International Journal of Performance Analysis in Sport

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rpan20

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To cite this article: Paul F. Talty, Kevin McGuigan, Mark Quinn & Paul A. Jones (2022): Agility demands of Gaelic football match-play: a time-motion analysis, International Journal of Performance Analysis in Sport, DOI: 10.1080/24748668.2022.2033519

To link to this article: https://doi.org/10.1080/24748668.2022.2033519

Published online: 07 Feb 2022.

INTERNATIONAL JOURNAL OF PERFORMANCE ANALYSIS IN SPORT
https://doi.org/10.1080/24748668.2022.2033519

Agility demands of Gaelic football match-play: a time-motion analysis

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ABSTRACT

Research into the physical demands of Gaelic football is limited with no research into the agility or change of direction (CoD) demands of the sport. This study examined the CoD demands of Gaelic football via a time-motion analysis of senior inter-county match play. The Bloomfield movement classification (BMC) was adapted for application to Gaelic football. A new "descriptor" was used in an effort to account for the decision-making component of agility by isolating actions that occurred during active engagement with play. Of 1,899 changes of direction (CoDs) identified, 1,035 occurred during active engagement in play. The left/right split for CoDs during active engagement in play was 47.1/49.9%, indicating no preference for completing actions to one side over the other. Whilst the most common CoDs were ≤90° (74.9%), 80% of CoDs greater than 270° took place during active engagement in play. CoD actions are very common in Gaelic football and may be more common than in other field and court sports. It is important that athletes are physically prepared to cope with the demands of very acute CoDs during meaningful periods of match play.

ARTICLE HISTORY
Received 27 October 2021
Accepted 18 January 2022

KEYWORDS
Gaelic football; agility; change of direction; time-motion; bloomfield movement classification

1. Introduction

Gaelic football is one of the national sports of Ireland and draws on crowds of over 80,000 spectators for the elite level inter-county competitions every year. The game comprises two periods of 30 minutes for age-group and adult club football, two periods of 30 minutes for age-group inter-county football and two periods of 35 minutes for adult inter-county football (Gaelic Athletic Association, 2020). It is an amateur sport played between two teams of 15 players (one goalkeeper, six defenders, two midfielders and six forwards) on a pitch of 130–145 m in length and 80–90 m in width. It is an intermittent, multi-directional, invasion game characterised by large quantities of high-speed running, accelerations and decelerations as well as shoulder-to-shoulder tackling, jumping, turning, catching and kicking (Malone et al., 2016; O'Donoghue & King, 2004).

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Although McErlean et al. (1998) and O'Donoghue and King (2004) first detailed the activity profile of women's and men's Gaelic football using time-motion analyses, The paper of Malone et al. (2016) was the first to provide a detailed description of match running performance during competitive elite Gaelic football match play. This paper demonstrated the high running demands that are placed on Gaelic football players with midfield players covering as much as 9,744 m. Independent of the position, the mean distance covered during match play was reported to be 8,160 ± 1,482 m, which equates to a relative work rate of 116 ± 21 $m.min^{-1}$. This compares favourably to other elite level football codes. Tuo et al. (2019) reported the relative work rate from the 2018 FIFA World Cup to be ranging from 100 ± 11 $m.min^{-1}$ for CONCACAF nations up to 107 ± 12 $m.min^{-1}$ for UEFA nations; Varley et al. (2014) reported total distances of 12,620 ± 1,872 m, 6,276 ± 1,950 m and 10,274 ± 946 m and relative work rates of 129 ± 17 $mmin^{-1}$, 97 ± 16 $mmin^{-1}$ and 104 ± 10 $mmin^{-1}$ in Australian rules football, rugby league and Australian top-flight soccer, respectively. Max velocity scores reported by Malone et al. (2016) and Tuo et al. (2019) indicate that elite level Gaelic football match play elicits higher maximum velocities than elite-level international soccer match play (~28.2 $km.hr^{-1}$ vs ~30.5 $km.hr^{-1}$). Malone et al. (2016) also reported a large number of accelerations being performed with a range from 142 for full backs up to 232 for midfielders. This number of accelerations is higher than those reported across Australian football (82 ± 26), rugby league (71 ± 38) and soccer (65 ± 21) by Varley et al. (2014). However, differences in methodology make it difficult to make direct comparisons between these two studies. Malone et al. (2017) expanded upon the findings from their initial investigation with a much larger dataset and sought to identify how running performance progressed during matches and how it differed based on the playing position. They demonstrated that midfielders, followed by half backs and half forwards, covered the greatest total distances, whilst factors such as total distance, high speed distance and number of accelerations decreased from the first quarter to the second and again in each subsequent quarter. Interestingly, a 2020 investigation by McGahan et al. (2020) indicated that players in the half forward line experienced the greatest running demands during match play with midfielders next. This difference in findings was acknowledged by the authors, and it was suggested that this could be due to tactical differences in play. It was also notable that despite a clear reduction in many running performance parameters, peak velocity was maintained throughout. Ryan et al. (2018) investigated the acceleration profile of inter-county Gaelic football match play across predefined 5-minute epochs. Players covered an average of 267 ± 45 m in acceleration in any 5-minute period, and the number of efforts ranged from 11 ± 5 to 13 ± 5. Like Malone et al. (2017), the authors noted performance decrements as the game wore on, while a follow-up study in 2020 demonstrated the position-dependent nature of acceleration profiles with midfielders engaging in the greatest number of efforts (Ryan et al., 2020).

