Short Communication

Physical Profiles of Regional Academy Netball Players

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Objectives: The purpose of this study was to evaluate the height, body mass and physical characteristics of English regional academy netball players by age category (under 15s, under 17s and under 19s).

Design and Methods: Data were collected on 50 regional academy players during the preseason period and comprised of height, body mass, and physical (single and triple hop, 5- and 10-m sprint, 505 change of direction speed, vertical jump, and cardiorespiratory fitness) characteristics.

Results: One-way analysis of variance revealed the under 19s group demonstrated superior ($p < 0.05$) performances compared to the under 15s group in single hop left (U15: 1.61 ± 0.18 m; U19: 1.88 ± 0.09 m; $p = 0.001$), single hop right (U15: 1.66 ± 0.17 m; U19: 1.87 ± 0.13 m; $p = 0.001$), triple hop left (U15: 5.10 ± 0.58 m; U19: 5.90 ± 0.39 m; $p = 0.001$), triple hop right (U15: 5.10 ± 0.50 m; U19: 5.86 ± 0.41 m; $p = 0.001$), 5-m sprint (U15: 1.15 ± 0.05 seconds; U19: 1.10 ± 0.07 seconds; $p = 0.032$), 505 left (U15: 2.59 ± 0.08 seconds; U19: 2.45 ± 0.08 seconds; $p = 0.001$), 505 right (U15: 2.54 ± 0.13 seconds; U19: 2.43 ± 0.06 seconds; $p = 0.007$), squat jump (U15: 0.34 ± 0.04 m; U19: 0.41 ± 0.05 m; $p = 0.001$), countermovement jump (U15: 0.35 ± 0.04 m; U19: 0.42 ± 0.05 m; $p = 0.001$), and cardiorespiratory fitness (U15: 16.40 ± 0.83 $km{\cdot}h^{-1}$; U19: 18.14 ± 1.10 $km{\cdot}h^{-1}$; $p = 0.001$). Moreover, the under 17s group reported significantly better ($p < 0.05$) performances in single leg hop left (U15: 1.61 ± 0.18 m; U17: 1.74 ± 0.12 m; $p = 0.033$), single hop right, triple hop left (U15: 5.10 ± 0.58 m; U17: 5.59 ± 0.35 m; $p = 0.008$), triple hop right (U15: 5.10 ± 0.50 m; U17: 5.50 ± 0.36 m; $p = 0.031$), countermovement jump (U15: 0.35 ± 0.04 m; U17: 0.39 ± 0.03 m; $p = 0.018$), and cardiorespiratory fitness (U15: 16.40 ± 0.83 $km{\cdot}h^{-1}$; U17: 17.56 ± 1.30 $km{\cdot}h^{-1}$; $p = 0.014$) than the under 15s group.

Conclusions: These findings highlight that height, body mass, and physical characteristics develop across age categories and provide normative data for English regional academy netball players.

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Key words: fitness testing ■ age category ■ youth athletes ■ anthropometry ■ player profiling

INTRODUCTION

Netball is a team sport that has one of the largest participation rates within the commonwealth, in particular the United Kingdom, Australia, and New Zealand. Played on a 30.5 m × 15.25 m court, divided into thirds each measuring 10.17 m, netball consists of four 15-minute quarters, separated by five-minute rest at half-time and three minutes between other quarters. Each team consists of seven players on the court at one time, with each area of the court accessible to each player determined by position. Thus, players are constantly involved in offensive and defensive manoeuvres, affecting the technical, tactical, and physical demands of each position.[1] In order to perform at high levels, players must be able to cope with the physical demands of the game.

Analysis of English Superleague match-play reveals players cover up to 8 km, dependent upon position.[1] For example, centre court players cover 8 km per game, whereas end court players (goal keepers and goal shooters) cover on average 4.2 km.[1] These differences are likely due to the differing roles of the aforementioned positions combined with positional restrictions during play relating to which areas of the court individual players can play in. Activity profiles of international netball suggests that all players are constantly performing high-intensity movement patterns (shuffling, running, sprinting, jumping)[2], therefore the ability to perform repeated high-intensity bouts and resist fatigue appears to be an important factor in netball performance. Consequently, it is important to optimise the assessment, preparation, and monitoring of physical characteristics for netball, to optimise performance and development.

