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Match running performance and skill execution improves with age but not the number of disposals in young Australian footballers

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ABSTRACT

This study investigated age-related differences in maturity, physical and functional characteristics and playing performance in youth Australian Football (AF). Young male players ($n = 156$) were recruited from 12 teams across 6 age groups (U10–U15) of a recreational AF club. All players were tested for body size, maturity and fitness. Player performance was assessed during a match in which disposals (kicks and handballs) and their effectiveness were coded from a video recording and match running performance measured using Global Positioning System. Significant main effects ($P < 0.01$) for age group were observed for age, years to peak height velocity, body mass, height, 20 m sprint, maximal speed over 20 m, vertical jump, 20 m multistage shuttle run, match distance, high-speed running distance, peak speed, number of effective disposals and percentage of effective disposals. Age-related differences in fitness characteristics (speed, lower body power and endurance) appeared to transfer to match running performance. The frequency in which players disposed of the football did not differ between age groups, however the effectiveness of each disposal (i.e., % effective disposals) improved with age. Match statistics, particularly those that evaluate skill execution outcome (i.e., effectiveness), are useful to assess performance and to track player development over time. Differences between age groups, and probably variability within age groups, are strongly associated with chronological age and maturity.

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KEYWORDS

Growth and maturity; peak height velocity; motor skill development; match analysis; physical fitness; youth

Introduction

In attempt to provide equitable competition and fair play, youth team sports are generally organised by age groups. The analysis of differences in measures of fitness in age categories has been widely addressed in the literature, with the main concern of understanding the development of athletic potential alongside biological growth in order to provide appropriate training for young athletes at different stages of development. Furthermore, data related to biological age, anthropometric characteristics and player fitness have been used as a tool for screening and selection of talent (Deprez et al., 2013; Robertson, Woods, & Gastin, 2015; Till et al., 2011; Vandendriessche et al., 2012).

Generally in team sports, previous investigations have shown that players with increased age and biological maturity perform better in fitness tests (e.g., strength, speed and endurance), especially during pubertal years (Gastin, Bennett, & Cook, 2013a; Matthys, Fransen, Vaeyens, Lenoir, & Philippaerts, 2013; Mendez-Villanueva et al., 2011). Nevertheless, available research providing information on the physical demands associated with competition, and how the evolution in the physical parameters is transferred to potential benefits in match performance, remains scarcer (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010). Football research in youth, conducted mostly in soccer (Buchheit et al., 2010; Castagna, Impellizzeri, Cecchini, Rampinini, & Alvarez, 2009; Castagna, Manzi, Impellizzeri, Weston, & Alvarez, 2010;

Rampinini et al., 2007) but also in rugby league (Gabbett, Stein, Kemp, & Lorenzen, 2013) and Australian Football (AF) (Gastin & Bennett, 2014; Gastin, Bennett, & Cook, 2013b), have reported that physical capacities (e.g., speed, repeated speed, lower body power, intermittent endurance and endurance) are related to physical match performance. The relationship, however, may not always be direct and can be influenced by tactical considerations, playing position and playing experience (Mendez-Villanueva, Buchheit, Simpson, Peltola, & Bourdon, 2011; Mooney et al., 2011). Specifically in AF, studies incorporating senior players have shown that components of fitness are related to player performance during competition (Gastin, Fahrner, Meyer, Robinson, & Cook, 2013; Mooney et al., 2011), and this is supported in junior AF within (Gastin & Bennett, 2014) and across (Gastin et al., 2013b) age groups. It is well established that AF is a fast paced intermittent and contact sport with players required to have high physical and physiological capacities (Gray & Jenkins, 2010), but it is also a skilful, tactical and mentally demanding sport (Young & Pryor, 2007). While the physical and fitness profiles of AF players have been extensively reported (Gray & Jenkins, 2010; Pyne, Gardner, Sheehan, & Hopkins, 2006; Robertson et al., 2015; Wisbey, Montgomery, Pyne, & Rattray, 2010), the majority of research has neglected to consider the skill qualities that influence playing performance (Sullivan et al., 2014b). It is known that being in possession of the ball is important for performance, along with

finding sufficient space to make effective use of it (O'Shaughnessy, 2006). Kicks and handballs are the primary skills in AF. Thus, disposals (sum of kicks and handballs) and their effectiveness are common measures of performance within AF (Tangalos, Robertson, Spittle, & Gastin, 2015) and provide a direct and more appropriate measure of football performance than measures of match running performance (Sullivan et al., 2014b). A previous study conducted in elite youth AF found that players who achieved a high number of possessions in a match had enhanced preseason physical (i.e., height, body mass, arm length, standing reach) and fitness (i.e., speed, acceleration and endurance) characteristics (Young & Pryor, 2007). Furthermore, high vote winners during matches (i.e., those considered subjectively by the club's match committee to be the best players in each match; grouped as high, medium or low for the season) were characterised by greater arm length and 5 m and 20 m sprint times.

