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Anthropometric and Physical Fitness Profile of Adolescent Inter-County Ladies' Gaelic Football Players

Teresa Molohan [1,*], Stephen Behan [1,2] and Áine MacNamara [1,*]

[1] School of Health and Human Performance, Faculty of Science and Health, Dublin City University, D09 W6Y4 Dublin, Ireland; stephen.behan@dcu.ie
[2] Insight SFI Research Centre for Data Analytics, Dublin City University, D09 W6Y4 Dublin, Ireland
* Correspondence: teresa.molohan2@mail.dcu.ie (T.M.); aine.macnamara@dcu.ie (Á.M.)

Abstract: The aim of this study was to determine the anthropometric and physical fitness profiles of inter-county female Gaelic football players from under-14 to under-18 age levels. A total of 156 athletes (U14, n = 33; U16, n = 64; U18, n = 59) participated in this study. Testing was conducted in a single session for each group and included anthropometric measures of standing and sitting height, weight, estimated age of peak height velocity (PHV), and maturity offset. Physical performance tests included squat jump (SJ), countermovement jump (CMJ) and drop jump (DJ), 0–5 m and 0–20 m sprint times, pro-agility test, medicine ball chest-pass throw, and YoYo intermittent recovery test level 1 (YoYoIR1). A one-way analysis of variance (ANOVA) was used to investigate differences between the age groups. Significant differences were identified between age groups for measures of height ($p < 0.001$, ES = 0.127), body mass (p.002, ES = 0.076), and estimated age of PHV ($p < 0.001$, ES = 0.612). No significant differences were found between age groups for any of the physical fitness tests except for the YoYoIR1, where a significant difference was found between the U14 and U18 age groups (p.029, $\eta 2p$ = 0.048). These findings may assist coaches to better understand female athletic development, provide insight on talent identification and development programmes, and provide reference data when working with this cohort so that realistic and attainable training goals can be achieved.

Keywords: female adolescents; Ladies' Gaelic football; fitness profile; maturation

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1. Introduction

Ladies' Gaelic football is one of the leading participation sports for females in Ireland [1]. As with other female team sports such as soccer, rugby, and Australian rules football, there has been a substantial increase in participation rates in recent years, with membership rising from 80,000 playing members in 2005 to over 200,000 today [1]. Participation in Gaelic sports is an integral part of children's and adolescent's formative years in Ireland [2]. Children from 8 to 12 years of age participate in non-competitive games (labelled Go Games) and then progress to competitive games organised at each age grade from under-13 to adult levels of competition. Adolescents compete in organised competitions at club and school level, with the best performing young players then selected to play for representative teams at county and provincial level [2]. As part of the player pathway, regional competitions are organised at under-14, under-16, and under-18 age grades at provincial and national level as a process marker of development with the aim of the pathway to support the development of young players to compete at senior representative level [3].

From a rules and game format perspective, men and women compete under almost identical conditions, and Gaelic football is often described as a hybrid of other invasion games such as basketball, rugby, soccer, and Australian rules football [4]. Matches are played between two teams of fifteen players on a rectangular pitch approximately 145 m long and 90 m wide, with one point scored when the ball is kicked over the crossbar (termed a point) and three points for a goal, a score under the crossbar [2]. The game is characterised as an intermittent high-intensity field sport involving multi-directional sprints, jumping, and evasion skills, as well as sport-specific skills including kicking, catching, soloing, handpassing, tackling, and blocking [4,5]. In common with other field invasion sports, physical attributes such as high-intensity running, repeated-sprint ability, jumping, strength, speed, and agility contribute to performance [6]. Therefore, to optimally perform in the game, players need to develop fitness attributes that enable them to maintain technique and skill levels while dealing with the physical demands of the sport [4].

During childhood, boys and girls follow similar rates of development in growth and maturation, and despite some consistent sex differences, strength, speed, power, endurance, and coordination develop at comparable rates [7]. Typically, the onset of the adolescent growth spurt occurs around age 10 for girls and about age 12 for boys, although this may vary considerably between individuals [8]. Peak height velocity (PHV) refers to the period of fastest growth in terms of height during adolescence [9]. Generally, girls experience PHV at an earlier age than boys (12 years versus 14 years) [8]. Despite girls achieving PHV earlier, the growth spurt is longer and more intense in boys, with adult height attained earlier in girls [8]. Performance differences between males and females begin to emerge at the onset of the adolescent growth spurt for nearly all components of fitness, with males making greater gains in most physical attributes apart from flexibility [6]. While male athletes continue to make gains in strength, speed, and power with increasing maturation, females tend to plateau in mid-to-late adolescence [10–12]. These differences are driven by a significant increase in circulating androgens in boys compared with girls, resulting in greater gains in muscle mass and lower gains in fat mass, and explain much of the difference between the athletic performance of males and females during adolescence and into adulthood [8,13].