Physiological profiling of athletes, particularly longitudinal investigations of physiological characteristics, can provide valuable information to coaches and sports scientists. The physiological requirements of netball are not fully understood due to a limited amount of research, however research findings suggest physical qualities such as speed, strength, power, agility, and aerobic and anaerobic endurance are highly important.[3] Given the importance of physical qualities for match performance[1,2], limited studies exist that consider the height, body mass, and physical characteristics of netball players. The results of several studies have demonstrated that differences in performance characteristics exist between playing levels within rugby league[4,5], rugby union[6,7], and lacrosse[8]. Surprisingly, no study has examined the height, body mass, and physical characteristics of academy netball players. Such analysis is required to monitor and develop athletic and functional capabilities in accordance with the long-term athlete development process to prepare athletes for higher levels of competition.[9]

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The countermovement jump (CMJ) and squat jump (SJ) are two commonly used vertical jump (VJ) field tests to assess lower-body explosive performance. Additionally, CMJ and SJ are commonly used to assess the stretch-shortening cycle (SSC) capabilities of athletes across various sports.[10] Previous research shows significant associations between CMJ and SJ to sprint performance.[11,12] Additionally, several landing strategies are possible within netball[13], with single leg and hop landings shown to occur frequently across all playing positions. Hewit et al.[14] reported that utilizing jump tests only performed in one direction may not represent an accurate player profile, as jump performance in one direction may not necessarily predict jump performance in another. Additionally, horizontal hop tests are commonly used to assess both performance and injury risk.[11,15] Lockie et al.[11] found unilateral broad jump to observe significant and inverse moderate to very strong associations ($r = -0.46$ to -0.73) with sprint performance in team-sport athletes. Thus, assessing vertical and horizontal jump performance may be of particular interest to prescribe and monitor the training of netball athletes, to create accurate player profiling.

Finally, physical profiling of regional academy netball players can provide normative data for height and body mass, and physical characteristics across age categories. Physical profiling of individual athletes would assist coaches and practitioners prescribe appropriate training programmes to aid in athletic development. Therefore, the purpose of the study was to evaluate the height and body mass and physical characteristics in English regional netball academy players across age categories (i.e., under 15s, under 17s, and under 19s) using a complete physical testing battery. It was hypothesized that height, body mass, hop and jump performances, and cardiorespiratory fitness would increase across age categories.

METHODS

Junior female netball players from a regional academy in the United Kingdom were assessed on a range of height and body mass (height, body mass) and physical (single and triple leg hop, CMJ and SJ, 5- and 10-m sprint, 505 change of direction speed [CODS]; and 30-15 intermittent fitness test [$30\text{-}15_{IFT}$]) characteristics across three age categories (under 15s, under 17s, and under 19s). This approach allowed comparison between regional academy netball players across age categories.

Subjects

Young female netball players ($n = 50$; age $= 15.8 \pm 1.4$ years; height $= 173.5 \pm 5.5$ cm; body mass $= 65.9 \pm 7.2$ kg;) participated in this study. All players were fully informed of the requirements of the investigation and provided appropriate consent to participate, with consent from the parent or guardian of all players under the age of 18. The investigation was also approved by the institutional review board.

Testing was conducted in the preseason during which time all participants were training with sessions comprising all the elements of performance including 4–5 netball-specific training sessions, plus 2 resistance training sessions each week. At the time of testing, participants were at the end of a 4-week general preparation mesocycle. All athletes rested the day before testing and were asked to attend testing in a fed and hydrated state, similar to their normal practices before training. All participants were familiar with the tests performed in this study as part of their normal training and monitoring regime. Before the start of testing, athletes were instructed to perform a standardized warm-up, as directed by the investigator. Warm-up included 10 minutes of non-fatiguing activation and mobilization exercises, including various bodyweight lunges and squats, interspersed with footwork and sprint mechanics drills, followed by some low-level bilateral and unilateral plyometric drills, replicating the athlete's standardized warm-ups before training. All testing was performed indoors on a hardwood netball court.

Procedures

All testing was performed on the same day during week five of the preseason training period. On arrival, all participants had their height (Stadiometer; Seca, Birmingham, United Kingdom) and body mass assessed (Seca Digital Scales, Model 707) while in bare feet, measured to the nearest 0.1 kg and 0.1 cm, respectively. Testing order was as follows: single and triple hop, VJ, sprint, CODS, and $30\text{-}15_{IFT}$. Standardized progressive warm-ups were applied before all tests to control potential variables and improve the reliability of all tests.

