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Performance indicators in club level Gaelic football

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ABSTRACT

Over 2000 Gaelic Football clubs compete annually for the honour of playing in the All-Ireland club finals in Croke Park in front of up to 30,000 people. There are no published performance data for club level Gaelic football, despite evidence of considerable performance analysis activity. This study aims to establish benchmark profiles for Senior, Intermediate and Junior grade club Gaelic football and investigate which variables are most closely associated with winning.

Data from all tiers of the Ulster club football championship of 2015 and 2016 ($n = 48$) were analysed using a range of validated operational definitions measuring 17 variables. Differences between winning and losing performance were tested using a **Mann-Whitney U** test.

Across all grades, **six** variables proved significant ($p < 0.05$), three were directly related to scoring (points, number of scores and total score), the others related to the effective use of possession (possession: scores ratio; turnover rate and productivity (scores per possession)). Several others are specific to certain grades, and are directly linked to successful performance at that level.

Our findings can be used by club coaches and analysts as comparable profiles for measuring team performance and targeting improvements associated with successful performance.

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1. Introduction

Gaelic football is one of four sports governed by the Gaelic Athletic Association (GAA) in Ireland. There are over **2200** GAA clubs across **32** Irish counties, catering for approximately 330,000 participants in Gaelic Football, Hurling, Handball and Rounders (Association, 2017). The organisation is based on the traditional parishes and counties of Ireland, with players typically playing for their local parish club. Every player participates in club game and the best also play at inter-county (elite) level. Within each county, every year, all clubs participate in a championship competition. There are three tiers of competition in each county; junior, intermediate and senior. The junior championship is contested by a selection of the weakest club teams, while the senior championship is contested by the strongest club teams. The intermediate championship is a bridging competition between junior and senior. A club can only compete in one championship each season. The winner of each county championship earns the right to represent their county in the corresponding tier of their provincial

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championship, of which there are four; Connacht, Leinster, Munster and Ulster. The four provincial winners all progress to an All-Ireland semi-final. Every year there is an All-Ireland champion at junior, intermediate and senior grade with the senior final traditionally played in Croke Park, on St. Patrick's Day, in front of an audience of around 30,000 spectators. 45

Club level games account for the vast majority of fixtures in the GAA calendar; however, there is currently no research into the performance characteristics of successful teams. A recent survey (Martin, Swanton, McGrath, & Bradley, 2017) highlighted the considerable interest in performance analysis by club level GAA coaches, while Behan and McGrath's (2016) case study illustrated the quite sophisticated performance analysis practices employed by senior GAA club coaches. Performance analysis is well established as a tool to assist coaches in providing objective data on actual sports performance (O'Donoghue, 2015). It is the comparison of these data with previous or model performances which helps coaches choose strategies and structure appropriate practice. To date, club level Gaelic football coaches have depended on profiling data from senior Intercounty Gaelic football research to identify and provide benchmark figures for performance indicators and insight into game intelligence. This research (for example, Bradley & O'Donoghue, 2011; Carroll, 2013; Mangan et al., 2017) is exclusively based on inter-county level Gaelic football games which last 70 min. A club level Gaelic football match lasts 60 min and it is not currently known if the metrics from the elite level can be applied to club games. 50 55 60

Despite the difference in match duration between inter-county and club games, the literature investigating the tactical demands of inter-county Gaelic football does provide clear direction for this study. A presentation at the World Congress of performance analysis in Sport in 2004 offered the first insight into descriptive statistics in inter-county Gaelic football (Martin, 2004) defining and identifying attack to shot ratios and the idea of territorial effectiveness. Carroll's (2013) study was the first to look at the relationship between various performance indicators and winning and losing in 57 inter-county Gaelic football matches. This research produced performance profiles for chosen variables, including performance relative to opposition. Attack efficiency (%), total shots and percentage of opposition kick outs won were identified as the main variables that potentially defined winning performance for "top" teams when competing against other "top" teams. 65 70

Bradley and O'Donoghue (2011) provided some insight into tactical game play with an objective analysis of counter attacking in Gaelic football. They identified that kicking long ball was unlikely to produce a successful outcome having regained possession, challenging the long-standing tactic of 'get the ball in early', a concept not dissimilar to that proposed in soccer by Bate (1988). Bradley and O'Donoghue (2011) found that as the number of passes during a counter attack increased, the possibility of creating scoring chances increased. The findings support more measured attacks, with control more important than speed of delivery, reflecting more closely what Jones, James, and Mellalieu (2004) found in English premier league soccer. Kickout distribution and outcome in Gaelic football was investigated by Daly and Donnelly (2018) who described its importance as a starter play and differentiated between kickouts "won clean" and those "broken" with data from nine Ulster championship games played in 2010. 75 80 85

Mangan et al. (2017) provide a deeper insight into kickout variables in a paper focusing

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on the relationship between technical performance indicators and running performance in 52 [inter-county](#) Gaelic football league and championship matches played between 2014 [and](#) 2016. Their study was the first to define and observe “possessions”, noting that teams were in control of the ball on average 69 (\pm 8) times. 90