It is worth noting that the GPS units used in the Gaelic football research outlined thus far sampled at a frequency of 4 Hz. Research has indicated that the reliability of unit sampling at lower frequencies (>10 Hz) is compromised as the speed of the action increases (Buchheit et al., 2014; Johnston et al., 2013; Vickery et al., 2014). It is also unclear how valid and reliable GPS units are in detailing acceleration and deceleration profiles in court and field sports (Buchheit et al., 2014; Duffield et al., 2010).

Despite the improved volume, scope and quality of research assessing the demands of Gaelic football, none of these studies have included specific reference to the agility or change of direction (CoD) demands of the sport. A possible explanation for this may lie in the fact that GPS technologies allow for the downloading of dozens of data points in a matter of minutes (STATsports, n.d.) but, as outlined above, do not lend themselves well to the assessment of rapid changes of direction (CoDs).

Studies that have sought to focus on agility performance have tended to lean on notational analysis methodologies, which provide a deeper insight into the subtleties of game-specific movement patterns and may support researchers in the pursuit of a fuller understanding of the demands of various sports. For example, Fox et al. (2014) sought to describe the offensive agility profiles of netball players. Video footage of all seven players from one team across three international matches was manually coded for attacking agility actions using Sportscode. Details were provided about the number of actions per game and the type of agility action utilised. There was an average of 242 ± 29.16 actions per game and the side-step was the most frequently used action accounting for an average of 130.67 ± 10.97 actions per game.

A study by Bloomfield et al. (2007a) utilised the Bloomfield Movement Classification system (Bloomfield et al., 2004) to conduct a time-motion analysis of 55 FA Premier League players for approximately 15 minutes each. According to their findings, the frequency of turns and swerves was highest amongst defenders (727 ± 203) and lowest amongst midfielders (608 ± 207), with turns of between 0° and 90° being most common across all positional groups. A follow-up abstract by Bloomfield et al. (2007b) sought to characterise the nature of turning performed in the same data sample. This study identified 5,115 individual turning actions, with 79% of these occurring during a transition from one form of locomotion to another.

More recently, Morgan et al. (2021) assessed the frequency of CoD actions in elite youth soccer. The authors discarded actions that occurred immediately prior to or following walking or preceded an arched run as well as those that took place whilst the player was in possession of the ball. In this study, players completed an average of 304.6 ± 50.3 CoDs per game with no apparent impact of the playing position, leg dominance or anthropometric measures on the frequency of CoD actions completed. CoDs ≤90° were significantly more common than all other angles, and the frequency of CoD actions diminished in the 2nd half compared to the 1st as well as from the first 15 minutes compared to all other 15-minute epochs.

Whilst GPS technologies provide large datasets in short timeframes, notational analysis is very labour-intensive. Bloomfield et al. (2004) stated that the analysis of a 5-minute segment of footage of soccer match play using the Bloomfield Movement Classification took roughly 2 hours to complete. This difference in processing time may go some way to explaining why so few studies have detailed the agility demands of various sports. Practitioners and researchers are always more likely to be drawn towards the more time efficient methodology.

