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Does the longitudinal development of physical and anthropometric characteristics associate with professional career attainment in adolescent Australian footballers?

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Abstract

This study sought to longitudinally and retrospectively determine the relationship between professional career attainment and the development of anthropometric and physical qualities in junior Australian footballers. Eighty adolescent male Australian footballers from a single state academy previously selected onto an under 16s talent development squad were classified by career attainment (professional team selection; n=17 and non-selected; n=63). Physical and anthropometric tests were conducted at the end of preseason during participation in under 16s and under 18s competitions. Tests included standing height, mass, stationary countermovement jumps, dynamic vertical jumps, 20 m sprints, agility and 20 m multistage fitness test. Both groups significantly improved all performance measures between the under 16 to under 18 levels. Athletes selected onto a professional team possessed significantly quicker 20 m sprint outcomes than non-selected athletes at both under 16 and under 18 levels, highlighting the importance of this physical capacity within talent development programs. Binary logistic regression was unable to predict an effect of any measures on career attainment. An inability of the binary logistic regression to identify qualities predictive of long-term career success likely highlights limitations associated with utilising unidimensional models of assessment in talent identification practices. As such development coaches and sport scientists should be aware that while physical capacities play a role in career attainment outcomes, other factors, such as tactical understanding and technical skill are also likely to be impactful.

Key Words: Career Progression, Development, Talent Identification, Physical, Longitudinal

Introduction

Specialised talent development programs seek to identify and develop junior athletes who have the potential to excel as adults in their chosen sport [1, 2]. Within talent development programs, objective performance tests are often used to assist in identifying junior athletes with the characteristics that are perceived to be important for long-term success in their chosen sport [1]. Research in team sports has consistently shown that objective performance tests can differentiate between athletes of higher and lower playing ability [3-6] and those who attain professional contracts [7-10]. However, whilst valuable these studies are often limited by cross-sectional methodologies, which do not take into account the idiosyncratic and non-linear nature of development that occurs in athletes during the adolescent years [11].

Longitudinal study designs may address this limitation. However, comparative to cross-sectional research, relatively few longitudinal and retrospective studies have been conducted to examine the objective performance capacities of professional athletes' during their adolescent development [12, 13]. The relative sparsity of longitudinal research is in part due to the logistically and administratively difficult nature of tracking athletes across a number of years. Whilst more difficult to implement, this study design can provide a wealth of knowledge to researchers and practitioners about the characteristics which are important in adolescent pathways for long-term professional career attainment. For example, in rugby league, athletes who gain professional selection have been shown to developmentally improve in sitting height, 60 m sprint, agility 505 and estimated $\dot{V}O_2max$ between 13 and 15 years of age to a greater extent than their peers who do not gain professional contracts [14]. While in 16-19 year olds, those who gained professional rugby league contracts developed their body mass and 10 m momentum to a greater extent when compared to their amateur counterparts who trained in the same adolescent academy [15].

Talent identification processes have existed in Australian football for a number of years, however longitudinal research is yet to explore the physical development of athletes at multiple time points in the adolescent development program based on professional career attainment. In Australian football, State Academies oversee the talent development programs of elite adolescent athletes [16]. Athletes are initially identified from regional competitions and progress into under 16 years of age (U16) or under 18 years of age (U18) talent development programs. These programs provide athletes with exposure to experienced coaches, sport scientists, medical and welfare support [17]. The programs are also designed to optimise talent development of adolescent athletes and ultimately enhance the likelihood of athletes being selected to professional Australian football clubs. Notably, it is within the Australian Football League (AFL) that athletes are paid professionally to train and compete. At an annual draft, AFL clubs typically select athletes once they are 18 years of age, from the adolescent development pathways and other elite competitions.

Australian football research has primarily used cross-sectional methodologies to examine anthropometric and physical determinants of talent identified athletes at various levels of the talent development pathway [3, 4, 10, 18]. This research has demonstrated dynamicity in the physical and anthropometric qualities that are explanatory of adolescent talent identification [3]. At the under 16 (U16) level, qualities considered to be most important for selection are height, dominant foot vertical jump and 20 m sprint time [3]. At the under 18 (U18) level, the most important physical qualities for gaining selection were body mass and 20 m sprint performance [3]. These findings suggest that a 'snapshot' approach may be inadvertently applied to the Australian football talent identification processes. That is, selection at each level is determined by athlete attributes most likely to enhance performance at the specific developmental stage and not necessarily considerate of qualities likely to enhance adult performance or professional career attainment [3].