Despite the growing popularity of female sports, there is a lack of female-specific research to assist coaches in physical team preparation. Much of the data collected in sports science and medicine, across all age groups and levels of competition, has focused on male athletes and reflect their experiences [14]. Females are significantly underrepresented in sport and exercise research and currently account for 39% of the total number of participants in sport and exercise medicine studies, while only 6% of studies are exclusively female [15,16]. Given the known anatomical, physiological, and endocrinological differences between males and females, it cannot be assumed that research on males can be directly applied to females [16]. Assessing female player capabilities, e.g., speed thresholds, strength norms, etc., using normative male data will underestimate female players' performance given the greater physical stature and physiological capacity of male players [17]

In addition to the physiological differences between males and females post-PHV, the sporting landscape in which female players operate is substantially different from that of their male counterparts, with significant differences in funding, resources, and support structures. In men's Gaelic games, there is now a growing body of research investigating fitness profiles, game demands, nutrition, performance analysis, and injury profiles of both club and inter-county football and hurling [18–23]. In contrast, research in ladies' Gaelic football is sparse, with only about a dozen papers published in total describing injury profiles, performance analysis, and the fitness characteristics of adult LGFA players [1,24–26]. Only two studies have examined the anthropometric and physical fitness characteristics of adult female Gaelic football players, and one has described the match-play demands [24,26,27]. At youth level, there is only one study describing the fitness profile of adolescent female players, and this was at club level [28]. The limited scientific literature leaves coaches to rely on personal experience and anecdotal reports when planning player preparation programmes.

Developing specific physical fitness capacities to meet the game demands of a sport is a primary goal when preparing players for competition [29]. Physical performance testing provides coaches with an opportunity to assess a player's physical qualities and has been used to inform decisions regarding talent identification, player monitoring and development, and player selection [30,31]. In addition, using objective approaches to assess physical performance can inform return-to-play decisions post-injury [28]. While no single characteristic, physical, technical, tactical, or psychosocial, can be used in isolation to predict success in sport, outcomes from validated field-based tests, such as the YoYoIR1 and linear sprint speed, have been linked to match performance [12]. Studies in soccer, Australian rules, Gaelic football, hurling, rugby league, and rugby union have found that both elite and selected players perform better in jumping, sprinting, agility, and endurance tests than their non-elite or non-selected counterparts [4,30–34]. Consequently, these physical qualities should be developed through structured strength and conditioning training in tandem with field-based technical and tactical training [34].

The primary aim of this study, therefore, was to determine the anthropometric and physical performance characteristics of inter-county female under-14, under-16, and under-18 players. Understanding the physical differences between various age groups will help to identify the physical characteristics related to each developmental stage and can be used as a basis for evaluating the efficacy of training interventions and monitoring player development. Additionally, the data can be utilised to aid in the development of training programmes designed to ease the transition to higher levels of competition. It was hypothesised that there would be significant differences in anthropometric characteristics between U14, U16, and U18 players, while there would be some significant differences in measurements of lower-body power, speed, and endurance between the groups.

2. Materials and Methods

2.1. Experimental Approach

A cross-sectional study design was used to compare the anthropometric and physical fitness characteristics of inter-county U14, U16, and U18 ladies' Gaelic football players. Prior to participating in this study, written parental consent and player assent were obtained. Participants were instructed to refrain from training for 24 h prior to testing to ensure maximal performance. Tests were completed in early pre-season in a single testing session for each group in an indoor hall and consisted of measurement of height and weight, 3 kg seated medicine ball throw (MBT), squat jump (SJ), countermovement jump (CMJ), drop jump (DJ), 0–5 m and 0–20 m sprint, pro-agility test, and YoYoIR1. All testing took place between 09:00 and 14:00, apart from one U14 group, who completed the testing between 19:00 and 21:00

2.2. Participants

A total of 156 inter-county female players from the U14 (n = 33), U16 (n = 63), and U18 (n = 58) panels participated in this study. The U14 players were all born in the same calendar year, while the U16 and U18 squads consisted of 15- and 16-year-old players and 17- and 18-year-old players, respectively. The U14 players participate in two field-based sessions per week, while the U16 and U18 players participate in two field-based and one gym-based session per week. Each field-based training session lasts 90–120 min. Players partake in approximately 10–12 inter-county games per season, including challenge matches in preparation for competition. In addition, they continue to play with their clubs and may partake in other sports at club and school level. At the time of testing, each squad had just completed their trials process for selection and had trained collectively for 2–4 weeks.

2.3. Procedure

Following the anthropometric measurements, participants completed a standardised warm-up lasting approximately 12 minutes consisting of running, activation and mobilisation exercises, and finally some potentiation exercises, including jumping and sprinting. As this was the first time the participants had engaged in fitness profiling and to mitigate against a possible learning effect, the SJ, CMJ, straight-line sprinting over 20 m, and 180-degree change of direction efforts were included as part of the warm-up. For the

MBT and DJ, demonstrations were provided. Adequate rest was provided prior to the commencement of testing. The order of testing is described in Figure 1 and was consistent across all testing sessions, from least to most fatiguing. Any player who was injured was excluded from the relevant tests.

