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

3

4 Ashley J. Cripps^a, Harry G Banyard^b, Carl T Woods^c, Christopher Joyce^a, Luke S. Hopper^d

5 ^a School of Exercise and Health Sciences, University of Notre Dame Australia, Fremantle

6 ^b Department of Health Science, Swinburne University of Technology, Melbourne, Australia

7 ^c Institute for Health and Sport, Victoria University, Melbourne, Australia

8 ^d Western Australian Academy of Performing Arts, Edith Cowan University, Perth, Australia

9

10 Corresponding Author: Ashley J Cripps

11 **Author details**

12 Dr Ashley J Cripps

13 University of Notre Dame, School of Health Sciences, Fremantle

14 Postal address: Po Box 1225, Fremantle, WA 6956

15 Email: ashley.cripps@nd.edu.au

16 ORCID 0000-0001-7706-2523

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18 **Abstract**

19 This study sought to longitudinally and retrospectively determine the relationship between
20 professional career attainment and the development of anthropometric and physical qualities
21 in junior Australian footballers. Eighty adolescent male Australian footballers from a single
22 state academy previously selected onto an under 16s talent development squad were
23 classified by career attainment (professional team selection; n=17 and non-selected; n=63).
24 Physical and anthropometric tests were conducted at the end of preseason during participation
25 in under 16s and under 18s competitions. Tests included standing height, mass, stationary
26 countermovement jumps, dynamic vertical jumps, 20 m sprints, agility and 20 m multistage
27 fitness test. Both groups significantly improved all performance measures between the under
28 16 to under 18 levels. Athletes selected onto a professional team possessed significantly
29 quicker 20 m sprint outcomes than non-selected athletes at both under 16 and under 18 levels,
30 highlighting the importance of this physical capacity within talent development programs.
31 Binary logistic regression was unable to predict an effect of any measures on career
32 attainment. An inability of the binary logistic regression to identify qualities predictive of
33 long-term career success likely highlights limitations associated with utilising unidimensional
34 models of assessment in talent identification practices. As such development coaches and
35 sport scientists should be aware that while physical capacities play a role in career attainment
36 outcomes, other factors, such as tactical understanding and technical skill are also likely to be
37 impactful.

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

39 **Introduction**

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

49 Longitudinal study designs may address this limitation. However, comparative to cross-
50 sectional research, relatively few longitudinal and retrospective studies have been conducted
51 to examine the objective performance capacities of professional athletes' during their
52 adolescent development^{12, 13}. The relative sparsity of longitudinal research is in part due to
53 the logistically and administratively difficult nature of tracking athletes across a number of
54 years. Whilst more difficult to implement, this study design can provide a wealth of
55 knowledge to researchers and practitioners about the characteristics which are important in
56 adolescent pathways for long-term professional career attainment. For example, in rugby
57 league, athletes who gain professional selection have been shown to developmentally
58 improve in sitting height, 60 m sprint, agility 505 and estimated $\dot{V}O_2\text{max}$ between 13 and 15
59 years of age to a greater extent than their peers who do not gain professional contracts¹⁴.
60 While in 16-19 year olds, those who gained professional rugby league contracts developed
61 their body mass and 10 m momentum to a greater extent when compared to their amateur
62 counterparts who trained in the same adolescent academy¹⁵.

63 Talent identification processes have existed in Australian football for a number of years,
64 however longitudinal research is yet to explore the physical development of athletes at
65 multiple time points in the adolescent development program based on professional career
66 attainment. In Australian football, State Academies oversee the talent development programs
67 of elite adolescent athletes¹⁶. Athletes are initially identified from regional competitions and
68 progress into under 16 years of age (U16) or under 18 years of age (U18) talent development
69 programs. These programs provide athletes with exposure to experienced coaches, sport
70 scientists, medical and welfare support¹⁷. The programs are also designed to optimise talent
71 development of adolescent athletes and ultimately enhance the likelihood of athletes being
72 selected to professional Australian football clubs. Notably, it is within the Australian Football
73 League (AFL) that athletes are paid professionally to train and compete. At an annual draft,
74 AFL clubs typically select athletes once they are 18 years of age, from the adolescent
75 development pathways and other elite competitions.