Hop Testing

The single and triple hop tests were used as a measure of horizontal jump performance. A 6-m long, 15-cm-wide line was marked on the floor, along the middle of which was a standard tape measure, perpendicular to the starting line. Each hop test began with participants placing the toes of both feet on the back of the start line, before balancing on the leg to be tested. Participants were instructed to use a countermovement, and no restrictions were placed on body angles attained during the preparatory phase of the jump or the arm swing used. Participants had to "stick" the landing for the trial to be counted. If the subject did not do this, the trial was disregarded and another was attempted. The distance was measured to the nearest 0.01 m using a standard tape measure, perpendicular from the front of the start line to the posterior aspect of the back heel at the landing.

In accordance with previous research,[16] participants performed 3 warm-up trials on each leg, for both hop tests. For the single hop, participants performed a simultaneous arm swing and crouch, then hopped as far forward as possible, taking off from one leg, before landing on the same leg. The triple hop involved participants performing 3 consecutive maximal hops along the line of the tape measure.[16] Further, three maximal trials were recorded on each leg for both tests, with one minute of rest between trials. The best performance of each leg from each hop test was used for further analysis.

Vertical Jump Testing

Vertical jump height data were collected using a portable jump mat (Just Jump; Probiotics, Huntsville, AL, USA). The athletes were familiar with all jumps and explosive exercise, permitting the use of warm-up sets for familiarization with the equipment to ensure reliable jump performances. Vertical jump tests began with the SJ condition. On stepping onto the jump mat, athletes were instructed to get in the "ready position," which consisted of the subject having their hands on hips and assuming a self-selected squat depth. Once in position, a countdown of "3, 2, 1 Jump" was given. A three second hold of the bottom position was used to eliminate the involvement of the SSC. If players failed to adhere to the strict protocol and either performed a countermovement or moved their hands off their hips, the trial was repeated after an additional one-minute rest. Athletes performed three trials with one minute of rest between trials. On completion of the SJ trials, athletes were provided with a rest period of three minutes before performing the CMJ trials. For the CMJ, athletes were instructed to perform a rapid eccentric phase, immediately followed by a rapid concentric phase with the intention to jump as high as possible. Countermovement jumps were performed with the hand on the hips, and countermovement depth of the eccentric phase was self-selected by the athletes to maximize CMJ height. Athletes performed three trials, with one minute of rest between trials. Alternate jump height was calculated from flight time (1/8 [g x t^2]) (where g = the acceleration due to gravity and t = air time), and subsequently corrected with the following equation: jump height = (0.8747 x alternative jump height) - 0.0666.[17] The best performance from each of the three trials was used for further analysis.

Sprint Testing

The 10-m sprint test was administered as a test of acceleration and sprint ability. All athletes performed three trials, with two minutes rest between trials, using "Brower photocell timing Gates" (model number BRO001; Brower, Draper, UT, USA) setup at 0-, 5-, and 10-m. Timing gates were placed at the approximate hip height for all athletes as previously recommended[18], to ensure that only one body part, such as the lower torso, breaks the beam. Athletes started 0.5 m behind the first gate, to prevent any early triggering of the initial start gate, from a two point staggered start. The best performance from each of the three trials was used for further analysis.

Change of Direction Speed Testing

Change of direction speed was assessed utilising a 505 test. All athletes performed three trials, with a two-minute rest between trials. Athletes started 0.5 m behind the photocell gates, to prevent any early triggering of the initial start gate, from a two point staggered start. Timing gates were again placed at the approximate hip height for all athletes. Athletes were instructed to sprint to a line marked 15 m from the start line, placing either left or right foot on the line, depending on the trial, turn 180° and sprint back 5 m through the finish.[4] If the subject changed direction before hitting the turning line, or turned off the incorrect foot, the trial was disregarded and the subject completed another trial after the rest period. The best performance from each of the 3 trials was used for further analysis.

The 30-15 Intermittent Fitness Test

The 30-15_{IFT} was performed as previously described[19] on a shorter shuttle-length (28 m). The 30-15_{IFT} consists of 30-s shuttle runs interspersed with 15-s periods of passive recovery. The initial running velocity was set at 8 km·h^{-1} for the first 30-s run and increased by 0.5 km·h^{-1} for every subsequent stage. Players ran back and forth between two lines set 28-m apart at a pace governed by a pre-recorded beep. During the 15-s recovery period, each player walked forward to the closest of the three lines (at the middle or at one end of the running area, depending on where the previous stage was completed), in preparation for the next stage. Players were instructed to complete as many 'stages' as possible, and the test ended when a player could no longer maintain the imposed running speed or when they were unable to reach a 3-m zone around each line at the moment of the audio signal on three consecutive occasions If players were unable to complete the stage, then their score was recorded as the stage that they last completed successfully, and the running velocity recorded as their maximal intermittent running velocity (V_{IFT}).