Knowledge of the physical characteristics and skill capabilities of young AF players may provide valuable insight related to age-associated benchmarks and contribute to the design of training programmes, development pathway strategies and the detection and selection of talent. However, there is a need to better characterise physical and fitness profiles, as well as better understand player match performance, including both physical and skill parameters, across age groups in recreational AF players. With all these in mind, the purpose of this study was to investigate age-related differences in maturity, body size, physical fitness, match running and football performance in young AF players.

Material and methods

Participants and design

A total of 156 young AF players (age: 9–15 years old), from 12 teams of a single amateur AF club (Melbourne, Victoria) participated in the study. The players trained and competed in 6 age group categories based on chronological age (U10, U11, U12, U13, U14, U15; 2 teams per age group). All protocols received institutional Research Ethics Committee approval and meet the ethical standards for the conduct of research in sport and exercise science (Harriss & Atkinson, 2015) with parental and/or guardian consent provided. Participants were provided with written and verbal information relating to the requirements of the study and were familiarised with testing procedures.

The study was conducted over a 14-week period during the 2013 junior metropolitan AF competitive season (May–August) and employed a cross-sectional observational design. At the time of the study, players were training 1–2 times per week (~60–90 min per session) and competing in 1 match per week. As part of their involvement in the study, each team undertook 1 fitness testing session during their normal scheduled training time (early evening between 16:30 and 19:30) and had time-motion and video data recorded during 1 competitive match. All testing was conducted at the same venue, and match rules and field size were the same for all age groups. Match duration was 60 min (4 × 15 min quarters) for the U10, U11, U12 and U13, and 80 min (4 × 20 min quarters) for the U14 and U15.

The data included in the present analysis were collected from 12 fitness test occasions and 12 matches.

Anthropometric measures

Anthropometric measures for height (to the nearest 0.1 cm; Seca stadiometer, Birmingham, the United Kingdom) and body mass (0.1 kg; electronic scales, Model UC-321, A&D Mercury Pty. Ltd., Australia) were measured in training uniform without shoes.

Maturity status

Maturity status was recorded as years to and from peak height velocity (Y-PHV) from a predictive equation based on chronological age, standing height, sitting height and body mass (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). The equation ($Y\text{-PHV} = -9.236 + (0.0002708 \times [\text{leg length} \times \text{sitting height}]) - (0.001663 \times [\text{age} \times \text{leg length}]) + (0.007216 \times [\text{age} \times \text{sitting height}]) + 0.02292 \times [\text{weight/height}]$) represents a reliable, non-invasive and practical measure of biological maturity in adolescent athletes (Mirwald et al., 2002). It has a coefficient of determination of $R^2 = 0.89$, a standard error of estimate of 0.59 years and a mean difference of 0.24 ± 0.65 years between actual and predicted maturity offset for a verification sample of boys (Mirwald et al., 2002).

Fitness characteristics

Fitness tests were performed to determine lower body power, running speed and running endurance. Prior to testing, players performed ~10 min of warm-up which consisted of jogging, sprinting and stretching. Lower body power was assessed through a vertical jump (VJ) using a Yardstick (Swift Performance Equipment, Queensland, Australia). Participants were instructed to stand with their feet shoulder width apart with the preferred arm closest to the Yardstick. Following this, they performed 3 counter-movement jumps to displace the highest possible vane (1 vane = 1 cm) with the best trial recorded. Sprint performance was assessed via a 20 m sprint using infrared timing gates (Swift Performance Equipment, Queensland, Australia). Gates were set up at 0, 15 m and 20 m to record the time (s), with the best of 3 trials recorded. Maximal speed ($\text{km} \cdot \text{h}^{-1}$) over 20 m was determined from the 15 to 20 m split. It is likely that this slightly underestimates true maximal speed as distances longer than 20 m (i.e., 30 m or 40 m) are required to reach a true maximum (Young et al., 2008). Running endurance was assessed using the 20 m multistage shuttle run test (multistage fitness test [MSFT], Australian Coaching Council, Australian Sports Commission, Canberra, Australia). The test involved continuous 20 m shuttle running at an incremental pace determined by a recorded timed auditory beep. A player was eliminated if they missed the beep (i.e., fell short of the 20 m distance) 2 times in succession. All tests were conducted on a natural grass surface on the same oval where players competed.

