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Differences in anthropometric and physical performance characteristics between U17, U19, and Senior Irish female international football players

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Abstract

This study aimed to compare the anthropometric physical performance characteristics of Irish female international footballers at U17, U19, and Senior age groups. Fifty-five (U17, *n* =24, U19, *n* =21, Senior, *n* = 10) female international football players participated in this study. The subjects underwent anthropometric measurements (height and body mass) and physical performance tests countermovement jump (CMJ), reactive strength index (RSI), 10-m, 20-m, 30-m linear sprint, and yo-yo intermittent recovery test level 1 (YYIR1). No significant differences were identified between any age groups for the anthropometric measures of height and body mass. Concerning the physical tests, senior players displayed greater CMJ scores in comparison with the U17 (P = 0.040). Senior players also possessed higher levels of reactive strength with large effect sizes present (ES = 0.83 - 0.92) in comparison to all age groups. No significant differences were identified between any of the age groups across the 10-m, 20-m, 30-m, and rolling 20-m linear speed assessments. Senior players covered the greatest distance in the YYIR1 (P = 0.0001) versus the U19 and U17. These results indicate there was no difference in the anthropometric profile of the age groups assessed. However, differences in physical performance characteristics were present between age groups, thus suggesting improvements in lower limb power and aerobic endurance are achievable in adulthood as players physically mature.

Keywords

Association football, countermovement jump, reactive strength index, soccer, sprinting, Yo-Yo intermittent recovery test, youth sport

Introduction

Female participation in football has experienced rapid growth in recent years. Global participation increased by 37% between 2000 and 2014 (22 million participants to 30 million).[1,2] The number of countries now competing at the highest level of women's football has also risen with the Women's World Cup tournament being expanded from 16 teams to 24 in 2015.[3] Despite this growth, a significant imbalance in the volume, depth, and consistency of scientific research on elite female footballers in comparison to their male counterparts is acknowledged within the literature.[4] Previous research investigating the physical performance characteristics of elite female footballers have made a comparison with male academy players as well as untrained and lower competition level female cohorts.[5,6] Only a small number of studies have documented the player anthropometric and physical performance characteristics differences between age groups of female international football players.[5–8]

Recent studies have shown senior female international players cover total distances within the range

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of 9 – 12 km during match play with up to 1.53 – 1.68 km covered at high speeds (>15 km.hr^{-1}).[9,10] Both total distance and high speed running covered amongst other performance metrics do vary across age groups and playing positions at international level.[10] The average total sprint distances during matches are between 0.10 – 0.46 km with reported top speeds as high as 30.5 km.hr^{-1}.[9–14] Also, the acceleration profile of female international players is highly influenced by playing position and age group.[10] For example, a midfielder will complete 149 ± 16.8, 172 ± 18.8, and 213.6 ± 16.9 accelerations during an international match at U17, U20 and senior international level respectively.[10] Subsequently demonstrating the physical demands of international football increase with an increase in age group. Female international football players rely on the aerobic system to maintain their performance levels throughout a 90+ minute match.[15] The anaerobic system is simultaneously taxed due to the sporadic nature of short duration intense actions such as repeated high-speed bouts (occurring 33 times during international matches).[16] This consists of sprinting, accelerations, jumping, tackling, shooting, and physical duels and they are all actions that play an influential role in the outcome of games.[10,16–19] As a result, the evaluation of player's lower limb power, linear speed, and aerobic endurance performance is extensively utilised to assess if players possess the required physical attributes to meet the match demands of international football.

It is widely documented within the literature that growth and maturation can be a highly influencing factor on height, body mass, and body fat percentage as well as physical performance tests in early to mid-teen female footballers.[20] Despite a lack of evidence on female youth international football players, some research demonstrates the performance of high-intensity activities lasting several seconds appear to plateau in the early to mid-teenage years in female players.[21] However, more recent findings demonstrate that progressive improvements in lower limb power, linear speed, and aerobic endurance and capacity have been achieved in adulthood by senior female international footballers.[5–8]

A more in-depth understanding of female international player's physical performance characteristics may aid coaches, strength and conditioning coaches and sports scientists to assess players within their national organisations player pathway by providing age-appropriate data on the physical performance requirements for international level football. Research indicates that lower limb power, sprint speed, and aerobic endurance can distinguish between club and international level players as well as selected/starting and non-selected/non-starting international players across numerous age groups.[5,6,8,22] This highlights the importance of physical performance characteristics for a player's development and chances of being selected to perform at international level. Therefore, this study aimed to compare the anthropometric, lower limb power, linear speed, and aerobic endurance performance of female players from under 17 to senior age groups from Irish international teams.