A drawback to this lack of detailed understanding of the agility demands of team sports is the difficulty in subsequently identifying appropriate agility tests by strength and conditioning or sport science practitioners. Tests, which invariably isolate the CoD speed subcomponent of agility, are often chosen based on the existence of data to which athletes can be compared (Nimphius et al., 2013). For

example, Brown and Waller (2014) recommended the use of the L-test (3-cone-test) as a measure of CoD speed in Gaelic football on the basis that Gaelic football resembled the sport of rugby league. Alternatively, Mullane et al. (2019) recommended the use of the 505 test, ideally in conjunction with an assessment of 10 m acceleration speed to allow for the calculation of the CoD deficit (CoDD). Whilst neither of these suggestions can be said to be inappropriate; as already outlined, they cannot be based on a thorough understanding of the agility profile of the sport of Gaelic football as this information does not currently exist.

Therefore, the purpose of this study was to examine the agility demands of elite Gaelic football by conducting a time-motion analysis of a select number of individual players during the 2018 Ulster Senior Football Championship (USFC). The USFC is one of the four provincial championships, which, alongside the All-Ireland series, forms part of the highest level of Gaelic football competition. Nine teams compete in a straight knockout format in what is generally regarded as the most competitive of the four provincial championships.

2. Materials and methods

2.1. Time-motion analysis

The time-motion analysis was carried out using the Bloomfield Movement Classification (BMC; Bloomfield et al., 2004). The BMC was chosen as the method of analysis due to the detailed framework it established for the analysis of dynamic team sports. It includes a detailed account of motions, directions, intensities and events whilst allowing space for adaptations to be made depending on the specific sport being analysed. The BMC included a series of "behaviours" to describe the motions/actions being undertaken by the player under analysis. In addition, it includes a series of "modifiers", which provide further layers of detail pertaining to the motions/actions being recorded. The BMC, as described and illustrated by Bloomfield et al. (2004), was originally designed for the analysis of soccer and is reproduced in Table 1.

2.1.1. Adaptation of the BMC

To apply the BMC to the sport of Gaelic football, some minor modifications to the "behaviours" and "modifiers" were made. Nacsport (Nacsport, Las Palmas de Gran Canaria, Spain) was chosen as the computerised notation software for the extraction of data, and as such, the terms "behaviours" and "modifiers" were altered to "categories" and "descriptors" in line with the common language of the Nacsport software package. An initial modified version of the BMC was created following detailed discussion with the lead supervisor and the secondary observer, who is a professional performance analyst familiar with these types of analyses as well as an experienced Gaelic football coach. A buttons template was created in NACsport, and an initial pilot data entry of 5 minutes of footage for a single player was carried out. This pilot data entry allowed for an assessment of the applicability of the adapted BMC as well as providing an opportunity to identify further modifications that were required to account for differences between Gaelic football and soccer in areas such as the physical contact between players and how the ball is handled.

Table 1. Original version of the bloomfield movement classification (Bloomfield et al., 2004).

BEHAVIOURS **(Modifiers in parentheses)**	MODIFIERS
1. TIMED	**(A) Direction**
	Forwards, Forwards Diagonally Right/Left, Sideways Right/Left, Backwards, Backwards Diagonally Right/Left, Arc Forwards Left to Right/Right to Left, Arc Backwards Left to Right/Right to Left, Arc Sideways Right/Left
Motion	**(B) Intensity**
Sprint (A + B), Run (A + B), Shuffle (A + B), Skip (A + B), Jog (A + B), Walk (A), Stand Still, Slow Down (A + B), Jump (C), Land, Dive (D), Slide (D), Fall, Get Up (B)	Low, Medium, High, Very High
	(C) Jump
Initial Channel	Vertical, Horizontal, Backwards, Sideways (E)
Start of Observation	**(D) Dive**
	Feet first, head first
2. INSTANTANEOUS (NON-TIMED)	**(E) Turn**
	Right/Left
Other Movement	**(F) Type**
Stop (B), Swerve (E), Impact (F + B)	Push, Pull, Pushed, Pulled, Others
	(G) Control
Turns	Right/Left Foot, Head, Chest, Thigh, Others
0°–90° (E)	**(H) Pass/Shoot**
90°–180° (E)	Long Range, Short Range, Others
180°–270° (E)	**(I) How**
270°–360° (E)	Right/Left Foot, Header, Backheel, Overhead, Others
>360° (E)	**(J) Dribble**
	Start, End
On the Ball Activity	**(K) Touches**
Receive (G), Pass (H + I), Shoot (H + I), Dribble (J + K), Tackle, Trick, Others	Start, 1–3, 4–6, 7–10,>10

Following this observation period, some further refinements were made to the BMC and clarifications were also made regarding the application of the "categories/descriptors" to a number of complicated scenarios that had been encountered. At all times, detailed discussions with the research team were carried out before any decisions were finalised. A further pilot data entry of the same 5 minutes of footage plus a further 5 minutes of footage of the same player was carried out to ensure satisfaction with the modified BMC and to act as a final period of familiarisation for the lead observer.

