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The Running Performance of Elite Ladies Gaelic Football with Respect to Position and Halves of Play

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RESEARCH

The running performance of elite ladies Gaelic football with respect to position and halves of play

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Abstract

Purpose The current investigation aimed to examine the running performance of elite Ladies Gaelic football (LGF) match-play and establish the within game positional profile, in addition to the running performance of players across halves of play.

Methods GPS technology was used to examine the running performance of thirty-three ($n = 33$) elite LGF players (age; 23 ± 5 years, height; 173 ± 5 cm, body mass; 63 ± 4 kg). Across the duration of the observational period, one hundred and thirty-one ($n = 131$) individual samples were collected over 15 competitive matches. Data were classified based on positional line and across halves of play. Running performance was determined across the following performance variables of total distance covered (m) (TD), relative distance ($m \cdot min^{-1}$), HSR ($\geq 4.4\ m \cdot s^{-1}$), RHSR (HSR; $m \cdot min^{-1}$), percentage HSR (% HSR), VHSR ($\geq 5.5\ m \cdot s^{-1}$), peak velocity ($m\ s^{-1}$), percentage peak velocity (% PeakV), accelerations ($n; \geq 3\ m \cdot s^{-2}$) and decelerations ($n; \leq -3\ m \cdot s^{-2}$),

Results Independent of position the mean distance covered during match play was 7319 ± 1021 m which equates to a relative work rate of $116 \pm 9\ m \cdot min^{-1}$. The high-speed distance of players was 1547 ± 432 m, which equates to a relative high-speed running distance of $25 \pm 11\ m \cdot min^{-1}$. The maximal velocity of players was $7.17 \pm 0.41\ m \cdot s^{-1}$ reflective of a relative maximal velocity of 86 ± 4 percent. The greatest distances were covered by half-backs, midfielders, and half-forwards, with these positions covering significantly greater distances than full-backs ($p \leq 0.05$; ES: 0.59–1.25; small-moderate) and full-forwards ($p \leq 0.05$; ES: 0.44–1.21; small-moderate). While TD and maximal velocity was shown not to change across halves of play, significant reductions ($p \leq 0.05$) were observed across HSR (ES: 0.64–1.02; moderate), accelerations and decelerations (ES: 0.59–1.20; moderate).

Conclusion The current investigation is the first of its kind within elite LGF, the data within the investigation can aid the coaching process by allowing for the development of sport-specific training regimen specific to the positional needs of elite LGF players.

Keywords Intermittent Team Sport · Positional demands · High speed running · GAA

Introduction

Gaelic football is one of the national sports of Ireland and can be characterized as a high intensity, intermittent field-sport [1]. The game is composed of repeated high intensity actions superimposed across periods of lower intensity activities such as walking, jogging, or standing [2, 3]. Playing teams consist of fifteen players made up of a goalkeeper, three full backs, three half backs, two midfielders, three half forwards and three full forwards, with an option of management to utilize up to 5 substitutions per competitive game [4]. Ladies Gaelic football (LGF) match-play consists of two halves of 30 min in duration. The game is played on a pitch

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measuring ~ 90-m wide and ~ 130–165 m long [5, 6] with H shaped goal posts at either end of the field [3]. If the ball is kicked over the bar one point is awarded, if the ball is kicked under the bar and into the back of the net, three points are awarded, and a goal is scored. LGF is played with both hand and foot with the ball transferred between players through kicking long or short or handpassing to a teammate. The sport can be seen as an invasion team sport with the aim of outscoring the opposition through gaining and maintaining possession to create scoring opportunities [5, 6]. Typical movements executed during a game play include kick passing, handpassing, jumping, catching, bouncing, blocking, tackling, solo running, sprinting, and changing direction [3, 6].

While the game is similar in structure to the male version of the game [6] some notable differences are seen between both variants of competition. LGF games are shorter in duration with match-play time controlled by a specific countdown timer. There is no bodily contact allowed within LGF. Kickouts are allowed to be taken out of the hand or off the ground at the 13 m line after a wide or at the 21 m line after a score. If a 45 m kick is scored over the bar, two points are awarded. Another distinct difference to the men's game is that the ball can be picked directly off the ground by hand [7]. Although LGF has an amateur status, the structure of the sport is comprised of elite (inter-county) and sub-elite (club) levels of play. Elite LGF players can complete up to five pitch-based conditioning or resistance training sessions per week in addition to pre-and post-game match analysis meetings ahead of any competitive match, ultimately these players must balance their competitive commitments within their personal and working lives [4].