Match running performance

Data relating to match running performance were collected using Global Positioning System (GPS) technology (SPI-HPU units, 1.2.1 firmware, 5 Hz interpolated to 15 Hz, Team AMS software version 2013_25_HPU, GPSports, Canberra, Australia). The number of satellites accessed during GPS data collection ranged from 7 to 13, with a horizontal dilution of precision approximating 2.0–2.5 (the software code rejects values above 4.0). For peak speed during the 20 m sprint in this study in this sample using these units, the typical error in comparison to a timing gate criterion was 3.0% ($n = 379$ trials, $r = 0.97$, speed = $22.7 \pm 2.6 \text{ km} \cdot \text{h}^{-1}$). Others have also reported acceptable levels of validity for total distance (2.8% error) and distance between 15 and 20 $\text{km} \cdot \text{h}^{-1}$ (7.5% error) (Rampinini et al., 2015) for a similar yet earlier model from GPSports (sampling at 5 Hz but not interpolated to 15 Hz). The unit was placed in a manufacturer supplied vest, subsequently modified to fit a child or adolescent, and positioned on the upper back between the shoulder blades. Measures obtained from GPS, included distance travelled in meters per minute ($\text{m} \cdot \text{min}^{-1}$) [total distance divided by time while on the field], high-speed running (HSR; $>14.4 \text{ km} \cdot \text{h}^{-1}$) distance ($\text{m} \cdot \text{min}^{-1}$) [total HSR distance divided by time while on the field], and peak speed ($\text{km} \cdot \text{h}^{-1}$) [the highest speed recorded in the match]. Distance measures were expressed relative to time while on the field to account for differences in match duration between the younger and older age groups and differences in playing time associated with team size and player rotations.

Match skills performance

Each team was filmed during 1 match. Two video cameras (JVC Everio GZ-MG330HAA, Yokohama, Japan) were set up at either side of the halfway point of the oval. The main camera used for coding the video was on an embankment elevated by approximately 10 m, with the second camera positioned at ground level on the opposite side to assist with coding any of the main footage that may have been obscured. Video recordings were downloaded to a computer post-match and analysed for disposals (kicks plus handballs) using Dartfish (TeamPro 6, Dartfish Pty Ltd, Switzerland) for frequency (number, n , and number per minute, $n \cdot \text{min}^{-1}$) and effectiveness (n , $n \cdot \text{min}^{-1}$ and percentage of total, %). These match statistics were used as indicators of individual player match skills performance. For kicking, effectiveness was defined as any kick that was marked, should have been marked, resulted in possession of a teammate or was put to the team's clear advantage (e.g., short kick – uncontested, long kick – 50/50 contest). For handballing, an effective disposal included any handball that was received by, or resulted in possession of a teammate or was put to the team's clear advantage. These operational definitions were refined from those previously used in youth AF research (Young & Pryor, 2007). To determine intra-rater reliability of the coding, the researcher responsible for data collection (Christie Tangelos) coded 1 randomly chosen match and returned after a 3-week washout period and recoded the same match. An identical process was run with a second

member of the research team to assess inter-rater reliability. These procedures resulted in Cohen's Kappa values of 0.80 and 0.82 for intra-rater and inter-rater reliability, respectively.

Statistical analysis

Descriptive statistics are presented as mean \pm SD. Prior to the main analyses, each of the independent variables were assessed with respect to their distribution and homogeneity of variance. A Pearson correlational matrix was constructed incorporating all variables to assess their level of association with age and maturity (Y-PHV). Correlation coefficients were interpreted as very strong ($r \geq \pm 0.7$), strong ($0.7 > r \geq \pm 0.5$), moderate ($\pm 0.5 > r \geq \pm 0.3$) and weak ($\pm 0.3 > r \geq \pm 0.1$) (Hopkins, Marshall, Batterham, & Hanin, 2009). In order to determine whether differences existed between each age group with respect to their anthropometric and fitness characteristics ($n = 6$), a one-way between-groups analysis of variance (ANOVA) was run. A second ANOVA was undertaken to determine whether differences existed between each group with respect to match performance characteristics ($n = 8$). For both ANOVA's, least significant difference pairwise post hoc tests were used where relevant to assess where differences lay. Critical P -values were reduced to 0.008 and 0.006 via the Bonferroni adjustment for both ANOVA's, respectively. Unless otherwise stated, statistical analyses were conducted using the IBM Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics 22.0.0, SPSS Inc., USA).