The finalised version of the modified BMC is outlined in Table 2, and the alterations made are detailed in Table 3.

Although the BMC was agreed upon from this point in the process, further clarifications and rechecking of the appropriateness of the various "categories/descriptors" took place throughout the data entry process. This allowed for care to be taken to ensure that data was entered appropriately for all footage analysed.

In addition to the alterations around "categories" and "descriptors", a small but fundamental alteration was made to the definition associated with "Turns". It was felt that the original definitions did not sufficiently take account of CoDs that occur in a cutting motion. As the original definitions referred to changes of direction purely as turns about a circle, this also did not allow for the recognition of a player travelling forwards/backwards, stopping and immediately walking backwards/forwards along the

Table 2. Modified version of the bloomfield movement classification.

CATEGORIES **(Descriptors in parentheses)**	DESCRIPTORS
1. TIMED	**(A) Direction** Forwards, Sideways Right/Left, Backwards, Arc Forwards Left to Right/Right to Left, Arc Backwards Left to Right/ Right to Left, Arc Sideways Right/Left
Motion Sprint (A), Run (A), Shuffle (A), Skip (A), Jog (A), Walk (A), Stand Still, Slow Down (A), Jump (C), Land, Dive (D), Slide (D), Fall, Get Up (B)	**(B) Intensity** Low, Medium, High, Very High
	(C) Jump Vertical, Forward, Backwards, Sideways (E)
On the Ball Activity On the Ball, Off the Ball	**(D) Dive/Slide** Feet first, Head first
Initial Channel 1st Half, 2nd Half	**(E) Turn** Right/Left, Forward/Backward
	(F) Type Shoulder Charge, Body Check, Push, Pull, Pushed, Pulled, Other
2. INSTANTANEOUS (NON-TIMED)	**(G) Engagement With Play** Actively/Not Actively Engaged
Other Movement Swerve (E), Impact (F + B)	
Turns 0°–90° (E) 90°–180° (E) 180°–270° (E) 270°–360° (E) >360° (E)	

original path of travel. This change in definition also necessitated the addition of the "Forward/Backward" "descriptor" under the heading "Descriptor" E. Operational definitions for all new categories and descriptors are detailed in Tables 4 and 5.

2.2. Participants and footage

Video footage was collected on players representing 4 positional groups (inside forward line, inside defensive line, attacking middle third and defensive middle third) from a range of inter-county sides during the 2018 USFC. Player positions and the duration of play analysed are detailed in Table 6. Footage was collected by the provincial governing body, and access to the footage was subsequently granted upon request to the same (Ulster GAA, Co. Armagh). Ethical approval was granted by the University of Salford Ethics Committee.

The footage used was from two video sources: one providing a wide-angle footage and the other providing a "PlayerCam" style footage. The wide-angle footage was always captured side-on to the pitch from an elevated position as close to the centre point of the field as allowed by the organisers. The "PlayerCam" footage was collected from a point in the stands that was most advantageous for the position being captured. For example, the footage of Players 2 and 3 was captured from a position close to the centre of the field, whilst the footage for Player 4 was collected from a position close to the 21 m line of the relevant end of

Table 3. Rationale for alterations made to the BMC.

Alteration	Rationale
Removal of "On the Ball Activity" as an instantaneous action	–The specifics of how the player interacted with the ball whilst in possession were of no interest in this study – This meant the removal of "descriptors" G-K as detailed in the original BMC – In order to identify whether or not a player was in possession, "On the Ball Activity" became a timed action
The "Stop" action was removed from the under the heading "Other Movement"	– "Stop" was deemed to be superfluous as this was sufficiently accounted for under timed actions where a player could be coded as having gone from being in motion to standing still
Under the heading "Initial Channel", "Start of Observation" was altered to "1st Half/2nd Half"	– Allowed for easy identification of actions taking place in the 1st vs 2nd half in games where more than one half were coded
"Descriptor" F had "Shoulder Charge" and "Body Check" added	– Both factors were based on pilot observations of match footage and account for the difference in tackle laws and physicality in Gaelic football vs soccer
"Descriptor" E had "Forward/Backward" added	– This was to account for an alteration to the definition of a "Turn" (discussed below)
"Descriptor" G was altered to identify if the player was actively engaged in the play when completing any given action	– A decision tree (Figure 1) was created to allow for the identification of instances where the player was actively engaged in the play or otherwise – The decision tree was developed by the lead author and approved by a panel of Gaelic football coaches with a combined years of coaching in excess of 100 – This descriptor was added to help distinguish between the most prevalent and impactful CoD actions