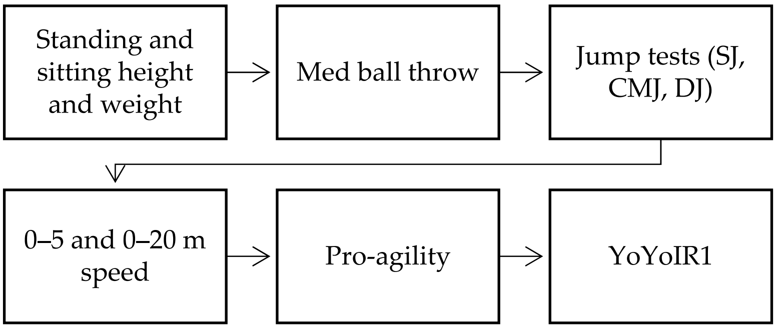

Figure 1. Test battery running order.

2.4. Anthropometric Measurements

For the assessment of height and weight, participants were dressed in shorts and t-shirt with trainers removed. Standing and sitting height were measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, Hamburg, Germany) with the head in the Frankfurt horizontal plane. Body mass was measured to the nearest 0.1 kg using an electronic weighing scale (Salter, SKU:9183 SV3R, Manchester, UK). Standing and sitting height, weight, and date of birth were used to estimate the occurrence of peak height velocity and maturity offset as described by Mirwald et al. [35]. The Mirwald equation has previously been reported to be a reliable (R^2 = 0.91, SEE = 0.50) and non-invasive practical solution for the measurement of biological maturity [33,36].

2.5. Jump Tests (SJ, CMJ, and DJ)

Jump tests were conducted using a Chronojump A2 System jump mat (Boscosystems, Barcelona, Spain). This equipment has previously been reported to be both valid and reliable (ICC = 0.99) [36]. Participants performed all three jump types with hands fixed and placed on the hips. For the SJ, participants stepped onto the mat and self-selected their starting position. They were then required to hold this position for 3 s before jumping as high as possible without performing a countermovement action. If players were observed performing a countermovement action, or if there were large differences between the jump attempts, they were asked to repeat the jump. The CMJ was performed with the participants starting from an upright position. Participants made a downward countermovement to a self-selected depth and then jumped as high as possible. Finally, drop jumps were performed with participants starting from an upright position on a 30 cm box. Participants were then instructed to step directly off the box, land on both feet, and immediately perform a jump for maximal height and land back on the mat. Each jump was performed twice, with the highest jump height recorded as a measure of performance. Reactive Strength Index (RSI) was subsequently calculated by dividing the participants' DJ height by the contact time on the mat [37]. The validity and reliability of these tests have previously been reported as high, with an ICC of 0.97 for the SJ and 0.98 for the CMJ [38]. Moderate to strong levels of reliability (ICC: 0.57–0.99; CV: 2.98–14%) for the RSI have been shown across a range of populations [37].

2.6. Medicine Ball Throw

Upper-body power was assessed using a 3 kg seated medicine ball throw. Participants sat on the ground with their backs supported against a wall, with knees together and legs extended out in front. A measuring tape was used to mark distances on the floor to a distance of 5 m. Participants were given a 3 kg medicine ball and were instructed to hold it with both hands close to the midline at chest height and then to throw it horizontally as far forward as possible. Distance was measured to the nearest 10 cm. Two attempts were allowed, with the furthest distance attained used for analysis. The MBT has been used to assess upper-body power in a variety of populations and has been shown to be a valid and reliable field test for upper-body power, with an ICC of 0.97–0.99 [39].

2.7. Sprinting and Change of Direction

Sprinting speed was assessed over 5 m and 20 m using electronic timing gates (Dashr Timing Systems, Lincoln, NE, USA). Participants started in a two-point start 0.5 m behind the initial timing gate and were instructed to set off in their own time and run maximally past the 20 m timing gate. Each participant completed two trials, separated by a 2–3 min rest period to allow full recovery between attempts. Times were recorded to the nearest 0.01 s, with the fastest attempt used for statistical analysis. ICC values of 0.87 and 0.97 have been reported for 5 m and 20 m, respectively [40].

Change of direction (COD) was examined using a modified version of the pro-agility test and timed using the electronic timing gates above (Dashr Timing Systems, Lincoln, NE, USA). Participants started in a neutral 2-point position on the centre line facing the tester. On 'Go', the participants sprinted 5 m to the right, turned off their right foot and then sprinted 10 m through the centre line to the left, turned off their left foot, and sprinted 5 m back to cross the centre line to finish the test. Participants were required to touch both endlines with their foot only. Each participant completed two trials, separated by a 2–3 min rest period to allow full recovery between attempts. ICC values for the pro-agility test range from 0.80 to 0.98 [41].

2.8. YoYo Intermittent Recovery Test Level 1

For the YoYoIR1, participants repeated 20 m shuttle runs at progressively increasing speeds from 10 to 19 km·h^{-1} dictated by an audio bleep from an app and played over a speaker. Each shuttle run was followed by a 10 s recovery period during which participants walked around a marker placed 5 m behind the finishing line. The test was terminated when participants failed to achieve the shuttle run in time on 2 occasions or if they felt unable to complete another run at the determined speed. The final level achieved, and total running distance were recorded. Test reproducibility for the YoYoIR1 has been reported with CVs ranging from 4.9% to 8.1% [42].