Results

Table 1 shows results from the first ANOVA relating to age and maturity, body size and fitness characteristics of the players according to the age group. Y-PHV, MSFT and VJ displayed a non-Gaussian distribution and thus were log-transformed prior to further analysis. Significant main effects ($P < 0.008$) for age group were observed for all characteristics: age, Y-PHV, body mass, height, 20 m sprint, maximal speed over 20 m, VJ and MSFT.

For the second ANOVA relating to age and match performance (Table 2), disposals per minute and effective disposals per minute displayed a non-Gaussian distribution and were log-transformed prior to further analysis. Significant main effects ($P < 0.006$) for age group were observed for all running performance measures (distance, HSR distance, peak speed) and percentage of effective disposals. Variables that did not show significant differences between age groups were the number of disposals, disposals ($n \cdot \text{min}^{-1}$) and effective disposals ($n \cdot \text{min}^{-1}$). Figure 1 (match running performance) and Figure 2 (match skill performance) provide individual data points for all players and illustrate both the variability within age groups and the changes across age groups.

Age and maturity were strongly associated with MSFT and very strongly associated with all other measures of body size and physical fitness (Table 3). Relationships were stronger for match running performance measures related to speed and HSR than for endurance (total distance). Age was weakly associated with the number and number per minute of effective disposals ($r = 0.31$ and $r = 0.24$, respectively) and

Table 1. Measures of age, maturity, anthropometric characteristics and fitness performance and comparisons between age groups (Mean \pm SD).

	Age group							
Variable	U10 (<i>n</i> = 29)	U11 (<i>n</i> = 39)	U12 (<i>n</i> = 26)	U13 (<i>n</i> = 22)	U14 (<i>n</i> = 16)	U15 (<i>n</i> = 24)	<i>F</i>	<i>P</i> -value
Age and maturity								
Age (years)	10.0 ± 0.4 ^{a,b,c,d,e}	11.0 ± 0.3 ^{b,c,d,e}	12.0 ± 0.3 ^{c,d,e}	12.9 ± 0.4 ^{d,e}	14.0 ± 0.3 ^e	15.1 ± 0.3	855.4	<0.001
Y-PHV (au)	−4.2 ± 0.3 ^{a,b,c,d,e}	−3.6 ± 0.4 ^{b,c,d,e}	−3.3 ± 0.5 ^{c,d,e}	−2.0 ± 0.5 ^{d,e}	−1.4 ± 0.7 ^e	−0.3 ± 0.7	226.2	<0.001
Body size								
Body mass (kg)	33.9 ± 4.3 ^{b,c,d,e}	38.4 ± 6.4 ^{b,c,d,e}	44.0 ± 8.1 ^{c,d,e}	50.4 ± 8.1 ^e	51.5 ± 8.9 ^e	59.7 ± 8.3	44.9	<0.001
Height (cm)	139.6 ± 5.6 ^{a,b,c,d,e}	146.9 ± 6.1 ^{b,c,d,e}	152.5 ± 6.9 ^{c,d,e}	162.4 ± 6.0 ^e	164.0 ± 8.6 ^e	172.9 ± 8.7	83.8	<0.001
Fitness performance								
Sprint 20 m (s)	4.0 ± 0.2 ^{b,c,d,e}	3.9 ± 0.2 ^{b,c,d,e}	3.7 ± 0.2 ^{d,e}	3.7 ± 0.3 ^{d,e}	3.4 ± 0.3	3.3 ± 0.2	36.5	<0.001
Maximal speed over 20 m (km · h ^{−1})	21.5 ± 1.4 ^{b,c,d,e}	21.6 ± 1.6 ^{b,c,d,e}	23.8 ± 2.3 ^e	23.4 ± 2.0 ^{d,e}	25.1 ± 2.6 ^e	27.0 ± 1.8	32.3	<0.001
VJ (cm)	31.1 ± 5.1 ^{b,c,d,e}	33.4 ± 5.5 ^{c,d,e}	35.6 ± 5.0 ^{d,e}	38.9 ± 6.3 ^{d,e}	47.4 ± 8.3	51.5 ± 6.7	40.6	<0.001
MSFT (stage)	6.4 ± 1.6 ^{b,c,d,e}	6.4 ± 1.6 ^{d,e}	7.0 ± 2.0 ^{d,e}	8.1 ± 1.7 ^{d,e}	8.3 ± 2.5	10.0 ± 1.7	14.6	<0.001

U10 – Under 10, U11 – Under 11, U12 – Under 12, U13 – Under 13, U14 – Under 14, and U15 – Under 15.

Y-PHV – years to and from peak height velocity; VJ – vertical jump; MSFT – 20 m multistage fitness test.

Significantly different ($P < 0.008$) from the older age group (i.e., only comparisons to the right are shown): ^a vs. U11, ^b vs. U12, ^c vs. U13, ^d vs. U14, ^e vs. U15.