76 Australian football research has primarily used cross-sectional methodologies to examine
77 anthropometric and physical determinants of talent identified athletes at various levels of the
78 talent development pathway^{3, 4, 10, 18}. This research has demonstrated dynamicity in the
79 physical and anthropometric qualities that are explanatory of adolescent talent identification
80³. At the under 16 (U16) level, qualities considered to be most important for selection are
81 height, dominant foot vertical jump and 20 m sprint time³. At the under 18 (U18) level, the

82 most important physical qualities for gaining selection were body mass and 20 m sprint
83 performance³. These findings suggest that a ‘snapshot’ approach may be inadvertently
84 applied to the Australian football talent identification processes. That is, selection at each
85 level is determined by athlete attributes most likely to enhance performance at the specific
86 developmental stage and not necessarily considerate of qualities likely to enhance adult
87 performance or professional career attainment³.

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

97 **Methods**

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

109 Athletes performed a battery of six physical fitness tests and anthropometric assessments, all
110 of which were performed indoors on hard wooden flooring. Prior to assessment of physical
111 fitness measurements, standing height (cm) and body mass (kg) were obtained. All athletes
112 then completed a standardised warm up consisting of light jogging, countermovement jumps
113 and dynamic stretching. Following the warm up, athletes performed fitness testing in a

114 randomised circuit manner with the following tests included: stationary countermovement
115 jump test, dynamic vertical jump (with a five metre run up) taking off left and right legs, 20
116 m sprints and AFL agility (assessed using timing gates at the start and end of the sprint; Swift
117 Performance Equipment, Lismore, Australia). The standard procedures for the
118 anthropometric and physical testing in junior Australian football were utilised⁴. For all
119 fitness tests which required multiple trials, a minimum of one minute was allocated between
120 trials and approximately two minutes rest between each station in the fitness testing circuit.
121 Once all athletes had completed the above assessments, a 20 m multistage fitness test
122 (MSFT) was completed. Athletes were provided with verbal encouragement throughout all
123 fitness testing.

124 In Australian football, athletes 18 years of age and older are eligible to be selected onto a
125 professional Australian football teams' roster. Therefore, for this study athletes were
126 classified based on their career attainment outcomes, as selected (onto a professional squad, n
127 = 17) or non-selected (n = 63). Descriptive statistics with Cohen's d effect size and 90%
128 confidence intervals were calculated for all dependent variables according to age category
129 and career attainment outcome. Effect size of $d < 0.2$ was considered trivial, $d = 0.2 - 0.59$
130 small, $d = 0.6 - 1.19$ moderate, $d = 1.2 - 2.0$ large, and $d > 2.0$ very large²⁰. A repeated
131 measures multivariate analysis of variance test (MANOVA) was initially conducted to
132 identify significant main effects for time between age category, for career attainment
133 outcomes (i.e. selected and non-selected), and whether an age category \times career attainment
134 outcome interaction existed. Partial eta squared (η^2) effect sizes were also calculated and
135 interpreted as 0.01 = small, 0.06 = medium and 0.14 = large²¹.

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

143 **Results**

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

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

151 ****INSERT TABLE ONE ABOUT HERE****

152 ****INSERT TABLE TWO ABOUT HERE****

153 The MANOVA revealed a significant effect of age category ($V=0.88$, $F=56.30$, $p<0.001$,
154 $\eta^2=0.879$) on all dependent variables. Career outcome analyses identified non-significant
155 main effects ($V=0.10$, $F=0.83$, $p=0.589$, $\eta^2=0.10$), however 20 m sprint outcomes
156 demonstrated medium, significant differences ($F=6.19$, $p=0.015$, $\eta^2=0.07$), with
157 professionally selected athletes demonstrating quicker 20m sprint outcomes. For the age
158 category \times career outcome interaction no significant difference was noted ($V=0.04$, $F=0.32$,
159 $p=0.965$, $\eta^2=0.04$). Binary logistic regression models did not demonstrate a predictive effect
160 of any of the anthropometric or physical performance measures on career attainment
161 outcome.