2.9. Statistical Analysis

Within-session test–retest reliability was established for MBT, SJ, CMJ, DJ, sprint speed, and pro-agility by randomly selecting 3 of the participants in each testing session to repeat the tests. Test–retest reliability was evaluated using intraclass correlation coefficients (ICCs). Basic descriptive statistics (mean, SD, range, minimum, and maximum) were calculated for all measures. The level of significance was set at $p < 0.05$, and all data are reported as mean ± SD. The assumption of normality was confirmed using the Shapiro–Wilks test. A one-way analysis of variance (ANOVA) was used to investigate differences between the age groups. When the F test was significant ($p < 0.05$), Bonferroni post hoc comparisons were performed to identify the level of difference between the age groups. Non-normally distributed data were analysed using a Kruskal–Wallis test. The magnitude of potential age group differences was determined using partial eta squared (η2p) effect size (ES). Values of 0.01, 0.06, and 0.14 were interpreted as small, medium, and large, respectively [43]. Data were processed using SPSS software version 27 (SPSS 27 IBM Corp., Armonk, NY, USA).

3. Results

3.1. Anthropometric Data

Anthropometric data for the age groups are presented in Tables 1 and 2. The mean height for the U14 group was 162 ± 5 cm, while the mean height for the U16 group was 166 ± 6 cm and for the U18 group was 168 ± 5 cm. The mean weight for the U14, U16, and U18 groups was 57.7 ± 7.1 kg, 59.5 ± 6.8 kg, and 63 ± 8.2 kg, respectively. There were significant differences in height (F (2,153) = 11.1, $p < 0.001$, ES = 0.127), weight (F (2,153) = 6.256, p.002, ES = 0.076), and age at PHV (F (2,153) = 120.627, $p < 0.001$, ES = 0.612) between the three groups. Post hoc Bonferroni analysis identified differences in height between the U14 and U16 groups (3.61± 1.15 cm) and the U14 and U18 groups (5.51 ± 1.17 cm) but not between the U16 and U18 groups. Differences were also found in weight between the U14 and U18 groups (5.30 ± 1.61 kg) and between the U16 and U18 groups (3.47 ± 1.34 kg) but not between the U14 and U16 groups. Significant differences were also found between all three groups for estimated age at PHV. The estimated age of PHV for the U14, U16, and U18 groups was 12.2 ± 0.3, 12.6 ± 0.4, and 13.4 ± 0.4 years, respectively.

Table 1. Anthropometric data of U14, U16, and U18 LGF Players.

Group		Standing Height (cm)	Sitting Height (cm)	Weight (kg)	Age @ PHV (Years)	Maturity Offset (Years)
U14 (*n* = 33)	Mean	162	83	57.7	12.2	1.5
	SD	5.5	2.7	7.1	0.3	0.3
	Range	24	11	28.5	1.3	1.6
	Minimum	153	76	43.3	11.6	0.7
	Maximum	177	87	71.8	12.9	2.3
U16 (*n* = 64)	Mean	166	85	59.5	12.6	2.5
	SD	5.5	3.4	6.8	0.4	0.6
	Range	29	15	36.9	1.9	2.2
	Minimum	152	77	41.8	11.8	1.3
	Maximum	181	92	78.7	13.7	3.5
U18 (*n* = 59)	Mean	168	86	63.0	13.4	3.6
	SD	5.1	3.0	8.2	0.4	0.5
	Range	26	15	42.5	2.2	2.0
	Minimum	155	81	49.5	12.2	2.6
	Maximum	181	96	92.0	14.4	4.6

Table 2. Comparison of mean differences in height, weight, and age at PHV.

			Mean Difference	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Standing Height	U14	U16	−3.608 *	1.153	0.006	−6.40	−0.82
		U18	−5.512 *	1.170	0.000	−8.34	−2.68
	U16	U14	3.608 *	1.153	0.006	0.82	6.40
		U18	−1.904	0.971	0.156	−4.25	0.45
	U18	U14	5.512 *	1.170	0.000	2.68	8.34
		U16	1.904	0.971	0.156	−0.45	4.25
Weight	U14	U16	−1.8304	1.5896	0.754	−5.678	2.017
		U18	−5.3035 *	1.6124	0.004	−9.206	−1.401
	U16	U14	1.8304	1.5896	0.754	−2.017	5.678
		U18	−3.4731 *	1.3387	0.031	−6.714	−0.233
	U18	U14	5.3035 *	1.6124	0.004	1.401	9.206
		U16	3.4731 *	1.3387	0.031	0.233	6.714
Age @ PHV	U14	U16	−0.4320 *	0.0824	0.000	−0.632	−0.232
		U18	−1.2137 *	0.0836	0.000	−1.416	−1.011
	U16	U14	0.4320 *	0.0824	0.000	0.232	0.632
		U18	−0.7818 *	0.0694	0.000	−0.950	−0.614
	U18	U14	1.2137 *	0.0836	0.000	1.011	1.416
		U16	0.7818 *	0.0694	0.000	0.614	0.950

* The mean difference is significant at the 0.05 level.

