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Journal Name	Sport Sciences for Health	
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Schedule	Received	10 August 2017
	Revised	
	Accepted	14 December 2017

Abstract

Background:

Fundamental movement skills (FMS) are basic observable patterns of movement and prerequisites to successful performance of sports specific skills. International research has found that children are not reaching their FMS developmental potential. Stability is a third construct of FMS; however, it is typically excluded from FMS assessment protocols. Limited research has examined FMS and balance proficiency in Irish children.

Aims:
This study aimed to examine FMS and balance proficiency in juvenile Gaelic games players.
Methods:
Thirteen FMS skills and dynamic balance were measured on 63 juvenile Gaelic games players (9.9 ± 1.3 years) using the Test of Gross Motor Development-3 and the Y Balance Test (YBT), respectively.
Results:
Children demonstrated high levels of mastery in the run (100%), slide (96.8%), underhand throw (95.2%), catch (93.7%), and overhand throw (93.7%). Boys performed significantly better in object control skills ($p < 0.0001$) and total FMS skills ($p = 0.002$) than girls. Boys also participated in Gaelic games more frequently ($p = 0.005$), for more hours per week ($p = 0.012$) and for more years ($p = 0.001$). Players that played more hours of Gaelic games per week performed significantly better in object control skills ($p = 0.04$). Boys and girls did not perform significantly different in the YBT.
Conclusions:
Irish juvenile Gaelic game players display higher FMS mastery in a range of FMS and balance proficiency than age-matched, general population. This suggests that participation in Gaelic games facilitates FMS development in children. However, low mastery levels were observed in certain skills; therefore, coaches should incorporate FMS development in coaching sessions.

Keywords (separated by '-')	Gaelic football - Hurling - FMS - Y Balance Test - Motor competency
Footnote Information	

Sport Sciences for Health
https://doi.org/10.1007/s11332-017-0421-2

ORIGINAL ARTICLE

Fundamental movement skill proficiency in juvenile Gaelic games

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Received: 10 August 2017 / Accepted: 14 December 2017

Abstract

Background Fundamental movement skills (FMS) are basic observable patterns of movement and prerequisites to successful performance of sports specific skills. International research has found that children are not reaching their FMS developmental potential. Stability is a third construct of FMS; however, it is typically excluded from FMS assessment protocols. Limited research has examined FMS and balance proficiency in Irish children.

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Conclusions Irish juvenile Gaelic game players display higher FMS mastery in a range of FMS and balance proficiency than age-matched, general population. This suggests that participation in Gaelic games facilitates FMS development in children. However, low mastery levels were observed in certain skills; therefore, coaches should incorporate FMS development in coaching sessions.

Keywords Gaelic football · Hurling · FMS · Y Balance Test · Motor competency

Introduction

Gaelic football and hurling (or camogie when played by females) are two of Ireland's national games and collectively are known as Gaelic games. They are one of the most popular sports for children in Ireland, with over 200,000 children playing in 1500 juvenile clubs across the country [1]. Gaelic games are high-intensity sports that require players to run, jump, catch, turn, and tackle [2]. Gaelic football also requires players to kick and solo (kick the ball to yourself while running), while hurling demands players to strike (swing to hit the sliotar using a hurley), block, and solo (keep the sliotar balanced/bouncing on the hurley while running) [2]. These sport-specific skills and specialised movement sequences are required during the games of Gaelic football and hurling. Fundamental movement skills (FMS) are the basic observable patterns of movement and are prerequisites to such skills and movement patterns. Successful performance of sports specific skills requires the ability to make specific modifications to the basic FMS [3]. FMS can be categorised as locomotor (e.g., running and skipping), object control (e.g., catching and striking), and stability skills (bending and transferring weight). They should be developed and mastered during childhood [3].

Childhood FMS mastery is associated with childhood psychological, physiological, and behavioural development, and may have important health implications [4]. In addition, as FMS are the prerequisites to specialised movement sequences essential for participation in physical activity and sports, the mastery of FMS during childhood assists in the creation of lifelong physical activity patterns with the

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likelihood of regular participation in organised sport and play purported to decrease with children who have not mastered FMS [5]. Indeed, a positive association between FMS competency and physical activity has been identified along with a positive relationship between FMS competency and cardiorespiratory fitness and an inverse relationship between FMS competency and weight status [4].

However, despite the potential contribution of FMS mastery to lifelong physical activity and health-related benefits, low levels of FMS mastery in children have been reported across several countries including Ireland [6], Singapore [7], Belgium [8], Australia [9, 10], and the United Kingdom [11, 12]. FMS acquisition is typically developmentally sequenced and children have the developmental potential to achieve FMS mastery by the age of 6 [3]. However, it does not occur naturally and successful acquisition, and mastery is dependent upon several internal and external factors, including motivational, psychological, biological, and cognitive [9], and opportunities to practice along with encouragement, instruction, and feedback. In Ireland, O'Brien et al. [13] revealed that only 11% of adolescents assessed achieved advanced FMS proficiency across a range of basic FMS, indicating that overall skill execution is low amongst Irish adolescent youth (12–13 years). This finding suggests that in the context of FMS, Irish children are performing below their expected developmental capability and are transitioning to adolescence without prior acquisition of basic FMS. Indeed, Bolger et al. [6] recently reported low levels of FMS proficiency among Irish primary school children, and classified 6-year-old boys and girls and 10-year-old girls as "average" relative to US norms, and FMS proficiency of 10-year-old boys as "below average". However, there is a distinct lack of data published regarding FMS proficiency levels of Irish children and it may not be appropriate to generalise international findings to an Irish context due to different cultural, educational, and traditional sporting pursuits in Ireland. Therefore, the aim of this study was to investigate FMS proficiency levels in Irish children engaging in the traditional Irish sports.