Though a commonly reported performance indicator in soccer, the validity of possession as a performance indicator is still largely unproven. Stanhope (2001) concluded that time in possession was not an indicator of success in the 1994 FIFA World Cup. However, Jones et al. (2004) found that possession was related to successful performance, although not due to strategic preference, but superior player ability. 95
More recently, Lago-Penas, Lago-Ballesteros, and Rey (2011) concluded that time in possession was indicative of success in the UEFA Champions League. Castellano, Casamichana, and Lago (2012) undertook an analysis of performance indicators in soccer using data from three FIFA world cups and concluded that shots on target and ball possession continued to remain key to success in soccer. 100

Another concept in relation to possession as a performance indicator is measurement of possession effectiveness; a method of normalising shooting/scoring relative to the number of possessions gained by a team (Hughes & Bartlett, 2002). Hughes and Franks (2005) demonstrated that successful teams displayed a better ratio for converting possession into shots on goal, while Lago-Penas et al. (2011) noted winning teams had a greater effectiveness than losing teams, with respect to the ratio of shots taken to goals scored – shot success. The same study also found total shots, shots on goal, passes and successful passes were factors in winning, losing or drawing performances. Prior to that, Lago-Penas, Lago-Ballesteros, Dellal, and Gomez (2010) concluded that total shots, shots on goal, crosses, crosses against and ball possession could potentially differentiate 105
between winning, drawing and losing performances. The work by Lago-Penas et al. (2010) [and](#) (2011)) provided performance profiles upon which teams could measure future performances, with a view to increasing chances of winning. In Gaelic football, Carroll (2013) measured both attack efficiency and shot efficiency, both of which are relative measures of possession effectiveness. However, neither variable takes into 110
account the two methods of scoring in Gaelic football; a goal, worth three points, and a point, worth a single point. A team’s final score is an aggregate of both at the end of the game. This study proposes a novel method for measuring possession effectiveness in Gaelic football which will calculate score return per number of possessions for each team – a measure of productivity. 115
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In a sporting sense, performance indicators can be used by coaches to assess individual or team performance, and are defined as “a selection, or combination, of action variables aiming to define some or all aspects of performance” (Hughes & Bartlett, 2002). O’Donoghue (2010) reinforced the need for performance indicators to represent some relevant and important aspect of play, while Wright et al., (2014, p. 713) 125
described finding the performance indicators associated with winning as the “Holy Grail” of performance analysis research. The concept of creating performance profiles which can be measured against previous performance and peer groups at a similar standard is well established. A review by Butterworth, O’Donoghue, and Cropley (2013) identified 11 criteria for effective performance profiling in sports coaching . They 130
highlight the importance of the profile being capable of representing typical performance, showing trends in a series of performances or capturing the essence of a single

performance. We are aware that a considerable amount of profiling and opposition analysis is undertaken by Gaelic games coaches at inter-county and club level (Martin et al., 2017), however none of the extant literature questions the stability of these data or their capacity to adhere to the criteria suggested by Butterworth et al. (2013). Hughes and colleagues (2001) advised that studies aiming to present performance profiles should present a percentage error plot showing mean variation as each match is analysed with a view to proving the data mean has stabilised appropriately. This research will address the absence of data from which club level Gaelic football coaches can benchmark and seek to establish to number of matches required to achieve some stability in the profile data.

While there is an increasing volume of published research specific to inter-county Gaelic football, there remains a dearth of information relevant to the club system, which constitutes the broadest playing and coaching population. This paper aims to identify performance indicators that may distinguish between winning and losing performances, and, establish performance profiles to benchmark successful performance across three grades; junior, intermediate and senior. It is envisaged that this study will provide valuable information for coaches and performance analysts at all levels of club Gaelic football, and enable better preparation of teams to achieve success.

2. Methods

Analysis of match events involved frequency counts of event types, outcomes and, in some cases, pitch location. The operational definitions (Appendix 1) and chosen performance indicators for Gaelic football (Table 1) used in this study were developed in three stages, a

Table 1. Chosen performance indicators.

Variable	Description
Possessions	Each time a team is in control (held in hand) of the ball. One possession will persist until the team loses control of the ball. Kickouts are not considered as possession until one team is in control of the ball.
Possession Share (%)	Possession, per team, expressed as a percentage of the total number of possessions gained by both teams over the course of the match
Attacks	When a team has control of the ball inside their opponent's 45m line, but are unable to generate a shot prior to losing possession.
Shots	An action that sends the ball directly towards the opposing teams' goal in an attempt to score a point or goal.
Attack Efficiency (%)	Number of shots expressed as a percentage of the total number of team attacks
Possession: Shots (%)	Number of shots expressed as a percentage of the total number of team possessions
Scores	Successful shots that result in a score
Possession: Scores (%)	Number of scores expressed as a percentage of the total number of team possessions
Goals	The ball going below the cross bar and between the posts
Points	When the ball is kicked or fisted over the crossbar and between the two posts
Shot Success (%)	Number of scores expressed as a percentage of the total number of team shots
Total Score	The overall points total of a team
Productivity	Number of points scored per 10 possessions. A measure of the effectiveness of possession. $(\text{Total Score}/\text{Possessions}) \times 10$.
Total Kick Outs Won (%)	Number of kick outs won, expressed as a percentage of the total number of kick outs taken in the game, by both teams
Total Turnovers	Number of times a team surrenders possession either directly to the other team, or beyond the pitch boundary without taking a shot
Turnover Rate (%)	Number of turnovers expressed as a percentage of the total number of team possessions
Free Kicks (Inside 45m)	Total number of free kicks conceded inside a team's defensive zone (45 m line)

review of Gaelic football performance analysis literature, drafting of operational definitions which were validated by an expert panel of coaches with a combined experience of 100 years in Gaelic football coaching (O'Donoghue, 2010). Match footage was made available from Ulster GAA and downloaded from an online file transfer system (www.wetransfer.com) onto a laptop computer (Lenovo Intel Core i7-5500U). Footage was analysed with a custom built tagging panel using Dartfish TeamPro (version 7) video analysis software (Dartfish Limited, Switzerland).

