Title: Influence of physical maturity status on sprinting speed among youth soccer players

Running Head: Varying influence of physical maturity

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Influence of physical maturity status on sprinting speed among youth soccer players

Abstract

The relative age effect is well documented with the maturation-selection hypothesis the most common explanation; however, conflicting evidence exists. We observed the birth-date distribution within an elite junior soccer academy. The influence of physical maturity status on anthropometric variables and sprinting ability was also investigated. Annual fitness testing was conducted over an eight-year period with a total of 306 players (age: 12.5 ± 1.7 y [range: 9.7 – 16.6 y]; stature: 156.9 ± 12.9 cm; mass: 46.5 ± 12.5 kg) drawn from six age categories (under-11s to -17s) who attended the same Scottish Premiership club academy. Measurements included mass, stature, maturity offset and 0-15 m sprint. Odds ratios revealed a clear bias towards recruitment of players born in quartile one compared to quartile four. The overall effect (all squads combined) of birth quartile was *very likely small* for maturity offset (0.85 years; 90% confidence interval 0.44 years to 1.26 years) and stature (6.2 cm; 90% confidence interval 2.8 cm to 9.6 cm), and *likely small* for mass (5.1 kg; 90% confidence interval 1.7 kg to 8.4 kg). The magnitude of the relationship between maturity offset and 15 m sprinting speed ranged from *trivial* for under-11s (r = 0.01; 90% confidence interval -0.14 to 0.16) to *very likely large* for under-15s (r = -0.62; -0.71 to -0.51). Making decisions about which players to retain and release should not be based on sprinting ability around the under-14 and under-15 age categories since any inter-individual differences may be confounded by transient inequalities in maturity offset..

Key words: *association football, youth, talent identification, relative age effect, athletic development*

INTRODUCTION

Fielding teams at the professional level in soccer that include homegrown players, developed through a club's youth academy system has been described as cost effective (25). Despite long-term financial benefits apparent in the development of homegrown players a considerable outlay is required to ensure each player has access to adequate coaching and training facilities throughout their soccer education (25). Due to the scale of investment it is important that clubs make informed decisions, with appropriate foresight, when recruiting, selecting and releasing young players.

The relative age effect (RAE) is well documented within youth soccer and relates to the uneven distribution of players' birth date relative to the general population (13). Youth soccer is typically organised into one-year age bands with a bias toward recruitment of players born in the first quarter of the selection year (9); a finding that has been reported in many countries (14). The existent research has documented the presence of the RAE in sport yet has failed to explain why the phenomenon exists (8). Of the proposed theories the most commonly cited is the maturation-selection hypothesis (27). It is posited that relatively older players are more physically mature than their younger counterparts, which may be advantageous in sports, which involve physical contact, for example soccer (21). Indeed, it is well understood that during the transition from childhood to adulthood physical maturity influences many characteristics relevant to sporting performance including stature, mass, aerobic power, strength and running speed (1, 18). However, it is less clear if advanced physical maturity results in superior physical performance within the context of a one-year age band.

It is unclear whether any relationships between physical maturity and measures of physical capacity are consistent throughout childhood and adolescence. Buchheit & Mendez-Villanueva (5) observed differences – varying in magnitude – in anthropometric and performance characteristics in relatively older and more physically mature under-15 players. In contrast, Carling et al. (7) reported few differences between relatively older and younger under-14 players. These conflicting studies illustrate that the relationships between relative age, maturity and physical capacity in youth soccer players remain unclear. Furthermore, studies focusing on one age category reveal only a partial view of the influence of maturity on physical qualities and the RAE, especially since many players are registered to the same club for successive seasons. Furthermore, Figueiredo et al. (11) observed that within a wide range of age categories (under-11s to -14s) the influence of physical maturity on measures of physical capacity differed depending on the category analysed. Similarly, Skorski et al. (23) and Lovell et al. (17) reported varying influence of relative age on physical performance markers across a wide range of age categories. These two studies, in addition to Buchheit & Mendez-Villanueva (5) are, to our knowledge, the only instances where magnitude based inferences have been used to quantify the *degree* of influence relative age has upon physical performance markers. The present study sought to contribute to this limited evidence base and report not only if physical maturity status had an influence on sprinting speed, within one-year age bands, but also the degree of the relationship. Understanding these relationships has important implications for coaches and practitioners concerned with identifying players for selection, retention and release at the end of each season.