Despite stability being identified as an FMS construct, it is not typically examined during FMS proficiency testing. Dynamic stability or balance is one of the foundation components in the performance of functional movements [14], and requires the person to maintain a stable body orientation during movement [3]. Deficits in dynamic balance can inhibit the performance of movement skills [14], such as FMS, and the addition of a balance assessment may allow for a more holistic assessment and greater understanding of FMS proficiency [15]. In healthy children, the Y Balance Test (YBL) is a viable and reliable tool for the assessment of unilateral stability and dynamic neuromuscular control [16]. The YBT requires children to maximally reach multi-directionally, in the anterior, posteriomedial, and posteriolateral directions while maintaining a single leg stance on the other leg [17]. Therefore, this study additionally aimed to investigate a multi-directional measure of dynamic balance alongside FMS proficiency in male and female juvenile Gaelic games.

Methods

Participants

Male and female juvenile players (males 34; females 29, 9.9 ± 1.3 years) were recruited from three Gaelic games clubs. Ethical approval was received from the university's ethics committee, and written informed consent, from parents/guardians, and participant assent were obtained prior to data collection.

Data collection

All data were collected during a 120 min once off testing session in each club. All participants were assigned an ID number which was attached to the front of the t-shirt at the beginning of testing. Participants underwent a standardised 5–10 min warm up prior to testing and data were collected using a six station circuit format, as displayed in Fig. 1.

Thirteen FMS skills were measured using the TGMD-3 assessment tool [18]. Six locomotor skills (run, gallop, hop, skip, horizontal jump, and slide) and seven object control skills (two-hand strike of a stationary ball, one-hand forehand strike of a self-bounced ball, one-hand stationary dribble, two-hand catch, kick of a stationary ball, overhand throw, and underhand throw) were examined. The skill was introduced and demonstrated to the participant once, followed by the participant completing one trial run. Each skill

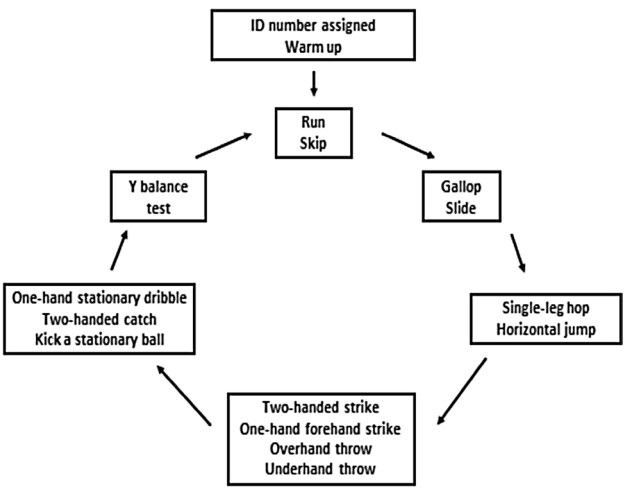

Fig. 1 Schematic diagram of stations and testing procedure

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was then performed twice while being videotaped (Canon, LEGRIA HF R706, Japan) and no feedback was provided to the participant. Participants were required to state their ID number prior to each skill for the confirmation of identification during analysis. Each skill was evaluated on three-to-five performance criteria. For each criterion, a score of one was awarded for the successful execution of the criterion and zero if it was not present. The score from both trials was then summed for a total score of each FMS which was used to calculate a locomotor subtest score (maximum 46), an object control subtest score (maximum 54), and a total TGMD-3 score (maximum 100). A participant was deemed to have demonstrated "Mastery" in a skill when all performance criteria for the skill were successfully executed in both trials, while "Near Mastery" was identified as the successful execution of all performance criteria except one in both trials [19]. "Poor" execution was identified as any performance below "Near Mastery". Following the testing session, the videotapes were used to score each FMS by three testers. Reliability was examined prior to scoring. Excellent inter-rater reliability [ICC 0.96 (95% CI 0.94–0.96)] between the three testers was noted and excellent intra-tester reliability was found when the testing was repeated 3 days later [Tester 1 ICC 0.89 (95% CI 0.84–0.92); Tester 2 ICC 0.88 (0.83–0.91); Tester 3 ICC 0.86 (95% CI 0.81–0.90)].

For the YBT, participants stood on one leg with their toes behind the line on the Y Balance Test kit platform. Participants reached as far as they could with the other leg, while keeping a stable stance, in the anterior, posteriomedial, and posteriolateral directions on both legs. Participants completed four practice trials that were not recorded to familiarise themselves with the test [14]. Following this, three trials were completed and the distance reached in centimeters was noted. Limb length was measured to the nearest centimeter from the ASIS to the medial malleolus [17]. The YBT scores in each direction were normalised by limb length and the composite score was calculated by the summation of the scores from each direction divided by leg length by three and multiplied by a hundred.

Data analysis

All data were entered into SPSS version 23.0 where all statistical analyses were performed. The mean and standard deviation of the FMS and YBT scores were calculated for all participants and by gender. Independent sample t tests were used to examine gender differences in FMS scores. The percentage of participants that achieved mastery, near mastery, and poor execution in the FMS skills was also calculated, and Chi-squared tests for independence were used to establish any gender differences in the percentage of participants achieving mastery, near mastery, or poor execution. An independent t test was utilised to examine differences between boys and girls for the YBT normalised scores. Pearson's product moment correlations were completed between (1) normalised YBT anterior, posteriomedial, posteriolateral, and composite scores and locomotor, object control, and FMS scores, and (2) locomotor, object control, FMS and composite YBT scores and hours per week partaking in sport, and hours per week and years partaking in Gaelic games. The strength of the relationship (r value) examined was classified according to Cohen [19] (small 0.10–0.29, medium 0.30–0.49 and large 0.50–1.0). Independent t tests were also used to identify any gender differences for years participating in Gaelic games, the frequency, and number of hours playing Gaelic games per week.