Currently there is a notable dearth of literature related to the match-play running performance during competition across LGF. This has resulted in coaches comparing the running performance of LGF to the male version of the game given the increased level of literature on the male game [6, 5, 8]. However, it is difficult to elucidate the demands of females to males due to factors such as gender, physiological profile, and rule variations [7, 9]. Due to this lack of research most ladies Gaelic football coaches tend to base their training process around methodologies or the running performance profiles of similar female sports such as camogie [10], AFL [11], and soccer [4, 12]. Ultimately, it is questionable whether these practices condition players appropriately to meet the skill, playing rules, number of players and duration that are all unique to LGF, given the lack of specific understanding related to the sporting or positional demands of LGF. This may result in players not being optimally prepared for the running requirements of competitive match-play [10]. Consequently, quantifying the running performance requirements of match-play can provide a detailed profile of the match-play positional differences in running requirements that may aid training content construction within the sport.

While LGF has been neglected in terms of literature there has been an abundance of research regarding the men's game which have found positional differences in the running demands of the sport [5, 6, 8, 13–16]. Consistently across these investigations the central positions (half back, midfield, half forward) have been shown to cover the greatest distances and have the greatest decline in running performance across halves [13] and quarters [14]. Similar trends regarding specific positional profiles, and decrements in running performance exist across other female sports such as soccer [12], field hockey [17–19], camogie [10, 20] and AFL [21]. However, to date no descriptive data across LGF match-play exist. Therefore, coaches are planning training content without being able to complete an appropriate needs analysis of the sporting requirements of match-play [22]. Hence, there appears to be a need for original research to illuminate these demands across competitive match-play within LGF.

Global positioning system (GPS) technology is now commonplace within elite LGF teams. Match running performance data helps to inform training practice. This provides coaches with the distances and intensities needed within specific training drills to prepare players to meet the demands of competition [1, 14, 15]. Previous literature across multiple sports has shown that position has a significant impact on the demands of match-play [5, 6, 14, 16]. Position specific understanding related to training drill construction would appear key in the preparation of elite LGF players. Given the lack of sports science research regarding LGF, it is difficult for coaches to make evidence-based choices regarding the replication of game-based running performance within training as the literature does not yet exist [7]. Research is needed to provide a better understanding for coaches so these stakeholders can make informed decisions regarding training construction [7]. These investigations would provide accurate, reliable, and relatable data that could eliminate guess work and coaching intuition or personal experiences when designing training as is common within Gaelic sports. Furthermore, the collection of data will support the development of female team sports with increased understanding around the physical requirements of match-play [4]. Creating a running performance profile for LGF could allow for data informed conditioning practices to ensure that players are exposed to adequate running demands within training, to allow them to meet the demands of match-play consistently across a competitive calendar [10, 20].

Therefore, the aim of the current investigation is to establish the positional running performance profile for elite LGF. It is hoped that the establishment of these running performance demands can aid the training process and provide some normative values for running performances

across match-play to coaches. We hypothesized that the middle three positions will cover the greatest distances across match-play with a temporal profile expected across halves.

Methods

Experimental approach to the problem

The current longitudinal study examined the running performance of elite LGF match-play regarding positions and halves using portable GPS technology. Elite LGF players were monitored in competitive Gaelic football matches across two season period, the 2021–2022 season (Jan 2021–March 2022) with National League, Challenge, and All-Ireland championship games included within the analysis. Across the duration of the observational period, one hundred and thirty-one ($n = 131$) individual samples were collected over 15 competitive matches. Only instances where a player was not substituted, remained in the same playing position, and completed a full game (~ 60 min) were included within the final analysis. Data were collected on players 1–15 times per player with each player tracked on average 8 times across the investigation period. Furthermore, data were classified according to the position of play during each specific match, producing the following number of samples per playing position full-back ($n = 31$), half-back ($n = 32$), midfield ($n = 22$), half-forward ($n = 24$) and full-forward ($n = 22$). All matches took place between 11:00 and 19:00 h. Temperatures during match-play ranged from 7 to 18 °C. The GPS data were used to determine key running performance variables during elite LGF match-play. During the investigation period matches took place on weekends with players completing a resistance training and two pitch sessions in the week leading up to competition. To aid performance, players were advised to adhere to recovery and nutritional protocols ahead of match. All players were instructed to refrain from strenuous physical activity 24 h prior to competition, increase their consumption of carbohydrates, lean proteins, and water, in line with typical pre-event nutritional practices within elite LGF teams.