Statistical Analyses

Data are presented as either mean ± SD or mean with 90% confidence intervals (90% CI) where specified, for each age category (i.e., under 15s, under 17s, and under 19s). Within-session reliability of dependent variables was examined using the intraclass correlation coefficient (ICC), and typical error of measurement (TE) expressed as a coefficient of variation (CV). Intraclass correlation coefficient, TE, and CV were calculated through an available online spreadsheet.[20] To assess the magnitude of the ICC, the threshold values were 0.1, 0.3, 0.5, 0.7, 0.9, and 1.0 for low, moderate, high, very high, nearly perfect, and perfect, respectively.[21] Normality of data was assessed by Shapiro–Wilk statistic, and homogeneity of variance was verified with the Levene test using SPSS software (version 17.0, SPSS, Inc., IL, USA). A series of one-way analysis of variance were conducted to analyse differences between age groups with an alpha level of $p \leq 0.05$. Where significant differences were found, Bonferroni post hoc analyses were completed to detect differences between age categories. The magnitude of differences between age groups was also expressed as standardized mean difference [Cohen' d, effect sizes, (ES)].[22] The ES were classified as trivial (≤ 0.19), small (0.20 - 0.59), moderate (0.60 - 1.19), large (1.20 - 1.99), and very large (2.0 - 4.0).

RESULTS

Within-session reliability for each performance measure are presented in Table 1. No statistically significant differences in the homogeneity of variance existed among age category within the Levene's test, and thus, equal variances were assumed. The mean and SD values for height and body mass, hop, VJ, sprint, CODS, and cardiorespiratory fitness characteristics of regional academy netball players by age category (under 15s, under 17s, and under 19s) can be found in Table 2. The table presents overall effects and ES between age categories.

One-way analysis of variance revealed that height was sig-

Table 1 Reliability statistics of each age category for single hop, triple hop, sprint, change of direction speed, and vertical jump performances.*

Reliability Variable	U15 ($n=15$) ICC (90% CI)	U15 ($n=15$) TE (90% CI)	U15 ($n=15$) CV% (90% CI)	U17 ($n=17$) ICC (90% CI)	U17 ($n=17$) TE (90% CI)	U17 ($n=17$) CV% (90% CI)	U19 ($n=18$) ICC (90% CI)	U19 ($n=18$) TE (90% CI)	U19 ($n=18$) CV% (90% CI)
Single Hop L (m)	0.90 (0.80-0.96)	0.06 (0.05-0.08)	3.9 (3.2-5.4)	0.82 (0.66-0.91)	0.06 (0.05-0.08)	3.4 (2.8-4.5)	0.83 (0.68-0.92)	0.05 (0.04-0.06)	2.7 (2.2-3.5)
Single Hop R (m)	0.91 (0.81-0.96)	0.06 (0.05-0.08)	3.7 (3.0-4.5)	0.91 (0.82-0.96)	0.05 (0.04-0.06)	3.0 (2.5-4.1)	0.90 (0.80-0.95)	0.05 (0.04-0.06)	2.5 (2.1-3.3)
Triple Hop L (m)	0.94 (0.88-0.98)	0.15 (0.13-0.21)	3.2 (2.6-4.4)	0.86 (0.73-0.93)	0.15 (0.13-0.20)	2.8 (2.4-3.8)	0.87 (0.76-0.94)	0.15 (0.13-0.20)	2.2 (2.2-3.5)
Triple Hop R (m)	0.89 (0.78-0.95)	0.13 (0.11-0.18)	2.6 (2.1-3.5)	0.89 (0.78-0.95)	0.13 (0.11-0.18)	2.4 (2.0-3.2)	0.95 (0.90-0.98)	0.10 (0.08-0.13)	1.8 (1.5-2.4)
SJ (m)	0.92 (0.83-0.97)	0.01 (0.01-0.02)	4.1 (3.3-5.6)	0.89 (0.79-0.95)	0.01 (0.01-0.02)	2.7 (2.3-3.7)	0.96 (0.92-0.98)	0.01 (0.01-0.02)	2.9 (2.4-3.9)
CMJ (m)	0.97 (0.93-0.99)	0.01 (0.01-0.01)	2.1 (1.7-2.9)	0.84 (0.70-0.93)	0.02 (0.01-0.02)	3.6 (2.9-4.8)	0.95 (0.91-0.98)	0.01 (0.01-0.02)	2.8 (2.3-3.7)
5 m (s)	0.71 (0.48-0.86)	0.04 (0.02-0.04)	2.3 (1.9-3.2)	0.74 (0.54-0.87)	0.04 (0.03-0.05)	3.1 (2.6-4.2)	0.79 (0.63-0.90)	0.03 (0.03-0.04)	2.9 (2.4-3.8)
10 m (s)	0.80 (0.61-0.91)	0.04 (0.03-0.06)	2.0 (1.7-2.8)	0.80 (0.63-0.90)	0.04 (0.03-0.05)	1.8 (1.5-2.4)	0.76 (0.57-0.88)	0.04 (0.04-0.06)	2.2 (1.9-2.9)
505 L (s)	0.69 (0.44-0.85)	0.05 (0.04-0.07)	1.9 (1.6-2.6)	0.56 (0.29-0.77)	0.09 (0.08-0.13)	3.6 (3.0-4.8)	0.64 (0.41-0.81)	0.07 (0.06-0.09)	2.6 (2.2-3.4)
505 R (s)	0.64 (0.38-0.83)	0.09 (0.07-0.12)	3.3 (2.7-4.6)	0.68 (0.45-0.84)	0.06 (0.05-0.08)	2.3 (1.9-3.1)	0.73 (0.53-0.87)	0.04 (0.03-0.05)	1.6 (1.3-2.1)