Results

Figure 2a, b presents the mean (SD) raw score for each FMS examined for boys and girls. While boys had a higher mean locomotor subtest score (42.65 ± 2.91 vs 42.59 ± 2.13), it was not significantly higher than the mean locomotor subtest score for girls and there was no statistically significant gender difference for any of the locomotor skills ($p > 0.05$). Boys had significantly higher mean object control subtest scores than girls ($p < 0.0001$) and executed the two-handed strike of a stationary ball and the two-hand catch significantly better than girls ($p = 0.017$ and $p < 0.0001$, respectively). Boys also scored significantly better than girls in the mean total TGMD-3 score ($p = 0.002$).

The percentage of FMS mastery, near mastery, and poor mastery for all participants are presented in Fig. 3a, b, and for males and females in Fig. 4a, b. One male participant (1.6%) demonstrated mastery in all 13 skills examined. All participants demonstrated mastery in the run and high levels of mastery were also demonstrated in the slide (96.8%), two-hand catch (93.7%), overhand throw (93.7%), and underhand throw (95.2%). The lowest levels of mastery were observed in the two-hand strike of a stationary ball with 23.8% of participants demonstrating mastery, 61.9% demonstrating near mastery, and 14.3% demonstrating poor execution of the skill. Low levels of mastery were also observed for the gallop (46%), horizontal jump (55.6%), and single leg hop (58.7%). There were no gender differences in the prevalence of mastery in any locomotor skills, but a higher prevalence of mastery was observed in boys for the two-hand strike of a stationary ball ($\chi^2 = 8.021$, $p = 0.018$) and kick ($\chi^2 = 29.348$, $p < 0.0001$).

The normative values of the YBT in the anterior, posteriomedial, posteriolateral, directions normalised for leg length, composite scores and differences between sides are presented in Table 1. No significant difference was found between boys and girls for the normalised YBT composite scores, and in the anterior, posteriomedial, and

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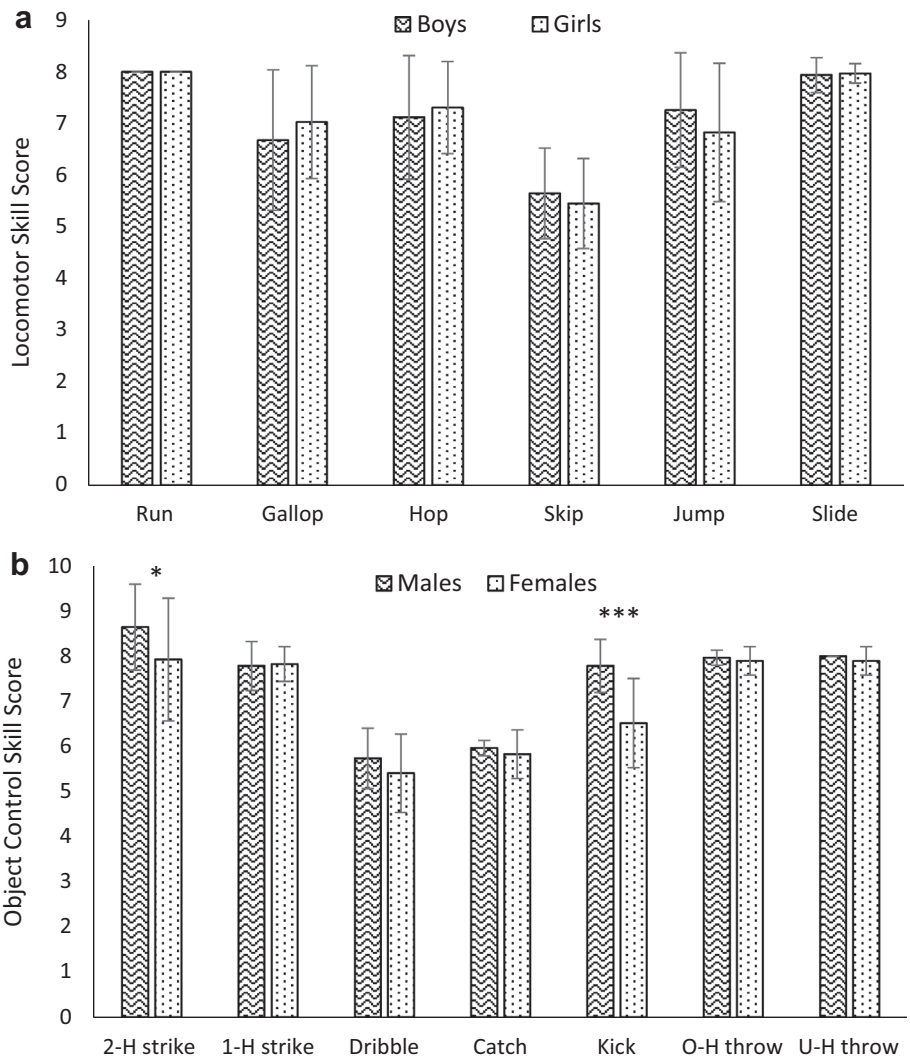

Fig. 2 **a** Mean and standard deviation of raw locomotor skill scores for males versus females. *Hop* single leg hop, *Jump* horizontal jump. **b** Mean and standard deviation of raw object control skill scores for males versus females. *$p < 0.05$; **$p < 0.001$; *2-H strike* two-hand strike of stationary ball, *1-H strike* one-hand forehand strike of self-bounced ball, *Catch* two-hand catch, *Kick* kick of stationary ball, *O-H throw* overhand throw, *U-H throw* underhand throw

posteriolateral directions ($p > 0.05$). Table 2 displays the correlation between normalised YBT scores and FMS proficiency. A small positive correlation was found between locomotor skills and posteriolateral ($r = 0.29$, $p = 0.02$) and composite ($r = 0.27$, $p = 0.03$) scores. With regard to total FMS score, a statistically significant weak relationship was found for posteriomedial ($r = 0.28$, $p = 0.03$) and composite ($r = 0.26$, $p = 0.04$) scores. Object control skill proficiency did not correlate to YBT scores ($p > 0.05$). In boys, a positive medium relationship was found between locomotor and total FMS scores and posteriomedial (L: $r = 0.46$, $p = 0.01$; FMS: $r = 0.49$, $p = 0.003$) and composite scores (L: $r = 0.47$, $p = 0.01$; FMS: $r = 0.48$, $p = 0.004$), respectively. A statistically significant large relationship was found in boys only between posteriolateral scores and locomotor ($r = 0.52$, $p = 0.002$) and total FMS ($r = 0.53$, $p = 0.001$) scores. No relationship between YBT scores and FMS proficiency was noted in girls ($p > 0.05$).