Table 4. Definitions of change of direction used for this study.

0°-90°	Turn ≤1/4 circle OR cut away from original direction of travel by ≤90°
90°-180°	Turn >1/4 circle but ≤ 1/2 circle OR cut away from the original direction of travel by >90°≤180°
180°-270°	Turn >1/2 circle but ≤ 3/4 circle OR cut away from the original direction of travel by >180°≤270°
270°-360°	Turn >3/4 circle but ≤ full circle OR cut away from the original direction of travel by >270°≤360°
360° +	Turn >full circle OR cut away from the original direction of travel by >360°

the field. Together, these sources provided clear, unobstructed images from an elevated position. A total of 5 players from 4 teams were selected for analysis in the study. Inclusion criteria were as follows

- Clear and unobstructed footage was available of a single player for at least 35 mins (regulation duration for one half of a game) of consecutive open play.
- Players were representative of one of the 4 positional groups outlined above.

More players were not included due to the time constraints associated with the extraction of data – see the "Procedure" section for further details.

Analysis commenced with the referee's whistle to signal the start of play for that half of the game and ended with the referee's final whistle signalling the end of that half of play. One exception to this was for Player 4 as problems with camera set-up meant that roughly 2 minutes at the start of regulation play were missed. However, as more than 35 mins of footage was collected and alternative representative footage of an inside forward line player

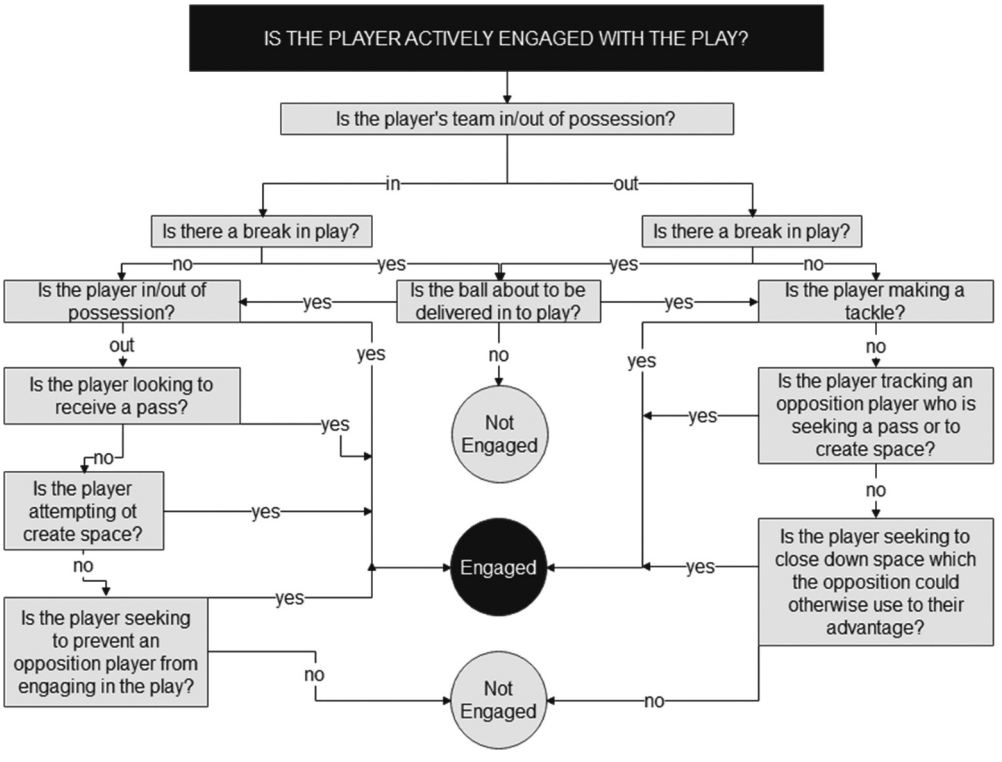

Figure 1. Decision tree used to determine whether a player was actively engaged in the play.