*ICC = intraclass correlation coefficient; TE = typical error; CV = coefficient of variation; CI = confidence interval; CMJ = countermovement jump; L = left leg; R = right leg; SJ = squat jump.

nificantly greater (p = 0.038) in the under 19s (1.76 ± 0.05 m) than in the under 15s (1.71 ± 0.06 m) age category. Small and moderate, yet non-significant differences were found between the heights of under 15s and under 17s (U15: 1.71 ± 0.06 m; U17: 1.73 ± 0.05 m; p = 0.99) and under 17s and under 19s (U17: 1.73 ± 0.05 m; U19: 1.76 ± 0.05 m; p = 0.152). Body mass was significantly different from the under 15s to under 19s (U15: 63.33 ± 3.15 kg; U19: 69.91 ± 7.97 kg; p = 0.033) whereas trivial and small non-significant differences were found between under 15s and under 17s (U15: 63.33 ± 3.15 kg; U17: 64.12 ± 7.69 kg; p = 0.062) and under 17s and under 19s (U17: 64.12 ± 7.69 kg; U19: 69.61 ± 7.97 kg; p = 0.99).

Significant differences between the under 15s and under 17s (U15: 1.61 ± 0.18 m; U17: 1.74 ± 0.12 m; p = 0.016), under 15s and under 19s (U15: 1.61 ± 0.18 m; U19: 1.88 ± 0.09 m; p = 0.001) and under 17s and under 19s (U17: 1.74 ± 0.12 m; U19: 1.88 ± 0.09 m; p = 0.014) single hop L were moderate to large; whereas differences for single hop R were small (U15: 1.66 ± 0.17 m; U17: 1.72 ± 0.14 m; p = 0.763), large (U15: 1.66 ± 0.17 m; U19: 1.87 ± 0.13 m; p = 0.001), and moderate (U17: 1.72 ± 0.14 m; U19: 1.87 ± 0.13 m; p = 0.010), respectively. Triple hop L was significantly different from the under 15s squad for both under 17s (U15: 5.10 ± 0.58 m; U17: 5.59 ± 0.35 m; p = 0.008) and under 19s (U15: 5.10 ± 0.58 m; U19: 5.90 ± 0.39 m; p = 0.001), whereas moderate and non-significant differences were observed between the under 17s and under 19s (U17: 5.59 ± 0.35 m; U19: 5.90 ± 0.39 m; p = 0.157). Significant differences between the under 15s and under 17s (U15: 5.10 ± 0.50 m; U17: 5.50 ± 0.36 m; p = 0.031), under 17s and under 19s (U17: 5.50 ± 0.36 m; U19: 5.86 ± 0.41 m; p = 0.049), and under 15s and under 19s (U15: 5.10 ± 0.50 m; U19: 5.86 ± 0.41 m; p = 0.001) triple hop R were moderate to large.