The vast majority of participants played both Gaelic football and hurling (87.30%, 55). Participants spent a mean of 3.98 ± 1.72 h per week playing Gaelic games and have played for a mean of 4.82 ± 2.05 years. However, compared to girls, boys participated significantly more frequently (6.56 ± 2.38 vs 5.12 ± 1.47 times, $p = 0.005$) and spent more hours (4.46 ± 1.99 vs 3.41 ± 1.15, $p = 0012$) per week playing Gaelic games in addition to being involved in Gaelic for significantly more years (5.67 ± 1.71 vs 4.12 ± 1.94 years, $p = 0.001$). The correlation between hours per week and years spent playing Gaelic games is presented in Table 3. A statistically significant correlation was only found between object control skills and hours spent per week playing Gaelic games ($p = 0.04$); however, the correlation was weak ($r = 0.26$). None of the other variables were found to be statistically correlated with proficiency levels ($p > 0.05$). Participants (95.2%, 60) primarily played at least one other sport

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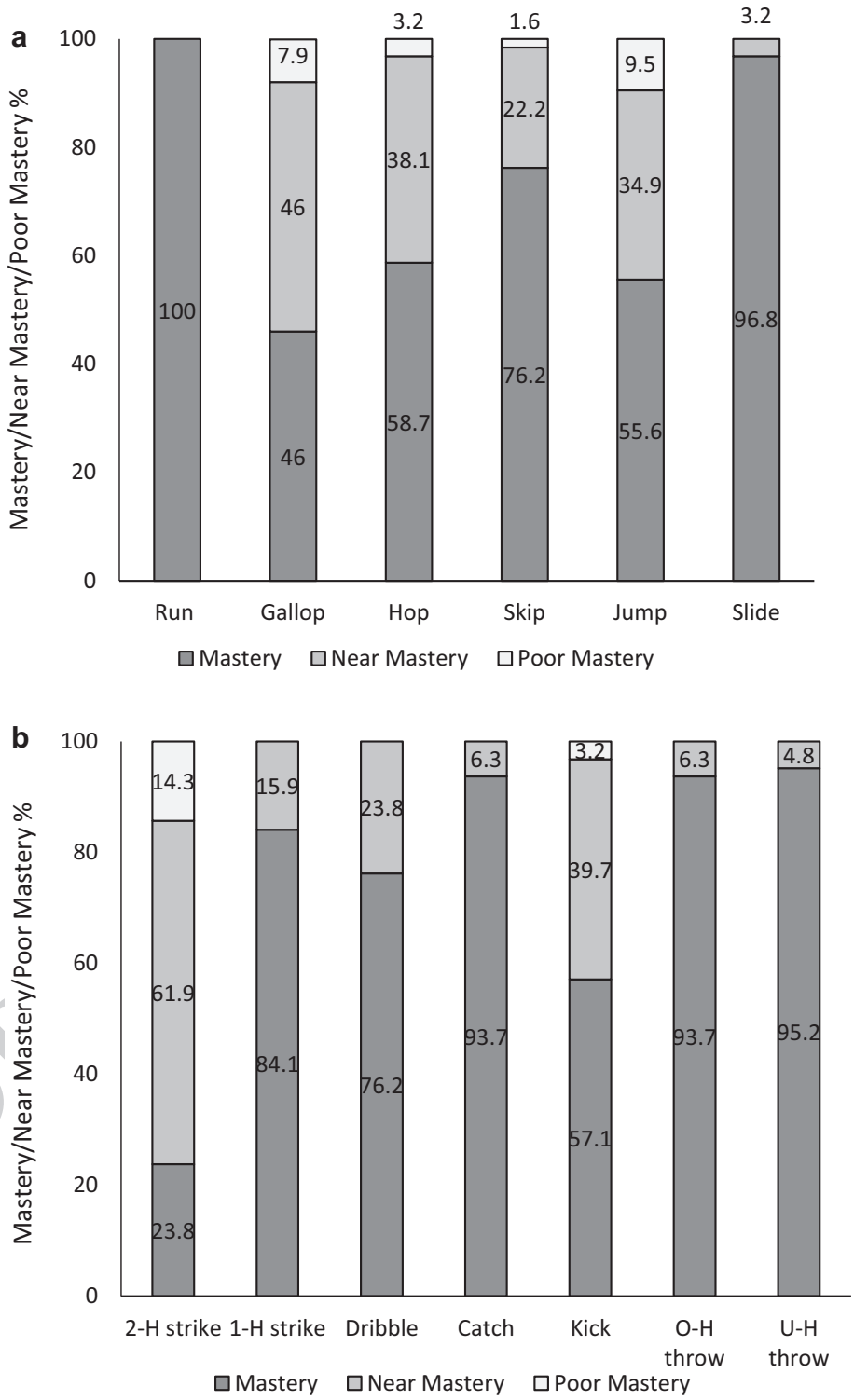

Fig. 3 **a** Percentage of FMS mastery, "near" mastery and "poor" mastery in locomotor skills for all participants. *Hop* single leg hop, *Jump* horizontal jump. **b** Percentage of FMS mastery, "near" mastery and "poor" mastery in object control skills for all participants. *2-H strike* two-hand strike of stationary ball, *1-H strike* one-hand forehand strike of self-bounced ball, *Catch* two-hand catch, *Kick* kick of stationary ball, *O-H throw* overhand throw, *U-H throw* underhand throw

outside of Gaelic games, and spent a mean of 6.43 ± 2.75 and 5.80 ± 3.73 h per week in sport and recreational activity, respectively. No significant relationship was found between total hours of sport played and FMS and balance proficiency ($p > 0.05$) (Table 5).

