Match-play demands of elite U17 hurlers during competitive matches

Running Head: Match-Play demands of U17 hurling

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ABSTRACT

The current study aimed to quantify the match-play workload in elite male under 17 hurlers, measuring the differences between first and second half and between positions. GPS (10-Hz) and heart-rate monitors were used to collect data from 76 players during 18 matches. Players' total distance (TD), relative distance (RD), high-speed running (HSR), the number and length of sprints and the total sprint distance (TSD) was 6483 ± 1145 m, 108 ± 19 m·min^{-1}, 583 ± 215 m, 18 ± 6, 15 ± 3 m and 272 ± 77 m respectively. Peak and mean heart-rate **were** 194 ± 8 b·min^{-1} and 167 ± 4 b·min^{-1} respectively. Decrements in TD ($p < 0.001$, ES = 0.72), RD ($p < 0.001$, ES = 0.72), HSR ($p < 0.001$, ES = 0.55), **the number of sprints** ($p < 0.001$, ES = 0.57), mean length of sprint ($p < 0.011$, ES = 0.25), TSD ($p < 0.001$, ES = 0.69), mean ($p < 0.001$, ES = 0.35) and peak heart-rate ($p < 0.001$, ES = 0.52) were found between halves. *Largely*-to-*very largely* greater TD, RD and HSR were covered by midfielders, half-backs and half-forwards compared to full-backs and full-forwards. No between-position difference was found in peak and mean heart-rate. The current results are the first to highlight the differences in external and internal position-specific workload in elite male under 17 hurlers. Coaches need to consider the position-specific demands and between-half drop-off to prepare young hurlers appropriately to repeat the match-play performances of competition.

Keywords: *Team Sport; Match Analysis; Positions; Heart Rate; High speed Running; Sprint Distance*

INTRODUCTION

Hurling is an Irish stick and ball invasion-type sport played on a 140 m x to 90 m playing area. Each team consists of 15 players (1 goalkeeper and 14 outfield players) split into five distinctive roles (full backs, half backs, midfielders, half forwards, full forwards) (31,32). The aim of the match is to outscore the opposition by striking the ball through the opposition goalposts, one point for over the crossbar and three points for under the crossbar (32). Hurlers perform unique skills like balancing the ball on the stick (hurley), catching the ball, striking the ball long distances (80-90 m) and tackling with the hurley (23). Players represent their home county and compete for an official Provincial and All-Ireland Championship at adult **(senior: players older than 18 yrs.),** under 21 (U21) and minor (U17) levels (23). The U17 competition was established in 2017 and is the first formal elite hurling championship with stand-alone fixtures, played in front of large attendances before senior championship matches. Despite the popularity and the significant training time allocated to hurling practice, limited studies are available to describe the match-play demands of competition (8,30–33). This information would provide coaches with competition demands and help them develop specific conditioning activities for training. Previously, it has been found that comparable senior match-play relative distance and speeds were covered in hurling small-sided games (16). In addition, quantifying the match-play demands of youth hurling competition would allow appropriate programs to be designed to aid the transition to adult competition (31–33).

Global positioning system (GPS) technology was used to quantify the players' activity profile and load during competitive matches (8,10,19,22,26,30–33). The TD, relative distance, distance covered at each intensity including HSR and sprint distance have been reported in hurling at senior (elite and sub-elite) (8,33) and U21 level (32). Senior hurlers (8,30) exhibited

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82 greater match-play running performances compared U21 hurlers (32). Furthermore, previous
83 research in hurling (elite and sub-elite senior and U21) have shown that running performance
84 deteriorated in the second half (8,30,32,33). This between-half analysis can present how these
85 metrics change as the match progresses and could be used to indicate the most demanding
86 periods of play (31). Moreover, similar to other team sports, positional differences exist within
87 senior (8,30) and U21 (32) hurling matches with significant variances observed in total distance
88 (TD) and high-speed running (HSR) between positions (8,32). Lastly, the assessment of heart-
89 rate (HR) provides a non-invasive method for monitoring the physiological response of match-
90 play in team sports (5,10,22,32,33) and recently in hurling (17,30,32,33). Results show that
91 senior (7,30,33) and U21 (32) hurlers' match-play HR mean (HR_{mean}) and HR peak (HR_{peak})
92 values are similar. In addition, decreases in HR_{mean} were observed between the first and second
93 halves in both senior (7) and U21 (32) hurlers. Currently, only positional HR_{mean} and HR_{peak}
94 are available for senior (30) and U21 (32) hurlers, yet no differences were observed between
95 playing positions (32). No similar HR_{mean} or HR_{peak}, positional HR or between-half HR
96 decrements data is currently available in youth level hurling.

