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Relative age effect: Characteristics of youth soccer players by birth quarter and subsequent playing status

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Abstract

Purpose: To compare characteristics of club level male soccer players 11 and 13 years of age, and to evaluate playing status in soccer two and 10 years after baseline by birth quarter (BQ).

Methods: Youth players 11 (n=62, born 1992, observed December 2003) and 13 (n=50, born 1990, observed April 2004) years were grouped by BQ. Baseline data included stature, weight, maturity status, functional capacities, soccer skills, goal orientation, and coach evaluation of potential. Playing status in soccer in 2006 and 2014 was also available. Baseline characteristics and subsequent playing status were compared by BQ.

Results: Baseline characteristics did not differ by BQ except for age and percentage of predicted adult height. Though not significant, coaches tended to rate players in BQ1as higher in potential. For those competing in soccer as adults, BQ2 (4), BQ3 (5) and BQ4 (2) were represented among players11 years, and BQ1 (3), BQ2 (2), BQ3 (1) and BQ4 (4) among players 13 years.

Conclusion: Although limited to small numbers, differences among players by BQ were inconsistent. The results indicate a need to extend potential explanations of the RAE to include behavioral variables, coaches, training environment, and perhaps the culture of the sport.

Key words: youth athletes, growth, maturation, fitness, skills, goal orientation

Introduction

The relative age effect (RAE) is defined by the difference between observed and expected birth date distributions of athletes in several sports. A significantly higher proportion of male soccer players from youth to professional levels are born in the first quarter of the soccer selection year, recognizing that the selection year has varied over time and between regions; the trend has been documented across a range of competitive levels, e.g., participants in the 1990 World Cup and 1989 Under-17 (U17) and Under-20 (U20) World Championships (Barnsley, Thompson & Legault, 1992), professional and youth Belgian players (Helsen, Starkes & van Winckel, 1998), senior semi-professional and amateur Belgian players (Vaeyens, Philippaerts & Malina, 2004), U17 players at regional camps (Glamser & Vincent, 2004), among others. It has also been suggested that the RAE is more apparent at higher levels of involvement in youth soccer (Mujika, Vaeyens, Matthys, Santisteban, Goiriena & Philippaerts, 2009), and is a factor in playing position (Towlson, Cobley, Midgley, Garrett, Parkin & Lovell, 2017).

The differential selection and/or success of boys born early in the selection year are often attributed to physical and functional advantages associated with advanced biological maturity status compared to peers/teammates, i.e., larger body size and greater strength, power and speed (Cobley, Baker, Wattie & McKenna, 2009). The RAE, however, has been documented well in advance of adolescence (Helsen et al., 1998: Helsen, van Winckel & Williams, 2005), while the selection bias favoring soccer players advanced in pubertal and skeletal maturity status emerges about 12-13 years and increases with chronological age (CA) and level of competition (Malina, 2003; Malina, Coelho-e-Silva & Figueiredo, 2013; Johnson, Farooq & Whiteley, 2017). Maturity status varies with method of assessment, e.g., established methods - skeletal age (SA) and pubertal status, versus predictions - predicted age at peak height velocity (PHV) and percentage of predicted adult height (Malina, 2017), and within method, e.g., Tanner-Whitehouse 3 (TW3) SAs are systematically lower than TW2 SAs in male soccer players 11-17 years (Malina et al., 2018).

The RAE is determined by the calendar, while biological maturity status (state of maturation at the time of observation) and timing (age at which a specific maturational event occurs) are highly heritable characteristics (Malina, Bouchard & Bar-Or, 2004). The independent nature of the preceding constructs is reflected in the CAs at which the RAE and maturity-related selection biases emerge and the degree to which they change with CA among youth soccer players. An older CA *per se* does not necessarily imply advanced maturity status compared to age peers. A player born early in the competitive year can be delayed in maturation and have little or no advantage in size or function, while another born late in the competitive year can be advanced in maturation with associated size and functional advantages (Malina et al., 2013).

Studies which consider variation in size, maturity, and functional, skill and personal characteristics of youth players by birth quarters (BQ) within single year CA groups may offer a developmental perspective of potential RAE effects and provide insights into the characteristics of youth players who persist in a sport. In this context, the purpose of this paper is twofold: first, to evaluate the growth, maturity status, functional capacities, soccer-specific skills, goal orientation and coach evaluation for potential success of youth soccer players 11 and 13 years of age by birth quarter (BQ), and second, to consider playing status in soccer of the players by BQ two and approximately 10 years after baseline.