Table 2. Measures of in-match running and skill performance, and comparisons between age groups (Mean \pm SD).

	Age group						<i>F</i>	<i>P</i> -value
	U10	U11	U12	U13	U14	U15		
Match running performance^f	(<i>n</i> = 27)	(<i>n</i> = 38)	(<i>n</i> = 23)	(<i>n</i> = 17)	(<i>n</i> = 16)	(<i>n</i> = 20)		
Distance (m · min ⁻¹)	77.8 ± 21.4 ^{d,e}	77.9 ± 25.2 ^{d,e}	93.0 ± 19.4	92.3 ± 23.2	99.8 ± 19.4	104.0 ± 20.5	6.1	<0.001
HSR distance (m · min ⁻¹)	6.3 ± 4.2 ^{b,c,d,e}	8.0 ± 4.5 ^{b,c,d,e}	12.5 ± 5.5 ^{d,e}	14.8 ± 8.0	16.4 ± 7.5	19.7 ± 5.8	18.4	<0.001
Peak speed (km · h ⁻¹)	20.2 ± 1.8 ^{b,c,d,e}	21.5 ± 2.4 ^{d,e}	21.9 ± 2.1 ^{d,e}	22.5 ± 1.9 ^d	24.6 ± 2.7	25.3 ± 2.3	17.0	<0.001
Match skills performance	(<i>n</i> = 29)	(<i>n</i> = 39)	(<i>n</i> = 26)	(<i>n</i> = 22)	(<i>n</i> = 16)	(<i>n</i> = 24)		
Disposals (<i>n</i>)	10.2 ± 8.2	9.5 ± 7.4	11.5 ± 8.0	8.5 ± 8.3	13.7 ± 7.3	10.6 ± 4.2	1.2	0.33
Disposals (n · min ⁻¹)	0.15 ± 0.11	0.17 ± 0.14	0.21 ± 0.13	0.23 ± 0.17	0.20 ± 0.09	0.16 ± 0.05	1.5	0.185
Effective disposals (<i>n</i>)	3.3 ± 3.3 ^d	2.7 ± 2.5 ^{d,e}	4.4 ± 3.8	4.2 ± 4.8	6.8 ± 4.4	5.3 ± 2.6	4.06	0.002
Effective disposals (n · min ⁻¹)	0.06 ± 0.04	0.06 ± 0.04 ^{c,d}	0.09 ± 0.06	0.11 ± 0.11	0.10 ± 0.06	0.08 ± 0.04	3.1	0.012
Effective disposals (%)	27.6 ± 22.6 ^{c,d,e}	26.1 ± 17.8 ^{c,d,e}	36.0 ± 18.9 ^e	45.3 ± 29.8	49.5 ± 16.4	52.4 ± 19.7	7.5	<0.001

U10 – Under 10, U11 – Under 11, U12 – Under 12, U13 – Under 13, U14 – Under 14, and U15 – Under 15.

HSR – high-speed running (>14.4 km \cdot h⁻¹).

Significantly different ($P < 0.006$) from the older age group (i.e., only comparisons to the right are shown): ^a vs. U11, ^b vs. U12, ^c vs. U13, ^d vs. U14, ^e vs. U15.

^fSlight variations in participant number in match running performance and match skills performance in each age group exist, as a small number of players chose not to wear the GPS unit during the match.

moderately with the percentage of effective disposals ($r = 0.41$) (Table 3). Y-PHV showed weak correlations with the number and number per minute of effective disposals ($r = 0.28$ and $r = 0.22$, respectively) but moderately correlated with percentage of effective disposals ($r = 0.41$).

Discussion

The aim of the present study was to assess the relationship between age and player characteristics, including match running and skill performance. Main findings showed that age-related differences were evident in fitness characteristics (speed, lower body power and endurance) in young AF players and that similar improvements across age groups were also observed in match running performance. In terms of football match performance, differences were not evident in the number of disposals, likely a result of players competing directly against their age group peers in an independent match event. However once in possession of the football, the effectiveness of each disposal (i.e., skill) appears to also improve with age.