97

98 Elite youth competitions serve as a development platform for future senior
99 performances. Therefore, the conditioning of youth players should rely on evidence-based
100 research that quantifies the physical match requirements (28). Previous studies have shown
101 differences in match-play outputs between youth and adult level players in team sports such as
102 Gaelic football (10,18,19,22), Australian football (27) and soccer (11). Even though the match-
103 play running performances and HR are described for senior (elite and sub-elite) (8,33) and U21
104 (32) level, currently, there **are** no data available to inform coaches of the match-play demands
105 at youth level. Since this level of competition (U17) was only recently established, this is the

first opportunity to collect such data. Therefore, the aim of the current study was to quantify the match-play demands in elite male U17 hurling players, investigating the differences between halves and positions.

METHODS

Experimental Approach to the Problem

The current investigation was designed as an observational study. The players in the current study were competing at an elite level for their age group and were selected as they were members of the county's squad that season. The participants were recruited from 3 different teams and categorized into common outfield playing positions of full backs (*n=16*), half backs (*n=16*), midfielders (*n=12*), half forwards (*n=16*) and full forwards (*n=16*) (8,30–32). Data were only included if a full match (60 min) was completed. All matches (*n = 18*) took place during the 2017 and 2018 playing seasons (May – September). GPS was used to determine specific running performance variables, and HR monitors were used to collect HR during elite U17 competitive matches. The players were requested to abstain from strenuous physical activity in the 24 hours before competitive matches and report to the match fully hydrated (32).

Subjects

Seventy-six elite male U17 hurlers with a mean (± *SD*) age, height and body mass of 16.6 ± 0.4 years, 177.4 ± 6.2 cm, 69.4 ± 6.1 kg respectively, volunteered to participate in the study. After ethical approval, the participants along with their parents/guardians were informed of the purpose, procedures and potential risks involved in the study. They were also informed

that they were free to withdraw from the study at any time. Written informed consent was obtained from the parents/guardians and participants in line with the procedures set and approved by the local Institution's Research Ethics Committee. The study was conducted according to the Declaration of Helsinki (1975) for studies involving human subjects.

Procedures

Height and body mass were assessed without footwear and minimal clothing using a stadiometer and weighing scales (Seca 217, Seca Ltd., Hamburg, Germany) on the first day of testing. The running performances were collected using a 10Hz GPS System and 100Hz tri-Axial accelerometer (STATSports Viper, Newry, Northern Ireland: Firmware 2.7.1.83) (1,32). The validity of these GPS units has previously been reported (2). Such GPS units reported distance bias of 2.53% during 10 m shuttle runs, and a bias of 3.5% in average speed during 20 m shuttle runs (2). Intra unit reliability showed a coefficient of variation of 1.6% during the 400 m distance trial (3). The GPS unit (dimensions 86 mm x 33 mm x 14 mm, mass 50 g) was placed 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 min before match commencement (15). A HR transmitter belt (Team Polar, Polar Electro Oy, Kempele, Finland) was worn around the chest which collected HR data throughout each match (30,32,33). Monitoring HR during invasion games has been found to be a valid measure of exercise intensity (24). The subjects were familiarized with GPS and HR technology during training sessions before data collection (30,32).

Data collected from the GPS units included TD (m) and relative distance ($m \cdot min^{-1}$). The intensity of each movement was categorized as the distances covered (m) in the following

zones, passive: ≤ 6.9 km·h^{-1}, slow: 7 - 11.9 km·h^{-1}, medium: 12 - 16.9 km·h^{-1}, HSR: 17 - 21.9 km·h^{-1} and sprint distance ≥ 22 km·h^{-1} (8,32). The total number of sprints (number of times players ran ≥ 22 km·h^{-1} and lasted at least 1 second) and the mean length of sprint were collected (8,32). HR_{peak} was taken as the highest HR recorded during the match and per half. HR_{mean} was assumed as the mean value of HR attained by the player during the entire competitive match-play duration and per half (22). Time spent in each HR zone (zone 1: 0 - 50 b·min^{-1}; zone 2: 50 - 80 b·min^{-1}; zone 3: 80 - 120 b·min^{-1}; zone 4: 120 - 160 b·min^{-1}; zone 5: > 160 b·min^{-1}) was also collected (22,32). GPS and HR data was downloaded to a computer through the STATSport analysis software (STATSport, Viper 2.7.1.83) to be stored and analysed after each match. On downloading, each GPS unit was labelled as the playing position. First and second half data was identified and 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. The analysis was performed using a two-way (position x half) mixed design (ANOVA). Across the range of analysis, the dependent variables were TD, relative distance, HSR distance, sprint distance (≥ 22 km·h^{-1}), the total number of sprints, mean length of sprint, HR_{peak} and HR_{mean} and time spent in each HR zone. Match periods (e.g., first and second half) and playing positions (full backs, half backs, midfielders, half forwards and full forwards) were the independent variables. When significant main effects were observed, a Bonferroni post hoc test was applied. **Standardized** effect size (ES) was calculated with < 0.20, 0.20 - 0.59, 0.60 - 1.19, 1.20 - 1.99 and ≥ 2.00 and interpreted as follows; *trivial, small,*