Subjects

Thirty-three ($n = 33$) elite LGF players with a mean ± SD, age (24 ± 5 years), height (170 ± 5 cm) and body mass (63 ± 4 kg) volunteered to participate in the study. Players were selected as they were current members of the county's squad for each respective season and were, therefore, deemed the most elite female players in the respective team's county at the time of analysis. Following ethical approval, participants were informed about the purpose, procedures, and benefits of the study. Written informed consent was obtained from all participants in line with the guidelines set by the local institution's research ethics committee (Technological University of Dublin, Dublin, Ireland).

Experimental procedure

During each game, participants wore an individual GPS unit (PlayerTek Pod; 10-Hz; Catapult Sports; Melbourne; Australia; Firmware: J3.20) sampling at 10-Hz and containing a triaxial accelerometer. The GPS unit (mass: 42 g; 84 mm × 42 mm × 21 mm) was placed within a protective pocket sewn into the jersey, between the player's shoulder blades. Prior to match-play data collection, participants performed a maximal velocity assessment as part of their pre-season testing battery, players performed maximal velocity efforts across a 40 m linear track to identify each players peak velocity ($m \cdot s^{-1}$). During the assessment players wore their assigned GPS unit with this data used to provide a percentage peak velocity (% Peak V) for players within match-play. Prior to the commencement of each match the devices were activated, and satellite lock established for a minimum of 15 min [23]. The validity and reliability of this specific device has been communicated within the published literature previously, with acceptable validity and reliability reported for the respective unit utilized within the current investigation [24, 25].

Following each competitive game, all GPS data were downloaded and analyzed retrospectively. GPS data were downloaded using proprietary software (PlayerTek Team Application; V2.5.5; Catapult Sports; Melbourne; Australia). Each player file was trimmed so that only data recorded when the player was playing were included for analysis, with the proprietary software providing raw velocity data at 0.10 s intervals. These data points were then sub-classified into halves. Data were exported into a customized Microsoft Excel spreadsheet (Microsoft, Redmond, WA, USA). The spreadsheet allowed analysis and presentation of total distance covered (m; TD), relative distance ($m \cdot min^{-1}$), High-speed running (HSR; m; ≥ 4.4 $m \cdot s^{-1}$), relative HSR (HSR; $m \cdot min^{-1}$), percentage HSR (% HSR), Very high-speed running (VHSR; m; ≥ 5.5 $m \cdot s^{-1}$). The above running performance thresholds were selected as they are common within LGF and have also been previously reported within female team sports literature [17–19]. PlayerLoad (PL; AU) was also analyzed across the duration of the study with this being defined as the rate of instantaneous change in accelerometer data across the three planes of movement [26]. Finally, peak velocity ($m\ s^{-1}$), percentage peak velocity (% Peak V), accelerations (n; ≥ 3 $m \cdot s^{-2}$) and decelerations

(n; ≤ − 3 m·s^{-2}) were also analyzed across the longitudinal period.

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 normality of the distribution of the data was checked by the Shapiro–Wilk's test and results were found to be normal. The analysis was performed using a two-way (position × half) mixed design (ANOVA). When an interaction occurred, a Bonferroni post hoc correction was used to detect differences between positions (five levels: full backs, half backs, midfielders, half forwards, full forwards) and playing halves (two levels: first and second half). The dependent variables across the range of analysis were, total distance covered (m) (TD), relative distance (m·min^{-1}), HSR (≥ 4.4 m·s^{-1}), Relative HSR (m·min^{-1}), percentage HSR (% HSR), PL (AU), VHSR (≥ 5.5 m·s^{-1}), peak velocity (m s^{-1}), percentage peak velocity (% PeakV), accelerations (n; ≥ 3 m·s^{-2}) and decelerations (n; ≤ − 3 m·s^{-2}), with match periods and playing positions as independent variables. Standardized effect sizes (ES) were calculated and interpreted with ≤ 0.20: trivial, 0.21–0.60: small, 0.61–1.20: moderate, 1.21–2.00: large and 2.01–4.00: very large as recommended by Hopkins [27]. Statistical significance was set at an accepted level of $p \leq 0.05$. Data are presented as mean, standard deviation (± SD), and 95% confidence intervals (95% CI).