Unsurprisingly, age-related differences were evident in body mass, maturity and physical fitness in young AF players. It is well known that in children, performances in various physical tests are affected by growth and maturation

(Figueiredo, Coelho E Silva, & Malina, 2011; Gastin et al., 2013b; Malina, Bouchard, & Bar-Or, 2004; Mendez-Villanueva et al., 2011). Research in junior AF has established very strong relationships between age (range 10–17 years) and 20 m sprint ($r = -0.81$) and MSFT ($r = 0.83$) (Gastin et al., 2013b) and between maturity (as measured by Y-PHV, age range 10–19 years) and 20 m sprint ($r = -0.77$) and MSFT ($r = 0.65$) (Gastin et al., 2013a). Within a more homogeneous group (i.e., an U15 age group), the relationship between maturity and 20 m sprint ($r = -0.53$) remains strong however almost disappears for MSFT ($r = 0.12$) (Gastin & Bennett, 2014). This suggests that speed and power are more influenced by growth and maturation, particularly leg length and body mass and muscle mass, than is endurance (Figueiredo et al., 2011; Malina, 2012).

While not directly assessed, the observed age-related differences in physical fitness appear to transfer to match running performance, with improvements across age groups evident. Relationships between age and peak speed and HSR distance were stronger than for total distance, again reflecting the more dominant influence of growth and maturation on measures indicative of speed and speed endurance than on endurance. Similar age-related differences in lower body power and running qualities have been observed in highly

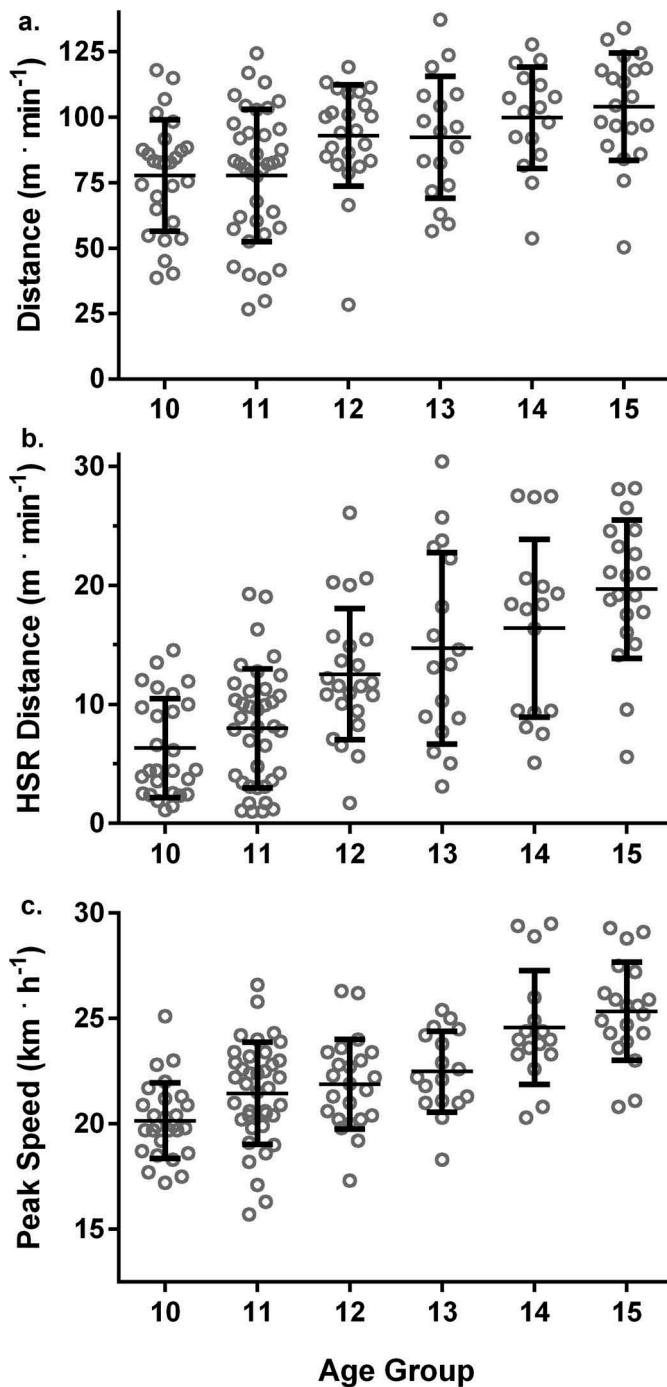


Figure 1. Match running performance across age groups for (a) distance travelled, (b) high-speed running (HSR) distance [distances covered at speeds $>14.4 \text{ km} \cdot \text{h}^{-1}$] and (c) peak speed [highest speed recorded in the match]. Data presented as mean and standard deviation, including individual player data points.

trained youth soccer players (Buchheit et al., 2010; Mendez-Villanueva et al., 2011), although between age group differences in sprint running measures disappeared when adjusted for age at peak height velocity (Mendez-Villanueva et al., 2011) and match running performance measures were position dependent when adjusted for age and playing time (Buchheit et al., 2010). The peak speeds observed during youth AF competition are slightly lower than for youth soccer competition, which could be a result of the training status of