177 *moderate*, *large* and *very large* differences respectively, as recommended by Hopkins (13).
178 Statistical significance was set at an accepted level of $\alpha < 0.05$. Data are presented as mean,
179 standard deviation (± SD) and 95% confidence intervals (95% CI).

180

181 **RESULTS**

182 Descriptive statistics for TD, relative distance, HSR, the number of sprints, the mean
183 length of sprint, total sprint distance, HR_{mean}, and HR_{peak} for the full match and per half are
184 presented in Table 1. Results showed that elite male U17 hurling players covered the greatest
185 distance in the passive zone (2510 ± 523 m, 95% CI 2431/2593). The distance covered in slow
186 and medium zones was 1474 ± 438 m (95% CI 1415/1528) and 1179 ± 553 m (95% CI
187 1102/1250) respectively. HSR and total sprint distance accounted for 9% and 4% respectively
188 of the TD covered during match-play. The peak running speed achieved in the full matches
189 was 28.1 ± 2.9 $km \cdot h^{-1}$.

190 Please insert Table 1 near here

191 Please insert Table 2 near here

192

193 The descriptive statistics for TD, relative distance, HSR, the total number of sprints,
194 the mean length of sprint, total sprint distance, HR_{mean} and HR_{peak} per position and per half are
195 presented in Table 2. Results comparing positions during the full match showed that full backs
196 covered less TD than half backs ($p < 0.001$, Mean Difference [MD] -1703 m, 95% CI -2209/-
197 1196, ES = -1.73), midfielders ($p < 0.001$, MD -2004 m, 95% CI -2579/-1430, ES = -2.61) and
198 half forwards ($p < 0.001$, MD: -1583 m, 95% CI -2095/-1072, ES = -2.52). Full forwards
199 covered less TD than half backs ($p < 0.001$, MD: -1465 m, 95% CI -2057/-872, ES = -1.47),

midfielders ($p < 0.001$, MD: -1767 m, 95% CI -2419/-1114, ES = -2.26) and half forwards ($p < 0.001$, MD: -1346 m, 95% CI -7943/-748, ES = -2.09). Full backs covered lower relative distance than half backs ($p < 0.001$, MD: -28 m·min^{-1}, 95% CI -37/-20, ES = -1.72), midfielders ($p < 0.001$, MD: -33 m·min^{-1}, 95% CI -43/-24, ES = -2.64) and half forwards ($p < 0.001$, MD: -26 m·min^{-1}, 95% CI -35/-18, ES = -2.49). Full forwards covered less relative distance than half backs ($p < 0.001$, MD: -24 m·min^{-1}, 95% CI -34/-15, ES = -1.44), midfielders ($p < 0.001$, MD: -29 m·min^{-1}, 95% CI -40/-19, ES = -2.22) and half forwards ($p < 0.001$, MD: -22 m·min^{-1}, 95% CI -32/-12, ES = -1.99). Full backs covered 373 ± 126 m at HSR during the match, which was lower than half backs ($p < 0.001$, MD: -293 m: 95% CI -395/-191, ES = -1.89), midfielders ($p < 0.001$, MD: -339 m: 95% CI -454/-224, ES = -1.90) and half forwards ($p < 0.001$, MD: -314 m: 95% CI -418/-210: ES= -2.22). Half backs ($p < 0.001$, MD: 215 m, 95% CI 94/336, ES = 0.78), midfielders ($p < 0.001$, MD: 261 m, 95% CI 128/393, 0.93) and half forwards ($p < 0.001$, MD: 236 m, 95% CI 113/359, ES = 0.99) travelled greater HSR distance than full forwards. Full backs accumulated a lower total sprint distance ($p = 0.026$, MD: -54 m, 95% CI -104/-3.7, ES = -1.13) and total number of sprints ($p < 0.001$, MD: -5, 95% CI -9/-2, ES = -1.11) compared to half forwards. In addition, full forwards performed less number of sprints than half forwards ($p = 0.005$, MD: -4, 95% CI -8/-1, ES = -0.77). There was no difference ($p > 0.05$) between positions for the mean length of sprint, peak speed, HR_{peak} and HR_{mean} during the full match.