Methods

The study was conducted in accord with established ethical standards (Harris & Atkinson, 2009). It was approved by the Scientific Committee of the University of Coimbra, and signed cooperative agreements were subsequently obtained from administrators of the participating clubs. Players and their parents or legal guardians were informed of the objectives of the study, specifically that the project included a baseline survey and a mixed-longitudinal phase following players over five years, and that participation was voluntary. Parents or legal guardians provided informed consent. Players were also informed that they could withdraw from the study at any time.

Sample. The sample included 159 male soccer players 11-14 years of age from five local soccer clubs (not resident academies) in the district of Coimbra during the 2003-2004 season. Youth soccer in Portugal is based on the calendar (January 1st – December 31st) and uses 2-year age groups. Accordingly, 87 players born in 1991 and 1992 were classified as *infantiles* (11.00 to 12.99 years, U13) and 72 players born in 1989 and 1990 were classified as *initiates* (13.00 to 14.99 years, U15) as of the December 31 deadline of the Portuguese Soccer Federation (*Federação Portuguesa de Futebol*). The competitive season was nine months, September through May, and included four training sessions (~90 minutes each) and one game per week (usually Saturday). Training sessions were pitch-based and included a combination of physical, technical and tactical dimensions.

This study was limited to 62 *infantiles* born in 1992 and 50 *initiates* born in 1990. Players born in 1992 were measured and evaluated in December 2003; CAs ranged from 11.0 to 11.96 years. Players born in 1990 were seen in early April 2004; CAs ranged from 13.30 to 14.26 years. Since data were collected in April, players in BQ1 were ≥14.0 years at observation. The numbers of players born in 1991 (25) and 1989 (22) were limited for analysis.

Player Characteristics. All data were collected under standard conditions within two week periods. Players were transported in small groups from their respective clubs to the

Coimbra University Stadium where they were measured and tested in an indoor facility. Hand-wrist radiographs for the assessment of skeletal maturity status were taken on the same day at a clinic close to the facility; chronological age (CA) was the difference between date of birth and date of the hand-wrist radiograph.

Baseline variables included height, weight and the sum of four skinfolds (triceps, subscapular, suprailiac and medial calf); two established indicators of maturity status: skeletal age (SA, Fels method, Roche, Chumlea & Thissen 1988) and clinically assessed stage of pubic hair (PH) development (Tanner, 1962); four measures of functional capacity: cardiorespiratory endurance (Yo-Yo intermittent endurance test level 1), power (counter-movement jump [CMJ] using the ergo-jump protocol), speed (fastest sprint in the 7-sprint protocol) and agility (10 x 5 m shuttle run); four soccer-specific skills: ball control with the body, dribbling speed, shooting accuracy and wall pass; and task and ego goal orientation. Details of the measurement and assessment protocols, technical errors of measurement for anthropometry, reliability coefficients for the functional and skill tests players have been described (Figueiredo et al., 2009a, 2011). Two additional variables were derived, predicted adult height (Khamis & Roche, 1994) and percentage of predicted adult height attained at the time of observation (Roche, Tyleshevski & Rogers, 1983); the latter is increasingly used as an indicator of maturity status among youth athletes (Malina, 2014, 2017).

Coaches, all of whom were accredited by the Portuguese Soccer Federation, evaluated the soccer playing potential of each player at the respective clubs using a 5-point scale: 1=very weak, 2=weak, 3=average, 4=good and 5=very good. Information on the reliability of the scale, however, was not available.

Players were classified as late, on time (average) or early maturing based on the difference of SA minus CA: *average*, SA within ± 1.0 year of CA; *late*, SA younger than CA by >1.0 year; and *early*, SA older than CA by >1.0 year (Malina, 2011, 2017), and also based on percentage of predicted adult height attained at the time of observation expressed as a *z*-score relative to age-specific means and standard deviations for percentage of adult height attained at half-yearly intervals by boys in the Berkeley Guidance Study (Bayer & Bayley, 1959): on time, *z*-score between –1.0 and +1.0; late, *z*-score below –1.0; and early, *z*-score above +1.0 (Malina, Coelho-e-Silva, Figueiredo, Carling & Beunen, 2012).