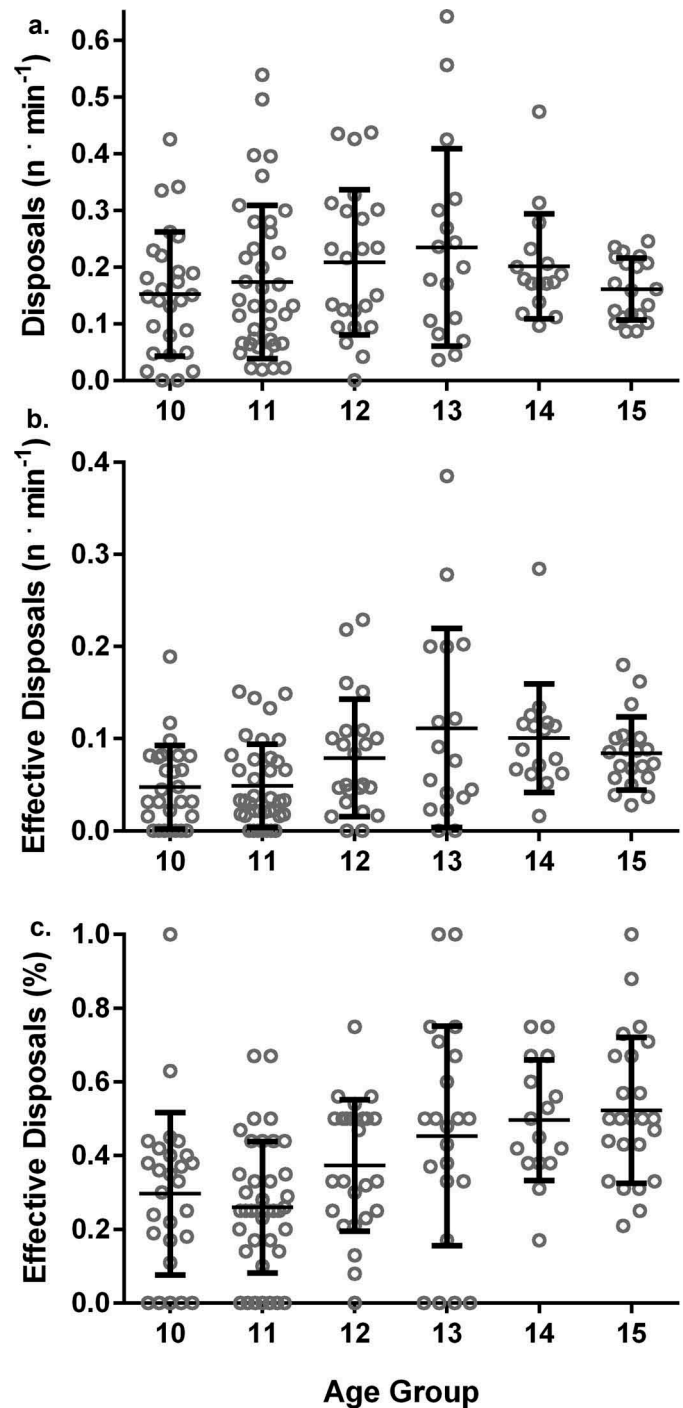


Figure 2. Match skill performance across age groups for (a) total disposals, (b) effective disposals and (c) effective disposals expressed as a percentage of total disposals. Data presented as mean and standard deviation, including individual player data points.

the recreational AF players in the present study in comparison to the highly trained soccer players (Buchheit et al., 2010) and/or the differences in match activity profiles between the 2 football codes (Varley, Gabbett, & Aughey, 2014).

The most novel finding of the present study was that the total number of disposals was not different between age groups but that effective disposals improved with age. Given competition is organised between age-matched peers, the number of disposals would not be expected to increase with

Table 3. Relationships (measured as Pearson's product moment correlations) between age and maturity and measures of body size, physical fitness, match running performance and match skill performance.