Analysis was carried out on full footage, including stoppage time, from 48 Ulster Club championship matches played in 2015 and 2016, including 16 junior, 16 intermediate and 16 senior matches. Games finishing in a draw ($n = 5$) were subsequently excluded from statistical analysis of winning versus losing performance. The games involved 44 different teams from nine Ulster counties. Each match was screened for operational errors by checking a minimum of 10 random events for accuracy. In the event of an error being detected, a correction was made and a further 10 items were checked in that match. This process was repeated until 10 consecutive "checked" items were considered accurate. An intra-operator test was carried out on one full match. The randomly selected match was analysed twice over a 4-week period with a low percentage error measured across all variables ($< 5\%$). To further test definitional and observational errors, inter-operator test was conducted with another experienced GAA analyst which produced a high level of agreement ($\kappa = 0.973$).

Data were assessed for stability through analysis of cumulative means relative to overall mean, with an error limit of 5% considered appropriate (Hughes et al., 2002). Data were grouped according to grade, and subsequent match outcome for the purposes of establishing stability for each dataset. Summary statistics (mean \pm SD) of 17 variables were calculated using SPSS statistical analysis software (version 20.0. Armonk, NY: IBM Corp.), and presented for winning and losing teams at junior, intermediate and senior level. All 17 variables (Table 2) across each grade

Table 2. Winning teams and losing teams performance profiles for senior grade Gaelic football teams (winning teams $n = 15$, losing teams $n = 15$) variables highlighted in grey indicate significant difference between winning and losing teams.

Grade	Win		Lose		P Value (MWU Test)
	Mean	Std Dev \pm	Mean	Std Dev \pm	
Possessions	41	6.07	41	3.93	0.692
Possession (%)	50.0	3.22	50.0	3.22	0.787
Attacks	30	5.13	27	5.01	0.096
Shots	23	4.06	20	4.04	0.080
Scores	14	2.77	9	2.87	0.001
Goals	2	1.30	0	0.64	0.007
Points	12	2.22	9	3.04	0.005
Total Score	17	4.83	10	3.08	0.000
Possession: Shots (%)	55.0	5.71	48.2	8.68	0.020
Possession: Scores (%)	32.7	4.56	22.5	6.35	0.000
Productivity	4.0	0.75	2.5	0.75	0.000
Attack Efficiency	75.3	7.69	74.6	7.77	0.709
Shot Success (%)	59.6	6.84	46.5	9.26	0.000
Total kickouts won (%)	47.2	7.41	52.8	7.41	0.085
Turnovers	21	4.24	25	4.98	0.023
Turnover Rate (%)	50.0	6.91	60.3	11.11	0.008
Free Kicks Inside 45m	7	2.40	6	1.79	0.216

were analysed for significant differences between winning and losing teams using a Mann-Whitney U Test in SPSS.

3. Results

3.1. Profile of winning performance at senior grade

Performance profiles at senior grade were established with respect to 17 performance variables, with 10 demonstrating significant differences between winning and losing teams (Table 2). Basic frequency counts; possessions, attacks and shots did not show significant difference between winning teams and losing teams. Possession share was also not a determinant of winning performance in senior club Gaelic football with winning teams and losing teams sharing possession evenly. winning teams recorded significantly ($p = 0.001$) more scores (mean = 14) compared to losing teams (9). This trend recurred across all scoring related variables, showing significant differences for goals ($p = 0.007$), points ($p = 0.005$) and total score ($p = 0.000$). 185 190

Five of the six relative variables, assessing effective use of possession, proved significantly different between winning teams and losing teams; possession: shots conversion ($p = 0.020$), possession: scores conversion ($p = 0.000$), shot success ($p = 0.000$), productivity ($p = 0.000$) and turnover rate ($p = 0.008$). Only attack efficiency ($p = 0.709$) showed no significant difference between winning teams and losing teams at senior grade with regard to possession effectiveness. Total kickouts won ($p = 0.085$) nor free kicks inside 45 m ($p = 0.216$) showed a significant difference ($p = 0.085$) between winning teams and losing teams. 195 200

3.2. Winning and losing performance profiles for intermediate grade Gaelic football

Results at intermediate grade (Table 3) demonstrated some interesting differences to those at senior grade. Possession share revealed that winning teams (mean = 52.7) enjoyed significantly ($p = 0.017$) more possession than losing teams (mean = 47.3). A number of frequency counts also differed, with attacks ($p = 0.040$) and shots ($p = 0.015$) both significantly greater for winning teams. 205