Five metre sprint performances were significantly faster in the under 19s than both the under 15s (U15: 1.15 ± 0.05 seconds; U19: 1.10 ± 0.07 seconds; p = 0.032) and under 17s (U17: 1.15 ± 0.07 seconds; U19: 1.10 ± 0.07 seconds; p = 0.036), whereas trivial and non-significant differences were found between under 15s and under 17s (U15: 1.15 ± 0.05 seconds; U17: 1.15 ± 0.07 seconds; p = 0.99). No significant differences (p > 0.05) were identified for 10-m sprint with only trivial or moderate effects identified between age categories (U15: 1.99 ± 0.08 seconds; U17: 1.98 ± 0.08 seconds; U19: 1.94 ± 0.08 seconds).

Change of direction speed 505 L was significantly faster in the under 19s than both the under 15s (U15: 2.59 ± 0.08 seconds; U19: 2.45 ± 0.08 seconds; p = 0.001) and under 17s (U17: 2.53 ± 0.12 seconds; U19: 2.45 ± 0.08 seconds; p = 0.041), whereas under 19s were significantly faster than the under 15s (U15: 2.54 ± 0.13 seconds; U19: 2.43 ± 0.06 seconds; p = 0.007) for 505 R.

Significant large differences were found for SJ between the under 15s and under 19s age categories (U15: 0.34 ± 0.04 m; U19: 0.41 ± 0.05 m; p = 0.001). Moderate differences were found between both the under 15s and under 17s (U15:

Table 2 Height and body mass, hop, sprint, change of direction speed, vertical jump and cardiorespiratory fitness characteristics of regional academy netball players by age category. *§

	U15 (*n* = 15)	U17 (*n* = 17)	U19 (*n* = 18)	U15 vs. U17 Cohen's d	U15 vs. U19 Cohen's d	U17 vs. U19 Cohen's d
Age (years)	14.47 ± 0.83	15.65 ± 0.79†	17.06 ± 1.11†‡	1.42	2.54	1.42
Height (m)	1.71 ± 0.06	1.73 ± 0.05	1.76 ± 0.05†	0.36	0.89	0.59
Body Mass (kg)	63.33 ± 3.15	64.12 ± 7.69	69.61 ± 7.97†	0.13	0.98	0.69
Single Hop L (m)	1.61 ± 0.18	1.74 ± 0.12†	1.88 ± 0.09†‡	0.89	1.91	1.21
Single Hop R (m)	1.66 ± 0.17	1.72 ± 0.14	1.87 ± 0.13†‡	0.37	1.39	1.12
Triple Hop L (m)	5.10 ± 0.58	5.59 ± 0.35†	5.90 ± 0.39†	1.03	1.60	0.78
Triple Hop R (m)	5.10 ± 0.50	5.50 ± 0.36†	5.86 ± 0.41†‡	0.90	1.64	0.90
SJ (m)	0.34 ± 0.04	0.38 ± 0.03	0.41 ± 0.05†	1.11	1.44	0.79
CMJ (m)	0.35 ± 0.04	0.39 ± 0.03†	0.42 ± 0.05†	1.11	1.49	0.53
5 m (s)	1.15 ± 0.05	1.15 ± 0.07	1.10 ± 0.07†‡	-0.05	-0.93	-0.81
10 m (s)	1.99 ± 0.08	1.98 ± 0.08	1.94 ± 0.08	-0.07	-0.61	-0.54
505 L (s)	2.59 ± 0.08	2.53 ± 0.12	2.45 ± 0.08†‡	-0.55	-1.73	-0.80
505 R (s)	2.54 ± 0.13	2.50 ± 0.09	2.43 ± 0.06†	-0.39	-1.08	-0.79
30-15IFT (km·h^{-1})	16.40 ± 0.83	17.56 ± 1.30†	18.14 ± 1.10†	1.02	1.72	0.47

*CMJ = countermovement jump; L = left leg; R = right leg; SJ = squat jump; 30-15IFT = 30-15 intermittent fitness test.
†Significantly different from U15 athletes ($p \leq 0.05$).
‡Significantly different from U17 athletes ($p \leq 0.05$).
§Values are expressed as mean ± SD.