To date, research is yet to examine the physical and anthropometric characteristics explanatory (if any) of career attainment at the U16 level, despite parameters clearly existing at the U18 level [9, 10, 19]. As such it is unknown whether any athlete attributes assessed in the talent pathway are pervasive of career attainment in earlier stages of the talent pathway. It is also unclear how athletes who are selected into the professional AFL physically develop during their adolescent years. Therefore, the purpose of this study was to longitudinally and retrospectively examine anthropometric and physical development of junior footballers throughout the AFL talent pathway based on the career attainment outcomes (i.e., gaining a professional contract or not).

Methods

Eighty adolescent male Australian footballers (age: 15.85 ± 0.37 years) who were selected onto a U16 State Academy between 2013 and 2015 participated in the study. After initial selection onto the U16 State Academy, athlete physical capacities were assessed and re-assessed at the U18 level (age 17.74 ± 0.45 years). During all assessment periods, testing was conducted during the final pre-season stages of the athlete's preparation phase of training. Training for athletes during this phase would typically involve 2-3 training sessions per week, inclusive of skill and tactical development, and strength and conditioning sessions. All athletes were required to be injury free and participating in regular training sessions at the time of testing. Informed consent was obtained from both the athletes and their parents/guardians and the study protocols were approved by the University Human Research Ethics Committee.

Athletes performed a battery of six physical fitness tests and anthropometric assessments, all of which were performed indoors on hard wooden flooring. Prior to assessment of physical fitness measurements, standing height (cm) and body mass (kg) were obtained. All athletes then completed a standardised warm up consisting of light jogging, countermovement jumps and dynamic stretching. Following the warm up, athletes performed fitness testing in a randomised circuit manner with the following tests included: stationary countermovement jump test, dynamic vertical jump (with a five metre run up) taking off left and right legs, 20 m sprints and AFL agility (assessed using timing gates at the start and end of the sprint; Swift Performance Equipment, Lismore, Australia). The standard procedures for the anthropometric and physical testing in junior Australian football were utilised [4]. For all fitness tests which required multiple trials, a minimum of one minute was allocated between trials and approximately two minutes rest between each station in the fitness testing circuit. Once all athletes had completed the above assessments, a 20 m multistage fitness test (MSFT) was completed. Athletes were provided with verbal encouragement throughout all fitness testing.

In Australian football, athletes 18 years of age and older are eligible to be selected onto a professional Australian football teams' roster. Therefore, for this study athletes were classified based on their career attainment outcomes, as selected (onto a professional squad, n = 17) or non-selected (n = 63). Descriptive statistics with Cohen's *d* effect size and 90% confidence intervals were calculated for all dependent variables according to age category and career attainment outcome. Effect size of $d < 0.2$ was considered trivial, $d = 0.2 – 0.59$ small, $d = 0.6 – 1.19$ moderate, $d = 1.2 – 2.0$ large, and $d > 2.0$ very large [20]. A repeated measures multivariate analysis of variance test (MANOVA) was initially conducted to identify significant main effects for time between age category, for career attainment outcomes (i.e. selected and non-selected), and whether an age category × career attainment outcome interaction existed. Partial eta squared (η^2) effect sizes were also calculated and interpreted as 0.01 = small, 0.06 = medium and 0.14 = large [21].

To assess if physical qualities could predict career attainment outcome, binomial logistic regression analyses were performed using the physical qualities at each age category and changes in physical qualities between the age categories, with career attainment outcome coded as a binary variable (1 = selected, 0 = non-selected). All anthropometric and physical testing variables were included in the initial models with step-wise backwards exclusion approach used to remove variables deemed non-significant ($p > 0.05$) to the model. All analyses were conducted with SPSS version 25.0 with significance levels set at $p < 0.05$.

Results

Descriptive results of the physical and anthropometric tests at both U16 and U18 age categories for the two different career attainment outcome groups can be seen in Table 1.

Small effects were evident at the U16 age group between athlete's selected and non-selected for values of height, mass, standing vertical jump, 20 m sprint and agility outcomes. Small to moderate effects were also evident at the U18 age group between athletes selected and non-selected for values of mass, running vertical jump right leg, standing vertical jump, 20 m sprint, agility and MSFT outcomes.

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The MANOVA revealed a significant effect of age category (V=0.88, F=56.30, $p<0.001$, $\eta 2=0.879$) on all dependent variables. Career outcome analyses identified non-significant main effects (V=0.10, F=0.83, $p=0.589$, $\eta 2=0.10$), however 20 m sprint outcomes demonstrated medium, significant differences (F=6.19, $p=0.015$, $\eta 2=0.07$), with professionally selected athletes demonstrating quicker 20m sprint outcomes. For the age category × career outcome interaction no significant difference was noted (V=0.04, F=0.32, $p=0.965$, $\eta 2=0.04$). Binary logistic regression models did not demonstrate a predictive effect of any of the anthropometric or physical performance measures on career attainment outcome.

