The Match Heart-Rate and Running Profile of Elite Under 21 Hurlers During Competitive Match-Play

Running Head: The Work-Rate of Elite Under 21 Hurling Match-Play

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Abstract

The aims of the current study were to examine the physical and physiological demands of elite under-21 male hurling match-play across halves of play and between positions. Global positioning systems (10-Hz) and heart rate (HR) monitors were used to collect data from 95 players during 10 games. Total distance (TD), **relative speed**, high-speed running (HSR), sprint distance, **total sprints** and **mean length of sprint** was 6688 ± 942 m, 112 ± 16 m·min^{-1}, 661 ± 203 m, 274 ± 111 m, **18 ± 8** and 16 ± 5 m respectively. **Players' mean HR (HR_{mean}) and peak HR (HR_{peak}) was 165 ± 9 b·min^{-1} and 190 ± 7 b·min^{-1} respectively.** Decrements in TD ($p < 0.05$, ES = 0.81), HSR ($p < 0.05$, ES = 0.69), and HR_{mean} ($p < 0.05$, ES = 0.80) were found between halves. Full-backs covered significantly less TD than half-backs ($p < 0.05$, ES = -1.24), midfielders ($p < 0.05$, ES = -1.39), and half-forwards ($p < 0.05$, ES = -1.85). Half-forwards covered a greater TD than full-forwards ($p < 0.05$, ES = 0.94), greater HSR than full-backs ($p < 0.05$, ES = 1.13), and sprint distance than half-backs ($p < 0.05$, ES = 1.41). Between-half decreases were evident in TD, HSR and HR_{mean} with no significant positional differences observed in TD, HSR, number of sprints, length of sprint, HR_{peak} and HR_{mean} between half-backs, midfielders and half-forwards. The current findings provide data that coaches should consider to customize training program design for under-21 hurlers.

Keywords: Team Sport; Match Analysis; Performance; **Match-Play Demands**; High-Speed Running; Sprint Distance

INTRODUCTION

Hurling is an Irish stick and ball invasion game. It is a physically demanding dynamic game with periods of high-intensity efforts similar to other team sports (6). The game is 60 minutes (30 minutes per half) in duration and is played on a pitch (140 m x 90 m) which is 40% larger compared to a soccer pitch (110 m x 70 m) and contested by two teams of 15 players (1 goalkeeper and 14 outfield players). Players' tactical and technical roles differ between the five distinctive positions (full back, half back, midfield, half forward, full forward) (6). The aim of the game is to outscore the opposing team by striking the ball through their goalpost (similar to rugby). Three points (goal) and one point are awarded once the ball successfully crosses the goal line under and over the crossbar respectively (23). Counties compete for a Provincial and All-Ireland elite Championship at adult (senior), under 21 (U21) and under 18 (minor) levels (23). Research that describes the work-rate match-play performances of hurling has lagged behind Gaelic football and other invasion team sports (5,6).

Global Positioning System (GPS) monitoring and HR technology have been used to track the players' training loads and physical demands during matches (5,6,12). The work-rate of hurlers is relatively high and comparable with other team sports (6). It was recently reported that elite senior hurling players covered 7617 ± 1219 m, 109 ± 17 $m \cdot min^{-1}$, 1134 ± 358 m (≥ 17 $km \cdot h^{-1}$) for total distance (TD), **relative speed ($m \cdot min^{-1}$)**, and high-speed running (HSR) distance, respectively (6). The same authors also showed that the lowest distance covered was observed in the top two speed-zones (815 ± 274 m at 17-21.9 $km \cdot h^{-1}$ and 319 ± 129 m at ≥ 22 $km \cdot h^{-1}$). Recording players' HR during match-play has previously been used to describe the intensity of team sport (7). The recorded peak HR (HR_{peak}) during a competitive senior hurling match was on average 194 ± 3 beats per minute ($b \cdot min^{-1}$) (5).

Players' HR ranged between 100 – 197 b·min^{-1} during the game and they displayed a mean HR (HR_{mean}) of 83% of HR_{peak}. Knowledge of the match-play demands can provide coaches with valuable information about the intensity of competition. Therefore, specific training practices can be undertaken as well as allowing for adequate dietary requirements to be provided (7).

Comparing metrics between first and second halves can present temporal changes in performance. It was previously shown that such metrics decrease as the match progresses in senior hurling and elite Gaelic football (6,14,22). Senior elite Gaelic footballers performed significantly less HSR and sprint distance in the second half compared to the first (16). In addition, youth Gaelic footballers completed a lower TD and HSR in the second half. A decrease in HR_{mean} was found between first (163 ± 14 b·min^{-1}) and second (160 ± 15 b·min^{-1}) halves during a competitive senior hurling match (5). To date, hurling running performances are presented per quarter of match-play (6). The performance of HSR was significantly lower in the second quarter compared to the first and the fourth quarter was lower than the third. The limited duration of half-time (15 minutes) was suggested to be insufficient to repeat high-speed running (6). In addition, the opposition, match outcome and the playing position in Gaelic football had a significant effect on TD and HSR performed in a game (17).