Discussion

This study investigated FMS proficiency levels in Irish juvenile Gaelic games players. While only one participant demonstrated mastery across all FMS examined, all children demonstrated mastery in the run and the prevalence

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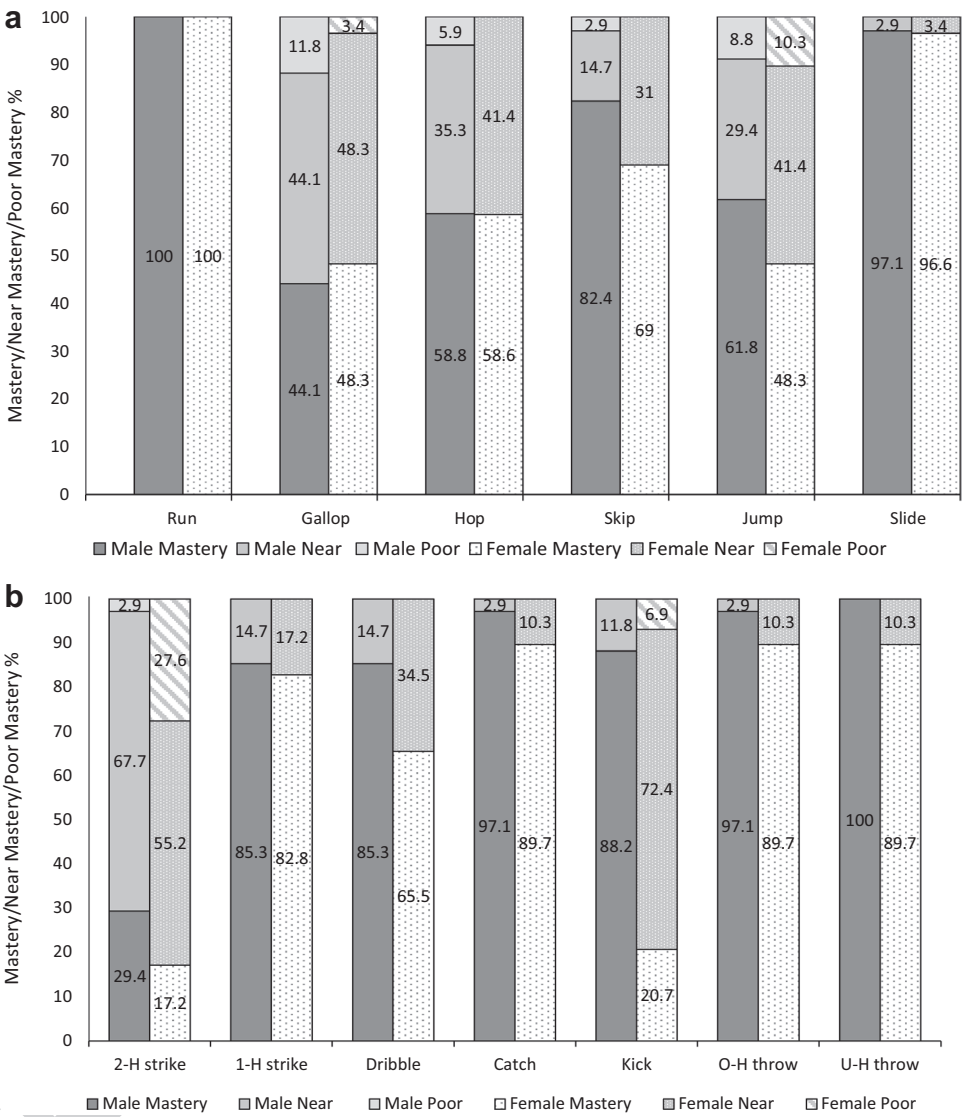

Fig. 4 **a** Percentage of mastery, "near" mastery, and "poor" mastery for males versus females in locomotor skills. *Hop* single leg hop, *Jump* horizontal jump. **b** Percentage of mastery, "near" mastery and "poor" mastery for males versus females in object control skills. *2-H strike* two-hand strike of stationary ball, *1-H strike* one-hand forehand strike of self-bounced ball, *Catch* two-hand catch, *Kick* kick of stationary ball, *O-H throw* overhand throw, *U-H throw* underhand throw

of mastery varied from 23.8 to 96.8% across the other FMS examined. No gender differences were observed among any of the locomotor skills. However, a higher prevalence of mastery was observed in boys for object control skills, with boys significantly more proficient than girls in overall object control subtest ($p < 0.0001$) and in particular the two-hand strike of a stationary ball ($p = 0.017$) and two-hand catch ($p < 0.0001$). Boys were also significantly more proficient than girls for total FMS scores ($p = 0.002$).

Motor competence can be assessed at an outcome level or process level. The TGMD-3, a successor to the valid and reliable TGMD-2, assesses gross motor skill competency at a process level through the qualitative analysis of a range of FMS and allows for the identification of a child's developmental skill level instead of their physical growth or maturation status [9]. Designed to evaluate motor skill competency in children, the TGMD-3 has been shown to have acceptable reliability [21] and norm-referenced values are currently being established. Through the use of the TGMD-3, this study identified that only one male participant demonstrated mastery in all 13 FMS assessed, despite the fact that children have the developmental potential to achieve mastery in FMS by the age of 6 [3]. However, to develop motor skill competency children must be afforded the opportunity to practice, receive instruct, develop, and learn FMS in an appropriate learning environment [9, 22]. The results of this study are similar to those reported by O'Brien et al. [13] who also reported that only one participant demonstrated mastery across all skills assessed. However, while this study was also completed with an Irish population, the participants were adolescent youths from the general population (12–13 years) who were assessed on only nine skills. The results of the current study on juvenile Gaelic games participants, in conjunction with those reported by O'Brien et al. [13] in the general

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Table 1 Normative values (M ± SD) for the YBT