Discussion

This study longitudinally and retrospectively examined the anthropometric and physical development of junior footballers throughout the AFL talent pathway based on career attainment outcomes. Age category (U16 v U18) had a significant, medium to large effect on all anthropometric and fitness outcomes indicating both the professionally selected and non-selected athletes continued to advance these capacities with age. Further, small to moderate differences in physical outcomes were noted between the selected and non-selected athletes at both age categories. However, only 20 m sprint outcomes differed significantly between those selected and those non-selected into the AFL. Notably, there was no age category x career outcome interactions present nor were test outcomes able to predict selection into the professional league.

Cross-sectional research into junior Australian football has consistently demonstrated physical performance parameters as key determinants of talent identification [3, 16] and professional team selection outcomes [9, 10, 19]. The current study highlighted that selected athletes possessed faster sprint performance compared to non-selected athletes, agreeing with previous literature [3, 9, 10]. Previous cross-sectional research used logistic regression modelling to establish optimised cut-off values for 20 m sprint performance in elite U18 footballers, with times of ≤ 2.99 s correctly identifying 76% of selected athletes [9]. Interestingly if this cut-off value is applied to the current studies cohort 65% (11 of 17 athletes) of the professionally selected athletes possessed times of ≤ 2.99 s at an U16 level while at a U18 level 70% (12 of 17 athletes) were below the cut-off time. The current study highlights that sprint performance is not only important for professional selection, but also developmentally stable as neither selected (Δ 20 m sprint = -0.03 ± 0.09 s) or non-selected (Δ 20 m sprint = -0.04 ± 0.09 s) athletes improve longitudinally to a greater extent (*d*= -0.11, trivial difference). Thus, given the apparent longitudinal importance and stability of sprint performance, practitioners should be aware that sprint outcome measures may serve a useful performance measure when talent identifying athletes at the U16 stages of the talent pathway.

The lack of age category x career outcome interactions and inability of the binary logistic regression models to predict career attainment outcomes in this study may highlight the longitudinal shortcomings associated with not applying a multidisciplinary approach to the talent identification process [22]. In Australian football, the vast majority of research has examined anthropometric and physical capacities that are discriminant of talented athletes, [16] however an athlete's career progression is likely a by-product of several determining factors. These are likely inclusive of physical, technical and tactical capacities [3, 23, 24], psychological constitution, and competition performance [25]. Multidisciplinary talent identification approaches have been shown to enhance the predictive outcomes of the athlete identification at junior levels of the Australian football talent pathway process [23, 24]. However, research is yet to explore the multitude of factors longitudinally to establish if particular qualities are more or less stable within junior athletes or important for career outcomes. Whilst this study fills a novel gap in the literature by exploring longitudinally how anthropometric and physical fitness measures develop and contribute to Australian football career attainment outcomes, further longitudinal, multidisciplinary research is needed to comprehensively examine the stability and influence on career attainment outcomes of other key contributing factors.

Future research may address some important limitations in the study. Firstly, biological maturity is considered a key measure which should be included when exploring the longitudinal change of anatomical and physical capacities of adolescent athletes [16]. Whilst the inclusion of a valid and reliable measure of maturity would have added to this study, the collection of such data is typically invasive, expensive or considered inaccurate for athletes post-peak height velocity [26]. A further limitation of this study was the inability to measure training loads across the duration of this study. Athletes involved in State Academies are typically involved in short term intensive training periods of roughly 3-4 months. However, outside of these intensive periods athletes primarily train with their regional clubs and so the training loads and exposure to other specialised training was not able to be quantified. It has been shown that large variability exist between training and match exposure between state and regional competition [27]. Future research should therefore seek to examine long-term training exposures in Australian footballers to determine potential impact on long-term development. Finally, this study only examined athletes from one State Academy and so the results of this study should be viewed with this context in mind. For example the small, unequal sample size may have been a limiting factor when assessing performance variables in the logistics regression models. Further, previous research has highlighted that anthropometric and physical performance outcomes differ between athletes from various regional competitions, [9] future research should therefore seek to include athletes from other State Academies to ascertain if the developmental trajectory of professionally selected athletes follow similar trends to those seen in this study.

Conclusion

This study investigated the longitudinal anthropometrical and physical development of adolescent U16 State Academy athletes in order to identify qualities pervasive of career attainment. All anthropometric and physical qualities improved for selected and non- selected groups with age. Significant differences were seen between professionally selected and non-selected athletes, with those selected possessing significantly faster 20 m sprint times, highlighting the importance of this physical quality in long-term career attainment outcomes. The inability of the binary logistic models to identify qualities predictive of long-term career attainment success may highlight the limitations associated with applying a unidimensional model of assessment to talent identification practices. Development coaches, sport scientists and recruiters for professional teams should be aware that when identifying athletes for selection, sprint performance may be a key physical performance measure in athletes who subsequently attain professional selection. However technical, tactical and psychological factors are also likely to influence career attainment outcomes and so should be considered in future research directions.