The outfield playing positions in hurling consists of two defensive lines of three, two midfielders and two attacking lines of three. The full back line, which are closest to their defensive goal are responsible for marking the full forward line and protecting the goal (23). The midfielders act as a link between attack and defense, the half back line's role is to mark the opposition half forward line and provide additional protection for their goal (6). All positions are free to move anywhere on the field. With players' ability to strike the ball long distances (80-90 m), the ball can be transferred to the opposite end of the field quite quickly, and scoring is possible from the opposition half back line. Similar to other team sports, positional differences exist within senior hurling matches (6). Previous results showed that senior hurling midfielders performed the highest volume of work (TD, HSR, and sprint distance) compared to backs or forwards. Comparing TD and HSR, players in the half-forward line were the second highest performers, with a similar profile being performed by half backs and full forwards, and full backs undertake the least (6). While it is known that positional differences exist in the running demands of match-play, no positional HR data is currently available in hurling.

Although the recent interest in hurling, no research has described the match-play running and HR values of under-age elite hurling players. Indeed, under-age (minor and U21) elite squads compete for their own championships, they are also seen as a stepping stone to be selected and perform at elite senior level. Increasing the knowledge of the match-play performances will assist coaches in identifying the movement requirements necessary to perform at the desired level. Given the limited match-play knowledge available in hurling, the running performances of under-age hurling have been interpreted from senior matches and even from other field games (6). Although the duration of U21 matches is ten minutes shorter, the pitch size, number of players per team and playing rules are similar to that of senior hurling. It would be useful for coaches to know if these physical and physiological demands are **sufficient** to prepare players for U21 competition and what differences if any exist between U21 and senior level. Therefore, the aims of the current study were to examine the physical and physiological demands of elite U21 male hurling match-play across halves of play and between positions. It was hypothesized that the physical and physiological demands would decrease between halves and would be position specific.

METHODS

Experimental Approach to the Problem

The current observational study was designed to examine the physical and physiological demands of elite male U21 hurling match-play across halves of play and between positions. All players in the current study were competing at the highest level for their age group (Provincial and All-Ireland U21 Championship) and were selected as they were members of the county's squad that season (2017). Data were only included if a full match (60-minutes) was completed. The players were classified according to their playing position during each match (i.e. full backs [n=22], half backs [n=21], midfielders [n=13], half forwards [n=19] and full forwards [n=20]) (6). All games (n = 10) took place between 14.00 and 21.00 hours, and temperatures ranged from 12 to 24°C. GPS was used to determine specific running performance variables, and HR monitors were used to collect HR during match-play. The players were requested to abstain from strenuous physical activity in the 24 hours before competitive matches and to report to the game fully hydrated.

Subjects

Ninety-five elite male U21 hurlers with a mean (± SD) age, height, body mass and predicted VO_{2max} of 20.8 ± 0.9 years, 181.4 ± 6.40 cm, 77.4 ± 2.86 kg and 66.08 ± 3.83 $ml \cdot kg^{-1} \cdot min^{-1}$ respectively, volunteered to participate in the study. After ethical approval, the subjects were informed of the purpose, procedures and potential risks involved. They were also informed that they were free to withdraw from the study at any time. Written informed consent and medical declaration were obtained from the participants in line with the procedures set by the local institution's research ethics committee. The local Ethics Committee approved all procedures, and the study was conducted according to the Declaration of Helsinki (1975) for studies involving human subjects.

Procedures

Height and body mass without footwear and minimal clothing using a stadiometer (Seca 217, Seca Ltd., Hamburg, Germany) and Seca Weighing Scales (Seca Ltd., Hamburg, Germany) were recorded during the familiarization session. The running performances were recorded using 10Hz GPS units and 100Hz triaxial accelerometer (STATSports, Viper, Northern Ireland: Firmware 2.28) (2–5). The GPS unit (dimensions 86 mm x 33 mm x 14 mm, mass 50 g) was placed within a pouch between the player's shoulder blades (upper thoracic-spine) in a sports vest and worn under the playing jersey. GPS activation and satellite lock were established 15 minutes before warm-up commencement (11). The number of satellites was 19 ± 7, and the horizontal dilution of precision was 1 ± 1 across all games. Beat-by-beat HR was continuously collected using a HR transmitter belt (Team Polar, Polar Electro Oy, Kempele, Finland) which was worn around the each subject's chest (13,18). Monitoring HR has been shown to be a valid measure of exercise intensity in invasion games (25). The participants were familiarized with GPS and HR technology during team training sessions before data collection.