Please insert Figure 1 near here

Players spent a significantly higher percentage (60%) of match-time over 160 b·min^{-1} compared with time spent between 120-160 b·min^{-1} (34%, $p < 0.001$), 80 - 120 b·min^{-1} (5%, p

< 0.001) 50 - 80 b·min^{-1} (1%, p < 0.001) and < 50 b·min^{-1} (0%, p < 0.001). Figure 1 shows the percentage of time spent in each HR zone per half.

There were between-half decrements in TD, relative distance, HSR and total sprint distance for all positions with the exception of full forwards. Each position performed a lower number of sprints in the second half compared to the first (Table 2). There were no differences (p > 0.05) found between positions for the total number of sprints, HR_{peak}, and HR_{mean} in the second half (Table 2).

DISCUSSION

To the best of the authors' knowledge, the current study was the first to examine the match-play demands in elite U17 hurling across halves of play and between playing positions. The overall running performances for the full game were lower than found at elite senior hurling (8,31,33) level but similar to U21 level (32). *Small*-to-*moderate* decreases in TD, relative distance, HSR, total number of sprints, mean length of sprint, total sprint distance, HR_{mean} and HR_{peak} were observed between halves. In addition, during the full duration of match-play positional differences existed. Overall the half backs, midfielders and half forwards covered *moderately*-to-*very largely* greater TD, relative distance, HSR, total number of sprints and total sprint distance compared to full backs and full forwards. A similar trend was observed in both the first and second halves. However, no differences were found for the mean length of sprint, HR_{mean} or HR_{peak}. This information can be used to inform coaches of the match-play demands of U17 hurling, where age-appropriate training programs may be designed.

Independent of playing position, U17 hurling players covered lower TD and HSR than senior players (≈ 7617 m and ≈ 815 m respectively) (8). In addition, U17 players covered less HSR distance and total sprint distance compared to senior hurlers (≈ 759 m and ≈ 486 m respectively) (31). The ten minutes additional playing time between U17 (60 min) and senior (70 min) levels almost certainly explain the larger metrics being covered in senior hurling, since relative distance is similar to senior hurlers (≈ 109 $m \cdot min^{-1}$) (8). Indeed, with a comparable match duration (60 min), U21 hurlers covered similar TD (≈ 6688 m), relative distance (≈ 112 $m \cdot min^{-1}$), total sprint distance (≈ 274 m) and the total number of sprints (≈ 18) (32) to U17 players. Even though pitch size, number of players and playing rules are common between levels, there may be differences in the team tactics implemented at senior level. In addition, U17s tend to have a lower training frequency compared to senior hurlers (usually 2 *vs.* 4 field sessions per week). The additional training time that senior hurlers have can be used for improving their technical skills, developing a style of play and increasing their physical conditioning so that they are able to perform greater running performances compared to U17 hurlers. **Furthermore, it could be argued that these U17 players may have not experienced full physical maturation which could have limited their running performance compared to senior players.** The maximum speed in U17 was comparable to both senior (≈ 29.6 $km \cdot h^{-1}$) (8) and U21 (≈ 29.1 $km \cdot h^{-1}$) (32) hurlers. In hurling, the ball can travel long distances (> 50 m) (32) from one area of the pitch to another. Thus, players may have to sprint to another location of the pitch to catch up with the ball, to support their teammate or to chase after opponents when they are in possession. This available space to sprint may allow players to reach similar maximum speed.

Based on running performances, U17 hurling is a higher demanding sport compared to youth Gaelic football (10,22). The current findings showed that TD was higher than previously reported in youth Gaelic football at both under 15 (U15) (≈ 5732 m) (22) and U18 (≈ 5774 m) (10) levels. Total sprint distance was also higher in elite U17 hurling players than observed in U15 Gaelic footballers (≈ 198 m) (22), while a different sprint threshold was used for U18 (≥ 20 km·h^{-1}) (10) making a direct comparison difficult with the current study. Youth Gaelic football players performed a similar total number of sprints at both U15 (≈ 19) and U18 (≈ 18) levels, and similar HR_{mean} (≈ 166 b·min^{-1}) at the U15 level than the current study's findings (10,22). No HR_{mean} values were reported at U18 level, only as a percentage of HR_{peak}, making a direct comparison difficult (10). The comparable nature of invasion-type games where players have to sprint to gain possession in both hurling and football may explain the similarities between results. In contrast, the larger TD and total sprint distance observed U17 hurling compared to youth Gaelic football may be due to a difference in the speed and frequency of the ball travelling between halves. In hurling, the ball is hit with the hurley and can move quickly from one area of the pitch to another compared to the ball being carried by a single player in Gaelic football. This may engage more players in contesting for possession more frequently and may explain why U17 hurlers covered more TD and total sprint distance than youth Gaelic footballers.