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Table 1. Anthropometric and physical qualities of Under 16 and Under 18 athletes classified by career attainment outcomes.

	U16			U18			Change from U16-U18		
	Non- selected (n=63)	Selected (n=17)	*d* (90% CI)	Non- selected (n=63)	Selected (n=17)	*d* (90% CI)	Non- selected (n=63)	Selected (n=17)	*d* (90% CI)
Age	15.86 ± 0.38	15.8 ± 0.38	-0.15 (-0.6-0.29)	17.74 ± 0.48	17.74 ± 0.31	0 (-0.44-0.44)	1.87 ± 0.71	1.94 ± 0.06	-0.11 (-0.55-0.34)
Height (cm)	184.15 ± 7.16	181.46 ± 6.46	-0.38 (-0.83-0.07)	185.48 ± 7.57	182.99 ± 6.12	-0.34 (-0.78-0.11)	1.33 ± 1.93	1.53 ± 1.33	-0.1 (-0.55-0.34)
Body Mass (kg)	74.34 ± 8.23	71.5 ± 8.88	-0.33 (-0.78-0.11)	81.78 ± 10.47	79.37 ± 11.31	-0.22 (-0.67-0.22)	7.44 ± 8.63	7.87 ± 8.34	-0.05 (-0.49-0.39)
Running VJ Left (cm)	75.62 ± 8.38	76 ± 7.06	0.04 (-0.4-0.49)	77.97 ± 7.13	79.12 ± 7.42	0.15 (-0.29-0.6)	2.35 ± 8.3	3.12 ± 5.95	-0.09 (-0.54-0.35)
Running VJ Right (cm)	69.13 ± 7.73	70 ± 8	0.11 (-0.33-0.56)	72.73 ± 7.13	74.94 ± 6.28	0.31 (-0.13-0.76)	3.6 ± 5.69	4.94 ± 7.25	-0.22 (-0.67-0.23)
Standing VJ (cm)	57.97 ± 7.63	59.65 ± 7.95	0.21 (-0.23-0.66)	64.95 ± 6.52	66.53 ± 5.79	0.24 (-0.2-0.69)	6.98 ± 8.33	6.88 ± 8.27	0.01 (-0.43-0.46)
20m Sprint (s)	3.06 ± 0.11	2.99 ± 0.11	-0.66 (-1.12--0.2)	3.02 ± 0.11	2.96 ± 0.1	-0.56 (-1.01--0.1)	-0.04 ± 0.09	-0.03 ± 0.09	-0.11 (-0.55-0.33)
Agility (s)	8.52 ± 0.31	8.35 ± 0.34	-0.51 (-0.96--0.05)	8.3 ± 0.28	8.2 ± 0.28	-0.34 -0.79-0.1)	-0.22 ± 0.27	-0.15 ± 0.32	-0.24 (-0.69-0.2)
MSFT Distance (m)	2297 ± 254	2347 ± 315	0.18 (-0.26-0.63)	2428 ± 235	2532 ± 197	0.45 (0-0.9)	131 ± 251	184.71 ± 342.6	-0.19 (-0.64-0.25)

Table 2. Repeated measures MANOVA examining age category, career attainment outcome and age category x career attainment interaction on anthropometric and physical qualities.

	Age Category			Career Outcome			Age Category x Career Outcome		
	F	p	$\eta2$	F	p	$\eta2$	F	p	$\eta2$
Age	476.90	<0.01	0.86	0.21	0.65	0.00	0.16	0.69	0.00
Height (cm)	32.97	<0.01	0.30	1.79	0.18	0.02	0.18	0.68	0.00
Body Mass (kg)	42.72	<0.01	0.35	1.26	0.26	0.02	0.03	0.85	0.00
Running VJ Left (cm)	6.45	0.01	0.08	0.18	0.67	0.00	0.13	0.72	0.00
Running VJ Right (cm)	26.79	<0.01	0.26	0.70	0.40	0.01	0.66	0.42	0.01
Standing VJ (cm)	37.20	<0.01	0.32	1.09	0.30	0.01	0.00	0.96	0.00
20m Sprint (s)	9.02	<0.01	0.10	6.19	0.01	0.07	0.39	0.53	0.01
Agility (s)	23.46	<0.01	0.23	3.29	0.07	0.04	0.78	0.38	0.01
MSFT Distance (m)	18.00	<0.001	0.19	1.85	0.18	0.02	0.53	0.47	0.01

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