When the possession effectiveness measures were considered, possession: scores ($p = 0.024$), productivity ($p = 0.012$), attack efficiency ($p = 0.038$) and turnover rate ($p = 0.043$) showed significant differences, with neither possession: shots ($p = 0.077$) nor shot success ($p = 0.130$) considered significantly different between winning teams and losing teams at intermediate grade. As with senior grade, neither total kickouts won ($p = 0.086$), nor free kicks inside 45 m ($p = 0.639$) proved significant indicators of successful performance. 210 215

3.3. Winning and losing performance profiles for junior grade Gaelic football

At junior grade (Table 4), all of the key frequency counts proved to be decisive in determining match outcome. Possessions ($p = 0.039$), attacks ($p = 0.007$), shots ($p = 0.010$) and scores ($p = 0.000$) all demonstrated significant differences between

Table 3. Winning teams and losing teams profiles for intermediate grade Gaelic football teams (winning teams $n = 13$, losing teams $n = 13$) variables highlighted in grey indicate significant difference between winning and losing teams.

Grade	Intermediate				P Value (MWU Test)
	Win		Lose		
Outcome	Mean	Std Dev \pm	Mean	Std Dev \pm	
Possessions	49	5.92	44	7.53	0.090
Possession (%)	52.7	4.86	47.3	4.86	0.017
Attacks	33	3.93	29	6.60	0.040
Shots	27	4.75	21	5.42	0.015
Scores	14	3.72	9	3.04	0.003
Goals	2	1.04	1	1.04	0.067
Points	12	4.48	8	2.53	0.008
Total Score	18	2.79	12	4.63	0.001
Possession: Shots (%)	55.1	11.13	47.7	8.99	0.077
Possession: Scores (%)	29.3	8.95	21.5	7.31	0.024
Productivity	3.7	0.78	2.6	1.08	0.012
Attack Efficiency	79.1	7.25	73.1	7.22	0.038
Shot Success (%)	52.7	12.45	45.1	13.27	0.130
Total kickouts won (%)	53.2	10.48	46.8	10.48	0.086
Turnovers	26	7.03	27	5.81	0.681
Turnover Rate (%)	52.3	10.88	60.5	9.36	0.043
Free Kicks Inside 45m	6	1.77	6	1.77	0.639

Table 4. Winning teams and losing teams profiles for junior grade Gaelic football teams (winning teams $N = 15$, Losing teams $N = 15$) variables highlighted in grey indicate significant difference between winning and losing teams.

Grade	Junior				P Value (MWU Test)
	Win		Lose		
Outcome	Mean	Std Dev \pm	Mean	Std Dev \pm	
Possessions	50	4.68	46	4.40	0.039
Possession (%)	52.0	3.09	48.0	3.09	0.003
Attacks	33	5.34	28	4.35	0.007
Shots	26	4.92	20	5.18	0.010
Scores	13	3.01	8	2.68	0.000
Goals	1	1.30	0	0.52	0.188
Points	12	2.94	8	2.76	0.000
Total Score	15	4.48	9	2.80	0.000
Possession: Shots (%)	51.1	7.30	43.5	9.74	0.040
Possession: Scores (%)	26.3	5.85	17.9	5.61	0.000
Productivity	3.1	0.89	2.0	0.59	0.001
Attack Efficiency	76.6	6.73	71.9	11.87	0.212
Shot Success (%)	52.2	13.37	41.7	12.95	0.046
Total kickouts won (%)	54.5	9.65	45.5	9.65	0.021
Turnovers	27	3.70	29	3.95	0.203
Turnover Rate (%)	55.0	6.55	63.2	8.85	0.014
Free Kicks Inside 45m	7	2.89	7	2.66	1.000

winning teams and losing teams. Interestingly, with both possession count and possession share important at junior grade, it is notable that total kickouts won is also significantly different ($p = 0.021$) with winning teams (mean = 54.5%) claiming possession from more kickouts than losing teams (mean = 45.5%). Furthermore, free kicks inside 45 m ($p = 1.000$) did not prove significantly different between winning teams and losing teams.

With the exception of attack efficiency ($p = 0.212$), all other measures of possession effectiveness proved significantly different between winning teams and losing teams at junior grade. Possession: shots ($p = 0.040$), possession: scores ($p = 0.000$), productivity ($p = 0.001$), shot success ($p = 0.046$) and turnover rate ($p = 0.014$) are all significantly different when comparing winning teams and losing teams. 230

3.4. Profile of winning performance across all grades of club Gaelic football

Across all three grades, 6 of the 17 variables proved significantly different. As expected, scoring measures, including scores, points and total score proved to be linked to winning performance. Profiles of winning teams compared to losing teams at each grade (Figure 1) differed for shot outcome (goals, points, unsuccessful shots, overall shot success), with winning teams returning an average of 14 scores per match, while losing teams return 9 scores. 235

The remaining significant key performance indicators across all grades were measures of possession effectiveness; possession: scores, productivity and turnover rate (Figure 2). Conversion rates of possession to scores show an interesting pattern across 240