The present study aimed to investigate the influence of relative age on physical maturity and sprinting speed within six consecutive age categories (U11-U17). Data were collected over eight seasons within a professional soccer academy. The first hypothesis was that relatively older players would be more physically mature than their younger counterparts within all age categories. The second hypothesis was that physical maturity would influence anthropometric measurements (stature and mass) and sprinting speed but that the strength of these relationships would not be consistent between all age categories.

METHODS

Experimental approach to the problem

An observational design was adopted for the present study. Anthropometric measures along with physical performance test results from youth players belonging to a professional soccer club academy were collected as part of routine fitness testing and analysed retrospectively. Players were assessed over an eight-year period (season 2007/08 to 2014/15).

Subjects

A total of 306 male elite youth players (age: 12.5 ± 1.7 y [range: 9.7 – 16.6 y]; stature: 156.9 ± 12.9 cm; mass: 46.5 ± 12.5 kg) who attended the same Scottish Premiership club academy participated. These players were drawn from six age categories including under-11, under-12, under-13, under-14, under-15 and under-17s. During the observation period some players were retained year after year and progressed through the age categories resulting in multiple observations in some instances (570 data points in total). All individuals joined the academy via a selection process administered by scouts affiliated with the club (subjective assessment) and were considered to be among the very best young players in Scotland. The benefits and risks associated with the current investigation were explained to the participants before signing an institutionally approved informed consent form. Written parental consent was also obtained prior to all physiological testing. The study was approved by The University of Glasgow, College of Medical and Life Sciences research ethics board and conformed to the recommendations of the Declaration of Helsinki.

Procedures

Relative age effect

To investigate the birth date distribution of the players, data were obtained from the General Registrars Office for Scotland concerning the number of births within the general population for the relevant years (1993-2004). This allowed a comparison between the expected and observed birth date distribution in the sample population. Youth soccer in Scotland is structured such that the selection year follows the calendar year (1st January to 31st December). Hence, players born in quartile one possessed a birth date in January, February or March and players born in quartile four possessed a birth date in October, November or December.

Physiological assessments

During the first week of September each season, players completed a series of physical assessment protocols. Club support staff conducted all tests; all possessed a postgraduate degree in sport science in addition to nationally recognized strength and conditioning certifications. Mass along with standing and seated stretch stature was recorded to the nearest 0.1 kg and 0.1 cm respectively, using calibrated scales (Avery Weigh-Tronix, UK) and a wall-mounted stadiometer (Holtain Ltd, UK). For the anthropometric assessments players removed their footwear and wore a training t-shirt and shorts. Maturity offset was calculated using the equation developed by Mirwald et al. (20) and has been used in previous research as an indicator of somatic maturity among youth soccer players (4, 6). Maturity offset represents the amount of time (in years) until or since an individual's predicted peak height velocity (PHV) and is calculated using an individual's stature, seated stature, mass, date of birth and the date of measurement (19). Maturity offset offers a logistically feasible way to estimate physical maturity among large groups such as in the present study. Over the course of the eight-year observation period a number of different tests were employed to characterise the players' physical capabilities. As such, the results from season to season were not always directly comparable. For example, a variety of different yoyo tests were used during the observation period. The only physical performance test included in the analysis was the 0-15 m sprint since this test was used with all squads every season. After the players had completed the anthropometric assessments they performed a standardized 15-minute warm up comprising light aerobic exercise and dynamic stretches. The sprint test was always the first task to be performed in the test battery after the warm up each year. The 0-15 m sprint test protocol allowed three attempts per player from a standing start 0.5 m behind the first timing gate; the fastest time was recorded for analysis. Players had approximately three minutes rest between efforts. The sprints were measured using electronic timing gates (Smartspeed, Fusion Sports, Australia) and conducted on the same indoor synthetic pitch each year. All participants wore soccer boots with moulded studs. The technical error of measurement for the 0-15m sprinting assessment according to the club's own quality control testing was 0.21 seconds.