Playing Status – 2005-2006 Season. Players were contacted in 2006 regarding their current status in the sport. Three groups were defined: Dropout - discontinued soccer; Club - continued at the same club; and Elite - selected for a regional team or elite Portuguese clubs. Transfer to another club requires the agreement of both sending and receiving clubs. Baseline characteristics of U13 and U15 players classified by playing status in 2006 have been reported (Figueiredo, Gonçalves, Coelho-e-Silva & Malina, 2009b). In 2006, players11 years at baseline included 15 dropouts, 40 club and 7 elite players, while players 13 years at baseline included 14 dropouts, 26 club and 10 elite players.

Playing Status – 2014. The baseline sample was personally contacted via facebook and/or telephone in March 2014 to request information on current participation status (yes/no) and level of participation (regional/national) in soccer, and young adult height (Portuguese adults have national identification cards which include height to the nearest centimeter). Chronological age was estimated as the difference between mid-March 2014 and date of birth; ages ranged from 21 to 25 years. Of the baseline sample in 2003-2004 (n=159), 35 continued participation in soccer (22%), 65 discontinued participation and 59 did not respond. Players in the latter two groups did not differ in baseline characteristics (Figueiredo, Coelho-e-Silva, Sarmento & Malina, under review). In 2014, the baseline samples of 11 (n=62) and 13 (n=50) year old players included, respectively, 4 national and 7 regional players, and 1 national and 9 regional players.

Analysis. Baseline characteristics were normally distributed except for the sum of skinfolds and ball control; the latter were transformed (log normal) for analysis. Descriptive statistics were calculated by BQ within each birth year (1990 and 1992) and compared with MANOVA; estimated effect sizes (η^2) were also calculated. Distributions of players by maturity status at baseline and by playing status in 2006 and 2014 were summarized by BQ and evaluated with the Chi square statistic. Alpha level was set $p<0.05$.

Results

11 Year Olds (observed December 2003)

Baseline Characteristics by Birth Quarter. The distribution and characteristics of 11 year old players by BQ are summarized in Table 1. The distribution by BQs does not differ significantly ($\chi^2 = 1.87$), although players born in the first two BQs of the year are slightly more represented. In addition to CA, only percentage of predicted adult height attained at baseline differs by BQ ($p<0.01$); both effects were considered large in magnitude. Players in BQ1 are significantly closer to predicted mature height than players in BQ4 ($p<0.01$). Of interest, predicted mature height of players in BQ4 is, on average, greater than that of players in the other three BQ groups, but the differences among BQs are not statistically significant. Nevertheless, trends in means by BQ may be of interest. Players in BQ1 are, on average, taller and heavier than players in other BQs, predicted mature height of players in BQ4 is, on average, greater than that of players in BQ1-BQ3. Performances of players in BQ1 and BQ3 in the shuttle run, sprint and counter movement jump are, on average, rather similar and greater than performances of players in BQ2 and BQ4, while the trend for the yoyo endurance run suggests BQ1>BQ2>BQ3=BQ4. Mean performances in the four soccer skills, in contrast, show no consistent trends among BQs, although players in BQ4 have, on average, the poorest performances in dribbling, passing and shooting. Differences in task and ego orientation among BQs are small, but task orientation is highest among players in BQ4 and ego orientation is lowest among players in BQ1. Player potential as evaluated by their respective coaches is highest, on average, for players in BQ1 and declines systematically with birth quarter.

Players in BQ4 are chronologically younger, but are advanced, on average, in skeletal maturity status (SA/CA ratio) compared to players in BQ1-BQ3 (Table 1). The advanced skeletal maturity status of players in BQ4 is also suggested in the number classified as early maturing (6 of 12) compared to players in the other BQs (Table 2). In contrast, the distributions of stages of PH and maturity classifications based on the percentage of predicted adult height attained at observation do not show a consistent pattern by BQ. The majority of players are pre-pubertal by stage of PH and are average and early maturing by percentage of predicted adult height.

Subsequent Playing Status by Birth Quarter. During the 2005-2006 season, 11 year old players (U13, *infantiles*) moved to U15 (*initiates*). Proportionally similar numbers of players in BQ1 through BQ3 were classified as dropouts and elite in 2006, while equal numbers of players in BQ4 were dropouts or club level players, and none were elite (Table 2).

As young adults in 2014, 11 of the 62 players (18%) were involved in soccer, seven regionally and four nationally (Table 2). Seven of the 11 players were born in BQ3 (n=5 of 14) or BQ4 (n=2 of 12), while four were born in BQ 2 (n=4 of 19). No players in BQ1 were involved in soccer regionally or nationally in 2014.