Results

Selected running performance variables across match-play and halves of play are shown in Table 1. Independent of position the mean distance covered during match play was 7319 ± 1021 m, which equates to a relative work rate of 116 ± 9 m·min^{-1}. The high-speed distance of players was 1547 ± 432 m, which equates to a relative high-speed running distance of 25 ± 11 m·min^{-1}. Players completed 20.6 ± 5.4% of match-play at high-speed, respectively, with players shown to complete 630 ± 287-m of very-high-speed running during match-play. Players undertook 42 ± 6 accelerations and 53 ± 9 decelerations, which equates to a relative acceleration number of 0.65 ± 0.14 a·min^{-1} and 0.84 ± 0.14 d·min^{-1}. The maximal velocity of players was 7.17 ± 0.41 m·s^{-1} reflective of a relative maximal velocity of 86 ± 4 percent.

The positional differences across match-play running performance are reported in Table 2. The results of post hoc analysis on reported main effects for playing position and playing half are presented in Table 2 and Fig. 1, respectively. For TD significant main effects were estimated for playing position ($F = 26.013$, $p < 0.001$). The greatest TD were covered by half-backs, midfielders, and half-forwards, with these positions covering significantly greater distances than full-backs (ES: 0.59–1.25; small-moderate), and full-forwards (ES: 0.44–1.21; small-moderate) ($p < 0.05$). For HSR and VHSR significant main effects were estimated for playing position ($F = 31.109$, $p < 0.001$; $F = 3.327$, $p < 0.001$). The greatest HSD were covered by half-backs, midfielders, and half-forwards, with these positions covering significantly greater distances than full-backs (ES: 1.33–2.02;

Table 1 The running performance profile of elite Ladies Gaelic football match play with respect to halves of play

	Full Game	1st Half	2nd Half	Diff (95% CI)	**ES (Inference)**
Running performance variables					
Total distance (m)	7319 ± 1021	3753 ± 511	3566 ± 356	− 187 (− 50 to − 213)	0.42 (*Small*)
Relative distance (m·min^{-1})	116 ± 9	117 ± 9	115 ± 12	− 2 (− 3 to − 8)	0.19 (*Trivial*)
High speed distance (m)	1547 ± 432	788 ± 132	759 ± 90*	− 29 (− 20 to − 145)	0.25 (*Small*)
Relative high-speed distance (m·min^{-1})	25 ± 11	26 ± 14	24 ± 10*	− 2 (− 4 to − 5)	0.16 (*Small*)
High speed running percentage (% HSR)	20.6 ± 5.4	20.9 ± 6.4	19.7 ± 2.4	− 1.2 (− 1.3 to − 2.4)	0.25 (*Small*)
Very high speed distance (m)	630 ± 287	332 ± 78	299 ± 54*	− 33 (− 18 to − 67)	0.49 (Small)
Maximal velocity (m·s^{-1})	7.17 ± 0.41	7.14 ± 0.61	7.08 ± 0.21	− 0.94 (− 0.34 to − 1.21)	0.14 (*Trivial*)
% Maximal velocity	86 ± 4	87 ± 3	86 ± 5	− 1 (− 4 to − 5)	0.24 (*Small*)
Accelerations (≥ 3 m·s^{-2})	42 ± 6	22 ± 3	20 ± 7*	− 2 (− 7 to − 12)	0.37 (*Small*)
Decelerations (≤ 3 m·s^{-2})	53 ± 9	27 ± 5	26 ± 10	− 1 (− 13 to − 21)	0.12 (*Trivial*)
PlayerLoad (AU)	313 ± 40	145 ± 44	168 ± 49*	26 (9–58)	-0.49 (*Small*)

Data is reported as mean ± SD, mean difference (90% CI) and effect size

Diff Difference, *CI* Confidence interval, *ES* Effect size

*Significant difference between 1st and 2nd halves of play ($p \leq 0.05$)