Materials and methods

Subjects

Fifty-five female international level footballers participated in this study. Ethical approval was obtained by the College Research Ethics Committee. The participants were informed of the risks of the study in person and writing and signed an informed consent document before the beginning of data collection and were free to withdraw from the study at any time. For those under the age of 18 years age parental or guardian signed consent was obtained. The study was conducted in accordance with the Declaration of Helsinki. Twenty-four players were members of the under 17-year-old team (U17) (mean ± SD; 16.5 ± 0.4 years) with a positional breakdown of (goalkeepers, $n = 4$, centre backs, $n = 3$; fullbacks, $n = 5$; centre midfielders, $n = 6$; centre forwards, $n = 3$; wide forwards, $n = 3$). Twenty- one belonged to the under 19 – year-old team (U19) (mean ± SD; 17.8 ± 0.6 years) with a positional breakdown of (goalkeepers, $n = 2$; centre backs, $n = 5$; fullbacks, $n = 2$; centre midfielders, $n = 6$; centre forwards, $n = 3$; wide forwards, $n = 3$). Ten players belonged to the senior national team (Senior) (mean ± SD; 22.5 ± 5.5 years) with a positional breakdown of (goalkeepers, $n = 1$; centre backs, $n = 1$; fullbacks, $n = 2$; centre midfielders, $n = 3$; centre forwards, $n = 2$; wide forwards, $n = 1$). Assessments included height, body mass, jump height, reactive strength, linear speed, and aerobic endurance capacity. Testing sessions took place in the afternoon (between 12:00 and 16:00) on the first day of each team's respective training camp during 2019 which was in season for the senior and U19 players and post-season for the U17 age group.

Anthropometric Assessments: All anthropometric measurements were collected with participants wearing a training kit consisting of a training jersey and shorts. Standing height (cm) was taken using a portable stadiometer, (Marsden, HM-250P Leicester, Rotherham, England) with participants standing barefoot in an upright position with the head in the frankfort plane measurements were recorded to the nearest 0.1cm using. Body mass (kg) was measured with participants standing barefoot on an electronic portable scale (Seca, model 769, Hamburg, Germany) and recorded to the nearest 0.1 kg.

Physical tests: Physical assessments were conducted in the following order: countermovement jump (CMJ), reactive strength index (RSI) via the 10/5 repeated jump test (10/5 RJT), 10-m, 20-m, 30-m linear sprints and Yo-Yo Intermittent Recovery Test, level 1 (YYIR1). All tests were separated by at least a 10-minute recovery period. Every test was performed indoors on a rubber track with all subjects wearing running shoes. Before the initiation of the testing session, participants underwent a structured 10-minute warm-up protocol consisting of jogging, running, lower limb mobility, and dynamic stretching movements followed by CMJ (3 reps) and CMJ into pogo hops (2 sets x 10 hops). On completion of the warm-up, a 5-minute recovery period was employed to assuage any effects of fatigue. Any participants deemed unfit by the medical staff were excluded from the studies.

Countermovement jump test: Jump height was determined by CMJ performed on a portable dual force plate system (Foredecks, FD 4000, London, United Kingdom). Force data was sampled at 1000 Hz. Each subject was weighed on the force plate for system calibration before testing. All players underwent a familiarisation trial for both vertical jump assessments (CMJ and RSI), whereby the players had the test protocol demonstrated to them by the researcher before performing a single submaximal effort. All participants then completed 3 maximal effort trials. Upon instruction, the subject made a downward countermovement to a self-selected depth and then jumped as high as possible. All jumps were performed with hands on the hips. Forcedecks software (Forcedecks, London, United Kingdom) was used to analyse all CMJs. The highest jump was used for the statistical analysis. ICC and CV for CMJ were (ICC = .95, CV = 4.4%), (ICC = .96, CV = 4.7%) and (ICC = .98, CV = 2.5%) for, U17, U19 and Seniors respectively.