YBT	All	Boys	Girls
Anterior			
Normalised right (%)	73.28 ± 8.91	74.75 ± 8.62	71.55 ± 9.08
Normalised left (%)	72.92 ± 7.42	73.68 ± 7.38	72.03 ± 7.50
Normalised (%)	73.10 ± 7.69	74.22 ± 7.52	71.79 ± 7.82
Difference (cm)	3.35 ± 2.75	3.32 ± 2.82	3.38 ± 2.72
Posteriomedial			
Normalised right (%)	111.85 ± 18.57	114.20 ± 18.11	109.9 ± 19.05
Normalised left (%)	113.75 ± 17.46	115.79 ± 19.19	111.35 ± 15.17
Normalised (%)	112.80 ± 17.41	115.00 ± 18.03	110.22 ± 16.60
Difference (cm)	4.84 ± 5.41	4.59 ± 5.82	5.14 ± 4.97
Posteriolateral			
Normalised right (%)	106.98 ± 16.38	107.60 ± 17.64	106.24 ± 15.03
Normalised left (%)	108.29 ± 16.19	106.47 ± 14.82	110.43 ± 17.68
Normalised (%)	107.63 ± 15.49	107.03 ± 15.52	108.33 ± 15.71
Difference (cm)	5.30 ± 4.04	5.76 ± 4.29	4.74 ± 3.71
Composite			
Normalised right (%)	97.17 ± 10.76	97.74 ± 11.67	96.49 ± 9.74
Normalised left (%)	97.37 ± 13.28	98.85 ± 13.63	95.63 ± 12.88
Normalised (%)	97.84 ± 12.59	98.75 ± 12.88	96.78 ± 12.39
Difference (cm)	3.89 ± 3.48	3.93 ± 3.63	3.84 ± 3.36

adolescent population and most recently by Bolger et al. [6] in Irish primary school children, indicate that Irish children are performing below their developmental potential. Thus, research in developing methods to improve FMS proficiency in Irish children, in general, may be warranted.

While the current study and the study by O'Brien et al. [13] both reported that only one participant demonstrated mastery across all skills examined, the current study found higher mastery levels than O'Brien et al. [13] for several skills including the run (100 vs 87%), catch (93.7 vs 68%), dribble (76.2 vs 61%), overhand throw (93.7 vs 45%), skip (76.2 vs 11%), and horizontal jump (55.6 vs 29%), despite the participants in the this study being approximately 3 years younger than those investigated by O'Brien et al. [13]. This is unexpected as age-related improvements in motor competency have previously been reported [23–25]. Butterfield et al. [25] observed a trend of an increase in the prevalence of FMS mastery in children from the age of 5–10 years in

Table 2 Correlation between normalised YBT scores and FMS proficiency

Normalised YBT scores	All						Boys						Girls					
	Locomotor		Object control		Total FMS		Locomotor		Object control		Total FMS		Locomotor		Object control		Total FMS	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Anterior (%)	0.20	0.11	0.06	0.64	0.20	0.11	0.26	0.13	− 0.73	0.68	0.21	0.23	0.16	0.42	− 0.02	0.92	0.09	0.63
Posteriomedial (%)	0.23	0.07	0.16	0.21	0.28	0.03*	0.46	0.01*	0.14	0.42	0.49	0.003*	− 0.16	0.41	0.06	0.78	− 0.07	0.71
Posteriolateral (%)	0.29	0.02*	0.01	0.94	0.22	0.08	0.52	0.002*	0.11	0.53	0.53	0.001*	− 0.07	0.71	− 0.02	0.93	− 0.06	0.76
Composite (%)	0.27	0.03*	0.09	0.49	0.26	0.04*	0.47	0.01*	0.10	0.58	0.48	0.004*	− 0.07	0.73	0.01	0.95	− 0.04	0.85

*Statistical significance

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Table 3 Correlation between FMS and composite YBT proficiency and hours spent in Gaelic games, sport, and years of playing Gaelic games

	Locomotor		Object control		Total FMS		Composite YBT	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Hours Gaelic games	0.03	0.80	0.26	0.04*	0.19	0.14	0.07	0.60
Years Gaelic games	0.03	0.84	0.13	0.32	0.10	0.43	− 0.04	0.78
Hours sport	− 0.04	0.75	− 0.01	0.95	− 0.04	0.78	− 0.06	0.63

*Statistically significant

four FMS, the catch, throw, kick, and strike, with rapid gains observed from 9 to 10 years. However, as expected, Irish adolescents from the general population performed better in the kick (57.0 vs 83.0%) and two-handed strike of a stationary ball (23.8 vs 44.0%).

Similarly, Bolger et al. [6] observed low FMS levels and no 10-year-old child demonstrated mastery across all FMS. However, while this current study investigated FMS levels in a cohort of Gaelic games players, Bolger et al. [6] investigated FMS levels in Irish school children from the general population, regardless of their participation in organised sport. In comparison to this previous study [6], juvenile Gaelic games players in the current study demonstrated higher mastery levels in eight FMS, including the run (100 vs 77.2%), hop (58.7 vs 36.6%), slide (96.8 vs 49.5%), horizontal jump (55.6 vs 13.9%), dribble (76.2 vs 50.5%), catch (93.7 vs 38.6%), two-handed strike of a stationary ball (23.8 vs 20.8%), and the overhand throw (93.7 vs 45.5%). This suggests that participation in the traditional Irish sports of Gaelic games facilitates the development of FMS in children, potentially due to greater opportunities for practice, instruction, and feedback associated with organised sport. However, lower levels of mastery in the gallop (46 vs 62.4%) and kick (57.0 vs 82.2%) were reported. The low levels of mastery for the kick in Irish children observed in the current study are surprising, as kicking is an essential skill in Gaelic football. However, the TGMD-3 kick assessment requires kicking a stationary ball off the ground, whereas in Gaelic football, in most instances, players kick the ball from the hand. Furthermore, deficits were primarily noticed in Irish girls in the current study (20.7%), whereas 88.2% of boys demonstrated mastery of the kick.