13 Year Olds (Observed April 2004)

Baseline Characteristics by Birth Quarter. The players were born in 1990, but were observed in April 2004; hence, players in BQ1 were ≥14 years at observation (Table 3). The distribution of players by BQs does not significantly differ ($\chi^2 = 2.32$), but players born in BQ1 and BQ2 comprise 60% of the sample. In addition to CA, percentage of predicted adult height attained at the time of observation differs significantly among BQs (p=0.01); both effects were considered large in magnitude.. Players in BQ2 and BQ1 are significantly closer to predicted mature height than players in BQ4 ($p \le 0.05$). Although not statistically significant, predicted mature height of players in BQ1 is, on average, less than predicted mature heights of players in the other BQs.

Although differences are not significant, players in BQ2 are, on average, taller and heavier than players in the other BQs. Performances in the shuttle run, sprint and yoyo endurance run are, on average, better among players in BQ3 compared to other BQs, while performance in the counter movement jump among players in BQ3 is poorer compared to players in the other BQs. Performances on the four soccer skill tests are variable among BQs and show no consistent trends. Differences in mean task and ego orientation scores among BQs are small and show no consistent trends, while coach evaluation of player potential is similar, on average, among players in BQ1 and BQ3, and is lowest among players in BQ4.

The ratio of SA to CA is, on average, identical in players in BQ2, BQ3 and BQ4. Although younger in CA than players in BQ1, players in BQ2-BQ4 are advanced in SA relative to CA. This is also reflected in distributions of players in BQ2-BQ4 by maturity status based on SA and percentage of predicted adult height; the majority of players in each BQ are on time or early maturing based on both indicators (Table 4). In contrast, 11 of 14 players in BQ1 are on time in skeletal maturity status. The distribution of stages of PH by BQ does not show a consistent trend.

Subsequent Playing Status by Birth Quarter. During the 2005-2006 season, 13 year old players (U15, *initiates*) moved to U17 (*juveniles*). In 2006, 8 of 10 players classified as elite were born in BQ1 and BQ2, and proportionally more players born in BQ1 and BQ4 persisted at the club level (Table 4). In contrast, proportionally more players born in BQ2 and BQ3 were represented among dropouts.

As young adults in 2014, 10 of the 50 players (20%) continued in soccer, nine regionally and one nationally. The regional players were distributed in BQ1 (n=3 of 14), BQ2 (n=2 of 16) and BQ4 (4 of 9), and the single national player was born in BQ3. The majority of players in BQ1 through BQ3 no longer competed in soccer.

Discussion

The RAE in soccer is often attributed to differential success of players born early in the selection year and to size, strength and power advantages associated with more advanced biological maturity status compared to peers (Helsen, Hodges, van Winckel & Starkes, 2000; Helsen et al., 2005). Data on the characteristics of players, however, were not considered in the overviews. Several studies of U10-U16 soccer players have generally noted differences in height and weight by BQ, but inconsistent differences in functional indicators (Deprez, Vaeyens, Coutts, Lenoir & Philippaerts, 2012; Deprez et al., 2013; Gill et al., 2014; Lovell, Towlson, Parkin, Portas, Vaeyens & Cobley, 2015). The preceding studies used predicted age at peak height velocity (PHV) as the indicator of maturation; the method, however, has major limitations (see below). In contrast, observations of youth soccer players across six age groups (U16-U21) indicated no differences in anthropometric and functional characteristics by BQ (Skorski, Skorski, Faude, Hammes & Meyer, 2016).

Among the 11 and 13 year old players in the present study, inter-individual variation in biological maturity status was a major confounder among BQs as evident in SA/CA ratios (Tables 1 and 3) and the distributions of players classified as late, average and early maturing on the basis of Fels SAs (Tables 2 and 4). Similar observations based on TW2 SAs were noted among U10- U15 Japanese players (Hirose, 2009).