Data collected from the GPS units included TD (m) and **relative speed ($m \cdot min^{-1}$)**. The intensity of each movement was categorized as the distances covered (m) in the following zones, passive: < 6.9 $km \cdot h^{-1}$, slow: 7-11.9 $km \cdot h^{-1}$, medium: 12-16.9 $km \cdot h^{-1}$, HSR: 17-21.9 $km \cdot h^{-1}$ and sprint distance (≥ 22 $km \cdot h^{-1}$) (6). The total number of sprints (≥ 22 $km \cdot h^{-1}$) and the mean length of sprint was collected (5,12–14,16,20). Peak HR (HR_{peak}) was taken as the highest HR and HR_{mean} was assumed as the mean value of HR attained by the player during the entire competitive match-play duration (18,21). Time spent in each HR zone (zone 1: < 50 $b \cdot min^{-1}$; zone 2: 50-80 $b \cdot min^{-1}$; zone 3: 80-120 $b \cdot min^{-1}$; zone 4: 120-160 $b \cdot min^{-1}$; zone 5: > 160 $b \cdot min^{-1}$) was also collected (21). GPS and HR data was downloaded to a computer through the STATSport analysis software (STATSport Viper 1.2) to be stored and analyzed after each game. On downloading, each GPS unit was labelled as the playing position. First and second half data was identified by a time stamp and manually exported into a Microsoft Excel spreadsheet (Microsoft, Redmond, USA).

Statistical Analysis

All statistical analysis was performed using SPSS for Windows (Version 22, SPSS Inc. Chicago, IL, USA). Descriptive analysis and assumptions of normality were verified before parametric statistical analysis was used. The analysis was performed using a two-way (position x half) mixed design (ANOVA) with a Bonferroni post hoc test. The dependent variables across the range of analysis were, TD, HSR distance, sprint distance, the total number of sprints (n), HR_{peak}, HR_{mean} and time spent in each HR zone, with match periods and playing positions as independent factors. When significant main effects were observed a Bonferroni post hoc test was applied. Standardised effect sizes (ES) were calculated with < 0.2, 0.21 - 0.6, 0.61 - 1.20, 1.21 - 2.00 and 2.01 - 4.0 and interpreted as follows; trivial, small, moderate, large and very large differences, respectively as recommended by Hopkins (10). Statistical significance set at an accepted level of $\alpha < 0.05$. Data are presented as mean, standard deviation (± SD) and 95% confidence intervals (95% CI).

RESULTS

Descriptive statistics for TD, **relative speed**, HSR, the total number of sprints, length of sprint, sprint distance, $HR_{peak,}$ and HR_{mean} are presented in Table 1. Results showed that elite male U21 hurling players covered the greatest distance in the passive zone [2743 ± 282 m (95% CI 2699 – 2811)]. The distance covered in slow and medium zones was 1635 ± 385 m (95% CI 1573 – 1726), 1368 ± 394 m (95% CI 1319 – 1462) respectively. HSR and sprint distance accounted for 10% and 4% respectively of the TD covered during match-play. The maximum velocity was 29.1 ± 1.9 $km\cdot h^{-1}$.

Please insert Table 1 near here

Results comparing positions during the entire match, showed that full backs covered a lower TD than half backs ($p < 0.05$, Mean Difference [MD] -870 m, 95% CI -1588 to -153, ES = 1.24), midfielders ($p < 0.05$, MD -1289 m: 95% CI -2112 to -465, ES = 1.39), and half forwards ($p < 0.05$, MD -1305 m: 95% CI -2042 to -568, ES = 1.85). Half forwards covered a greater TD than players in the full forward line ($p < 0.05$, MD 768 m, 95% CI 15 to 1523, ES = 0.94). Full backs covered a lower **relative speed** than half backs ($p < 0.05$, MD -15 $m\cdot min^{-1}$, 95% CI -26 to -3, ES = 1.24), midfielders ($p < 0.05$, MD -21 $m\cdot min^{-1}$: 95% CI -35 to -8, ES = 1.39), and half forwards ($p < 0.05$, MD -22 $m\cdot min^{-1}$: 95% CI -34 to -9, ES = 1.85). Half forwards performed a greater distance at HSR than full backs ($p < 0.05$, MD 190 m, 95% CI 15 to 364, ES = 1.13), and a higher sprint distance than half backs ($p < 0.05$, MD 137 m, 95% CI 43 to 231, ES = 1.41). There was no difference ($p > 0.05$) between positions for the total number of sprints, mean length of sprint, HR_{peak}, and HR_{mean}.

Please insert Figure 1 near here

For the entire match, players spent 65% of the match time over 160 $b\cdot min^{-1}$ compared with 32% ($p < 0.05$) between 120-160 $b\cdot min^{-1}$, 3% ($p < 0.05$) between 80-120 $b\cdot min^{-1}$ and no time was spent in the lowest two zones (< 50 $b\cdot min^{-1}$, $p < 0.05$, 50-80 $b\cdot min^{-1}$, $p < 0.05$). No difference was found between positions for the percentage of game time spent in each HR zone. Figure 1 shows the percentage time spent in each HR zone per half.