Table 5. Definitions of new categories and descriptors used for this study.

Categories	
Operation	**Definition**
1st Half	1st half of game being analysed
2nd Half	2nd half of game being analysed
On the Ball	The player is in active possession of the ball in play
Off the Ball	The player is not in active possession of the ball
Descriptors	
Operation	**Definition**
Impact Type	
Shoulder Charge	Shoulder-to-shoulder contact between two players
Body Check	Deliberate obstruction of a player's forward/backward momentum
Turn	
Forward	Head, shoulders and hips go from moving directly backwards to directly forwards
Backward	Head, shoulders and hips go from moving directly forwards to directly backwards

was not of similar quality, this footage was deemed sufficient for inclusion. As is evident from Table 6, each of these halves of play included some additional time to allow for breaks in play. All additional minutes covered by the footage were included in the analysis.

Table 6. Player position and duration of analysis.

Player	Representative Position	Duration of Analysis
1	Attacking Middle Third	36:51 mins
2	Defensive Middle Third	41:25 mins
3	Defensive Middle Third	41:27 mins
4	Inside Forward Line	35:29 mins
5	Inside Defensive Line	44:47 mins
	Total	199:59 mins

2.3. Procedure

All footage was imported to the Nacsport software, which was hosted on the lead observer's laptop (Lenovo ideapad 320S). As per Bloomfield et al. (2007a), coding took place during the day in a well-heated private room with the laptop on a non-reflective surface. Due to the detailed nature of the BMC, the process of data entry was extremely time-consuming with 5 minutes of game footage typically requiring 3 hours for complete data entry. As a result of this, the lead observer took regular "eye-breaks" by looking away from the screen for periods varying from 5 to 60 minutes as required. The lead observer was familiarised with the use of the software and the detail of the adapted BMC through a pilot data entry as described above. This footage was then discarded, and the process began at the start of the same footage on a different day. A frame rate of 25 fps was used for all footage, and video was paused and scrolled as necessary to provide an accurate start and finish time of each category. Nacsport assigns keyboard shortcuts as standard to video player functions such as "M" or "N", allowing for frame-by-frame play and rewind, respectively. Additional keyboard shortcuts can also be assigned to the categories and descriptors, and this was done by the lead observer to assist with the coding process.

Coding of all footage was completed in two stages. The first stage involved the coding of all actions occurring during match play and the addition of all appropriate "descriptors" barring "Descriptor" G. All footage was passed through the first stage by the lead observer. The second stage was conducted by a secondary observer and involved the addition of "Descriptor" G to all actions coded. The observer for this second stage was an experienced Gaelic football coach and performance analyst with extensive experience in coding Gaelic football matches for the identification of discrete and continuous events. The second observer was also part of the panel of coaches who approved the use of the decision tree required for "Descriptor" G (Figure 1) and so was intimately familiar with that process.

2.4. Reliability

Inter- and intra-observer reliability was evaluated to assess the robustness of the modified BMC using Cohen's kappa, in line with recommendations from O'Donoghue (2015). The lead observer analysed the opening block of 5 minutes of footage of Player 4 twice for the purpose of the intra-observer reliability assessment, and the second observer analysed the same 5-minute block of footage for the purpose of the inter-observer reliability assessment. Data were arranged in line with the methodology outlined by O'Donoghue and Holmes (2015, ch 9, pp. 223–231), and the reliability of entries for all "categories", "descriptors" A-F and "descriptor" G was assessed using SPSS v 26 (IBM Corporation, New York, USA). Strength of agreement was interpreted in line with recommendations

from Altman (1991, as cited in O'Donoghue, 2015), whereby a score is very good if greater than or equal to 0.8, good if between 0.6 and 0.8, moderate if between 0.4 and 0.6, fair if between 0.2 and 0.4 and poor if less than 0.2.

Cohen's kappa for intra- and inter-observer reliability is described in Table 7 and is described as kappa (95% confidence interval), p-value.

2.5. Analysis

Following the completion of the coding process, the raw data was exported to Excel for analysis. Absolute and relative (CoD min^{-1}) frequency counts were calculated for total CoD actions completed, the direction of travel of CoD actions, and the angle of execution of CoD actions. Frequency counts were carried out for all actions completed and for actions completed during active engagement in play. Due to the small sample size, all results were pooled into one large sample for the purpose of this analysis.