Based on the ratio of SA to CA, 11 year old players in BQ4, though chronologically younger, were advanced, on average, in skeletal maturity status compared to peers in other BQs (Table 1), while 13 year old players in BQ2, BQ3 and BQ4 were, on average, similar in maturity status and advanced compared to players in BQ1 (Table 3). The maturity-related trends in each age group were also apparent in distributions of players by skeletal maturity status and BQ, while corresponding distributions of players by stage of PH were not consistent. Except for one boy (PH3), the 11 year old players were pre-pubertal (PH1, 63%) or early pubertal (PH2, 35%) with little variation by BQ (Table 2). Among 13 year olds, the 9 players in BQ 4 were in PH stages 2 and 3, while players in BQ1-BQ3 were in PH stages 2, 3 and 4 (Table 4). The discrepancy between indicators reflects the fact that SA and stage of PH measure different though related aspects of biological maturation during adolescence (Malina, 2017). Moreover, stages of PH provide no information on age at entry into or time in a stage.

In contrast to the preceding, percentage of predicted adult height, a non-invasive indicator of maturity status, differed significantly among BQs in the two age groups (Tables 1 and 3). Players in BQ1 (both 11 and 13 year olds) and BQ2 (13 year olds) were closer to predicted adult height than players in BQ4, but distributions of players by maturity status based on percentage of predicted adult height did not differ among BQs, although only three 11 year old and no 13 year old players were classified as late maturing. The results, though seemingly contradictory to those for SA and stage of PH, highlight the uniqueness of different indicators of maturity status; though related, the three indicators each measure a different component of biological maturation – skeletal, sexual, somatic (Malina et al., 2004; Malina, 2017).

Maturity-associated differences in body size, strength and power of males are not clearly defined in late childhood/early adolescence, but increase with age during adolescence (Malina et al., 2004). The two age groups considered in the present report, 11 and 13 years, would be labeled, respectively, as early and mid-adolescent. The youngest players (BQ4) in each CA group may thus benefit from advanced maturity status as associated advantages in size (larger) and athleticism (greater power, strength and speed) which may offset potential disadvantages of being the youngest players in the group (limited time, experience and/or opportunities to develop their skills). Age-related mismatches in experience, technical, tactical and/or psychosocial development may explain, in part, the presence of the RAE among youth players prior to the emergence of biological maturity-associated selection biases. By inference, the cognitive, social, emotional and behavioral development of youth players merits attention in evaluating interactions among the RAE, CA, biological maturity status, size and skill. Among youth soccer players 13-17 years, for example, elite players scored better on tests of metacognition (executive function), cognitive flexibility and inhibitory control than sub-elite players (Huijgen et al., 2015). Moreover, heights and weights did not differ between players 16-18 years who were selected and deselected, while the former were characterized by better performances on functional (shuttle sprint), technical (dribbling) and tactical (positioning, deciding) tasks (Huijgen, Elferink-Gemser, Lemmink & Visscher, 2014).

Studies of the RAE are increasingly using predicted age at peak height velocity (PHV) as the maturity indicator. Mean predicted ages at PHV were similar by BQ in elite U13 (13.6-13.7 years) and U 15 (13.9-14.0 years) soccer players (Deprez et al., 2013), but tended to increase from BQ4 to BQ1 (youngest to oldest CA) in other studies (Deprez, 2012; Gil et al., 2014; Lovell, 2015). The observations contrast the common notion that differential selection and/or success of players born early in the selection year is associated with physical and functional advantages associated with advanced biological maturity status compared to teammates born later in the year (Cobley et al., 2009). Advanced maturity status based on predicted age at PHV was also suggested as central to the RAE among elite basketball players 13-14 years (Torres-Unda et al., 2016) and alpine ski racers (Müller, Müller, Hildebrand & Raschner, 2016). Although mean ages at PHV varied negligibly among BQs in alpine skiers, predicted ages at PHV were, on average, earlier in national compared to provincial skiers, leading to the conclusion that "relatively younger athletes seem to have a chance of selection only if they are early maturing" (Müller et al., 2016, p.11).

The preceding results must be interpreted cautiously given limitations of the prediction equations for maturity offset - time before PHV, and derived age at PHV - CA minus offset (Mirwald, Baxter-Jones, Bailey & Beunen, 2002; Moore et al., 2015). In several validation studies, predicted ages at PHV increased, on average, with CA and perhaps body at prediction, increased with CA within individuals (i.e., intra-individual variability), and had reduced ranges of variation; moreover, relative to observed ages at PHV, predicted ages at PHV were overestimated in early maturing and underestimated in late maturing boys and girls (Malina & Kozieł, 2014a, 2014b; Malina, Choh, Czerwinski & Chumlea, 2016; Kozieł & Malina, 2018). Thus, earlier predicted ages at PHV in soccer players in BQ4 likely reflected their younger CA compared to players in BQ1 who were chronologically older. Similarly, the more elite national level skiers were chronologically younger (boys 11.6±0.5, girls 11.5±0.6, range both sexes 10.3-12.3 years) than provincial level skiers (boys 12.3±1.2 years, girls 12.4±1.3 years, range both sexes 9.8-15.4 years) (Müller et al., 2016).