Small-to-*moderate* decreases in TD, relative distance, HSR, total number of sprints, total sprint distance, mean length of sprint, HR_{mean} and HR_{peak} were found between first and second halves. Similarly, elite senior (7,8) and U21 (32) hurling players' TD, relative distance, HSR, total sprint distance, HR_{mean} and HR_{peak} performances deteriorated as the match progressed. Running performance decrements between halves are probably associated with

293 reductions in players' performance (21). These differences may be a result of fitness levels,
294 style of play or tactical ploys (8). In addition, fatigue has been previously suggested as a
295 possible cause of performance deterioration between halves, as substitutes performed greater
296 relative running demands than those who played the full duration of matches (6,21). The format
297 of the U17 Provincial championships requires teams to play four matches in five weeks, with
298 two teams having to play four consecutive weeks. In addition, two matches are played in three
299 weeks in the All-Ireland qualifier rounds following the Provincial final. This condensed fixture
300 schedule may also explain the drop-off in running performances in the second half (14).
301 Strategies that include the optimal time to make substitutions to reduce the overall drop-off in
302 running performance warrants further investigation. In soccer, the ability to maintain HSR (≥
303 18 $km \cdot h^{-1}$) was shown to be a critical aspect of performance (21) and match outcome (25).
304 Hurling training activities for U17 players need to include sufficient space to allow players to
305 achieve and maintain running speeds over 17 $km \cdot h^{-1}$ and 22 $km \cdot h^{-1}$, so they can be conditioned
306 to perform and repeat these efforts during match-play.

307

308 With respect to positional differences, the current study found that half backs,
309 midfielders and half forwards performed greater TD, relative distance and HSR compared with
310 full backs and full forwards. Similar between-position results for TD and relative distance were
311 found at U21 level (32). However, at senior level midfielders out-performed the other positions
312 in TD, HSR and total sprint distance (8). It was previously suggested that midfielders at senior
313 level move up and down the pitch to provide a "link" between backs and forwards (8). In
314 addition, the level of tactical awareness of the seniors might be more developed compared to
315 U17s. At senior level, midfielders move between attack and defense while half backs and half
316 forwards may read the game and hold their positions. In contrast, U17 half backs, midfielders

317 and half forwards may follow the ball rather than reading the play and anticipating where the
318 ball may go, thus running more. Previously, a pacing strategy was observed in team sports
319 (9,29) and has been suggested to be related to the training experience. Consequently, while
320 senior hurlers may have developed this pacing strategy, U17s may suffer from a lack of playing
321 experience. Therefore, this may have resulted in U17 hurlers performing unnecessary running.
322 Lastly, half forwards performed more sprints compared to full backs and a greater total sprint
323 distance than full backs and full forwards in the current study. During match-play, half
324 forwards are free to move to create space or gain possession, whereas full backs and full
325 forwards tend to stay closer to the goals to prevent scores and to score respectively. This
326 additional running area may have created the opportunity to cover more distance at maximal
327 intensity.

328

329 Full forwards were the only position that experienced no temporal decrements in TD,
330 relative distance, HSR and total sprint distance. In the current study, full forwards covered less
331 TD, relative distance, HSR distance during the full match than half backs, midfielders and half
332 forwards. This may explain why full forwards could repeat similar metrics in both halves.
333 Interestingly, although similar TD, relative distance, HSR and total sprint distance was found
334 in full backs and full forwards, only full backs experienced temporal decrements in the second
335 half. Full backs and full forwards mark each other during the match, thus why such a difference
336 exists is not clear. Further investigation into the number of ball possessions in full backs *vs.*
337 full forwards may highlight why full forwards are able to maintain their running performance
338 between halves. Moreover, it is acknowledged that the fitness profile of each position could
339 raise further differences in the physical abilities between full forwards and full backs, this needs
340 additional investigation.