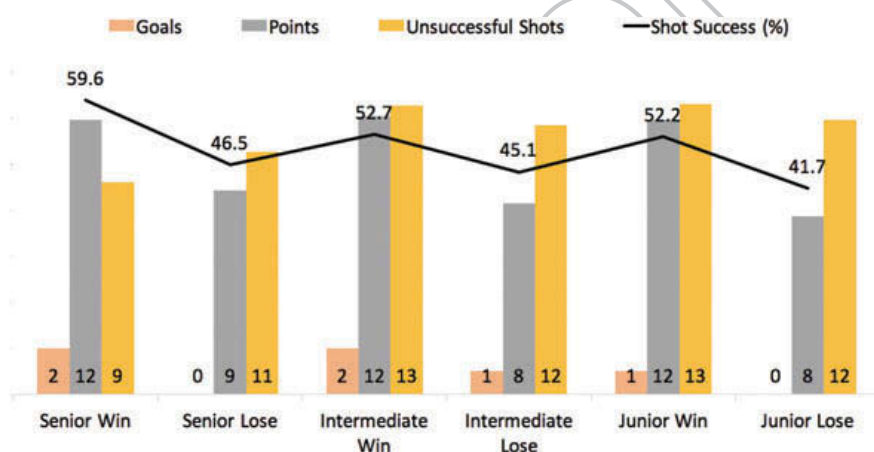


Figure 1. Scoring profiles of winning team and losing performance across all grades of club level Gaelic football, including goals, points, unsuccessful shots and shot success.

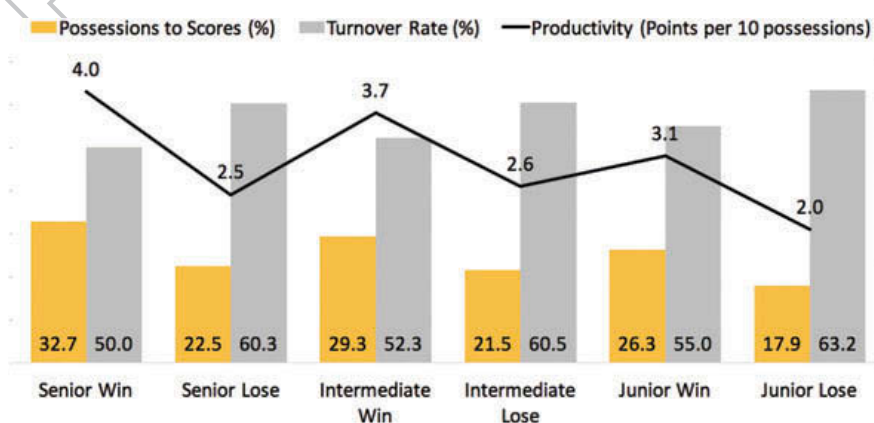


Figure 2. Conversion rates of possessions to scores, turnover rate and productivity of winning versus losing teams across all grades of club level Gaelic football.

the grades, with winning teams at senior grade the most effective at converting possessions to scores, followed by winning teams at both intermediate and junior grades. All three winning groups demonstrated better conversion rates than the losing teams, with winning teams scoring almost once from every three possessions (29.4%), while losing teams needed approximately five possessions to convert a single score (20.6%).

Productivity proved to be significantly different across all grades as winning teams returned a greater total of points per 10 possessions than losing teams. Similar to possession: scores, winning teams at senior level demonstrate the most clinical scoring performances, returning 4 points from every 10 possessions, in contrast to just 2.5 points from the same number of possessions for senior losing teams. The differences between grades is also evident, with winning teams at senior grade (4.0) superior to intermediate teams (3.7) who are in turn superior to junior teams (3.1).

3.5. Testing stability of performance profiles

Datasets were grouped according to grade and outcome and each variable tested for stability. Cumulative means for each variable were calculated for each group of analysed matches and measured against limits of error ($\pm 5\%$) about the overall mean (Hughes et al., 2001). Stability of all variables was established within 10 (possession %, possession: shots % (Figure 3)), 11 (possessions, shots, scores, points, possession: scores %, turnover rate) and 13 (turnovers, free kicks, attacks, kickouts won, goals, total score, productivity, attack efficiency, shot success) matches, thereby confirming the suitability of the data presented for use in performance profiling. The possession: shots stability profile is presented (Figure 3) as an illustration of the process followed to ensure stability of each datasets.

4. Discussion

This is the first study to investigate performance indicators in club level Gaelic football. It provides initial data to establish normative profiles of successful performance across the three tiers of club Gaelic football, which caters for almost a third of a million participants annually (Association, 2017). Given the evidence of many GAA club

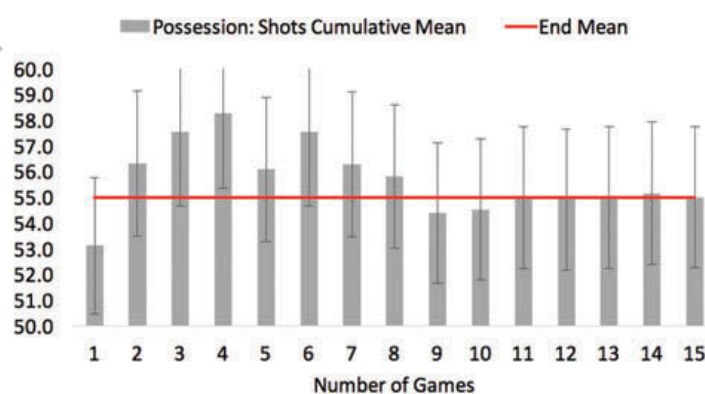


Figure 3. Stability profile of possession: shots ratio for winning teams playing in senior grade. Bars represent cumulative mean as each game is added to the sample.

coaches using performance analysis to varying degrees (Martin et al., 2017), this study also suggests which performance indicators can be considered “key” performance indicators in club level Gaelic football (Wright et al., 2014). Importantly, this paper has also demonstrated the need for performance analysis practitioners in Gaelic football to consider the stability of their data before assuming normative profiles have been established. Hughes et al. (2001) identified issues with assuming four, six or eight games were enough for a normative profile without undertaking suitable stability testing, and this study supported that assertion. There are notable differences for number of games required to establish stable profiles for each variable in club Gaelic football, ranging from 10 to 13 games in this study.