Coach perceptions of potential for success among youth players are a unique feature of the study. Potential was rated on a five-point scale from very weak (1) to very high (5). Although the validity and reliability of the scale was not established, mean rankings by the coaches were generally highest for players in BQ1 and lowest for players in BQ4 (Tables 1 and 3). The trend in mean ratings begs the following: What information do coaches of youth players use to evaluate potential – body size, maturity status (actual or perceived), fitness, skill, behavior, or some combination thereof? Some evidence suggests that evaluations of ability and potential in soccer players 10-11 years of age by academy scouts were skewed by differences in relative age, with older players receiving the most favorable evaluations (Mann & van Ginneken, 2017). It is possible that interactions between the RAE and coach/scout perceptions of size and biological maturity status interact to influence expectations and prognoses of player potential. Moreover, decisions about retention and promotion at younger ages should perhaps be transitory and reversible, permitting time for potential catch-up of players who were not among the elite at early phases of the process.

A unique feature of the present study was the follow-up of playing status in soccer about ten years after baseline. Among players born in 1992 (11 years), none of 17 players in BQ1 were active in soccer in young adulthood, while 11 of the 45 players in the other three BQs (24%) participated at the regional and national levels (Table 2). Among players born in 1990 (13 years), all four BQs were represented among the 9 regional and one national players in young adulthood

(Table 4). The majority of regional players was born in BQ4 and BQ1 (7 of 9), while the single national player was born in BQ3. Although limited to small numbers, the results highlight difficulties inherent in efforts to predict eventual playing status from BQ and characteristics of youth players.

It is recommended that those working with youth athletes and also researchers recognize that the RAE and biological maturation are independent constructs. Strategies designed to counter the RAE, e.g., competitions based on average team age and age-ordered team bibs (Mann & van Ginniken, 2017), and maturity-based selection bias merit serious consideration and perhaps implementation at the appropriate developmental stages. At these stages, more attention should perhaps be focused on age-related differences in general motor and sport-specific skills, in technical and tactical competencies, and also in cognitive and social development related to the sport. These strategies would be best implemented at the grass roots level in advance of the selection of players for select teams and professional academies. Bio-banding strategies, wherein players are grouped by estimated maturity status rather than CA for specific competitions and training, may be implemented in late childhood and early adolescence, when maturity associated variance in size and function begin to emerge (Cumming, Lloyd, Oliver, Eisenmann & Malina, 2017). Potential benefits of bio-banded competitions have been noted among early and mid-adolescents players as several English academies. Early maturing chronologically younger players within the maturity band benefited from exposure to superior physical and technical challenges and from being mentored by older, more experienced players, while late maturing chronologically older players benefited from having opportunities to demonstrate their physical, technical and tactical skills and to adopt positions of leadership on the maturity banded team (Cumming et al., 2018).

Interactions among relative age within a competitive age group, biological maturity status, functional and behavioral characteristics, and potential sport outcomes for youth players merit systematic study. Players born early in the selection year and advanced in maturity status, for example, will likely have advantages in both physical and psychosocial development and skills, while players born later in the selection year and also delayed in maturity status compared to peers will likely need to have and/or develop exceptional physical, technical and/or tactical skills if they are to be competitive and persist within their team.

This study is not without limitations. It is based on small numbers of regional youth players 11 and 13 years of age born, respectively, in 1992 and 1990. The lack of consistent differences in size, maturity status, adiposity, functional capacities, skills and goal orientation by BQ should thus be interpreted with care. Alternatively, the comprehensive baseline data for each player and the short- and long-term follow-up status in the sport are unique. Several observations are of interest. First, 11 year olds competing in soccer in young adulthood (Table 2) were born in BQ2 (4), BQ3 (5) and BQ4 (2), while none were born in BQ1; and allowing for small numbers, there were proportionally more early maturing players in BQ4 compared to BQ1. Second, among 13 year olds playing soccer in young adulthood, all four BQs were represented (Table 4); one (BQ3) played nationally and nine regionally, BQ1 (3), BQ2 (2) and BQ4 (4). And third, coaches of the players as youth gave, on average, highest scores for potential to players in BQ1.