Reactive strength index: Participants completed 3 trials of the 10/5 repeated jump test (10/5 RJT) with a minimum of one minute's rest between each trial.[23] The 10/5 RJT has been demonstrated to be a reliable and valid assessment method of RSI in female team sport athletes.[24] The 10/5 RJT required the participants to perform a counter movement jump followed by 10 maximal rebound jumps.[23] During the test, participants were instructed to maintain hands akimbo to standardise the protocol and negate upper body interference.[25] Additionally, participants were asked to maximise jump height and minimise ground contact time, specifically prompted "imagine the floor was a hot surface, jump as high as possible and to imagine their leg is like a stiff spring rebounding off the ground."[26]

The Optojump (Microgate, Bolzano, Italy) photocell system was used to measure each 10/5 RJT trial. The Optojump (Microgate, Bolzano, Italy) system recorded contact time (CT) (s) and flight time (s) and automatically derived jump height (JH) (m) from the flight time using the equation JH (m) = (gravity × flight time)2/8, where gravity = 9. 81 $m.s^{-1}$.[27] RSI was then calculated by utilising the acquired data in the following equation RSI= JH (m)/CT(s).[28] RSI was calculated for each jump utilising the aforementioned equations, the 5 best non-consecutive jump heights with a ground contact time of less than 250ms were averaged to define an overall RSI for each trial.[23] The trial with the best RSI score was used for statistical analysis. ICC and CV for RSI were (ICC = .95, CV = 7.3%), (ICC = .98, CV = 4.9%) and (ICC = .99, CV = 3.7%) for, U17, U19 and Seniors respectively

Linear speed: Linear speed was assessed over 10-m, 20-m, 30-m using photocell timing gates (Witty-gate, Microgate, Italy). Participants started 0.5m behind the initial timing gate in a two-point split stance and were instructed to start when ready and run maximally to a marker place 2-m beyond the 30-m timing gate. Each player performed 2 submaximal efforts sprints before 3 maximal efforts separated with a minimum of 2 minutes of a rest period. Times were recorded to the nearest 0.01 with the fastest time of the three efforts at each distance was used for analysis. The rolling 20-m time was calculated by subtracting the 10-m time away from the 30-m time with the fastest time used for analysis. ICC and CVs for 10-m, 20-m and 30m fell between the range of (ICC = .86 – .99, CV = 1 – 2.7%) for all age groups.

Yo-Yo Intermittent Recovery Test, Level 1: The subjects completed the YYIR1 test as described by Krustrup et al.[29] The test was performed using an audio recording. Each athlete performed repeated 20m shuttle runs at increasing velocities with 10 seconds of active recovery. During the active recovery, participants walked around a marker placed 5-m behind the finishing line. An individual's test was terminated when the subject failed to reach the starting line within the allotted time on two occasions or the participant felt unable to complete another shuttle at the assigned speed. The total distance covered by a subject was used as the performance measure. Only outfield players were included in the YYIR1 age group comparison.

Statistical analysis

The assumption for normality was confirmed using the Shapiro-Wilks test. A one-way analysis of variance was used to investigate age group differences. When the F test was significant ($P < .05$), Bonferroni post-hoc pairwise comparisons were performed to identify the level of difference between age groups. To determine the magnitude of difference between the age groups, the effect size (ES: Cohens *d*) was calculated, and values of 0.2, 0.5, and above 0.8 were interpreted as small, medium, and large, respectively.[30] The (SPSS, version 25.0, SPSS Inc., Chicago, IL, USA) software package was used for analysis. All results are shown as mean ± SD.

Results

Table 1 shows the results of anthropometric data between the age groups. Anthropometric measurements of height and body mass were similar for all age groups (see Table 1). Although the senior age group were taller (ES = 0.56, ES= 0.40,) and heavier (ES = 0.40, ES = .62,) in comparison to U19 and U17 peers respectively.

Age group influenced CMJ performance ($P \leq 0.05$) with senior players (32.5 ± 4.1 cm) displaying higher (ES = 0.74) CMJ scores than U19 (29.2± 4.5 cm) age group, whilst higher scores (P = 0.042, ES = 1.02) were identified in comparison to U17 (28.6 ± 3.4 cm) (see Figure 1(b)). Senior players demonstrated greater RSI scores (1.56 ± .25 m/s) as large effects were present in comparison U19 (1.34 + .28 m/s, ES = 0.83) and U17 (1.30 ± .31 m/s, ES = 0.92) age groups. Trivial differences existed between U17 and U19 age groups for CMJ (ES = 0.16) and RSI performance (ES = .13).

Table 1. Anthropometric characteristics of different age groups of Irish female international footballers (mean ± SD).