Table 7. Cohen's kappa for reliability of observations.

	Intra-Observer Reliability	
		Interpretation
Categories	0.810 (95% CI, 0.780–0.840), p = <0.001	Very good
Descriptor G	0.752 (95% CI, 0.713–0.791), p = <0.001	Good
Descriptor A-F	0.760 (95% CI, 0.728–0.792), p = <0.001	Good
	Inter-Observer Reliability	
		Interpretation
Categories	0.825 (95% CI, 0.796–0.854), p = <0.001	Very good
Descriptor G	0.744 (95% CI, 0.705–0.783), p = <0.001	Good
Descriptor A-F	0.813 (95% CI, 0.783–0.843), p = <0.001	Very good

Table 8. Frequency count of absolute and relative (CoD min^{-1}) change of direction actions during the entire duration of analysis and during active engagement with play.

	Entire Duration of Analysis				Active Engagement in Play			
	Total CoD	Mean (SD)	CoD min^{-1}	% of Total	Total CoD	Mean (SD)	CoD min^{-1}	% of Total
All Directions	1899	379.80 (67.20)	9.50	100.00	1035	207.00 (52.31)	5.18	100.00
Left	900	180.00 (32.51)	4.50	47.39	488	97.60 (28.66)	2.44	47.15
Right	939	187.80 (36.66)	4.70	49.45	517	103.40 (23.54)	2.59	49.95
Forward	29	5.80 (3.92)	0.15	1.53	19	3.80 (2.93)	0.10	1.84
Backward	31	6.20 (2.14)	0.16	1.63	11	2.20 (1.72)	0.06	1.06
≤90°	1367	273.40 (56.83)	6.84	71.99	776	155.20 (40.91)	3.88	74.98
>90°≤180°	483	96.60 (14.12)	2.42	25.43	234	46.80 (10.23)	1.17	22.61
>180°≤270°	38	7.60 (1.36)	0.19	2.00	16	3.20 (2.32)	0.08	1.55
>270°≤360°	9	1.80 (0.75)	0.05	0.47	7	1.40 (0.49)	0.04	0.68
>360°	2	0.40 (0.49)	0.01	0.11	2	0.40 (0.49)	0.01	0.19

3. Results

The results are illustrated in Table 8. Across a total of 199 minutes and 59 seconds, 5,499 actions were identified. Of those actions, 1,899 were identified as CoDs. 1,035 of these were completed during active engagement in play. This accounts for 54.5% of all CoDs. The percentage left/right split for all actions was 47.39/49.45% and 47.15/49.95% for actions occurring during active engagement in play. Of all changes of direction, 71.99% took place between 0 and 90°, with the next most common range being 91–180°, which accounted for 25.43% of all CoD actions. During active engagement in play, these numbers moved to 74.98% and 22.61%, respectively. There were just two CoD actions >360° recorded, and both of these occurred during active engagement with play.

4. Discussion

This study described the change of direction (CoD) actions most common to Gaelic football match play. The Bloomfield Movement Classification (BMC) was utilised as the method of analysis due to the significant level of detail it provides for the analysis of dynamic team sports. In adapting some of its details and definitions, the original suggestion of Bloomfield et al. (2004) to adapt the framework as required for the context of a new sport and the needs of a new analysis was followed. An attempt to account for the decision-making component of agility was made by filtering for the number of actions that took place during active engagement in play.

Due to the adaptations made to the BMC and to ensure repeatable results, inter- and intra-observer reliabilities for the identification of "Categories", "Descriptor" G (involvement in play) and "Descriptor" A-F were assessed using a single 5-minute block of footage. This analysis resulted in kappa coefficients of between 0.744 and 0.825, illustrating a good to very good level of agreement (O'Donoghue, 2015) between and within observers. This is in line with the level of agreement reported by Bloomfield et al. (2004) and indicates that this adapted BMC could be used in future time-motion analyses of Gaelic football.

Of the 5,499 actions identified, 34.5% were CoDs. This compares to just 19.2% of actions identified by (Bloomfield et al., 2007b) being coded as "turning" actions. This may be a result of the change in definition applied in this study where CoDs were no longer not only defined simply as turns about a circle but also encompassed cutting actions. The difference may also highlight the different locomotion patterns associated with Gaelic football and soccer where the larger pitch and different tactical approach to the game may simply lend itself to more CoD actions in Gaelic football. A systematic review by Taylor et al. (2017) indicated that the movement profile of various dynamic team sports differed considerably with the specific demands of each sport, lending itself to a different set of physical and physiological demands.