341

342 Quantifying HR has been used to assess the intensity of the exercise performed during
343 matches (1,4,12,32,33). Interestingly, even though match running performances differ between
344 U17 and elite senior hurlers, the results from the current study reported similar HR_{mean} (≈ 163
345 $b \cdot min^{-1}$) (7). However, consideration must be made as the absolute HR_{mean} recorded presently
346 and in senior hurlers may correspond to different relative HR_{mean}, given the difference in age.
347 Similar HR_{mean} findings were observed in elite youth Gaelic football players (≈ 166 $b \cdot min^{-1}$)
348 (22). The stop-start activity, catching the ball, contesting with opponents for possession and
349 scoring are similar in both hurling and Gaelic football. This may explain the similarities in
350 HR_{mean} at both games. However, U17 hurlers' HR_{mean} is lower than found in similar age-graded
351 soccer players (174 $b \cdot min^{-1}$) (5). The playing numbers (soccer 11 *vs.* hurling 15), pitch size
352 (110 m x 70 m *vs.* 140 m x 90 m) and the additional ten minutes of match duration in soccer
353 may account for these differences. The current findings showed no difference in HR_{mean}
354 between positions. Even though TD and HSR distance were different between positions, the
355 players covered similar sprint distance and number of sprints. Since the HR is elevated
356 following a sprint effort and may remain high afterwards, the similar sprint distance covered
357 may be hypothesized to account for the comparable HR_{mean} between positions. The percentage
358 of match-time spent over 160 $b \cdot min^{-1}$ was greater than the time spent in any other HR zone.
359 This is comparable to elite youth Gaelic football players (61%) (22) and U21 hurlers (65%)
360 (32). Interestingly, redistribution in the time spent within each HR zone was observed between
361 each half. Indeed, compared to the first half, the players spent a lower amount of time in the
362 top HR zone and increased the time spent in the bottom four HR zones in the second half. This
363 is coupled with the decrements in TD, relative distance, HSR distance, the number of sprints,
364 the mean length of sprint and total sprint distance in the second half. Conditioning the players

365 to tolerate the fatigue-induced responses might mitigate the decrements in running performance
366 over time.

367

368 The present study comes with some acknowledged limitations. Firstly, although the
369 match time was 60 min, the number of stoppages and therefore the duration for which the ball
370 was in-play was not considered. Further studies should account for both absolute and ball-in-
371 play time as this may display higher relative match-play demands. Secondly, the number of
372 ball possessions per position were not included in the present study. Some playing positions
373 may have accumulated more possessions and thus been involved in the play more than other
374 positions. This could have had a knock-on effect on the running performance and HR values.
375 The current study did not assess the players' maximal HR during a test. Therefore, HR_{peak}
376 results in this study are game-related and may not represent the players true HR_{peak}. Further
377 studies should use the players' actual HR_{peak} and compare it with their HR_{peak} during match-
378 play to indicate of how close the players are exercising to their maximal effort. Finally, the
379 current study did consider the impact of match outcome on the running performances and HR
380 values. Previously, Gaelic football players were observed to cover greater distances in games
381 that ended in draws or narrow score margins (20). Future studies need to include this factor
382 when assessing the match-play demands of competition.

383

384 **PRACTICAL APPLICATIONS**

385 An appropriate conditioning program needs to be put in place for U17 hurlers to
386 progress them to the greater demands at senior level. Notably, these age-graded players are
387 used to participating in friendly and official matches for the full year, specifically moving from

388 school- to combining sub-elite- and elite- and then again back to school-competitions. This
389 limits the time available for conditioning. Therefore, a dedicated training period should take
390 place to prepare them for the match-play demands of competition. This focused training period
391 could also limit the temporal decrements between halves. Particularly, half backs, midfielders
392 and half forwards have been shown to outperform full backs and full forwards. Consequently,
393 these middle three positions need further conditioning to meet the higher match-play demands.
394 In addition, consideration needs to be made about positional changes and timing of substitutes
395 to ensure the players in the most physically demanding positions sustain the levels of physical
396 performance required. Finally, hurlers spend more time over 160 $b \cdot min^{-1}$ during a match.
397 Therefore, activities that aim to replicate the match-play demands should monitor HR
398 throughout and limit the duration of stoppages between training activities so that HR can
399 remain high. This knowledge of the match-play running performances and HR values will
400 allow coaches and conditioners to design specific training programs to prepare elite U17 hurlers
401 for the demands of competition. In addition, the current results can help coaches compare U17
402 competition with U21 and senior match-play demands, which can then be used to transition
403 players between competition levels.