Age group	N	Age (y)	Height (cm)	Body mass (kg)
Under 17	24	16.5 ± 0.4	167.1 ± 6.2	59.8 ± 7.0
Under 19	21	17.8 ± 0.6	166.1 ± 5.9	61.5 ± 7.8
Senior	10	22.5 ± 5.5	169.7 ± 7.0	65.0 ± 9.5
Total	55			

Linear sprint assessment indicated senior players were faster than both the U17 and U19 age categories 10-m, 20-m 30-m, and rolling 20-m distances. A range of small effect sizes (ES = 0.27 – 0.35) were present between the senior and U19 cohorts whilst medium effect sizes (ES = 0.54 – 0. 69) existed across all linear sprint distances when the senior players were compared to the U17 age group. U19 players were faster than U17 with small effect sizes (ES = 0.30 – 0.33) present between the two age groups across all linear sprint distances. Senior players covered (1457 ± 259 m,) greater distance in YYIR1 test versus U17 (981 ± 245 m, ES = 1.88) and U19 (883 ± 238 m, ES = 2.31) age groups (P = 0.001) (see Figure 1(a)).

Discussion

The main objective of this study was to describe and compare the anthropometric and physical performance characteristics of female international footballers from different age groups. The findings highlighted no significant differences between the age groups for the anthropometric measures of height and body mass. Although U17 players were lighter than all other age groups, whilst the U19 players were shorter (see Table 1). In terms of the physical performance tests, the results of this study indicated that there were no differences between the U17 and U19 players for CMJ, RSI, all linear speed distances, and YYIR1 test assessments. In addition, the senior players demonstrated similar results to the U17 and U19 age groups in the RSI and all linear speed distances. Although some differences were established between seniors and U17 in CMJ and YYIR1 performance whilst only YYIR1 performances differed when compared to the U19 age group.

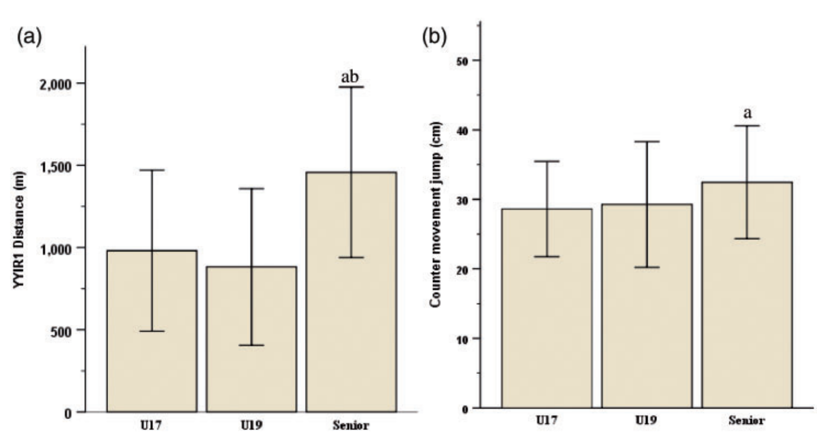

Figure 1. Total distance covered in YYIR1 (a), countermovement jump (b). [a] Different from under 17; [b] different from under 19.

Analysis of the CMJ data contrasted with the findings of Vescovi et al.[21] which indicated a plateau in CMJ performance between 17 and 21 years of age whilst this current study reported a large effect size difference between the U17 and senior age groups. This mirrors previous findings within the literature as it has been shown that younger players possess lower CMJ values than senior players.[7,8] More recent evidence by Ramos et al.[6] established a similar trend with large effect sizes present ($P = \leq 0.001$, $ES = 1.24$) between the same age groups. Although the CMJ performance of the U19 age group in this study concurs with Vescovi[22] in terms of a plateau it does contrast with both Castagna and Castellini[7] and Ramos et al.[6] who found U19 and U20 cohorts achieved significantly greater CMJ scores in comparison with their U17 international peers whilst this current study highlighted trivial differences ($ES = 0.16$) in CMJ performance between the U19 and U17 age groups.

It has been previously argued that biological maturation in females ceases at 17 years of age and any improvements in physical performance tests in older age groups may be attributed to physiological adaptations elicited by exposure to greater total training load and an increase in match demands.[6] Senior players have been shown to undertake higher volumes of total distance, high intensity running, sprinting, accelerations, and decelerations during international competition than their U17 equivalents.[10] Therefore, it is plausible that a training program specifically designed to meet the increased match and training demands of senior female international football elicits physiological adaptations such as greater stretch reflex, enhanced neural potentiation, and increased elastic energy reutilisation which in turn enhances CMJ performance.[6,31]