Please insert Table 2 near here

All positions performed a lower TD in the second half. Full forward's HSR, and total sprints were the only position to significantly decrease between halves (Table 2). Half backs, half forwards and full forwards had a lower HR_{mean} in the second half compared to the first half. In the first half, full backs covered a lower TD than half backs ($p < 0.05$, MD -507 m, 95% CI -875 to -140, ES = 1.29), midfielders ($p < 0.05$, MD -669 m, 95% CI -1090 to -247, ES = 1.49) and half forwards ($p < 0.05$, MD -628 m, 95% CI -1005 to -251, ES = 1.43). Full backs covered a lower **relative speed** than half backs ($p < 0.05$, MD -17 $m \cdot min^{-1}$, 95% CI -29 to -5, ES = 1.29), midfielders ($p < 0.05$, MD -22 $m \cdot min^{-1}$, 95% CI -36 to -8, ES = 1.49) and half forwards ($p < 0.05$, MD -21 $m \cdot min^{-1}$, 95% CI -34 to -8, ES = 1.43) in the first half. There was a greater HSR distance performed by half forwards compared to full backs in the first half ($p < 0.05$, MD 102 m, 95% CI 3 to 200, ES = 1.05). Half forwards also completed a higher sprint distance than half backs in the first half ($p < 0.05$, MD 67 m, 95% CI 7 to 127, ES = 0.98). No differences were found between positions for the total number of sprints, mean length of sprint, HR_{mean} and HR_{peak} in the first half.

Regarding differences between positions in the second half, full backs covered a lower TD than midfielders ($p < 0.05$, MD -620 m, 95% CI -1196 to -44, ES = 0.98) and half forwards ($p < 0.05$, MD -677 m 95% CI -1193 to -161, ES = 1.55). Full backs covered a lower **relative speed** than midfielders ($p < 0.05$, MD -21 $m \cdot min^{-1}$, 95% CI -40 to -1, ES = 0.98) and half forwards ($p < 0.05$, MD -23 $m \cdot min^{-1}$, 95% CI -40 to -5, ES = 1.55) in the second half. Midfielders performed a greater HSR distance than full backs ($p < 0.05$, MD 119 m: 95% CI 4 to 234, ES = 0.78), and half forwards covered a greater sprint distance than half backs ($p < 0.05$, MD 70 m: 95% CI 10 to 130, ES = 1.20). No differences were found between positions for the total number of sprints, mean length of sprint, HR_{mean} and HR_{peak} in the second half.

DISCUSSION

The aims of the current study were to describe the physical and physiological demands of elite male U21 hurling match-play across halves of play and between positions. As hypothesized, the physical and physiological demands decreased between halves and differences exist between positions for some but not all metrics. The overall total running performances were lower than found at elite senior hurling level (6). Trivial to moderate decreases were observed between halves for TD, **relative speed**, HSR, HR_{peak}, and HR_{mean}, whatever the playing position. Positional differences existed for TD, **relative speed**, HSR, and sprint distance, but not for the number of sprints, HR_{peak} and HR_{mean} during the full duration of match-play. In addition, each position performed a lower TD in the second half compared to the first half. To the best of the authors' knowledge, the current study was the first to examine the physical and physiological profiles across halves of play and positional lines during elite male U21 hurling match-play. Therefore cross-comparison to previous literature in hurling is challenging.

Independent of playing position, players at elite U21 hurling covered a lower TD (6688 ± 942 m), and distance covered in the passive (3110 ± 334 m), slow (1797 ± 463 m) and medium (1576 ± 589 m), HSR (815 ± 274 m) and sprint distance (319 ± 129 m) zones compared to senior hurling. It is important to note the difference in playing time between elite U21 (60-minutes) and elite senior (70-minutes) levels. The ten minutes additional playing time will almost certainly account for the greater TD and distance at each intensity being covered in the senior game. However, when **relative speed** is compared between these levels, U21's covered a similar distance to seniors' (109 ± 17 $m \cdot min^{-1}$) (6). The current results showed that TD was greater than that reported in youth Gaelic football at both under 15 (U15) (5732 ± 1047 m) and under 18 (U18) levels (5774 ± 737 m) (8,21). Differences in

Gaelic football team tactics, the players' age (U18) and the physiological capacity between levels may account for a higher TD being performed at U21 level (20). The players in the current study covered less TD compared to U16 soccer players (6600 ± 1480 m) (1) and U18 elite Australian football players (10786 ± 2052 m) (9). The longer playing duration (soccer 2 x 40 mins; Australian football 103 ± 12 mins), differences in technical skills, and rules between matches may have accounted for U21's covering less distance.