404

405

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Figure captions

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

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

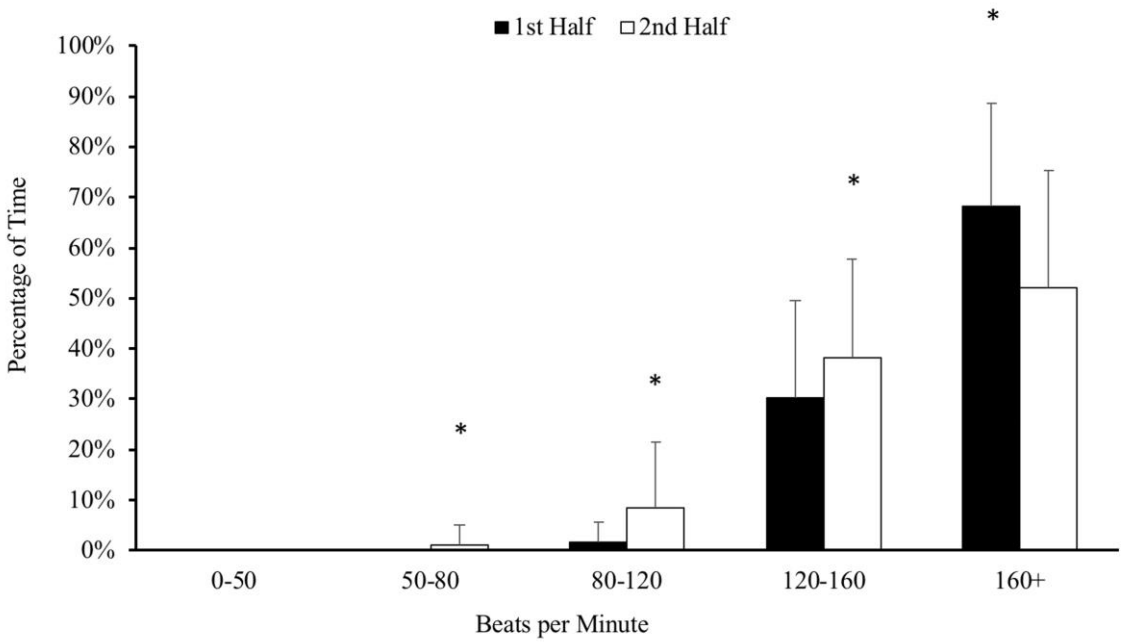

Table 1: The total, first and second half running and HR values. Data are presented as mean ± SD, difference (95% CI) and effect size

	Total	1st Half	2nd Half	Difference 95% CI	Effect Size
Total Distance (m)	6483 ± 1145	3486 ± 728	3007 ± 586 *	-436 (-525 to -347)	0.72
Relative Distance ($m \cdot min^{-1}$)	108 ± 19	116 ± 24	100 ± 20 *	-14 (-18 to -12)	0.72
High-Speed Running (m)	583 ± 215	329 ± 132	263 ± 108 *	-62 (-77 to -47)	0.55
Number of Sprints (n)	18 ± 6	10 ± 4	8 ± 3 *	-2.3 (-2.8 to -1.9)	0.57
Mean Length of Sprint (m)	15 ± 3	16 ± 4	15 ± 4 *	-1.0 (-1.8 to -0.2)	0.25
Total Sprint Distance (m)	272 ± 77	153 ± 50	121 ± 43 *	-32 (-40 to -24)	0.69
HR_{mean} ($b \cdot min^{-1}$)	167 ± 4	168 ± 4	166 ± 7 *	-1.7 (-2.4 to -1.0)	0.35
HR_{peak} ($b \cdot min^{-1}$)	194 ± 8	193 ± 6	189 ± 9 *	-3 (-5 to -3)	0.52

TD = Total distance, HSR = High speed running, HR = Heart rate, HR_{peak} = Peak heart rate, HR_{mean} = Average heart rate, CI = Confidence interval.