Statistical Analysis

Data are presented as the mean ± SD. Prior to all analyses plots of the residuals versus the predicted values revealed no evidence of non-uniformity of error. In athletic research, it is not whether there is an effect but how big the effect is that is important; use of the P value alone provides no information about the direction or size of the effect or the range of feasible values (2). The odds ratio, with uncertainty expressed as 90% confidence intervals, was used to examine birth date distribution of our players against an expected equal distribution (e.g., the general population). Here, all comparisons were made between quartile 1 and quartile 4 and the magnitude of the odds ratio was assessed against thresholds of trivial >1.5, small, >3.4, and moderate >9.0 (15). The effects of birth quartile (quartile 1 versus quartile 4) on player maturity, stature and mass were analysed using a mixed linear model (SPSS v.22, Armonk, NY: IBM Corp) with random intercepts. Standardised thresholds for small, moderate and large changes (0.2, 0.6 and 1.2, respectively) calculated from between-player standard deviations of all players in each respective squad, were used to assess the magnitude of all effects (15). Inference was subsequently based on the disposition of the confidence interval for the mean difference to these standardised thresholds and calculated as per the magnitude-based inference approach using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely (15). Inference was categorised as unclear if the 90% confidence limits overlapped the thresholds for the smallest worthwhile positive and negative effects (15). To interpret the magnitude of the variability in maturity offset within each squad, we doubled the standard deviation for each respective squad and compared against a scale of 0.2 (small), 0.6 (moderate), and 1.2 (large) of the between-player standard deviation across all squads (24). Finally, Pearson's correlations were used to determine the relationship between player maturity and sprinting speed and the following scale of magnitudes was used to interpret the magnitude of the correlation coefficients: <0.1, trivial; 0.1-0.3, small; 0.3-0.5, moderate; 0.5-0.7, large; 0.7-0.9, very large; >0.9, nearly perfect (15).

RESULTS

Age distribution

Odds ratio's revealed a clear bias in frequency, when compared to our reference population, of players born in quartile 1 versus quartile 4 within each playing squad. The magnitude of this bias was small for under-11s (Odds ratio 2.7; 90% confidence interval 1.7 to 4.3), under-12s (2.1; 1.4 to 3.2) and under-13s (3.1; 2.0 to 4.9), and moderate for under-14s (3.7; 2.3 to 6.0), under 15s (4.7; 2.6 to 8.7) and under 17s (4.3; 1.7 to 10.6).

Effect of birth quartile on player maturity, stature and mass

Descriptive anthropometry for each age category is presented in Table 1. The overall effect (all squads combined) of birth quartile (quartile 1 versus quartile 4) was very likely small for player maturity (0.85 years; 90% confidence interval 0.44 years to 1.26 years) and player stature (6.2 cm; 90% confidence interval 2.8 cm to 9.6 cm), and likely small for player weight (5.1 kg; 90% confidence interval 1.7 kg to 8.4 kg). Within-squad analyses for player maturity, stature and mass are presented in Tables 2, 3, and 4, respectively; differences ranged from unclear to large for player maturity and stature, and unclear to moderate for player mass. After doubling the standard deviation of maturity offset within each playing squad, the magnitude of variability was small for under-11s and under-12s, and moderate for all remaining squads.