In addition, comparable maximum speeds (29.6 ± 2.2 $km\cdot h^{-1}$) and sprint distance (> 22 $km\cdot h^{-1}$) (319 ± 129 m) (6) were performed between U21 and senior players. The resemblance in gaining and maintaining possession to score, the playing rules, playing numbers and pitch size between both levels may account for similar **relative speed**, sprint distance and maximum speed being performed. In addition, players at U21 level performed a higher sprint distance than observed in U15 Gaelic football (198 ± 147 m). However, differences in the sprinting speed-zone (≥ 20 $km\cdot h^{-1}$) classification used previously at U18 Gaelic football level made it difficult to directly compare with the present results (8). The total number of sprints completed at both U15 (19 ± 5) and U18 (18 ± 5) youth Gaelic football players were similar to the current study's findings. The mean length of sprint performed by U21 hurlers is similar to that performed in elite senior and underage soccer (16 – 19 m) (1,27,29). However, there is no comparable data available for the mean length of sprint in hurling match-play. Previously it has been found that comparable match-play **relative speed** and speeds were covered in hurling small-sided games (12). Thus training activities that include small-sided games would be of benefit to prepare hurlers for match-play. Moreover, HR_{mean} (166 ± 11 $b\cdot min^{-1}$) at U15 level was also comparable with the current study's findings (8,21). No HR_{mean} values were reported at U18 level, only as a percentage of HR maximum, making a direct comparison difficult (8).

Moderate decreases in TD, **relative speed**, HSR, HR_{peak} and HR_{mean} were found between first and second halves. Similar running performance decrements were observed in elite senior hurling and senior Gaelic football players' (6,15,16). These between-half decrements may be due to motivation, energetic status, tactical demands, or other match-related factors (6,26). It can be argued that fatigue affects running performance, as substitutes were found to perform more running per minute than those who played the full duration of matches (4,19). There was no difference in the total number of sprints, length of sprint and sprint distance found between halves. Given the small number of sprints performed in the first half, players may have recovered to repeat a comparable amount in the second half. The ability to maintain HSR ($\geq$ 18 km·h^{-1}) has been shown to be a critical aspect of performance and match outcome in soccer (19,28). Given the significant drop-off observed in the current study, training activities that prepare players to sustain high-speed running for the duration of match-play may be beneficial.

Players in the full back line performed the least TD, with significant differences found between half backs, midfielders and half forwards but not the full forward line. Furthermore, the half forward line covered significantly more TD than the full forward line. Interestingly, contrary to previous findings in elite senior hurling, midfield players in the current study performed similar TD compared with half backs and half forwards (6). The dynamic nature of the half back, midfield and half forward positional roles may account for those positions performing a greater TD than players in the full back and full forward positions. During the game, midfield, half back and half forward line players may retreat into their own half to gain possession while defending and move into the opposition half while attacking. In contrast, the full forward line usually remains close to the opposition goals to provide an option to gain possession from clearances and to score goals. The full back line performs similar movements to the full forward line as their role is to mark them tightly to prevent them gaining possession and scoring. Since half forwards and half backs retreat into a defensive position towards their own goals to regain possession from puck outs, this additional movement may account for similar distances being covered by midfielders. Senior elite hurling players performed greater TD in each position (full backs 6548 ± 786 m: half backs 8046 ± 686 m: midfield 8999 ± 676 m: half forward 7975 ± 845 m: full forward 6530 ± 1112 m) compared with U21 players. The ten minutes of additional match time in senior hurling matches compared to U21 hurling may account for senior players covering more TD. Furthermore, differences in HSR exist between full backs and half forwards. In the current study, there was no difference between full back, midfield and full forward positions for sprint distance. However an interesting finding showed that half forwards covered a greater sprint distance than half backs as these positions are supposed to be marking each other. A possible reason may be due to a common tactical ploy performed just as a puck out is being taken. Players in the half forward line often sprint to the opposite side of the field to create space and run to the oncoming ball to gain possession. Frequently, however, players in the half back positions employ a zonal marking tactical ploy and remain in place and mark the half forward that is approaching their position.

Overall, the current players performed a lower **relative speed** in the second half compared with the first half. From the current results, it is unclear if match outcome, fitness levels or team tactics influenced the decrease in performance (6). In addition, only full forwards performed a significantly lower HSR distance and a total number of sprints in the second half. Previously it has been shown that the majority of HSR efforts occur close to the ball, hence a limited amount of ball possessions in the second half may account for these decreases (23).

Full backs covered less **relative speed** than half backs, midfielders, and half forwards in the first half and midfielders and half forwards in the second half. Further differences in distance covered exist at HSR velocity, where full backs covered less than half forwards in the first half and less than midfielders in the second half. Compared to half backs, midfielders and half forwards, full backs attempt to stay close to the goal to decrease the opportunities to concede goals. Conversely, half back, midfield and half forward line positions can move freely to gain possession and create scoring chances. Such different tactical actions could be responsible for players in the full back line performing less **relative speed** and HSR distance. Half forwards covered a greater sprint distance than half backs in each half. As previously suggested, the half forwards role in creating space and gaining position often sees them moving into the opposite end of the field, while in contrast, the half back line often remains in their defensive position to deny the space available to full forward line.