0.34 ± 0.04 m; U17: 0.38 ± 0.03 m; p = 0.057) and under 17s and under 19s (U17: 0.38 ± 0.03 m; U19: 0.41 ± 0.05 m; p = 0.053). Countermovement jump was significantly different from the under 15s squad for both under 17s (U15: 0.35 ± 0.04 m; U17: 0.39 ± 0.03 m; p = 0.018) and under 19s (U15: 0.35 ± 0.04 m; U19: 0.42 ± 0.05 m; p = 0.001), whereas small non-significant differences were observed between the under 17s and under 19s (U17: 0.39 ± 0.03 m; U19: 0.42 ± 0.05 m; p = 0.277).

Maximal intermittent running velocity was significantly greater in the under 19s to that of the under 15s (U15: 16.40 ± 0.83 km·h^{-1}; U19: 18.14 ± 1.10 km·h^{-1}; p = 0.001), whereas small non-significant differences were observed between the under 17s and under 19s (U17: 17.56 ± 1.30 km·h^{-1}; U19: 18.14 ± 1.10 km·h^{-1}; p = 0.001). Also, V_{IFT} was significantly greater in the under 17s that that of the under 15s (U15: 16.40 ± 0.83 km·h^{-1}; U17: 17.56 ± 1.30 km·h^{-1}; p = 0.014).

DISCUSSION

Limited research is available that presents the height and body mass and physical characteristics of netball players. Therefore, the purpose of the study was to evaluate the height and body mass and physical characteristics in English regional academy netball players across age categories (i.e., under 15s, under 17s, and under 19s) using a complete physical testing battery. The results of this study indicate that differences in height and body mass (height and body mass) and physical characteristics (hop, VJ, sprint, CODS, and cardio respiratory fitness) exist across the three age categories.

The results of the current study indicate that the greatest single and triple hop values were produced by the under 19s group, and were followed in order by the under 17s, and under 15s. These findings are consistent with previous research indicating lower-body power measures to increase with age[23], and in response to training interventions[24]. Although, it should be noted hop and VJ tests are not direct measures of lower-body power[25], the differences in hop distance among age categories may be attributed to increased power production, resulting in greater hop distance. This notion is supported by Peterson et al.[26] who found strong relationships between VJ height (r = 0.84), and VJ peak power (r = 0.70) and horizontal jump performance in collegiate athletes. It should be noted that the horizontal hops performed in this study were unilateral, whereas Peterson et al. used a bilateral broad jump. Additionally, previous research has observed significant associations between unilateral horizontal jumps to sprint and CODS.[27] However, further research is warranted to support this contention.

Despite no significant differences being reported between under 15 and under 17 for SJ height, and under 17 and under 19 age categories for SJ and CMJ height, it is argued that non-significant results do not necessarily imply the nonexistence of a worthwhile differences in performance measures. From our findings there is evidently a trend of increased VJ performance over time, however sample size and measurement variability can mask important effects. Additionally, the two-year age gap between groups may possibly be a reason for the lack of statistical significance when comparing between consecutive groups in these specific measures. Similar findings have been reported by Lloyd et al.[28] who found SJ and CMJ performance increases through the ages of 10 - 16+, and that significant differences were evident when comparing age groups that differed by 3 years or more, not when comparing between consecutive age groups. Furthermore, athletes within the current study were primarily categorised on playing ability, and secondly by age. For example, younger athletes (e.g. 16-year-old) could be in the U19s age category as their skill level is deemed superior to that of the U17s category, which may also mask the differences in performance measures, especially as maturational status has been shown to affect performance in numerous athletic tasks.[28-30] In this study, we found significant differences in SJ and CMJ performances between under 15 and under 19 age categories, which support the work by Lloyd et al.[28] and Darrall-Jones et al.[7], suggesting that jump height increases with age. Additionally, the same authors found CMJ peak power to significantly increase with age. Although the study by Darrall-Jones et al.[7] used age categories with two- and three-year differences, the significant differences may be attributed to the increased training history of the male academy rugby union players. From the superior testing results in the Darrall-Jones et al.[7] study, it could be speculated that strength- and power-related resistance training commonly carried out by rugby union players, whereas although the athletes in the current study participated in strength and conditioning sessions, however from the authors experience traditional strength and power exercises are not common training practices of the majority of young female netball athletes. Additionally, it should be noted the work by Darrall-Jones et al.[7] focused on male academy rugby players, therefore the developmental tendency of the physical characteristics between the subjects used by Darrall-Jones et al.[7] and the ones in the present study should be interpreted with caution. However, it may be recommended that youth athletes aim to increase relative strength levels to improve lower-body power production. Further, it should be noted that the previously mentioned study[7] used laboratory-based measures to calculate VJ height, whereas the current study used field-based methods. Although field-based methods are highly valid and practical to utilize within testing and training sessions[31], laboratory-based methods may provide a more thorough understanding of the underlying factors which influence improved VJ performance.[32]