Variable	Age (<i>n</i> = 156)	<i>P</i> - value	Y-PHV (<i>n</i> = 156)	<i>P</i> - value
Age	–	–	0.936	<0.001
Y-PHV	0.936	<0.001	–	–
Body mass	0.765	<0.001	0.848	<0.001
Height	0.853	<0.001	0.932	<0.001
Sitting height	0.788	<0.001	0.952	<0.001
Leg length	0.783	<0.001	0.770	<0.001
Sprint 20 m	–0.753	<0.001	–0.740	<0.001
Maximal speed over 20 m	0.707	<0.001	0.707	<0.001
Vertical jump	0.766	<0.001	0.772	<0.001
MSFT	0.611	<0.001	0.577	<0.001
Match variables				
Distance	0.428	<0.001	0.358	<0.001
Peak speed (in match)	0.634	<0.001	0.637	<0.001
HSR	0.648	<0.001	0.594	<0.001
Disposals (<i>n</i>)	0.095	0.239	0.056	0.484
Disposals (<i>n</i> · min ^{–1})	0.100	0.239	0.065	0.441
Effective disposals (<i>n</i>)	0.313	<0.001	0.280	<0.001
Effective disposals (<i>n</i> · min ^{–1})	0.237	0.007	0.218	0.014
Effective disposals (%)	0.412	<0.001	0.405	<0.001

Y-PHV – years to and from peak height velocity; MSFT – multistage fitness test; HSR – high-speed running.

age and any difference between youth and senior AF competition is likely most dependent on differences in match duration (60–80 min compared with approximately 120 min). The average number of disposals (kicks and handballs) in the present study ranged from 9.5 to 13.7 while elite AF averages for the same 2013 season were 16.3 (AFL, 2013). Match football skill, as measured by the effectiveness of disposals, has not previously been recorded in the literature in youth AF. The number of effective disposals generally increased across age groups and a weak to moderate association with age was observed. When expressed as a percentage of total disposals (which also accounts for differences in match duration between the younger and older age groups), the association with age strengthened, with the percentage approximately doubling from the U10 to U11 age groups (26–28%) to the U15 age group (52%). In elite senior AF, disposal effectiveness (around 72%) has been linked to team success (Sullivan et al., 2014a). Assessment of football skill is also not well documented in AF although kicking and handball accuracy skill tests have been recently introduced in AF talent selection programmes (Woods, Raynor, Bruce, & McDonald, 2015). Commentary and recommendations related to the importance of motor skill development and multidimensional assessment in team sports appears to be increasing in the literature (Forsman et al., 2015; Hendricks, Lambert, Masimla, Durandt, & Gabbett, 2015; Tangalos et al., 2015).

The relationship between chronological age and biological maturity is very strong and because of this collinearity the associations between the characteristics measured in this study are similar for both these variables. As might be expected, this is most evident in a research design that considers differences across age groups. Of more practical interest, however, is whether these differences are also evident within an age group where individuals compete against their age-matched peers. The data presented for individual players indicates considerable variability in match running and skill performance measures. These within-group differences are likely a

result of a multitude of factors, many of which are not directly addressed in the present study (e.g., playing position, match opponent/style of play/score differential, training history, motor and perceptual-cognitive skill). Explanatory factors that are linked to the research question include differences related to chronological age (e.g., the relative age effect; (Woods, Robertson, & Gastin, 2015)) and biological maturity (e.g., early versus late maturers (Gastin & Bennett, 2014)). It is possible that some of the variability observed, particularly at the extremes within each age group, relate to a combination of age and maturity where older more mature players have an advantage over younger less mature players (Gastin & Bennett, 2014). This seems more evident in physical rather than skill characteristics, such that training and more importantly selection practices should emphasise the development of skill and perceptual-cognitive abilities over physical performance measures. This is supported by related outcomes from the present study's data set, with individual player match performance being most highly correlated and best predicted by a coach's subjective assessment of skill (Tangalos et al., 2015).

A number of limitations need to be acknowledged and considered when interpreting the results presented in this study. Only 1 match was analysed per player which does not account for high match-to-match variability in physical and technical performance observed in senior AF (Kempton, Sullivan, Bilsborough, Cordy, & Coutts, 2015) and the influences associated with different opposition, including game style and score differential. Our rationale was that having 2 teams from each age group and a larger overall sample size would overcome this limitation, although collecting data over several matches per player would have been preferred. Future research should look to confirm the findings of the present study in a similar cohort over multiple matches. Match duration was also different between the younger and older age groups. Data related to match running performance were therefore expressed relative to time. Skill performance data were expressed as both counts and relative to time, although the percentage of effective disposals is independent of time and was used as the main finding to support the conclusion that skill improved with age. Finally maximal speed was measured over 20 m.

In summary this study has clearly demonstrated age-related differences in body size, maturity, physical fitness and match running performance in young AF players ageing in range from 9 to 15 years. In terms of football match skill performance, there were no differences between age groups in the number of disposals, however the effectiveness of these disposals increased with age. These data are likely the first to directly demonstrate age-related improvements in football skill within competition in youth AF. Match statistics, particularly those that evaluate skill outcome (i.e., per cent effectiveness), are useful to assess performance and to track player development over time.

Disclosure statement

No potential conflict of interest was reported by the authors.

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