The influence of possession on winning performance varies in accordance with grade of performance. At senior level, neither possession count nor possession share differ between winning teams and losing teams, while at intermediate grade greater possession share is linked to winning performance. At junior grade, both increased possession count and possession share is linked with winning performance. Numerous studies in soccer have suggested more possession is linked to winning performance (Castellano et al., 2012; Jones et al., 2004; Lago-Penas et al., 2011), while Higham, Hopkins, Pyne, and Anson (2014) identified more possession as a key performance indicator of success in Rugby sevens. Mangan and colleagues’ (2017) paper measured possessions in the context of running performance in senior inter-county Gaelic football, however they used a different definition that incorporates each starter play kickout kick even if this is lost. This was a discussion point at our project design stage with the coaching panel opting for a definition separating the act of the kickout as a starter play, and beginning possession when it is secured out the field, as it allows for a “cleaner” and “truer” calculation of further performance variables. Measurement of possession count, coupled with score line enables calculation of various ratios including possession to shots, to turnovers and to scores that is ultimately the measure of productivity.

While concluding that possession was related to successful performance, Jones et al. (2004) suggested this did not appear due to strategic preference, but due to superior player ability. A similar reason is likely in club level Gaelic football, with superior player ability at senior grade resulting in teams competing evenly for possession, while at lesser grades there may be a greater imbalance of ability, with better players securing more possession, and providing the foundation for successful performance. Perhaps the ability to secure possession is the basis of success at junior and intermediate tiers, and only when teams achieve this can they progress to, and compete, at senior grade. While possession as a stand-alone measure is not a key performance indicator of success at senior grade, it remains a vital ingredient for the calculation many of the other variables that are directly linked to winning performance, potentially justifying the effort required to collect these data by analysts and coaches.

Kickout success was significantly linked to winning at junior grade, while in intermediate Gaelic football, kickout success was higher but not significant for winning teams. Senior club Gaelic football showed the opposite pattern, with losing teams enjoying greater kickout success, albeit not at a significant level. At inter-county level, Carroll (2013) demonstrated that winning teams in the top tier won a greater share of opposition kickout when playing against other ‘top’ teams. The kickout as a restart mechanism is unique to Gaelic football, and as such there is little published research.

Daly and Donnelly (2016) found 7.4% of kickouts were taken short, with a success rate of 87%. The changing nature of kickout strategy in Gaelic football was evident in a coaching article (McGuigan, 2015) which noted 36% of kickouts were short, a considerable increase in five years since Daly and Donnelly's (2016) data was collected. Mangan and colleagues (2017) data support this trend reporting a short kickout average of 30% with 92% retention. This tendency to use short kickouts may explain why the senior club losing teams in this study enjoy greater kickout success than winning teams. losing teams will have more kickouts, take a significant number short and secure possession. The significantly higher turnover rate evident in senior losing teams would explain why they do not convert this kickout dominance into match success.

Successful teams at intermediate and in particular junior grade potentially secure the platform for success through kickout dominance, which in turn leads to possession dominance. This kickout dominance may be due to inferior player ability at these grades, limiting the potential for success of the short kickout strategies that senior teams are able to employ. Losing teams do not possess the same ability to effectively execute short kickouts and thus lose a significant portion to the winning teams at junior and intermediate level. Traditionally, winning the "midfield battle" is considered vital to winning a match (McGuigan, 2015). At senior and intermediate grade, winning the kickout battle is not vital to winning performance, but at junior level, it is a key performance indicator of successful performance. The introduction of the "Mark" to Gaelic football in 2017, awarded for a clean catch from a kickout, may influence teams' kickout strategies and data from the current study will form an interesting benchmark to measure any change.

Absolute turnover count is significantly lower for winning teams compared to losing teams at senior grade of club level Gaelic football. Similar patterns exist at intermediate and junior grade but were not considered significant, reflecting the findings of Carroll (2013) that turnover count was not explicitly linked to winning performance. However when turnover rates are considered, a different picture emerges. When turnovers are calculated as a rate relative to total possession count (Hughes & Bartlett, 2002), the results proved significantly lower for winning teams across all three grades of club football. Winning teams had significantly lower turnover rates (senior = 50%, intermediate = 52.3%, junior = 55%) compared to losing teams (senior = 60.3%, intermediate = 60.5%, junior = 63.2%) across all grades. Whether due to technical/tactical superiority or workrate, winning teams gave away possession significantly less than their opponents. Our results suggest that turnover rate is a key performance indicator for club level GAA, thus it may be appropriate to for GAA analysts to test this metric on broader datasets, particularly at elite level.