3.2. Test–Retest Reliability

Within-session test–retest measurements for the SJ, CMJ, DJ, 0–5 m speed, 0–20 m speed, pro-agility, and MBT are presented in Table 3. The Pearson's correlation coefficients for the SJ, CMJ, DJ height, 0–5 m speed, 0–20 m speed, pro-agility, and MBT were 0.95, 0.94, 0.93, 0.96, 0.93, 0.92, and 0.91, respectively, indicating excellent reliability.

Table 3. Within-session reliability data.

	SJ (cm)	CMJ (cm)	DJ (cm)	Speed 5 m (s)	Speed 20 m (s)	Pro-agility (s)	MBT (m)
Pearson correlation	0.952 *	0.941 *	0.927 *	0.934 *	0.965 *	0.916 *	0.906 *
Sig. (2-tailed)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
N	15	15	15	15	15	15	15

* Correlation is significant at the 0.01 level (2-tailed).

3.3. Physical Fitness Performance Data

Descriptive data and comparison of mean differences for the three groups are presented in Tables 4 and 5. There were no significant differences among the three groups for any of the physical fitness tests with the exception of the YoYoIR1 test, (Figure 2), where a significant difference was found between the U14 and U18 groups ($F(2,147) = 3.645$, p.029, $\eta 2p = 0.048$ (moderate)).

Table 4. Physical fitness results for U14, U16, and U18 players.

		N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
MBT (m)	U14	33	3.4	0.3	0.1	3.3	3.5	2.8	4.0
	U16	63	3.5	0.3	0.0	3.4	3.6	3.0	4.3
	U18	58	3.6	0.4	0.0	3.5	3.7	2.8	4.4
YoYoIR1 Distance (m)	U14	32	750	306	54	640	860	240	1440
	U16	62	868	308	39	790	946	240	1680
	U18	54	944	348	47	849	1039	320	2200
Speed 5 m (s)	U14	32	1.19	0.10	0.02	1.15	1.22	1.02	1.39
	U16	62	1.16	0.08	0.01	1.14	1.18	1.00	1.36
	U18	57	1.16	0.10	0.01	1.14	1.19	0.94	1.45
Speed 20 m (s)	U14	32	3.52	0.18	0.03	3.45	3.59	3.19	3.83
	U16	62	3.53	0.15	0.02	3.50	3.57	3.17	4.08
	U18	57	3.58	0.25	0.03	3.51	3.65	3.11	4.48
Pro-agility (s)	U14	32	5.71	0.29	0.05	5.61	5.81	5.20	6.62
	U16	62	5.73	0.35	0.04	5.64	5.82	5.08	6.82
	U18	55	5.59	0.31	0.04	5.51	5.68	4.94	6.30
SJ (cm)	U14	32	25.0	3.4	0.6	23.7	26.2	16.8	31.9
	U16	62	23.2	3.0	0.4	22.4	23.9	14.8	29.4
	U18	57	24.3	4.8	0.6	23.0	25.6	13.0	35.0
CMJ (cm)	U14	32	27.5	3.7	0.6	26.1	28.8	19.6	35.1
	U16	62	26.3	3.5	0.4	25.4	27.2	17.4	36.5
	U18	57	27.3	5.0	0.7	25.9	28.6	14.5	38.6

Table 4. *Cont.*

		N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
DJ Contact Time (s)	U14	32	0.222	0.027	0.005	0.212	0.232	0.170	0.285
	U16	62	0.225	0.034	0.004	0.216	0.234	0.157	0.359
	U18	56	0.219	0.026	0.004	0.212	0.226	0.151	0.265
DJ Height (cm)	U14	32	25.5	3.4	0.6	24.2	26.7	17.9	34.3
	U16	62	25.7	3.7	0.5	24.7	26.6	17.0	36.9
	U18	56	26.4	4.9	0.7	25.0	27.7	15.9	36.8
RSI	U14	32	1.2	0.2	0.0	1.1	1.2	0.8	1.9
	U16	62	1.2	0.2	0.0	1.1	1.2	0.7	2.0
	U18	56	1.2	0.3	0.0	1.1	1.3	0.7	1.9

Table 5. Mean physical fitness comparisons between U14, U16, and U18 players.

			Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
MBT	U14	U16	−0.0589	0.0692	1.000	−0.226	0.109
		U18	−0.1516	0.0702	0.098	−0.322	0.018
	U16	U14	0.0589	0.0692	1.000	−0.109	0.226
		U18	−0.0927	0.0586	0.348	−0.235	0.049
	U18	U14	0.1516	0.0702	0.098	−0.018	0.322
		U16	0.0927	0.0586	0.348	−0.049	0.235
YoYoIR1 Distance	U14	U16	−117.742	70.296	0.288	−288.00	52.52
		U18	−194.444 *	72.047	0.023	−368.95	−19.94
	U16	U14	117.742	70.296	0.288	−52.52	288.00
		U18	−76.703	60.114	0.612	−222.30	68.90
	U18	U14	194.444 *	72.047	0.023	19.94	368.95
		U16	76.703	60.114	0.612	−68.90	222.30
Speed 5 m	U14	U16	0.02458	0.02036	0.688	−0.0247	0.0739
		U18	0.02374	0.02067	0.758	−0.0263	0.0738
	U16	U14	−0.02458	0.02036	0.688	−0.0739	0.0247
		U18	−0.00084	0.01717	1.000	−0.0424	0.0407
	U18	U14	−0.02374	0.02067	0.758	−0.0738	0.0263
		U16	0.00084	0.01717	1.000	−0.0407	0.0424
Speed 20 m	U14	U16	−0.01418	0.04346	1.000	−0.1194	0.0911
		U18	−0.05908	0.04410	0.547	−0.1659	0.0477
	U16	U14	0.01418	0.04346	1.000	−0.0911	0.1194
		U18	−0.04490	0.03664	0.667	−0.1336	0.0438
	U18	U14	0.05908	0.04410	0.547	−0.0477	0.1659
		U16	0.04490	0.03664	0.667	−0.0438	0.1336