The results from the current study reported similar HR_{mean} in first and second halves compared with senior elite hurling players (first half 163 ± 14 b·min^{-1}, second half 160 ± 15 b·min^{-1}) (5). The similarity in players' age, the common technical skills of striking, soloing, tackling for possession and running to support players in possession in both U21 and senior level hurling matches may account for the comparable HR_{mean} results. Related findings were observed in elite youth (166 ± 11 b·min^{-1}), and senior Gaelic football (169 ± 9 b·min^{-1}) matches (21,24). The comparable invasion type game, number of players, and size of pitch may account for these similarities. Temporal decrements were observed in HR_{mean} between halves. Given the global running performance decreased in the second half, this may explain players reaching a similar HR_{mean} compared to the first half. Players in the current study spent a higher percentage of match time over 160 b·min^{-1} than any other HR zone, which is comparable to elite youth Gaelic football players (61 ± 24 %) (21).

Differences were observed between halves in the top three HR zones. Players spent a longer time in the highest HR zone (> 160 b·min^{-1}) in the first half and a greater time in HR zone 4 (120-160 b·min^{-1}) and zone 3 (80-120 b·min^{-1}) in the second half. Furthermore, no differences in HR_{mean} and HR_{peak} were shown between positions. Even though full backs covered the least TD, they performed a similar total number of sprints and sprint distance compared with other positions. Repeating sprints over a variety of distances may have kept their HR elevated. Half backs, half forwards and full forwards all experienced a decrease in HR_{mean} between halves. Each position also performed less TD, HSR and sprint distance between halves. This reduced volume of activity may have resulted in a lower HR_{peak} and HR_{mean} in the second half.

The present study comes with some acknowledged limitations. Firstly, the current study did not consider the level of opposition or match outcome. These may have influenced the match running and HR values. Secondly, no measure of the number of times the ball entered each half was included. It has been previously shown that HSR occurs close to the hurling ball (23). Including the number of times, the ball entered each half within the study may help explain the differences in running and HR values between positions. Further analysis of the work-rate demands which include accelerations, decelerations and metabolic power profiles of U21 hurling players need to be investigated. Finally, U21 championship games can often take place three days following elite senior games, players who play in both games may still be experiencing fatigue from the senior game, this may have influenced the results.

PRACTICAL APPLICATIONS

Trainers and conditioners involved in preparing U21 hurlers should be aware of the running and HR values completed within matches as the requirements are different from seniors. Performance decrements were observed between halves for TD, **relative speed** and HSR. Training activities need to be carefully planned to sufficiently prepare players to be able to repeat TD, **relative speed** and HSR distance for the full duration of the match. Players in the full back line covered less TD compared to half backs, midfielders and half forwards. However, they perform a similar number of sprints, mean length of sprint and sprint distance. The commonality among the middle three positions (half backs, midfielders and half forwards) emphasizes the need for players to be able to complete the same running performance. Players in all positions should complete similar training activities that allow them to perform the same amount of sprints. Monitoring TD, **relative speed**, HSR and sprint distance should be undertaken to ensure players in particular positions can achieve the necessary volume required. Furthermore, management selecting players to play in the half back and half forward positions should consider those players who can complete similar running performances to midfielders. The highest percentage of match time is spent above 160 $b \cdot min^{-1}$, therefore monitoring HR within training is important to ensure that the activities being performed are intense enough to elevate HR similar to match-play. Strategies to reduce the temporal deterioration between halves need to be investigated. Coaches should consider the player's running and HR match-play performances to maximise the planning and implementation of training activities.

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Figure 1. Mean % time ± **SD** spent in each heart rate zone per position is shown.

* Significant difference **($p < 0.05$)** between halves

Table 1: The running and HR values for the total game, first and second halves. Data are presented as mean ± SD, mean difference (95% CI) and effect size

CI = confidence interval. Min = minute, HR = Heart rate, HR_{mean} = Average heart rate, HR_{peak} = Peak heart rate

* Significantly different **($p < 0.05$)** from first half

Table 2: The total, first and second half running and HR performances per position. Data are presented as mean ± SD, mean difference (95% CI) and effect size

Diff = Mean difference, HR = Heart rate, HR_{mean} = Average heart rate, HR_{peak} = Peak heart rate

* Significantly different ($p < 0.05$) from first half

[a] Significantly different ($p < 0.05$) from full backs

[b] Significantly different ($p < 0.05$) from half backs

[c] Significantly different ($p < 0.05$) from half forwards

Table 1: The running and HR values for the total game, first and second halves. Data are presented as mean ± SD, mean difference (95% CI) and effect size