Winning teams at junior and intermediate level generated significantly more attacks and shots than losing teams at corresponding grades. Senior teams exhibited similar patterns, with typically more attacks and shots than losing teams; however, the differences were not significant at senior grade. Previous studies in Gaelic football and similar sports have linked increased shot count to winning performance (Carroll, 2013; Clear, Hughes, & Martin, 2017; Lago-Penas et al., 2011). This study concurs at junior and intermediate grade; however, it is notable that shot count at senior grade is not key to winning performance. This suggests that other factors differentiate between winning and losing at senior grade. It is plausible that the significant differences at

intermediate and junior tier are a by-product of the possession dominance that was also observed for winning teams at these grades; that is, if they have more possessions than their opponent they will generate more attacks and shots, assuming similar conversion rates. These findings lend further weight to the previous assertion that possession dominance provides the basis for success at junior and intermediate tiers. 365

Scores, points and total score are all significantly greater for winning teams when compared to losing teams, and, as expected, can be considered key performance indicators for club Gaelic football at all grades. At senior grade, winning teams are also likely to score significantly more goals – perhaps providing an important insight into one of the key differences between winning and losing at senior grade – the ability to score goals. The real value of this study lies not in proving the importance of these measures, but in providing the first profile of successful performance for teams at each grade of club football. Carroll (2013) previously produced a profile of winning performance in inter-county Gaelic football, but this was difficult to apply to the 60 min club game. As an example, senior teams referring to the current study can now target two goals and 12 points, or a total score of 17/18 points as a scoring return likely to result in successful match outcome. Teams at each grade can also gauge what a successful defensive performance looks like. 370 375

Mangan and colleagues, (2017) reported possession effectiveness (shots per possession) in relation to running performance of the various playing positions in Gaelic football. However this is not a commonly used metric and their (Mangan et al., 2017) definition of possession differed from that adopted in this study. In soccer, Hughes and Franks (2005) demonstrated that successful teams displayed a better ratio for converting possession into shots on goal. The current study shows that winning Gaelic football teams across all grades demonstrated superior ability to convert possessions to shots, with winning junior and senior teams converting significantly more possessions to shots than losing counterparts. Intermediate teams also showed similar patterns albeit marginally outside the limits of significance. The significant relationships highlighted here suggest that further exploration of this metric is warranted. 380 385

In soccer, Lago-Penas et al. (2011) and in AFL, Robertson, Back, and Bartlett (2016) linked winning performance to a superior ratio of shots taken to goals scored, while Carroll (2013) in Gaelic football tested shot success but concluded that it was not a key performance indicator of winning performance in inter-county football. Clear et al. (2017) recently found that shot efficiency impacted significantly on match outcome in inter-county hurling. At junior and senior grade, shot success was a significant factor for successful performance, with successful teams delivering a higher conversion rate. Intermediate teams also tended to convert more shots, although not to a significant level. The ability to generate shots from attacking positions (attack efficiency) was previously identified as a key performance indicator of winning performance in Gaelic football (Carroll, 2013). Current results were not conclusive, with only winning teams at intermediate level proving superior in this phase of possession. 390 395 400

The ability to convert possessions to scores proved significant across all grades. Winning teams at all grades converted significantly more possessions to scores when compared against losing teams. In fact, winning teams achieve a score from approximately three possessions, while losing teams take almost five possessions to generate a score. This study is the first to introduce a measure of overall productivity to Gaelic 405

football. Productivity is a measure of a team's total score relative to the number of possessions enjoyed which proved significantly higher for winning teams across all club grades. While it is not surprising that winning teams are more productive on the scoreboard, this method of measuring possession effectiveness in Gaelic football can now be considered a valid means of gauging performance, and more specifically, how efficient a team is in their use of possession. The explanation for this is likely due to a combination of skill level, tactical awareness, and the ability to execute the required skills as demanded by tactical approach. Ultimately, taking scores relies on the ability to read the opposition defence and exploit weaknesses, as well as understanding how to get the right players (shooters) in possession in the right areas (scoring zone). While providing evidence that productivity is a key performance indicator for Gaelic football, this study also supplies coaches with credible reference points regarding required scoring return from possession. From a training perspective, this measure can potentially be implemented to training games, both from an attacking and defensive standpoint in order to develop an awareness of effective use of possession and effective defending.

While it is valuable to put these club Gaelic football data in the public domain, it should be noted that the sample data for this study derived from one province and further studies are required to test its universality. Another limitation could be the fact that the data was collected in 2016 before the introduction of the "Mark" for a clean catch from kickouts. We also acknowledge that this study could be criticised for not considering the multi-faceted inter-relationships between variables in such a chaotic game (MacKenzie & Cushion, 2012). Examining how variables interact for a more holistic picture of the club Gaelic football game is certainly a future research aim, requiring a considerably greater volume of data.

5. Conclusion

This study presents a number of opportunities to undertake further research in this area, including; replication of the current study in other provinces; extending this research into subsequent seasons to monitor changing patterns; and incorporating measures of defensive play to consider interaction between attacking and defensive play (Harrop & Nevill, 2014). A number of specific studies could potentially inform coaching with regard to the variables measured within this study. For example, shooting patterns could be analysed to establish potential scoring "hot-spot" maps for each grade.

Our research has established benchmark profiles for each club competition level and identified that in addition to scoring measures (scores, points and total score); possession: scores ratio, turnover rate and productivity, can be considered key performance indicators of winning performance across all grades. Our findings can be used by club coaches and analysts as comparable profiles for measuring team performance and targeting improvements associated with successful performance.