Table 5. *Cont.*

			Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Pro-agility	U14	U16	−0.01822	0.07081	1.000	−0.1897	0.1533
		U18	0.11823	0.07233	0.313	−0.0569	0.2934
	U16	U14	0.01822	0.07081	1.000	−0.1533	0.1897
		U18	0.13645	0.06026	0.075	−0.0095	0.2824
	U18	U14	−0.11823	0.07233	0.313	−0.2934	0.0569
		U16	−0.13645	0.06026	0.075	−0.2824	0.0095
SJ	U14	U16	1.7900	0.8415	0.105	−0.248	3.828
		U18	0.6594	0.8539	1.000	−1.408	2.727
	U16	U14	−1.7900	0.8415	0.105	−3.828	0.248
		U18	−1.1306	0.7094	0.339	−2.848	0.587
	U18	U14	−0.6594	0.8539	1.000	−2.727	1.408
		U16	1.1306	0.7094	0.339	−0.587	2.848
CMJ	U14	U16	1.1337	0.9057	0.638	−1.059	3.327
		U18	0.1948	0.9191	1.000	−2.031	2.420
	U16	U14	−1.1337	0.9057	0.638	−3.327	1.059
		U18	−0.9388	0.7635	0.662	−2.788	0.910
	U18	U14	−0.1948	0.9191	1.000	−2.420	2.031
		U16	0.9388	0.7635	0.662	−0.910	2.788
DJ Contact Time	U14	U16	−0.002998	0.006487	1.000	−0.01871	0.01271
		U18	0.003116	0.006604	1.000	−0.01288	0.01911
	U16	U14	0.002998	0.006487	1.000	−0.01271	0.01871
		U18	0.006114	0.005494	0.803	−0.00719	0.01942
	U18	U14	−0.003116	0.006604	1.000	−0.01911	0.01288
		U16	−0.006114	0.005494	0.803	−0.01942	0.00719
DJ Height	U14	U16	−0.1985	0.9096	1.000	−2.401	2.004
		U18	−0.8955	0.9261	1.000	−3.138	1.347
	U16	U14	0.1985	0.9096	1.000	−2.004	2.401
		U18	−0.6970	0.7704	1.000	−2.563	1.169
	U18	U14	0.8955	0.9261	1.000	−1.347	3.138
		U16	0.6970	0.7704	1.000	−1.169	2.563
RSI	U14	U16	−0.00187	0.05624	1.000	−0.1381	0.1343
		U18	−0.06045	0.05726	0.879	−0.1991	0.0782
	U16	U14	0.00187	0.05624	1.000	−0.1343	0.1381
		U18	−0.05857	0.04763	0.662	−0.1739	0.0568
	U18	U14	0.06045	0.05726	0.879	−0.0782	0.1991
		U16	0.05857	0.04763	0.662	−0.0568	0.1739

* The mean difference is significant at the 0.05 level.

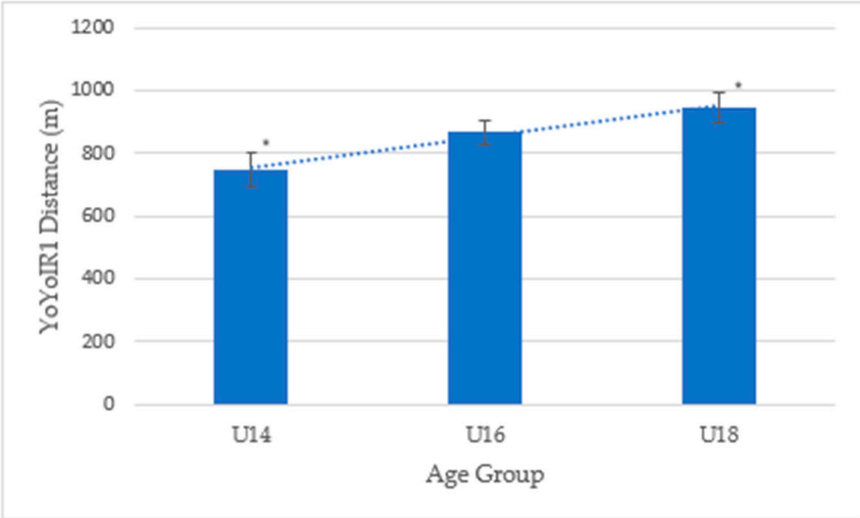

Figure 2. YoYoIR1 distance in inter-county ladies' Gaelic football with regard to age group (mean ± SE). * Significant difference between U14s and U18s ($p < 0.05$).