	Total	**1st Half**	**2nd Half**	**Difference 95% CI**	**Effect Size**
Total Distance (m)	6688 ± 942	3541 ± 479	3147 ± 615 *	393 (272 – 513)	0.71
Relative Speed ($m \cdot min^{-1}$)	112 ± 16	118 ± 16	105 ± 21 *	13 (9 – 17)	0.70
High-Speed Running (m)	661 ± 203	348 ± 113	313 ± 118 *	32 (9 – 55)	0.30
Number of Sprints (n)	18 ± 8	9 ± 5	9 ± 4	0.7 (-0.3 – 1.6)	0.00
Length of Sprint (m)	16 ± 5	16 ± 7	16 ± 6	0.5 (-1 – 2)	0.00
Sprint Distance (m)	274 ± 111	142 ± 68	132 ± 69	8 (-8 – 25)	0.15
HR_{mean} ($b \cdot min^{-1}$)	165 ± 9	170 ± 9	161 ± 12 *	9 (6 – 12)	0.85
HR_{peak} ($b \cdot min^{-1}$)	190 ± 7	189 ± 7	184 ± 13 *	5 (2 – 8)	0.48

CI = confidence interval. HR = Heart rate, HR_{mean} = Average heart rate, HR_{peak} = Peak heart rate

* Significantly different ($p < 0.05$) from first half

Table 2: The total, first and second half running and HR values per position. Data are presented as mean ± SD, mean difference (95% CI) and effect size

		Full Backs (n = 22)	**Half Backs (n = 21)**	**Midfield (n = 13)**	**Half Forwards (n = 19)**	**Full Forwards (n = 20)**
Total Distance (m)	Total	5945 ± 676	6816 ± 729 [a]	7234 ± 1128 [a]	7251 ± 732 [a]	6482 ± 889 [c]
	1st Half	3142 ± 442	3649 ± 337 [a]	3810 ± 452 [a]	3770 ± 434 [a]	3474 ± 432
	2nd Half	2804 ± 462 *	3167 ± 570 *	3424 ± 766 * [a]	3481 ± 410 * [a]	3008 ± 666 *
	Diff (95% CI)	338 (92 – 584)	482 (231 – 734)	387 (67 – 707)	289 (25 – 554)	467 (209 – 724)
	ES	0.75	1.03	0.61	0.68	0.83
Relative Speed ($m \cdot min^{-1}$)	Total	99 ± 11	114 ± 12 [a]	121 ± 19 [a]	121 ± 12 [a]	108 ± 15 [c]
	1st Half	105 ± 15	122 ± 11 [a]	127 ± 15 [a]	126 ± 15 [a]	116 ± 14
	2nd Half	94 ± 15 *	106 ± 19 *	114 ± 26 * [a]	116 ± 14 * [a]	100 ± 22 *
	Diff (95% CI)	11 (3 – 20)	16 (8 – 25)	13 (2 – 24)	10 (1 – 19)	16 (7 – 24)
	ES	0.73	1.03	0.61	0.68	0.86
High-Speed Running (m)	Total	537 ± 177	672 ± 138	722 ± 328	726 ± 157 [a]	684 ± 179
	1st Half	284 ± 104	355 ± 100	351 ± 143	386 ± 89 [a]	375 ± 117
	2nd Half	253 ± 100	317 ± 81	372 ± 191 [a]	341 ± 87	310 ± 115 *
	Diff (95% CI)	31 (-16 – 78)	38 (-10 – 86)	-21 (-82 – 40)	45 (-5 – 95)	65 (16 – 114)
	ES	0.30	0.42	0.12	0.51	0.56
Number of Sprints	Total	17 ± 8	16 ± 7	14 ± 8	22 ± 9	19 ± 7
	1st Half	8 ± 5	9 ± 4	7 ± 4	11 ± 5	11 ± 5
	2nd Half	9 ± 4	7 ± 4	8 ± 5	11 ± 5	8 ± 4 *
	Diff (95% CI)	-0.2 (-2.1 – 1.8)	1.1 (-0.9 – 3.1)	-0.7 (-3.2 – 1.8)	0.6 (-1.5 – 2.7)	2.4 (0.3 – 4.4)
	ES	0.22	0.50	0.22	0.00	0.66
Length of Sprints (m)	Total	16 ± 5	14 ± 5	18 ± 5	16 ± 5	16 ± 5
	1st Half	16 ± 1	14 ± 1	18 ± 2	15 ± 2	16 ± 1
	2nd Half	16 ± 1	14 ± 1	17 ± 2	17 ± 1	17 ± 1
	Diff (95% CI)	-0.3 (-4 – 3)	-0.4 (-4 – 3)	0.4 (-4 – 5)	-1.6 (-5 – 2)	-0.5 (-4 – 3)
	ES	0.00	0.00	0.50	1.26	1.00
Sprint Distance (m)	Total	267 ± 101	207 ± 82	262 ± 137	344 ± 110 [b]	292 ± 95
	1st Half	142 ± 68	107 ± 55	131 ± 66	174 ± 80 [b]	154 ± 59
	2nd Half	125 ± 51	100 ± 52	131 ± 98	170 ± 64 [b]	139 ± 70
	Diff (95% CI)	16 (-18 – 51)	7 (-28 – 42)	1 (-44 – 46)	3 (-34 – 41)	15 (-21 – 51)
	ES	0.28	0.13	0.00	0.06	0.23
HR_{mean} $b \cdot min^{-1}$	Total	165 ± 11	164 ± 9	166 ± 8	167 ± 8	165 ± 10
	1st Half	168 ± 12	170 ± 8	169 ± 7	171 ± 5	172 ± 9
	2nd Half	163 ± 11	158 ± 15 *	162 ± 10	163 ± 14 *	159 ± 12 *
	Diff (95% CI)	5 (-1 – 12)	12 (6 – 18)	7 (-1 – 15)	8 (2 – 15)	12 (6 – 18)
	ES	0.43	1.00	0.81	0.76	1.23
HR_{peak} $b \cdot min^{-1}$	Total	191 ± 7	190 ± 6	190 ± 3	188 ± 7	191 ± 9
	1st Half	191 ± 8	188 ± 8	188 ± 6	188 ± 6	191 ± 8
	2nd Half	186 ± 8	186 ± 7	186 ± 3	177 ± 24	187 ± 9
	Diff (95% CI)	5 (-2 – 11)	2 (-4 – 8)	3 (-6 – 11)	11 (4 – 18)	4 (-2 – 10)
	ES	0.63	0.27	0.42	0.63	0.47