The previous international research [9, 10, 12, 26] indicates that children are not reaching their FMS developmental potential. The results of this current study revealed that juvenile Gaelic games participants have higher mastery levels in a range of FMS compared with international age-matched children in the general population [7, 24, 27–29]. Higher mastery levels, compared to 9-year-old American children [28], were observed in this study for seven skills including the catch (93.7 vs 76%), dribble (76.2 vs 72%), overhand throw (93.7 vs 52%), run (100 vs 85%), horizontal jump (55.6 vs 44%), hop (58.7 vs 52%), and slide (96.8 vs 81%). Similarly, higher levels of mastery were exhibited in six skills (catch, dribble, overhand throw, run, hop, and slide) compared to 9-year-old Chinese children [27], seven skills (catch, kick, strike, dribble, overhand throw, run, and slide) compared to 9-year-old Portuguese children [29] and five skills (catch, kick, strike, overhand throw, and run) compared to 9-year-old Australian children [24]. These higher levels of FMS mastery exhibited across a range of FMS in juvenile Gaelic games players demonstrate the benefits of participation in organised sports such as Gaelic games that require upper and lower limb coordination as well as various locomotor skills.

In contrast to some of the age-matched international research [27–29], mastery in Irish juvenile Gaelic games participants did appear to be lower in the gallop and in some instances the strike. Interestingly, the strike had the lowest level of mastery (23.8%) in all FMS investigated in the current study, despite being a key skill in the Gaelic games of hurling and camogie. However, hurlers and camogie players are taught a different hand-grip than required in the TGMD-3 assessment which may impact on their ability to achieve mastery when assessed [6]. When comparing such research, it is important to note that while all of these studies utilised process-oriented measures of FMS, different process-oriented tools, such as the TGMD-2, have previously been used to assess FMS competency and identify the prevalence of mastery. Variations between skills assessed across different process-oriented measures do not allow for the direct comparison of studies and limits comparisons to common skills.

Gaelic games are the traditional Irish sports, and are one of the most popular sports played in Ireland, with 81% of primary schools partaking in Gaelic games [30]. All participants in the current study played either Gaelic football or hurling/camogie, with 87.3% of participants playing both sports. The previous national and international research has predominantly focused on a representative sample of children based in primary schools [7, 12, 24, 27], to ensure inclusion of children that partake and do not take part in organised sport are examined. Therefore, while the physical education curriculum in primary schools has the potential to influence FMS development in children, so too does childhood involvement in organised sport like Gaelic games. Involvement in such organised sport may play a pivotal role in FMS development in children and several studies have

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suggested that intercultural differences in motor competence may be the result of differences in traditional national sports and popular sporting culture [27, 31]. This study is the first of its kind to support the idea that participation in traditional national sport of Gaelic games may provide an appropriate, relevant, and structured environment for the development of FMS, with opportunity to practice, facilities, equipment, instruction, encouragement, and feedback.

In the current study, boys outperformed girls in mean total FMS scores ($p = 0.002$). This difference in overall skill level may be predominantly explained by differences in object control skills rather than locomotor skills. Similar to the previous international research [8, 9, 32], Irish boys achieved significantly higher object control skills ($p < 0.0001$). Specifically, boys performed better than girls in the two-hand strike of a stationary ball ($p = 0.017$) and the kick ($p < 0.0001$) and similarly demonstrated a higher prevalence of mastery in both of these skills (29.4 vs 17.2% and 88.2 vs 20.7%, respectively). Interestingly, the lowest level of proficiency across all FMS was observed in the two-hand strike of a stationary ball for both boys (29.4%) and girls (17.2%). Boys were marginally better than girls in the overall locomotor subtest score, but this difference was not significant ($p > 0.05$). This finding is in agreement with the previous research that has similarly reported no gender differences in locomotor skills [8, 32, 33]. However, research regarding gender differences in locomotor skills is conflicting, with some research reporting that girls are more proficient at locomotor skills [9], while others have reported that boys are more proficient [34, 35]. With minimal physical and biological differences that could potentially result in motor performance differences between genders noted before puberty, other factors explaining gender differences in FMS at this age have been proposed and include children's socialisation, physical activity preferences, or bias for specific sporting activities [9, 35]. In the present study, all children were physically active and exposed to similar sporting activities and opportunities through participation in Gaelic games (5.90 ± 2.13 times per week for a duration of 3.98 ± 1.72 h per week), in comparison to other research, that may have examined children from the general population [7, 8, 12, 24, 27]. Therefore, gender differences in object control skills would not have been expected. However, boys in the current study were involved in Gaelic games for a significantly longer time than girls (5.67 ± 1.71 vs 4.12 ± 1.94 years, $p = 0.001$) and engaged in Gaelic games significantly more times per week ($p = 0.005$) and for significantly longer duration each week ($p = 0.012$) than girls. This may explain, at least partially, the significantly better object control skills and overall TGMD-3 results observed in boys.

To date, no research has published normative data for the YBT in Irish children, and therefore, this study provides current children-specific reference values for boys and girls that play Gaelic games in Ireland. The YBT has been examined in Gaelic games, however, solely in male adolescents and collegiate players [36]. Faigenbaum et al. [16] examined the YBT in 188 US school male and female children aged between 6.9 and 12.1 years. This study reported YBT reach distances, without normalising for leg length; therefore, for comparison purposes, the reach distances are presented. Irish school children that play Gaelic games had a greater reach distance for anterior (56.57 ± 6.29 vs 51.1 ± 8.3 cm), posteriomedial (86.27 ± 13.08 vs 75.3 ± 10.0 cm), posteriolateral (82.49 ± 11.43 vs 71.5 ± 11.7 cm), and composite (225.33 ± 27.36 vs 197.9 ± 27.3 cm) directions than the US school children. In addition, the YBT reference values for Irish boys in this study were higher than male Saudi school children aged between 12 and 15 years for posteriomedial (115.00 ± 18.03 vs 100.88 ± 10.97%), posteriolateral (107.03 ± 15.52 vs 105.13 ± 9.77), and composite (98.75 ± 12.88 vs 93.91 ± 8.52) scores [37]. In contrast, Saudi school children performed better in the anterior direction (75.71 ± 7.80 vs 74.22 ± 7.52%) [37]. The higher proficiency in Irish children in this study compared to the US and Saudi Arabia from the general population is more than likely due to the fact that only children that played Gaelic games were recruited, in contrast to school children. Therefore, these physically active children that all play Gaelic games, may have developed their balance proficiency to a greater extent than a population that includes those who may not take part in sport or high levels of physical activity. This greater balance proficiency compared to Saudi males is especially noteworthy, as the boys in the current study were younger.