Table 2 The positional running performance profile of elite Ladies Gaelic football match play. Data is reported as mean ± SD

	Full back	Half back	Midfield	Half forward	Full forward
Total distance (m)	6764 ± 919[bd]	7766 ± 804[d]	7832 ± 722[ade]	7300 ± 873	6934 ± 760[bd]
Relative distance (m·min^{-1})	106 ± 14[bd]	123 ± 12[d]	124 ± 10[ade]	116 ± 12	110 ± 11[bd]
High speed distance (m)	1191 ± 321[bde]	1643 ± 359	1874 ± 352[abde]	1650 ± 365	1377 ± 276[bd]
Relative high-speed distance (m·min^{-1})	19 ± 5[bde]	26 ± 6	30 ± 6[ade]	26 ± 4	22 ± 5[bd]
High speed running percentage (% HSR)	17 ± 4[bde]	21 ± 3	24 ± 3[ade]	21 ± 4	20 ± 2
Very high speed distance (m)	413 ± 121[bde]	594 ± 184d	902 ± 180[abde]	634 ± 151	611 ± 197
Maximal velocity (m·s^{-1})	6.94 ± 0.40	6.98 ± 0.32	7.45 ± 0.22	7.32 ± 0.36	7.17 ± 0.28
% Maximal velocity	84 ± 3	87 ± 4	88 ± 4	86 ± 2	87 ± 4
Accelerations (≥ 3 m·s^{-2})	47 ± 6[c]	40 ± 5	38 ± 5	41 ± 7	47 ± 8[c]
Decelerations (≤ 3 m·s^{-2})	54 ± 5[c]	51 ± 4[c]	44 ± 3	56 ± 5[c]	59 ± 6[c]
PlayerLoad (AU)	286 ± 41[bcd]	332 ± 37	332 ± 39	331 ± 44	287 ± 36[bcd]

[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
[e]Significantly different ($p < 0.05$) from full forwards