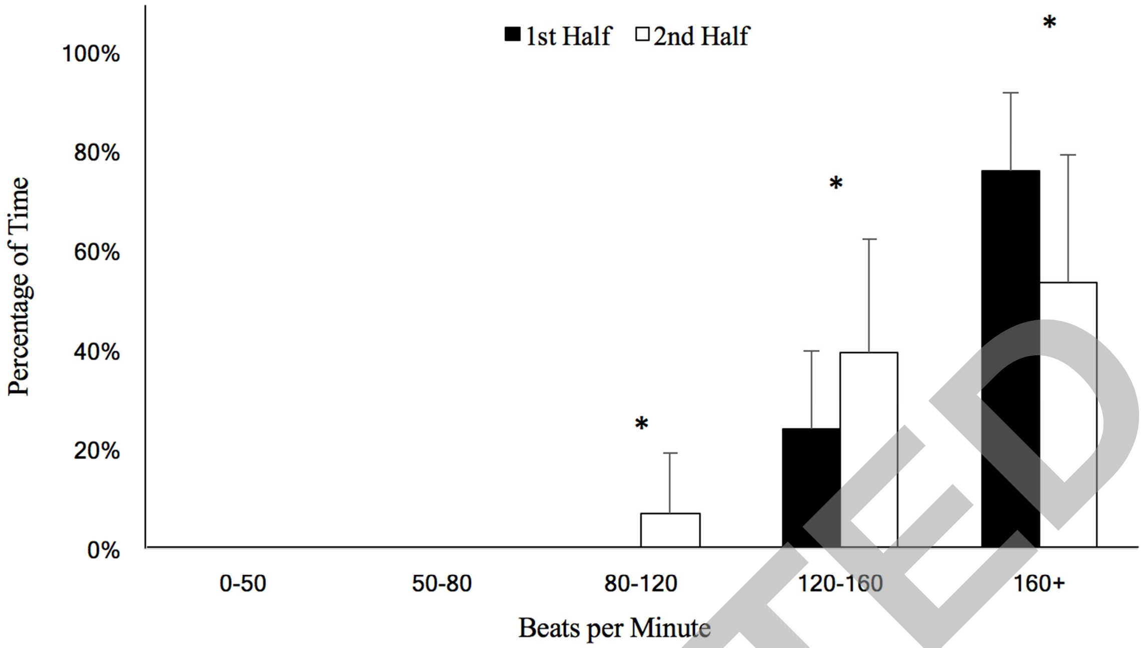
Diff = Mean difference, HR = Heart rate, HR_{mean} = Average heart rate, HR_{peak} = Peak heart rate

* Significantly different ($p < 0.05$) from first half

[a] Significantly different ($p < 0.05$) from full backs

[b] Significantly different ($p < 0.05$) from half backs

[c] Significantly different ($p < 0.05$) from half forwards


1st Half
2nd Half
100%
80%
60%
40%
20%
0%
Percentage of Time
*
*
*
0-50
50-80
80-120
120-160
160+
Beats per Minute