For performance analysts this research demonstrates the potential to utilise more relative measures of performance in Gaelic football with turnover rates, the possession: scores ratio and productivity all strongly associated to winning. While it is onerous to collect possession counts, it is vital in the calculation of the rates and ratios, which may provide a more accurate assessment of performance than frequency counts. This study also highlights the need for GAA performance analysts to consider data stability when developing, analysing and presenting performance profiles for their team.

Disclosure statement

AQ17 No potential conflict of interest was reported by the authors.

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Appendix 1. Operational definitions used for the purposes of match analysis

Action/Outcome	Definition
Possession	Each time a team is in control (held in hand) of the ball. One possession will persist until the team loses control of the ball. Kickouts are not considered as possession until one team is in control of the ball.
Unsuccessful Possession	When a team surrenders possession without having progressed the ball beyond their opponent's 45m line.
Unsuccessful Attack	When a team plays the ball across their opponents 45m line, either via a hand or foot pass, but the intended recipient is unable to gain control of the ball, and possession is lost.
Attack Retained	When a team has control of the ball inside their opponent's 45m line, but are unable to generate a shot prior to losing possession.
Shot	An action that sends the ball directly towards the opposing teams' goal in an attempt to score a point or goal.
Kickout	Any time the goalkeeper kicks the ball from the ground as a result of the ball travelling over the end line having been last touched by a player on the opposing team.
Won Clean	When a member of the kicking team secures possession, outside their 45m line, directly from the kick out, without any touches from any other player.
Won Short	When a member of the kicking team secures possession, inside their 45m line, directly from the kick out, without any touches from any other player.
Won Break	When a member of the kicking team secures possession, anywhere on the pitch following the ball having been contacted by any other player.
Won Side line	When the kicking team are awarded a side line ball following a kick out being contacted by an opponent, without full control being taken.
Won Free	When the kicking team are awarded a free kick before possession is secured by either team.
Lost Clean	When a member of the non-kicking team secures possession, outside their 45m line, directly from the kick out, without any touches from any other player.
Lost Short	When a member of the non-kicking team secures possession, inside their 45m line, directly from the kick out, without any touches from any other player.
Lost Break	When a member of the non-kicking team secures possession, anywhere on the pitch following the ball having been contacted by any other player.
Lost Side line	When the non-kicking team are awarded a side line ball following a kick out being contacted by an opponent, without full control being taken.

(Continued)

(Continued).

Action/Outcome	Definition
Lost Free	When the non-kicking team are awarded a free kick before possession is secured by either team.
Turnover	When a player in possession surrenders possession to the opposition through physical contact, an unsuccessful shot or pass, or through committing a foul.
Hand Pass	An attempt by a player to transfer possession to another player on their team by using the hand or fist.
Kick Pass	An attempt by a player to transfer possession to another player on their team by using the foot.
Tackle	An action intending to dispossess an opponent who is in possession of the ball.
Free Conceded	Any action that is considered by the referee, to be an infringement on the rules of Gaelic football
Unforced Error	Any action that results in loss of control of the ball, without pressure from an opponent, an attempt to pass the ball, or free being conceded.
Unsuccessful Shot	Any unsuccessful attempt at scoring that surrenders possession to the opponent.
Shot	An action that sends the ball directly towards the opposing teams' goal in an attempt to score a point or goal.
Goal	The ball going below the cross bar and between the posts.
Point	When the ball is kicked or fisted over the crossbar and between the two posts.
Wide	A shot that travels wide of either side of the goal posts.
Short	When the ball falls short of the opposing goal when attempting to score a point or goal
Saved	The goal keeper stopping the ball from going between the two posts.
Post	The ball striking the post or crossbar, and returning to play.
Blocked	When any player from the opposition team (other than the GK) block the shot from reaching the target or going between the two posts.
Possession Won	Refers to the location on the pitch where possession was gained by a team
Defensive Third	Between a team's end line and the nearest 45m line.
Middle Third	Between the two 45m lines.
Attacking Third	Between the opponents' end line and the nearest 45m line.
Possession Source	Refers to the method via which possession was gained by a team
Own Kick Out	When possession is secured from a teams' own kick out.
Opposition Kick Out	When possession is secured from the opposition kick out.
Turnover Won	When possession is secured from any variation of turnover from the opposition.
Throw Up	When possession is secured following a throw up between two or four players by the referee.
45m Kick	When a team is awarded a 45m kick
Regained	When a team secures possession following a loss of control of their previous possession, providing their opponent is unable to claim possession.
Free Conceded	Any action that is considered by the referee, to be an infringement on the rules of Gaelic football
Inside 45m	When a free is conceded inside a teams' defensive 45m line.
Outside 45m	When a free is conceded outside a teams' defensive 45m line.
Aggressive	Any free conceded that relates to an infringement on the rules in relation to other players.
Technical	Any free conceded that relates to an infringement on the rules in relation to the ball.
Other	Any free conceded that relates to any issue outside of the above definitions regarding aggressive and technical fouls.
Card Awarded	When a player is shown a coloured card in relation to their discipline
Yellow	When a player is shown a yellow card.
Red	When a player is shown a red card.
Black	When a player is shown a black card.