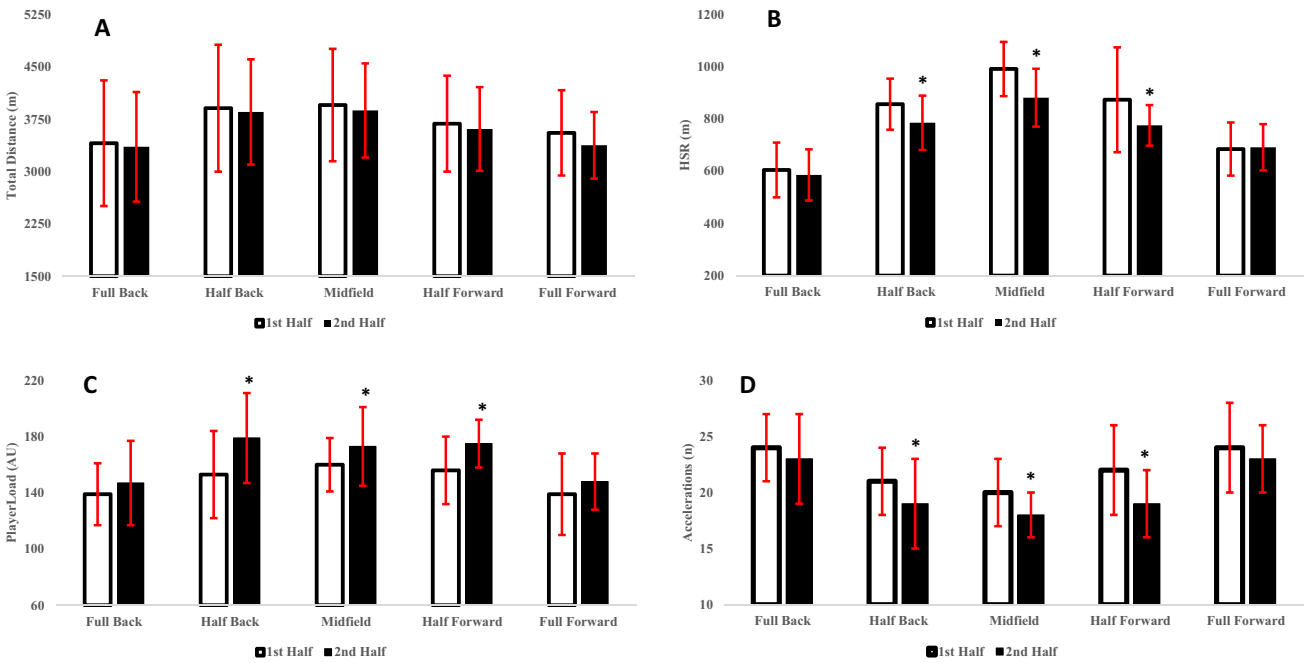

Fig. 1 The positional running performance profile of elite Ladies Gaelic football match play with respect to **A** Total Distance, **B** high-speed running (m; ≥ 4.4 m·s^{-1}), **D** PlayerLoad, **D** Accelerations (n; ≥ 3 m·s^{-2}), across halves of play. Data is reported as mean ± SD. *Significant difference between 1st and 2nd halves of play p (≤ 0.05)

moderate-large), full-forwards (ES: 0.85–1.59; moderate-large) ($p < 0.05$). When VHSR was considered, midfielders covered significantly greater distances when compared to other positions (ES: 1.61–3.18; large-very large) ($p < 0.05$). Non-significant differences were reported across positions for maximal speed and percentage maximal speed. Finally, half-backs, midfielders and half-forwards were observed to accumulate more PL across match-play when compared to other positions ($p < 0.05$).

Figure 1 depicts the temporal changes in TD, HSR, PL and Accelerations by playing half. No differences were observed across TD across halves of play for all positions ($p \geq 0.05$; ES: 0.09–0.16; trivial). HSR was shown to be lower in the second half for half backs (ES: 0.70; moderate),

midfielders (ES: 1.02; moderate), and half forwards (ES: 0.64; moderate), respectively, with no other differences reported with respect to positional decrements. VHSR was showed similar trends for being lower in the second half for half backs (ES: 0.83; moderate), midfielders (ES: 1.32; large), and half forwards (ES: 0.69; moderate). Accelerations and decelerations also decreased across halves of play for the middle-three positional lines ($p < 0.05$; ES: 0.59–1.20; moderate). Increases in PL were observed across all positions during match-play ($p < 0.01$; ES: 0.45–2.11; moderate-large). Furthermore, non-significant *trivial* effects were reported for maximal velocity and percentage maximal velocity for all positions across match-play.

Discussion

Despite the plethora of GPS research in the male versions of Gaelic team sports, research in female Gaelic team sports is still at the embryonic stage [4]. Therefore, the aim of the current investigation was to examine the running performance of elite LGF match play. While further establishing the within game positional profiles of match-play and understanding the temporal running profiles across halves of play. We hypothesized that the middle three positional lines (half back, midfield, and half forward) would cover the greatest distances across match play with increased reductions in running performance across these positions expected across halves. It is hoped that by establishing running demands and normative values for LGF, that coaches can utilize these data to design position specific drills within training, to better prepare the players for the specific running profiles of match-play. The main findings from the current investigation are that, independent of position, the mean distance covered during match play was 7319 ± 1021 m with players completing 1547 ± 432 m over the assigned HSR threshold, equating to a relative total and HSR running intensity of 116 ± 9 m·min^{-1} and 25 ± 11 m·min^{-1}, respectively. These data show that players complete 20.6 ± 5.4% of match-play above the HSR threshold set within the investigation. Furthermore, when considering the mechanical demands of competition, players undertook 42 ± 6 accelerations and 53 ± 9 decelerations, which equates to a relative acceleration number of 0.65 ± 0.14 a·min^{-1} and 0.84 ± 0.14 d·min^{-1}. Finally, players maximal velocity was shown to be on average 7.17 ± 0.41 m·s^{-1} reflective of a relative peak velocity of 86 ± 4 percent. Further, we have shown reductions in running performance across halves of play for multiple running performance indices during match-play. To the authors knowledge this is the first investigation to provide these data across the LGF training process, with these data now providing a normative data to coaching staff.