While no previous research has examined reference values in female children, no significant difference was noted in balance proficiency between boys and girls in this study ($p > 0.05$). This supports other findings of this study, as girls were shown to perform similar to boys in locomotor skills, where stability is an inherent prerequisite. In fact, in Irish boys that partake in Gaelic games, a moderate-to-strong correlation was found in the current study between locomotor scores and YBT composite ($r = 0.47$, $p = 0.01$), posteriomedial ($r = 0.46$, $p = 0.01$), and posteriolateral ($r = 0.52$, $p = 0.002$) scores. Similarly, Ulrich and Ulrich [38] noted that balance proficiency significantly predicted a qualitative rating of jumping and hopping, which are two locomotor skills examined in the TGMD-3; however, this was in younger children aged 3–5 years. Interestingly, there was no relationship noted between the YBT scores and FMS scores in girls, despite no significant difference being reported between boys and girls for balance proficiency. No relationship between objective control skills and balance proficiency was noted ($p > 0.05$), which may indicate that stability is not as critical a component to the performance of object control

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skills in comparison to locomotor skills. Therefore, these findings indicate that stability is an inherent component in the performance of FMS using the TGMD-3, particularly for locomotor skills, and stability skills should be taught and assessed when examining fundamental movement skill proficiency in children.

No significant correlation between FMS or balance proficiency and hours spent playing sport or years spent playing Gaelic games was found. This is despite research demonstrating that motor competence, using the TGMD-2, can significantly predict children's likelihood to reach the 60 min per day moderate-to-vigorous physical activity (MVPA) guidelines [39]. However, since the children in this study generally tended to be notably physically active and heavily involved in sport each week (6.43 ± 2.75 h) compared to a sample of 507 Irish girls (3.7 ± 2.5 h) aged 9.4 ± 1.7 years [40], for a similar number of years (4.82 ± 2.05 years), this may explain the lack of a relationship between hours playing sport and proficiency. Interestingly, those children that played more hours of Gaelic games per week performed significantly better in object control skills ($r = 0.26$, $p = 0.04$). This finding supports the previous research by Barnett et al. [41] on 244 boys and girls, that those with higher object control skills, were more likely to have higher cardiovascular fitness ($p = 0.01$). Object control skills incorporate skills that are essential to Gaelic games, such as kicking, striking, and catching; therefore, it is expected that those children who take part in more Gaelic games each week, would be more competent in performing these skills. However, despite reaching statistical significance, the strength of the relationship was weak.

Practical applications

Irish juvenile Gaelic game players are performing better than age-matched national and international children from the general population in a range of FMS skills and balance. Therefore, it seems that coaching in Gaelic games to juvenile players is facilitating the development of FMS including the catch, run, dribble, overhand throw, and slide. However, two skills where mastery is lacking in this population include the two-handed strike of a stationary ball and the gallop. These two skills are potentially highly related to the development of critical sports specific skills required in Gaelic games, such as jumping for a ball and the two-handed strike of a sliotar required in hurling/camogie. In addition, only one in four girls achieved mastery in the kick, which is an essential skill required in Gaelic football. However, differences in the techniques to strike a sliotar and kick during Gaelic games may account for reduced mastery. Potentially, adapting or incorporating additional skill assessments for use in specific sports should be considered. Despite the fact that girls in this study took part in Gaelic games weekly, they performed significantly worse than boys in the object control skills. Thus, coaches in female juvenile Gaelic games should target the object control skills in their coaching sessions. Therefore, while Gaelic games appear to be assisting the development of FMS in children, coaches should be further educated on the importance of FMS and the implementation of FMS training into coaching sessions to assist in the future development of sport-specific skills and a potential pathway for lifelong physical activity. Particular attention should be paid to the skills highlighted as poorly executed in this study. The inclusion of a stability or balance test to the FMS assessment protocol is beneficial, and coaches should consider the inclusion of a stability test when examining FMS in children and incorporate this skill into their coaching.

Limitations

Due to the YBT screening setup, children were able to view their scores during testing, which may have influenced their motivation in the test. The current study was limited due to the relatively small sample size; therefore, future research should expand this current study. In addition, this study examined FMS and balance proficiency solely in Gaelic games. Future research should examine proficiency levels among other popular sports played in Ireland and physically inactive children to establish normative data across the population.

Conclusion

Despite the reported benefits associated with FMS competency, there is a distinct lack of research investigating FMS proficiency and balance in Irish children. Balance proficiency and mastery levels across a range of FMS in Irish juvenile Gaelic games players are higher than age-matched national and international norms for the general population. This demonstrates the advantageous effects to motor skill development in children who participate in organised traditional sports such as Gaelic games. While girls and boys were similar in locomotor skills and YBT proficiency, boys performed superior to girls in object control skills. This may be due to the fact that boys spent more time each week playing Gaelic games, played more frequently, and had been involved in Gaelic games for significantly more years than girls. Participation in Gaelic games, therefore, can facilitate FMS development in children, and organised sports such as this, that provide coaching to children in a structured environment with opportunities to practice FMS and provide appropriate feedback and instruction on FMS skills, is advantageous. However, Irish juvenile Gaelic games players did perform poorly in certain FMS skills, in particular

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the girls. Therefore, coaches should be further educated on FMS, and FMS interventions to target these skills should be included in coaching sessions.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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