Insert Tables 1, 2, 3 and 4 near here

Relationship between player maturity and sprinting speed

The magnitude of the relationship between maturity offset and 15 m sprinting speed was trivial for under-11s (r = 0.01; 90% confidence interval -0.14 to 0.16) and under-12s (r = -0.04; -0.20 to 0.13), very likely small for under-13s (r = -0.26; -0.39 to -0.11), possibly large for under-14s (r = -0.53; -0.62 to -0.41), very likely large for under-15s (r = -0.62; -0.71 to -0.51), and likely small for under-17s (r = -0.26; -0.50 to 0.02).

DISCUSSION

The uneven birth date distribution observed was commensurate with that reported by many others (13, 16). A widely reported explanation for the RAE phenomenon is the maturation-selection hypothesis, which proposes that relatively older players are more advanced in physical maturity than their younger counterparts and that this confers a performance advantage (27). This theory makes intuitive sense since it is well established that attributes relevant to soccer performance such as sprinting speed, strength and aerobic capacity improve during growth and maturation (18). However, the magnitude of the relationship between physical maturity and such performance attributes within the context of one-year age categories has not been widely investigated. Specifically, to our knowledge only three other studies have assessed the practical relevance of the relationships between relative age, physical maturity and physical performance measures using magnitude based inferences (5, 17, 23).

Overall, physical maturity was related to chronological age, with older players displaying greater maturity offset values, although the strength of the relationship differed depending on the specific category considered (Table 2). This superior maturity status manifested itself as both greater stature (Table 3) and mass (Table 4) up until the under-17 age category when the trend was reversed, however, again the magnitude of the relationships varied depending on age category. The stature and mass of the players in the present study were comparable to results reported previously (17, 23). The strength of the relationships between stature, mass and birth quartile increased from the under-11 ('likely small' for both stature and mass) through to the under-15 age categories ('possibly moderate' for stature; 'likely moderate' for mass) and then reversed among the under-17 players. This reversal should be interpreted with caution since the number of under-17 players observed in the current study was small. This is an interesting finding as it demonstrates that the influence of physical maturity is not necessarily consistent throughout childhood and adolescence. Vaeyens et al. (26) also reported that the influence of physical maturity on numerous performance parameters varied depending on age category. Indeed, our analysis demonstrates that the magnitude of variability in relation to maturity offset status differed between younger (under-11 and -12s) and older (under-13 to -17s) players perhaps explaining some of the inconsistencies.

Similarly, the influence of physical maturity on 0-15 m sprinting speed varied depending on age category. The greatest magnitudes were observed in the under-14 and -15 age categories where physical maturity had a possible and very likely large positive effect respectively. Combined with the fact that the older players in these two age categories were generally more physically mature than their younger counterparts; the maturation-selection hypothesis appears valid. It seems very plausible that scouts could associate physical precocity – in the form of sprinting ability and physical dimensions – with 'talent' especially when one considers how valuable a commodity speed is within the sport of soccer (10). The most common action prior to scoring a goal at the professional level is straight-line sprinting, highlighting the importance of this attribute (10). Adolescent boys typically pass through their PHV around 14 years of age and peak weight velocity follows soon after (18, 22). The greatest inter-individual discrepancies in stature and muscle mass are likely to occur around the chronological age of 14 when some players will be pre- and others will be post-pubertal. Beunen et al. (3) reported that differences in physical maturity between players influenced physical performance to the greatest degree around the chronological ages of 14-15 years in Belgian teenagers, reinforcing this theory. Maturity-associated differences between players at this developmental stage are temporary and likely to diminish as less developed players mature. Indeed, the present results hint at this, with minimal differences in sprinting speed observed among players of differing physical maturity status within the under-17 age category. The potential for players to be released from their clubs based on transient maturational differences during early adolescence may result in a loss of available talent at the upper echelons of the game when age categories are no longer important.