As hypothesized the middle three positional lines covered the greatest TD, HSR, VHSR during match play. These positions were also seen to accumulate more PL across match play, when compared to full forwards and full backs. While reported for the first time within Ladies football within the current investigation, the above trends for specific positional profiles being present within team sports is not a surprising finding and is common within most competitive team sport games [12–14, 17, 21, 28]. Within Gaelic football, the middle three lines of play, are anecdotally termed as the "transitional lines"; indeed, these lines of half back, midfield and half forward are typically involved in both attacking and defensive plays during match-play, as such they move up and down the pitch in tandem with attacking and defensive situations of play. This may be related to these positional lines accumulating increased running distances. Overall, the data presented are in line with previous data from elite level of Gaelic football and hurling [3, 8, 7, 10, 13, 14]. While not examined within the current study, specific tactical set-ups of teams, have shown full-backs and full-forwards tend to be specifically assigned player specific marking duties, as such full-forwards and full-backs exert similar running performance profiles as shown within the current investigation. Furthermore, full-backs have previously been shown to cover less running across match play within elite male, Gaelic football match-play, similar in nature to the current investigation. This may be related to specific tactical decisions by coaches to encourage a sweeper (plus one) defensive system, whereby the center half-back (number 6) or half-forward (number 10 or number 12) assists the full-back line. This reduces the running demands of full-backs, while increasing the running requirements of half-forwards, overall advancements in tactical setups of teams have been seen within LGF, but it is yet to be elucidated if these profiles will increase given the push towards a more holistic tactical set-up for positions of play to provide outlets for each other in attacking and defensive situations.

When the temporal profile of match-play was considered, the data showed no changes in TD covered across halves for all positions. High speed running was found to decline across halves for the central three positional lines, in addition to very high-speed running. From a mechanical perspective the number of accelerations and decelerations these central players engaged in also declined as match play progressed. These data suggest that coaches need to have a plan on how best to expose these players to appropriate acceleration and deceleration-based training, given the known eccentric and concentric muscular damage caused by these actions, and there repetitive nature during competitive match-play [29]. The data within the current investigation may indicate that the tactical roles of specific positions elicit greater running demands, compared to the inside lines resulting in increased fatigue, or specific

pacing strategies being employed related to specific passages of play. These differences in the demands of playing positions are like what has been previously reported for elite senior male match-play, whereby full-back and full-forward positions covered significantly less total and HSD than all other positions [8, 7, 13, 14, 16]. Further positional profiles have been shown within multiple female sports [7, 12, 18–21, 24]. Our data show that reductions in running performance are present across halves of play. These suggests that players tend to experience an initial decrement in running performance when the game is considered across halves of play, but it is yet to be determined if this reduction is progressive across subsequent segments of play such as quarters. Future research should aim to address this within elite LGF. Further, it is unknown if these reductions are related to coaching tactics, physiological fatigue, glycogen depletion or specific pacing strategies being employed by players [25, 28]. Overall, the data reported across this investigation may inform coaches with respect to session content design, allowing them to understand if specific training content is resulting in players accumulating the required running intensities players will experience during match-play.

The ability for players to attain maximal velocity has been shown to be an important performance quality within team sports; indeed, within soccer, these events have been shown to occur during successful attacking periods resulting in goal scoring chances being created or converted [30]. Within the current investigation players were shown to achieve on average $86 \pm 4\%$ of their individual maximal velocity during match-play equating to a mean maximal velocity of 7.17 ± 0.41 m·s^{-1}. The mean velocity attained within LGF is in line with previous data reported within elite ladies' sport [17–21]. Within the current data there was no positional differences in maximal velocity capabilities suggesting that the attainment of high percentages of maximal velocity is a holistic requirement of elite LGF match-play. Practitioners may utilize these data to construct training drills that allow for the attainment of regular exposures to high percentages of maximal velocity. Previously within team sports specific maximal velocity drills in addition to constructed game specific training drills, such as small-sided games, have been shown to allow the attainment of higher percentages of peak velocity depending on player-numbers and pitch dimensions [31]. These exposures to peak velocity can be monitored live within training, or retrospectively across specific rolling time windows. For example, a 10-day rolling window, ensuring players have regularly attained match-play requirements or above with respect to maximal velocity. While there may be a risk-reward strategy at play here with respect to maximal velocity exposure, it has previously been shown that regular exposures aid athletes in reducing the risk of lower limb injury within Gaelic sports [15].