One potential explanation for the lack of any differences between Irish U17 and U19 age groups may be attributed to the competition structures currently available for elite female footballers in Ireland. The Football Association of Ireland only operates national league and cup competitions for elite female club level players at U17 and senior age groups. Consequently, all U19 players deemed to possess the required technical and tactical ability are progressed to the senior national league competition. A scenario which may be detrimental to their long term physical development. Match play time can be severely limited for these players as some U19 players do not possess the required physical performance characteristics to warrant a starting place at senior level. Due to limited match playtime and the fact small-sided games and technical and tactical pitch-based training have been shown not to meet the demands of elite female match play, regular exposure to high speed running and sprinting may be vastly reduced.[32] As a result, the U19 players competing at senior level potentially experience decreased total training loads and exposure to the strength and power-based high-intensity actions of match play which may explain the lack of difference in CMJ performance with the U17 age group in this current study.

Reactive strength assesses a player's ability to effectively brake and withstand forces over a certain period before producing a propulsive force.[33] Depending on the age group and playing position a player may perform between 71 – 205 decelerations and 143 – 247 accelerations during an international match.[11] Therefore, assessment of female international football player's stretch-shortening cycle capabilities is of interest to sports scientists and strength and conditioning coaches.[24] To the author's knowledge, this study is the first to report the RSI measures of female international football players across several age groups via the 10/5 repeated jump test. In this study the senior age group ($1.56 \pm .25$ m/s) exhibited higher levels of reactive strength in comparisons to the U17 ($1.31 \pm .31$ m/s) and U19 ($1.34 \pm .28$ m/s) categories. These results could be attributed to the senior group's greater force production capabilities. This was reinforced by the CMJ and linear speed data in the current study. However, it must be noted the underpinning mechanisms of stretch-shortening cycle development during maturation have yet to be clarified within the literature.[31]

RSI has been previously assessed in female collegiate level team sport athletes and elite female club level footballer utilising the 10/5 repeated jump and drop jump protocols respectively.[25,34] Coymns et al.[24] reported lower levels of RSI ($1.22 \pm .47$ m/s) in collegiate level female team sport athletes when compared to the athletes in this current study (see Table 2). These differences may be attributed to the competition level and training status of the athletes involved in both studies (i.e. collegiate vs international). As other vertical jump assessments have been shown to distinguish international level players from their first and second division club level counterparts.[8] Additionally, Emmonds et al.[35] reported an even lower mean RSI score of ($1.17 + .14$ m/s) in elite female club level players via a 40cm drop jump. However, the cohort in Emmonds et al.[35] study displayed faster, 10-m, 20-m, and 30-m times than all age groups in this current and greater CMJ scores than the U17 and U19s age groups would appear to indicate greater or similar levels of lower limb power. Therefore, it may be suggested that RSI scores obtained from 10/5 RJT and 40 cm drop jumps are not directly comparable in elite female football players due to the differing nature of the test protocols.

The findings of the linear speed assessments in this study support those found by Vescovi[22] which reported

Table 2. Linear sprint ten-meter split times and reactive strength index (mean ± SD) for all age groups.

Age group	N	10m (sec)	20m (sec)	30m (sec)	Rolling 20m (sec)	RSI (m/s)
U17	24	1.95 ± .05	3.36 ± .09	4.70 ± .16	2.74 ± .12	1.30 ± .31
U19	21	1.92 ± .10	3.32 ± .15	4.64 ± .22	2.70 ± 13	1.34 ± .28
Senior	10	1.89 ± .09	3.26 ± .17	4.57 ± .26	2.65 ± .17	1.56 ± .25

a plateau in sprinting performance over 18.2-m for female footballers between the ages of 14 – 21 years old. In this study, 10-m, 20-m, 30-m, and rolling 20-m sprint performance were similar between all ages groups. In contrast, Ramos et al.[6] revealed senior players to be faster over 20-m than U15, U17, and U20 players whilst Haugen et al.[8] discovered senior players to be faster over 10-m than junior international players. The senior cohort in this study were slower (1.89 ± .09 vs 1.67 ± .07 sec) over 10-m than their Norwegian counterparts in Haugen et al.[8] with a comparable scenario present over 20-m versus the Brazilian cohort in Ramos et al.[6] (3.26 ± .17 vs 3.23 ± .02 sec). Additionally, the U17 and U19 age groups (see Table 2) in this investigation achieved faster 0–20-m times than the U17 (3.44 ± 0.1 sec) and U20 (3.38 ± .01 sec) cohorts present within the Ramos et al.[6] study which may help to explain the lack of difference in linear speed performance between senior and all other age groups in this current study. However, it must be acknowledged the linear speed test protocols implemented by Haugen et al.,[8] Ramos et al.[6] and this current investigation were not identical for example in both this study and Haugen et al.[8] athletes started 0.5m behind the start line whilst this information is not disclosed in Ramos et al.[6]