4. Discussion

The purpose of this study was to compare the anthropometric and physical performance characteristics of inter-county female Gaelic Football players from three different age groups. The findings highlighted differences between the age groups for the anthropometric measures of height and body mass and estimated age at PHV. In terms of the physical performance tests, the results of this study indicated that the U18 group performed better than the U14 group in terms of aerobic endurance, as measured by the YoYoIR1, but there were no significant differences between the three groups in measurements of upper- and lower-body strength and power, speed, and change of direction.

Growth and maturation have a significant influence on the development of female athletes and are characterized by an increase in height, weight, and body fat percentage and by a maturation of the endocrine, cardiovascular, nervous, and muscular systems, leading to changes in performance [44,45]. In this study, the average age of onset of PHV as determined by the Mirwald equation for the U14 cohort was 12.2 ± 0.3 years, 12.6 ± 0.4 years for the U16 group, and 13.4 ± 0.4 years for the U18 group, indicating average to late maturation for female inter-county footballers, with the latest maturers dominating at U18 level. The Mirwald equation has previously been used in research in adolescent female soccer players to determine their stage of maturation and has been reported to be a reliable (R^2 = 0.91, SEE = 0.50) and non-invasive practical solution for the measurement of biological maturity [33,35]. However, two longitudinal studies highlighted the limitations of the maturity offset prediction equations and predicted ages at PHV [46,47]. A further study on the growth and maturation of female soccer players also found the same limitations in the maturity offset equation [9]. In these studies, predicted ages at PHV were, on average, later than actual age at PHV from 10 to 18 years in girls. The difference between predicted and actual ages at PHV increased linearly with increasing chronological age (CA) at prediction in girls, although the increases from 11 to 14 years were not statistically significantly different [46]. The authors concluded that predictions of age at PHV may be useful near the time of actual PHV among some average- and late-maturing girls within a narrow CA range but should not be used as a retrospective indicator of maturing timing in older girls as most are biologically mature and have stopped growing [45]. Therefore, while this study indicated that later-maturing girls dominated at U18 level compared to the other groups, the results should be taken with caution given the limitations of non-invasive prediction equations compared to more invasive measurements [9].

No significant differences were found between the three groups for the SJ and CMJ (U14 SJ 25.1 ± 3.4 cm, U16 SJ 23.2 ± 3.0 cm, U18 SJ 24.3 ± 4.8 cm; U14 CMJ 27.5 ± 3.7 cm, U16 CMJ 26.3 ± 3.5 cm, U18 CMJ 27.3 ± 5.0 cm). This is consistent with previous research by Vescovi et al. (2011), who showed improvements in CMJ performance until 15–16 years after which there was a plateau until 21 years [12]. Similarly, Ramos et al. (2021) found that U15 and U17 international soccer players did not display significant differences in the vertical jump, sprint, and specific endurance capacities between each other [48]. In contrast, Castagna and Castellini (2013) found large differences between female U17 and U19 international soccer players for SJ and CMJ (U17 SJ 28.2 ± 2.5; U19 SJ 29 ± 2.1; U19 SJ 32.8 ± 2.9; U19 CMJ 34.3 ± 3.9) [49]. As biological maturation ceases at 17 years in females, improvements in physical performance tests in older age groups may be attributed to physiological adaptations elicited by increased total training load and an increase in match demands. These include greater stretch reflex, increased elastic energy potentiation, and enhanced neural potentiation, all of which would enhance CMJ performance [44,45].

There were no significant differences in this study in DJ height and consequently RSI between the U14, U16, and U18 groups, indicating that the force production capabilities of the three groups were similar (U14 DJ 25.5 ± 3.4 cm, U16 DJ 25.7 ± 3.7 cm, U18 DJ 26.4 ± 4.9 cm; U14 RSI 1.16 ± 0.2, U16 RSI 1.17 ± 0.2, U18 RSI 1.22 ± 0.3). Measures of strength are significantly and positively associated with RSI, indicating that stronger individuals achieve higher RSI scores [38]. There are very limited data available on normative scores for the RSI for adolescent female athletes. Emmonds et al. (2019) reported mean RSI scores of 1.17 + 0.14 m/s in elite female club-level players [34]. However, this was via a 40 cm drop jump, and as drop jump height affects performance, these results are not directly comparable.

The seated medicine ball throw assesses upper-body muscular power by measuring the maximal distance an individual can throw a medicine ball from an isolated, seated position [50]. Again, there were no significant differences between the three groups (U14 3.4 ± 0.3 m, U16 3.5 ± 0.3 m, U18 3.6 ± 0.4 m), indicating that upper-body strength and power gains did not occur due to maturation. There are currently no normative data for female athletes on the 3 kg MB throw. Biggar et al. assessed the seated med ball throw in a group of 12–15-year-old female physical education students, but a 2 kg med ball was used, so the results are not comparable [50].