PlayerLoad has been demarcated as an index of locomotor efficiency within team sports previously [26, 31]. Our data showed a positional specificity with respect to PL; additionally, a consistent increase in PL across halves of play was observed across all positions of play. This data agrees with previous literature within team sports [26, 31]. Increases in PL can be related to increases in locomotor loading for every meter covered by players during match play. For example, players may be completing increased number of lower threshold accelerations to complete similar locomotor distances across halves of play due to increased fatigue and an inability to accelerate at a higher rate of speed. Ultimately, as time progresses during match-play it is apparent that there is an associated increase in locomotor fatigue and this in turn may be related to increased injury risk later during match-play for players. Given the above, PL may represent a live measure of reduced locomotor efficiency within elite LGF. Locomotor efficiency can be used to identify fatigued players, or those with potential increased injury risk during training and match play. From a practical perspective the monitoring load is key for optimizing players readiness to perform. However, it is important for conditioning staff to assess multiple components of loading along with other contributing factors before modifying players loading or game-based minutes. Knowing that players locomotor efficiency is compromised across match play, coaches may look to time substitutions around these periods to mitigate against any risk factors for injury and reductions in potential performance. Future research within elite ladies Gaelic football, should aim to further understand locomotor efficiency through ratio analysis used within other team sports [32, 33].

It is important to acknowledge the limitations that may be associated with the present study. First, the game outcome (win or loss) was not considered. Previous research in other team sports has shown that the game outcome may influence the volume of running activity performed [9]. Future studies should investigate how the game outcome may affect the running performance profile of match-play. Second, the technical skills within this study were not investigated. Previous research conducted in elite Gaelic football [16] revealed that technical performance could relate to positional running demands. Future studies should investigate how these technical skills can impact running performance during match-play. Finally, sprint performance should be demarcated for analysis to understand the specific sprint distances require of players during match, in line with previous investigations within Camogie [20]. Given that players have different physical and physiological capacities, it is suggested that further studies aim to analyze the running performance of players, across individualized speed thresholds. The current study only included full game observations, whereby a player was not substituted and remained in the same

position for the entire game. Within Ladies Gaelic football management can make five substitutions per game, with substitutions typically occurring due to injuries, specific tactical requirements, or when management feel players are fatiguing. Future research should attempt to quantify the running demands in substituted players to determine if these players demonstrate different running demands. Future research should aim to analyze the running performance of ladies Gaelic football across different divisions or playing levels. Finally, there is a requirement to expand the current understanding of running demands within Elite ladies Gaelic football across quarters of match play, and further to understand the duration specific maximal running performance of match-play.

Conclusions

Training specificity is important to stimulate training adaptation, to improve match-play performance. Understanding the running performance profile of match-play is important in the construction of appropriate training drills and conditioning drills by coaches; however, to date there is a dearth of data related to the elite level of LGF. The present data are the first of its kind within elite LGF and indicates that match-play is intermittent in nature and places high running performance demands on players. Periods of high-speed running have been shown to occur ~ 20% of the time during competitive play, and result in significant reductions in running performance across halves of play. Furthermore, these running demands result in a reduction in locomotor efficiency across halves of play as indicated by increased PL accumulation across positions in the second half of play. Our data have shown a specific positional profile across match-play that coaches should consider when constructing training to replicate the running performance profile of match-play. Specifically, the middle three transitional lines (half-back, midfield, half-forward) of play were shown to cover increased running performance across match, when contrasted against the inside lines (full-back and full-forward) of play. Further, the positions who completed the highest running performance were shown to have the highest decrement in running across halves of play. The data are the first to elucidate the running performance requirements of match-play for elite ladies Gaelic football players. Coaches can now use these data to ensure players can meet or exceed the running performance requirements during match-play. As such the normative data presented herein is important to coaches, allowing them to develop drills that can appropriately provide the position specific running required to sustain match-play demands within an appropriately periodized training program.

Conflict of interest

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Author contributions Cliodhna O'Connor, Aideen McGunness, John Duggan and Shane Malone drafted the methodology to be followed for the manuscript. Aideen McGuinness, Shane Malone and Cliodhna O'Connor collected the data. Shane Malone, Amy Murphy and Kieran Collins completed the statistical analysis and drafted the original draft of the manuscript. All authors reviewed the manuscript prior to submission.

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