A lack of published data on the YYIR1 test for international level female players has been acknowledged within the literature but more recent publications have documented YYIR1 values as high as (1760 ± 240 m) and as low as (837 + 256 m) in female senior international teams.[34,36,37] In this current investigation, the seniors YYIR1 performance was 65% higher than that of the U19 players, which would be an abnormally large disparity between the two age groups. Considering the highest previously recorded difference within the literature was a 45% increase in YYIR1 performance between senior and U20 international players.[6] Furthermore, the U17 age group outperformed the U19 age group by 11%. This large disparity versus the senior and underperformance in comparison to the U17 age group may be attributed to the absence of national-level club competition structures for elite female football players in Ireland from U18 up to senior level.

Recent evidence demonstrates YYIR1 performance increases with age from early to mid-teen (U12 – U16 years) in elite regional level youth female footballers.[36,37] However, the long-term relationship between enhancements in YYIR1 performance and physical maturation into adulthood has yet to be established in international female footballers.[38] Our study highlighted senior players covered greater total distance during the YYIR1 when compared to the U19 and U17 age groups (see Figure 1(a)) mirroring the findings of Ramos et al.[6] where senior players (1510 ± 320 m) also displayed superior YYIR1 scores versus U15 (710 ± 210 m), U17(720 ± 230 m) and U20 (860 ± 240 m) age categories. Furthermore, Mujika et al.[19] established the same pattern between senior and junior elite female club players with the seniors ($P = 0.001$) outperforming the junior players in the YYIR1(1224 ± 255 m vs 826 ± 160 m). Based on the presented literature it is fair to suggest that significant improvements in aerobic endurance are attainable in adulthood for elite female football players.

In conclusion, the results of this study demonstrated senior players possessed higher levels of lower limb power and aerobic endurance due to greater performances in CMJ and YYIR1 tests. It is also the first study to assess both the fast (10/5 RJT) and slow (CMJ) stretch-shortening cycle capabilities across numerous age groups of female international football players. The primary limitation to the generalisation of these results is the small senior age group sample size. The current study also failed to include specific playing position anthropometric or physical performance characteristics or account for the influence of biological maturation. As a result, only age group data was presented without assessing the influence of early or late biological maturation of individual players. Therefore, these results must be interpreted with caution. Nonetheless, the results of this study do echo previous findings documented within the literature with similar differences between senior and U17 age categories in lower limb power and aerobic endurance and capacity present in Italian, New Zealand, Norwegian and Brazilian cohorts of female international football players.[5–8]

It appears the absence of a national club level competition structure for all elite female footballers in Ireland possibly hinders the continued physical development of the U19 cohort.

Unexpectedly, the U19 age group had similar outcomes on the physical performance tests when matched against the U17 group. In contrast to the results of this investigation, Italian, New Zealand, and Brazilian cohorts of female U19 and U20 international football players displayed greater levels of lower limb power, aerobic endurance, and strength when compared to their respective U17 peers.[5–7] The apparent lack of progression or visible stagnation of the Irish U19 age group's physical performance characteristics could be associated with the gaps in the club competition structures provided to elite female players in Ireland.

Practical applications

The long term athletic development of female international players should be a key priority for the player development pathways of national organisations.[38,39] The findings of this study provide age-appropriate data for coaches, strength and conditioning, and sports scientists working with elite female international players at multiple age groups. The capacity to evaluate the physical performance characteristics of female football players and compare them with age-appropriate data can aid player development pathways and individualise training programs.

The YYIR1 performance has been shown to distinguish between selected and non-selected international female players across multiple age groups[6,40] and the levels of high intensity running increased in the 2019 women's world cup in comparison to the 2015 tournament.[41] This reinforces the need to concurrently develop numerous physical performance characteristics such as aerobic endurance, speed, and strength to adequately prepare for the requirements of senior level international football. This can be achieved by prescribing specific strength training sessions, utilising warm-ups before training to develop speed and agility whilst small-sided games can be employed to develop the aerobic system in a game-specific manner.[38] However, any training program designed to develop the physical performance characteristics for international football must be strategically planned, individualised, and age-appropriate in order to address the influence of growth and maturation.[42]

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