In contrast, the influence of physical maturation on sprinting speed within the younger age categories (under-11 to -13s) was minimal. This suggests that relatively older and more physically mature players in the earlier age categories were not selected because they were faster than their younger counterparts. Within the younger age categories (under-11, -12 and -13s) the mean differences in stature and mass between those born in quarters one and four were small to non-existent; ranging from one to four centimeters and one to two kilograms respectively (see Tables 3 & 4). It is questionable whether such small differences could have resulted in such a profound influence on selection. This raises the question; if differences in stature, mass and sprinting ability are so small why were relatively older players disproportionally chosen? At the elite youth level it may be that only the most biologically advanced late-born players are considered for selection, thus, creating homogenous groups.

Gil et al. (12) reported superior sprinting ability, agility and stature among relatively older compared to relatively younger non-elite youth soccer players. The RAE may simply appear to be unrelated to physical capacity at the elite youth level because of the formation of homogenous groups.

The present results demonstrate some likeness to previous findings; however, some discrepancies are apparent. Lovell et al. (17) found the greatest disparities in birthdate distribution at the youngest age category observed (under-9) in addition to the age categories around expected PHV (under-13 to -16s). The under-11 age category was the youngest observed in the present study and so a direct comparison cannot be made, however, like Lovell et al. (17) we observed the greatest RAE to be present among under-15 players. In contrast to Lovell et al. (17) and Skorski et al. (23) we investigated the relationship between physical maturity (rather than birth quartile directly) and sprinting ability. However, we also demonstrated that physical maturity and birth quartile were likely related (Table 2). Lovell et al. (17) reported superior anaerobic performance – including sprinting ability – among relatively older players in the under-10 to -14 age categories. In contrast, the present results indicate minimal advantages in sprinting ability related to relative age within the under-11 to -13 age categories. The explanation for this discrepancy is unclear; however, it may be attributable to differences in the sample populations. The data presented herewith originate from a single academy whereas Lovell et al. (17) included data from 17 separate clubs. The present data may be indicative of a particular selection strategy at the club in question. However, since data were collected over the course of eight seasons any nuances related to the club's selection strategy at least highlight a consistent approach. In addition, the academy observed was attached to a Scottish top-division club whereas the club academies observed by Lovell et al. (17) represented the third and fourth tier of English professional soccer.

PRACTICAL APPLICATIONS

The current results support the maturation-selection hypothesis but only at specific developmental stages (under-14 and 15s). However, questions remain especially within the earlier age categories; which are synonymous with players' initial selection into performance programmes. At the under-14 and under-15 age categories relatively older players were generally more mature and this manifested as faster sprinting speed. However, at the younger age categories while older players were generally more mature this did not translate to superior sprinting ability. Practitioners should be aware that the influence of physical maturity on sprinting speed varies throughout physical development. Crucially, it would appear that making decisions about which players to retain and release should not be based on sprinting ability around the under-14 and under-15 age categories since any inter-individual differences may be confounded by transient inequalities in physical maturity status.

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Table 4. Within-squad comparisons for the effect of birth quartile (quartile 1 versus quartile 4) on player mass.

Squad	Quartile 1 Mean ± SD (kg)	Quartile 4 Mean ± SD (kg)	Mean difference (90% CI)	Qualitative inference
Under 11's (Q1 n=47, Q4 n=16)	35.1 ± 3.8	33.1 ± 3.0	2.0 (-0.2 to 4.2)	Likely small
Under 12's (Q1 n=40, Q4 n=21)	36.8 ± 4.6	37.0 ± 4.1	-0.2 (-2.6 to 2.2)	Unclear
Under 13's (Q1 n=53, Q4 n=17)	41.9 ± 7.7	40.7 ± 3.5	1.2 (-1.9 to 4.3)	Unclear
Under 14's (Q1 n=54, Q4 n=12)	51.3 ± 9.8	47.2 ± 4.8	4.1 (-0.4 to 8.6)	Likely small
Under 15's (Q1 n=37, Q4 n=9)	61.2 ± 9.1	54.3 ± 4.5	7.0 (2.3 to 11.6)	Likely moderate
Under 17's (Q1 n=16, Q4 n=3)	65.4 ± 6.2	74.9 ± 15.5	-9.5 (-19.0 to -0.1)	Likely moderate

CI, confidence interval; Q, quartile

Table 3. Within-squad comparisons for the effect of birth quartile (quartile 1 versus quartile 4) on player stature.