Although 10-m sprint performances were not significantly different between age categories, 5-m sprint performances were significantly faster in the under 19s than both the under 15s and under 17s. These differences may be attributed to age related-[33], maturation-[34], or training-related factors[35]. It is likely that the training volume experienced at the under 19s level exceeds that which the under 17s and under 15s experienced. Thus, athletes with greater strength, speed, and plyometric training experience may produce different values of 5-m sprint performance compared to those who are younger and have less history in a similar training environment. However, due to no significant differences in 10-m sprint performance, the same notion cannot be assumed. Possible explanations for the lack of significant differences between age categories may be due to measurement error associated with the testing protocol. Our results suggest mean differences in 10-m sprint performances between age categories to lie within the TE of measurement error across all age categories, thus making it difficult to interpret small differences in performance. Additionally, time-motion studies suggest mean sprint times of 1.0 - 1.7 seconds to be common during national and international competition.[1,2] It is therefore likely that such differences were observed in 5-m sprint performance between age categories due to it being a more sports-specific assessment of sprint performance, as compared to 10-m sprint assessment.

Statistically significant differences in 505 performance existed among age categories examined within this study. The under 19s group produced faster performances than both the under 15s and under 17s when turning off the left leg. In addition, the under 19s produced faster performances than the under 15s when turning off the right leg. Though not reported in the current study, no significant difference ($p > 0.05$) was observed in 10-m approach velocity between age categories. Also, no technique or strength measures were assessed within the current study, however previous research in female basketball athletes show faster athletes apply increased braking forces and shorter ground contact times during 505 performances.[36-38] Additionally, the same authors found faster athletes to observe greater eccentric and isometric strength values as compared to slower athletes. Therefore, differences in 505 performances between age categories may be attributed to superior movement mechanics and strength capacity. However, further research in female netball athletes is needed to support this contention. Similar to sprint performances, no significant differences in 505 performances were observed between under 15 and under 17 age categories. The current study observed mean differences of 0.04 - 0.06 seconds in 505 performances between under 15 and under 17 age categories, whereas the TE was 0.05 - 0.09 seconds, possibly indicating no significant differences were observed due to measurement and biological noise associated with the 505 testing protocol in the current study. For example, Barber et al.[39] demonstrated high within-session reliability during 505 testing in female netball players (ICC = 0.95; standard error of measurement = 0.04 seconds), when only performing turns on the dominant leg. Additionally, the mean age (23.9 years) was considerably higher than the athletes used in the current study, and had >5 years' experience playing the sport, making comparisons in reliability measures between studies difficult given the difference in subject characteristics and testing procedures.

Our study shows significant differences in maximal intermittent running velocity between under 15 and under 19 age categories, which is consistent with previous work[40] suggesting V_{IFT} to increase with age and playing standard in female handball players. Further, significant differences in V_{IFT} were observed between under 15 and under 17 (16.40 ± 0.83 vs. 17.56 ± 1.30; $p = 0.014$) age categories, in agreement with recent work demonstrating increases in V_{IFT} as small as 0.5 $km \cdot h^{-1}$ to be considered 'real' and meaningful in male rugby league and female handball players.[41,42] Taken together, these findings suggest improvements in V_{IFT} could be deemed 'real', however further research is needed to support this contention.

CONCLUSION

This study presents normative data for height and body mass and physical characteristics for regional academy netball players from under 15s to under 19s age categories. The findings demonstrate that height, body mass, hop distance, VJ height, 5 m sprint, CODS and cardiorespiratory fitness tend to improve with age. These findings suggest that height and body mass and physical characteristics develop at different rates in regional academy netball players possibly because of increases in body size and training status during this period. However, to the author's knowledge, the current study is the first to profile the physical characteristics of academy netball players through the use of a field-based testing battery. The findings could be used to establish identification criteria and for monitoring and assessment of academy netball player's strengths and weaknesses. Additionally, normative data derived from laboratory-based methods may provide a more accurate assessment of physical characteristics as compared to field-based methods.

COMPLIANCE

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