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

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

		Full Backs	Half Backs	Midfield	Half Forwards	Full Forwards
Total Distance (m)	Total	5342 ± 792	7044 ± 1145 [a]	7346 ± 742 [a]	6925 ± 399 [a]	5580 ± 817 [bcd]
	1st Half	2792 ± 368	3787 ± 909	3821 ± 360	3955 ± 299	2874 ± 333
	2nd Half	2550 ± 542 *	3257 ± 538 *	3525 ± 413 *	3013 ± 224 *	2705 ± 645
	Diff (95% CI)	-242 (-423 to -61)	-531 (-704 to -357)	-296 (-516 to -76)	-941 (-1119 to -764)	-169 (-406 to 68)
	ES	-0.52	-0.71	-0.76	-3.57	-0.33
Relative Distance (m·min^{-1})	Total	89 ± 2	117 ± 19 [a]	122 ± 12 [a]	115 ± 7 [a]	93 ± 14 [bcd]
	1st Half	93 ± 12	126 ± 30	127 ± 12	132 ± 8	96 ± 11
	2nd Half	85 ± 18 *	109 ± 18 *	118 ± 14 *	100 ± 7 *	90 ± 22
	Diff (95% CI)	-8 (-14 to -2)	-16 (-23 to -12)	-9 (-17 to -3)	-31 (-37 to -25)	-5 (-14 to 2)
	ES	-0.52	-0.69	-0.69	-4.26	-0.35
High-Speed Running (m)	Total	373 ± 126	666 ± 180 [a]	712 ± 218 [a]	687 ± 155 [a]	451 ± 140 [bcd]
	1st Half	206 ± 68	383 ± 109	399 ± 134	394 116	244 ± 82
	2nd Half	167 ± 85 *	283 ± 106 *	314 ± 107 *	328 ± 68 *	225 ± 72
	Diff (95% CI)	-39 (-70 to -9)	-101 ± (-130 to -71)	-85 (-122 to -48)	66 (-97 to -35)	-19 (-59 to 21)
	ES	-0.51	-0.93	-0.70	-0.69	-0.25
Number of Sprints	Total	15 ± 3	18 ± 6	18 ± 5	21 ± 7 [a]	16 ± 6 [d]
	1st Half	9 ± 2	10 ± 5	11 ± 3	12 ± 4	9 ± 3
	2nd Half	7 ± 1 *	8 ± 3 *	7 ± 3 *	9 ± 3 *	7 ± 4 *
	Diff (95% CI)	-1.9 (-2.9 to -0.9)	-1.6 (-2.5 to -0.7)	-3.5 (-4.7 to -2.3)	-3.3 (-4.3 to -2.3)	-1.4 (-2.4 to -0.3)
	ES	-1.27	-0.49	-1.33	-0.85	-0.57
Mean Length of Sprint (m)	Total	14 ± 2	15 ± 2	16 ± 4	16 ± 3	16 ± 2
	1st Half	15 ± 4	16 ± 3	16 ± 5	17 ± 4	14 ± 3
	2nd Half	14 ± 4	15 ± 3	14 ± 2 *	14 ± 4 *	17 ± 6 *
	Diff (95% CI)	-1.3 (-2.8 to 0.2)	-1.5 (-3.0 to 0.0)	-2.3 (-4.4 to -0.2)	-3.5 (-5.4 to -1.6)	3.4 (1.5 to 5.3)
	ES	-0.25	0.33	-0.53	-0.75	0.63
Total Sprint Distance (m)	Total	242 ± 33	273 ± 95	294 ± 91	296 ± 59 [a]	263 ± 81
	1st Half	132 ± 18	155 ± 67	176 ± 51	167 ± 34	140 ± 50
	2nd Half	109 ± 21 *	117 ± 52 *	132 ± 46 *	128 ± 31 *	126 ± 56
	Diff (95% CI)	-23 (-39 to -7)	-38 (-54 to -23)	-44 (-64 to -24)	-39 (-58 to -21)	-14 (-36 to 7)
	ES	-1.18	-0.63	-0.91	-1.20	-0.26
HR_{mean} (b·min^{-1})	Total	168 ± 4	167 ± 4	167 ± 3	167 ± 4	166 ± 2
	1st Half	168 ± 4	169 ± 4	169 ± 3	167 ± 5	166 ± 3
	2nd Half	167 ± 5	165 ± 5 *	166 ± 5 *	167 ± 5	165 ± 3
	Diff (95% CI)	-0.8 (-2.4 to 0.7)	-3.9 (-5.4 to -2.4)	-2.1 (-3.9 to -0.2)	-0.8 (-2.5 to 0.8)	-0.9 (-2.6 to 0.9)
	ES	-0.22	-0.88	-0.73	-0.00	-0.33
HR_{peak} (b·min^{-1})	Total	196 ± 6	194 ± 10	194 ± 6	192 ± 6	191 ± 8
	1st Half	195 ± 6	192 ± 4	194 ± 6	191 ± 6	190 ± 8
	2nd Half	189 ± 8 *	190 ± 10	188 ± 6 *	190 ± 7	185 ± 12 *
	Diff (95% CI)	-5.9 (-8.6 to -3.2)	-1.4 (-4.1 to 1.3)	-5.5 (-8.8 to -2.2)	-1.5 (-4.3 to 1.3)	-5.1 (-8.1 to -2.1)
	ES	-0.85	-0.26	1.00	-0.15	-0.49

HR = Heart rate, HR_{peak} = Peak heart rate, HR_{mean} = Average heart rate, Diff = Difference, CI = Confidence interval, ES = Effect size

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* 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 midfielders

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