162 Discussion

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

173 Cross-sectional research into junior Australian football has consistently demonstrated
174 physical performance parameters as key determinants of talent identification^{3, 16} and
175 professional team selection outcomes^{9, 10, 19}. The current study highlighted that selected
176 athletes possessed faster sprint performance compared to non-selected athletes, agreeing with

177 previous literature^{3,9,10}. Previous cross-sectional research used logistic regression modelling
178 to establish optimised cut-off values for 20 m sprint performance in elite U18 footballers,
179 with times of ≤ 2.99 s correctly identifying 76% of selected athletes⁹. Interestingly if this cut-
180 off value is applied to the current studies cohort 65% (11 of 17 athletes) of the professionally
181 selected athletes possessed times of ≤ 2.99 s at an U16 level while at a U18 level 70% (12 of
182 17 athletes) were below the cut-off time. The current study highlights that sprint performance
183 is not only important for professional selection, but also developmentally stable as neither
184 selected (Δ 20 m sprint = -0.03 ± 0.09 s) or non-selected (Δ 20 m sprint = -0.04 ± 0.09 s)
185 athletes improve longitudinally to a greater extent ($d = -0.11$, trivial difference). Thus, given
186 the apparent longitudinal importance and stability of sprint performance, practitioners should
187 be aware that sprint outcome measures may serve a useful performance measure when talent
188 identifying athletes at the U16 stages of the talent pathway.

189 The lack of age category x career outcome interactions and inability of the binary logistic
190 regression models to predict career attainment outcomes in this study may highlight the
191 longitudinal shortcomings associated with not applying a multidisciplinary approach to the
192 talent identification process²². In Australian football, the vast majority of research has
193 examined anthropometric and physical capacities that are discriminant of talented athletes,¹⁶
194 however an athlete's career progression is likely a by-product of several determining factors.
195 These are likely inclusive of physical, technical and tactical capacities^{3,23,24}, psychological
196 constitution, and competition performance²⁵. Multidisciplinary talent identification
197 approaches have been shown to enhance the predictive outcomes of the athlete identification
198 at junior levels of the Australian football talent pathway process^{23,24}. However, research is
199 yet to explore the multitude of factors longitudinally to establish if particular qualities are
200 more or less stable within junior athletes or important for career outcomes. Whilst this study
201 fills a novel gap in the literature by exploring longitudinally how anthropometric and physical
202 fitness measures develop and contribute to Australian football career attainment outcomes,
203 further longitudinal, multidisciplinary research is needed to comprehensively examine the
204 stability and influence on career attainment outcomes of other key contributing factors.

205 Future research may address some important limitations in the study. Firstly, biological
206 maturity is considered a key measure which should be included when exploring the
207 longitudinal change of anatomical and physical capacities of adolescent athletes¹⁶. Whilst the
208 inclusion of a valid and reliable measure of maturity would have added to this study, the
209 collection of such data is typically invasive, expensive or considered inaccurate for athletes

210 post-peak height velocity ²⁶. A further limitation of this study was the inability to measure
211 training loads across the duration of this study. Athletes involved in State Academies are
212 typically involved in short term intensive training periods of roughly 3-4 months. However,
213 outside of these intensive periods athletes primarily train with their regional clubs and so the
214 training loads and exposure to other specialised training was not able to be quantified. It has
215 been shown that large variability exist between training and match exposure between state
216 and regional competition ²⁷. Future research should therefore seek to examine long-term
217 training exposures in Australian footballers to determine potential impact on long-term
218 development. Finally, this study only examined athletes from one State Academy and so the
219 results of this study should be viewed with this context in mind. For example the small,
220 unequal sample size may have been a limiting factor when assessing performance variables in
221 the logistics regression models. Further, previous research has highlighted that
222 anthropometric and physical performance outcomes differ between athletes from various
223 regional competitions, ⁹ future research should therefore seek to include athletes from other
224 State Academies to ascertain if the developmental trajectory of professionally selected
225 athletes follow similar trends to those seen in this study.

226 **Conclusion**

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

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321

322 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)	<i>d</i> (90% CI)	Non- selected (n=63)	Selected (n=17)	<i>d</i> (90% CI)	Non- selected (n=63)	Selected (n=17)	<i>d</i> (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) MSFT	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)
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)

323

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

	Age Category			Career Outcome			Age Category x Career Outcome		
	F	p	η^2	F	p	η^2	F	p	η^2
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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