. In addition, we must be careful when making direct comparisons of absolute values, even if the exact same cut-offs are used, owing to the substantial differences between tracking systems [26].

▶ **Figs. 1** and ▶ **2** show a high-intensity activity profile, in which wide midfielders had superior performance compared to other

▶ **Table 1** Overall activity profiles by playing position as mean values ± s for U17 elite soccer players.

Playing position	Number of player-match observations	Total distance (m)	High-intensity running distance (m)	Sprinting distance (m)	Number of accelerations (n)
Center defenders	23	10396.8 ± 534.4[b]	508.3 ± 182.0[c]	85.1 ± 61.4	119.0 ± 17.8[f]
Wide defenders	22	11366.9 ± 679.1	748.8 ± 269.1	116.5 ± 78.0	143.1 ± 42.0[g]
Center midfielders	27	11989.4 ± 939.4	782.9 ± 297.0	105.4 ± 101.2	155.6 ± 36.1
Wide midfielders	12	11546.3 ± 838.5	1044.2 ± 168.2[d]	224.4 ± 82.4[e]	185.2 ± 30.1
Center forwards	12	11508.5 ± 831.4	854.8 ± 146.0	143.3 ± 71.9	167.9 ± 16.5
p-value[a]	-	<0.0001	<0.0001	<0.0001	<0.0001

[a] p-value for test of equal means; [b] p<0.05 vs. each of the other four positions; [c] p<0.05 vs. each of the other four positions; [d] p<0.05 vs. wide defenders and center midfielders; [e] p<0.05 vs. center defenders, wide defenders and center midfielders; [f] p<0.05 vs. center midfielders, wide midfielders and center forwards; [g] p<0.05 vs. wide midfielders.

▶ **Fig. 1** Performance data in 15-min intervals by playing position. Data are presented as means with standard deviations as error bars. For position: $p < 0.0001$ for all three performances. For time: $p < 0.0001$ for high-intensity running and acceleration and $p = 0.0002$ for sprint. For position time interaction: $p > 0.05$ for all performances. For period 76–90 min: $p < 0.0001$ vs. the mean of the 5 other time periods.

▶ **Fig. 2** Performance data in the peak 5-min period during the game, the 5 min following the peak, the average 5 min and the final 5 min of the game. Data are presented as means with standard deviations as error bars. For positions: $p = 0.0007$ for high-intensity runs, $p = 0.053$ for sprint and $p < 0.0001$ for acceleration. For position time interaction: $p > 0.05$ for all performances. For Peak vs. Next, Next vs. Ave and Ave vs. Final, see figure.

playing positions but also the most pronounced drop in external load in the last 5-min period. In addition to covering the longest HIR and sprinting distances and having the largest number of accelerations, wide midfielders also displayed the highest maximum speed of $30.3 \, km \cdot h^{-1}$. In sum, the physical load on these players seems to be greater than that of other playing positions, and this may explain the larger drop in performance the last 5-min period. It has been argued that center midfielders have less space to perform high-speed actions but perform more accelerations than other playing positions [29]. This is not supported by our study, in which both wide midfielders and center forwards had more accel-

▶ Table 2 Maximum speed by playing position for U17 elite soccer players.

Player position	Number of player-match observations	Maximum speed, km·h^{-1} [a,b]	Lowest maximum speed, km·h^{-1}	Highest maximum speed, km·h^{-1}
Center defenders	23	29.0 ± 1.9	24.8	31.7
Wide defenders	22	29.6 ± 1.0	27.9	31.1
Center midfielders	27	28.6 ± 1.5	25.2	31.8
Wide midfielders	12	30.3 ± 1.5	27.0	32.8
Center forwards	12	29.2 ± 1.9	25.5	31.9
[a] values are means ± s; [b] p-value for test of equal means 0.0241; p < 0.05 for center midfielders vs. wide midfielders.				

erations than center midfielders. Wide midfielders were also the player position most often substituted, perhaps because of the drop in end-of-match external load; thus we had only 12 match observations for this group.

Our study confirmed that coaches tend to prefer fast players as wide midfielders in Norwegian youth elite soccer, because wide midfielders had the fastest maximum speed (▶ Table 2). Wide center forwards had the fastest mean maximum speed among English Premier League academy players (mean age 19.9 years) and only this position had a greater maximum speed than the U17 players in the present study [1]. In contrast, center forwards (n = 52) had the highest maximum speed (27.0 km·h^{-1}) in a study of elite U13–U17 players [3], but we must take into consideration the use of different tracking methodologies.

Recent studies have shown that acceleration, both positive and negative, can require high effort without any high-speed actions [15, 23, 31]. During a match, elite adult and youth players showed a more pronounced decline in accelerations than in HIR and sprinting distances, indicating that accelerations may be a more sensitive measure of drop in external load [2, 25]. The present study showed a significant decline not only in accelerations but also in HIR and sprinting distances the last 5 min of the matches.

As a drop in external load is clearly demonstrated toward the end of matches, one may consider a redisposition of center defenders. Indeed, they move less than other players during the match and thereby could have some extra energy and produce more attacking power. Non-fatigued center defenders could be sent to forward attacking positions, while using other fatigued players as cover. However, our data indicate that center defenders had a drop in external load similar to other players during the last 5 min of matches. This is supported by significantly fewer accelerations in center defenders compared to wide midfielders, center midfielders, and center forwards. In contrast, player load (effort) per m has been found to be significantly higher in center defenders than in other playing positions, as measured by ZXY-Sport Tracking [12]. The algorithm calculating player load has not been validated and may overestimate the effort required for jumping, sliding, and backward running, because goalkeepers using ZXY Sport Tracking accumulate a very high player load per m traveled. This may be due to shaking of the transponder during jumps and dives, aggregating a high player load (personal observations).

Limitations

There are several limitations to this study. ZXY Sport Tracking uses uniform speed thresholds that cannot be individualized depending on the varying maximum speed of different players. On the other hand, using thresholds identical to other studies of both youth and adult elite soccer players allows for the comparison of results [30, 31]. The metabolic cost of accelerations varies, because creating an acceleration when traveling at 18 km·h^{-1} is much more demanding than creating one when traveling at 4 km·h^{-1}. Because most observations in the present study are from home-team players, contextual skewness of the results may have appeared [29]. All matches were either tied, or one team led by one goal up until the final minutes, indicating that any effect of controlling the match at the latter stage should be minor. But interpreting the drop in external load at the end of the game or temporarily after the most intense period is highly complex, because it could be attributed to physical or mental fatigue, pacing strategies, contextual factors, or a combination of these factors.

Practical considerations

Match length for U17 players in Norway is set at the same time as for adult players, i. e., two 45-min periods. The degree of drop in external load demonstrated in this study raises the question whether such young players are able to cope with matches of such long duration. Considering the physical demands required for different playing positions during match play, training emphases should differ. To overload players during training, it might be better to focus on peak playing position intensities rather than mean values, so that players are prepared for the most demanding periods of matches.

Conflict of Interest

Authors declare that they have no conflict of interest.

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