We identified an average of 207.00 ± 52.31 CoD actions during active engagement in play for a single half of match play. This compares to 130.67 ± 10.97 offensive agility actions in women's netball (Fox et al., 2014), an average of 304.6 ± 50.3 actions for a full match in elite youth soccer players (Morgan et al., 2021) and an average of 637.08 ± 159.79 during full duration in-season elite-level professional soccer matches (Granero-Gil et al., 2020). Significant methodological differences again make it difficult to draw direct comparison to these other sports. As mentioned, Fox et al. focused entirely on offensive agility, whilst Morgan et al. discarded actions that occurred immediately

prior to or following walking or preceded an arced run as well as those that took place whilst the player was in possession of the ball. The study by Granero-Gill used inertial sensors to identify CoDs with little detail on how these actions were identified. However, the higher CoD demands of Gaelic football would be in line with the higher frequency of accelerations and decelerations reported by Malone et al. (2016) and Ryan et al. (2018) compared to those reported by Varley et al. (2014) for other professional football codes.

According to the data presented here, a vast majority of CoD actions that occur in Gaelic football are shallow in nature (≤90°). This is in line with findings by Morgan et al. (2021) in youth soccer. The dominance of this type of action is heightened during active engagement in play when the distribution increases from 71.99% to 74.98%. This increase may indicate that during open play, shallower CoDs are both prevalent and impactful. However, CoDs at more acute angles (>180°) were not eliminated and so the potentially impactful nature of these actions cannot be ignored. Indeed, it may be instructive to note that only 2 CoDs greater than 360° were recorded in our analysis and both occurred during active engagement in play. This observation lends itself to a recommendation to ensure that players are exposed to CoDs, which occur at very acute angles as a means of ensuring preparation for worst case scenarios that athletes may encounter during match play.

Although it may be reasonable to expect that players would have a preference for executing a CoD action on one leg over the other, the data presented here does not support this. The left/right split of 47.15/49.95% during active engagement in play does not show a strong preference for one side over another. Although they did not report the exact breakdown of left/right split, Morgan et al. (2021) did state that there was no difference between left/right CoDs. Assessing interlimb asymmetries prior to collecting game footage for use in time-motion analyses may help to shed further light on this area in future research.

4.1. Limitations

A key limitation to this study is the limited sample size. Although a large number of total actions and CoDs were identified, this was only across 5 players. Although this provides an interesting insight into the detail surrounding CoD actions during match play, it is difficult to extrapolate these findings significantly without performing a similar analysis on a broader sample of individual players.

A further limitation is the introduction of several rule changes by the GAA from the beginning of 2020. Amongst these changes, two may impact on the movement profiles of outfield players: the advanced mark and the kick out. The advanced mark allows for a free kick to be awarded to the attacking team when a kick pass of at least 20 m is delivered from on or outside the 45 m line to a player who receives the ball before it touches the ground on or inside the 45 m line. This rule may particularly impact on players in the inside defensive and attacking lines, which were not detectable in this analysis. Rules related to the kick out were adapted to require that all kick outs must travel at least 13 m and outside the 20 m line. This may have an impact on the tactical nature of kick outs and could influence middle third players in particular.

5. Conclusion

This is the first study to attempt an in-depth analysis of the agility demands of Gaelic football match play. It adds to the recent research describing the locomotion demands of Gaelic football and further highlights the difference in demands between Gaelic football and other team sports such as soccer. Unlike previous research, this study specifically highlights the significant number of CoD actions that occur during the game. This serves to highlight the importance of developing the correct physical characteristics to be able to successfully execute these actions on a repetitive basis and also highlights the importance of developing the correct cognitive processing to execute the actions in a manner that positively impacts performance. With the identification of the most prevalent forms of CoD actions, this research may also form the basis for selection of appropriate CoD speed tests when designing a battery of fitness tests for Gaelic football. No previous research has taken this approach to understanding the CoD demands of a sport before deciding what is the most appropriate test to be used for assessing performance. Future research in this area should focus on the technique of CoD used by the players as well as considering physical performance asymmetries that may account for any differences in the preferred direction of travel for CoD actions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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