No significant differences in sprinting speed were found over 0–5 m, 0–20 m, or in the pro-agility test (U14 0–5 m 1.19 ± 0.1 s, U16 1.16 ± 0.08 s, U18 1.16 ± 0.1 s; U14 0–20 m 3.52 ± 0.18 s, U16 3.53 ± 0.15 s, U18 3.58 ± 0.25 s; pro-agility U14 5.71 ± 0.29 s, U16 5.73 ± 0.35 s, U18 5.59 ± 0.31 s). This is in agreement with Vescovi et al. (2011), who reported a plateau in sprinting performance over 18.2 m for female soccer players after 14 years of age [12]. Similarly, Doyle et al. (2021) found no significant differences in sprinting speed over 20 m between U17 and U19 Irish international soccer players, while Ramos et al. (2021) found no significant differences between U15, U17, and U20 Brazilian international soccer players [44,48]. Vescovi et al. (2011) found a modest improvement in female soccer players' performance on the pro-agility test up to 15–16 years, after which a plateau occurred [12].

The YoYoIR1 was the only test in which significant differences in performance were found, and this was between the U14 and U18 groups only. No significant differences were found between the U14 and U16 groups or between the U16 and U18 groups (U14 750 ± 306 m, U16 868 ± 308 m, U18 944 ± 348 m). Emmonds et al. (2020) found that YoYoIR1 performance increases with age from early to mid-teens (U12 to U16) [34]. Similarly, Ramos et al. (2021) found increasing YoYoIR1 scores in U15 (710 ± 210 m), U17 (720 ± 230 m), and U20 (860 ± 240 m) Brazilian international soccer players. They also found that senior players covered a far greater distance on the YoYoIR1 (1510 ± 320 m), indicating that improvements in aerobic capacity are attainable into adulthood [48].

5. Limitations and Future Research

This study has a number of limitations. All but three of the participants were tested for the first time, and while jumps, linear sprints, and change of direction sprints were included in the warm-up to ensure familiarisation, it is possible that a potential learning effect influenced performance. As each panel had a large number of players, it was not possible to conduct testing within a narrow timeframe to account for possible circadian variation within the performance data. Several players also partake in multiple sports with school and clubs, and while each player was requested not to partake in physical activity in the 24 h prior to testing, compliance with this request could not be guaranteed. In addition, the data came from a single county with a large playing population, and it is possible that these findings are reflective of similar types of counties and not those with smaller playing populations who also compete at inter-county level. There is therefore a need for data sharing between counties and within the LGFA in order to understand how ladies' Gaelic football develops along the talent development pathway. Research is also required to determine changes in the physical fitness profile throughout the inter-county season, longitudinal studies to measure the effectiveness of a long-term athletic development programme, the physical and physiological demands of the game at each age grade, between playing positions, and between club and inter-county players. Ascertaining the running demands at each age grade, level, and position will help inform training practice and allow coaches to design data-informed training drills and practices to adequately prepare players for the demands of the game [27,51].

All three groups in this study were tested in early pre-season, just after selection to their respective panels, and as such these results represent baseline figures for strength, speed, power, and endurance. Although athletic development programmes have the potential to optimise performance and mitigate injury risks, none of the groups had engaged in a continuous structured programme of athletic development, while senior players engage in up to five sessions per week, including two resistance-based sessions [51]. In the absence of specific neuromuscular training, females plateau in mid-to-late adolescence for factors such as strength and speed, while peak power in girls' plateaus around 16 years [8,11]. However, progressive improvements in lower-body strength and power, speed, and endurance have been achieved into adulthood with appropriate training [33,44,45,48]. A number of studies have highlighted differences in these qualities between senior and junior groups and between competitive standards [12,29,30,44,45,48]. Currently, there are no published data on these fitness characteristics for senior inter-county female Gaelic football players, but it is likely that substantial differences exist between underage players and senior players. Research to establish the fitness profile of senior players is also warranted. This will enable differences between underage and senior levels to be established and may provide a foundation for the establishment of training programmes to assist with competition level transitions [27].

6. Conclusions

In conclusion, the current study is the first to describe the anthropometric and physical fitness characteristics of inter-county ladies' Gaelic football players across age grades. This study demonstrated that U14, U16, and U18 inter-county ladies' Gaelic football players did not differ significantly in terms of upper- and lower-body strength and power, sprint speed, and change of direction speed, while moderate differences were found between the U14 and U18 groups for aerobic endurance only. The long-term athletic development of adolescent inter-county players should be a key priority for talent pathways. There is a need to strategically develop physical qualities such as strength, speed, and aerobic endurance to help reduce the risk of injury and to adequately prepare for the demands of ladies' Gaelic football at the current age grades and into senior level. This may be achieved by prescribing strength training sessions, using the warm-up as a tool to develop athleticism, speed, and agility, and using small-sided games to build the aerobic system in a game-specific way in addition to traditional conditioning approaches [44,51]. The current study provides a first step in providing age-appropriate data to coaches working with inter-county teams across three age groups and may aid long-term player development pathways and individualise training programmes for these players.

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