Squad	Quartile 1 Mean ± SD (cm)	Quartile 4 Mean ± SD (cm)	Mean difference (90% CI)	Qualitative inference
Under 11's (Q1 n=47, Q4 n=16)	143.7 ± 3.4	139.5 ± 3.8	4.2 (1.9 to 6.6)	Likely small
Under 12's (Q1 n=40, Q4 n=21)	146.9 ± 5.5	145.9 ± 4.8	1.0 (-1.6 to 3.5)	Unclear
Under 13's (Q1 n=53, Q4 n=17)	154.1 ± 6.0	151.5 ± 3.6	2.6 (-0.1 to 5.4)	Likely small
Under 14's (Q1 n=54, Q4 n=12)	164.7 ± 7.2	159.9 ± 4.5	4.7 (1.2 to 8.3)	Possibly moderate
Under 15's (Q1 n=37, Q4 n=9)	172.4 ± 6.6	168.3 ± 4.6	4.2 (0.2 to 8.1)	Possibly moderate
Under 17's (Q1 n=16, Q4 n=3)	175.2 ± 4.8	181.6 ± 7.2	-6.4 (-11.7 to -1.0)	Possibly large

CI, confidence interval; Q, quartile

Table 2. Within-squad comparisons for the effect of birth quartile (quartile 1 versus quartile 4) on maturity (as measured by the maturity offset equation).

Squad	Quartile 1 Mean ± SD (years)	Quartile 4 Mean ± SD (years)	Mean difference (90% CI)	Qualitative inference
Under 11's (Q1 n=47, Q4 n=16)	-2.69 ± 0.25	-3.11 ± 0.33	0.42 (0.28 to 0.57)	Possibly large
Under 12's (Q1 n=40, Q4 n=21)	-2.10 ± 0.39	-2.39 ± 0.35	0.29 (0.11 to 0.47)	Possibly moderate
Under 13's (Q1 n=53, Q4 n=17)	-1.24 ± 0.26	-1.64 ± 0.36	0.40 (0.19 to 0.61)	Likely moderate
Under 14's (Q1 n=54, Q4 n=12)	-0.02 ± 0.62	-0.65 ± 0.44	0.63 (0.33 to 0.94)	Likely moderate
Under 15's (Q1 n=37, Q4 n=9)	1.16 ± 0.61	0.34 ± 0.49	0.82 (0.50 to 1.13)	Likely large
Under 17's (Q1 n=16, Q4 n=3)	2.10 ± 0.48	2.35 ± 1.10	-0.25 (-0.88 to 0.39)	Unclear

CI, confidence interval; Q, quartile

Table 1. Descriptive anthropometric data for each age category.

Squad	Stature Mean ± SD (cm)	Seated stature* Mean ± SD (cm)	Mass Mean ± SD (kg)	Maturity offset Mean ± SD (years)
Under 11's (n=120)	142.7 ± 5.1	115.2 ± 2.6	34.9 ± 4.6	-2.80 ± 0.33
Under 12's (n=96)	147.4 ± 5.8	117.1 ± 3.0	38.0 ± 5.5	-2.16 ± 0.41
Under 13's (n=105)	153.6 ± 6.0	119.9 ± 3.3	41.9 ± 5.9	-1.34 ± 0.46
Under 14's (n=111)	163.9 ± 6.9	125.0 ± 3.9	51.2 ± 8.6	-0.20 ± 0.59
Under 15's (n=99)	171.8 ± 6.6	130.1 ± 3.7	60.5 ± 7.8	0.98 ± 0.57
Under 17's (n=39)	174.7 ± 5.4	132.1 ± 3.7	66.0 ± 9.4	1.94 ± 0.68

*Seated stature was measured with participants sitting on a 40cm wooden box