The results highlight the need to expand sample sizes and potential discussions of the RAE beyond growth, maturity status, function and skill to behavioral variables and training environments, including coaches. Retrospective studies of the training experiences and histories of successful adult players grouped by birth quarter may provide further insights into the RAE and commonalities and differences in the process of player development.

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Table 1. Characteristics (means and standard deviations) of players born in 1992 (n=62, 11 years) by birth quarter and results of MANOVAs and estimated effect sizes (η^2). All players were measured and tested within a two week interval in December 2003.

	Birth Quarters									
	1st (n=17)		2nd (n=19)		3rd (n=14)		4th (n=12)			
Variables	M	SD	M	SD	M	SD	M	SD	F	η^2
Chronological Age, yrs	11.9	0.1	11.6	0.1	11.4	0.1	11.1	0.1	320.65[a]	0.94
Skeletal Age, yrs	12.2	1.1	11.7	1.5	11.5	1.3	11.8	1.6	0.60	0.03
SA/CA ratio	1.03	0.10	1.01	0.13	1.01	0.12	1.07	0.15	0.67	0.03
Height, cm	145.7	5.6	142.4	5.0	143.2	7.4	142.1	6.2	1.17	0.06
Predicted adult ht, cm	171.6	5.1	170.8	4.9	171.1	6.6	172.3	5.0	0.20	0.01
% Predicted adult height	84.9	1.8	83.4	1.3	83.7	1.9	82.4	2.0	4.83[b]	0.20
Weight, kg	39.0	4.3	36.8	4.9	35.1	7.3	38.3	7.5	1.26	0.06
Sum Skinfolds, log n	3.46	0.27	3.47	0.44	3.26	0.39	3.60	0.50	1.67	0.08
Functional Capacities:										
Shuttle run, s	20.6	1.4	21.1	1.5	20.7	1.2	21.2	1.0	0.87	0.04
Counter move jump, cm	26.2	5.1	25.6	5.9	26.7	4.5	24.0	2.9	0.77	0.04
Sprint, s	8.49	0.45	8.66	0.51	8.43	0.36	8.58	0.51	0.83	0.04
Yoyo endurance run, m	1320	697	1248	731	1074	602	1070	674	0.51	0.03
Soccer Skills:										
Ball control, log normal	2.44	0.90	2.48	0.92	2.74	1.00	2.58	0.81	0.32	0.02
Dribbling speed, s	15.7	1.3	16.0	2.2	15.9	1.7	17.3	1.9	1.99	0.09
Passing, n	17.6	3.3	17.3	3.0	17.2	4.0	16.9	3.2	0.10	0.01
Shooting, pts	6.5	2.7	6.0	2.3	6.4	2.7	5.2	1.8	0.85	0.04
Goal Orientation										
Task	4.23	0.51	4.15	0.45	4.31	0.49	4.38	0.32	0.71	0.04
Ego	1.85	0.54	2.13	0.83	2.30	0.62	2.18	0.72	1.16	0.06
Potential, coach evaluation	3.47	1.01	3.21	1.27	3.14	1.23	2.42	1.17	1.98	0.09

[a]$p<0.001$, [b]$p<0.01$

Table 2. Distributions of players born in 1992 (n=62, 11 years) by maturity status based on SA and percent predicted adult height and by stage of pubic hair at baseline (December 2003) and by playing status in 2006 and in 2014 within birth quarter, and results of Chi square analyses

		Birth Quarters				
		1st (n=17)	2nd (n=19)	3rd (n=14)	4th (n=12)	χ^2
Maturity status at 11 years						
Skeletal:	Late	1	5	2	2	
	On time	11	9	9	4	
	Early	5	5	3	6	6.10 (ns)
% Adult Height:	Late	1	0	1	1	
	On time	11	14	7	8	
	Early	5	5	6	3	3.06 (ns)
Pubertal:	PH 1	11	12	9	7	
	PH 2	6	7	4	5	
	PH 3	0	0	1	0	3.81 (ns)
Subsequent playing status						
2006	Dropout	2	4	3	6	
	Club	12	13	9	6	
	Elite	3	2	2	0	7.13 (ns)
2014	NR+NLP*	17	15	9	10	
	Regional	0	2	4	1	
	National	0	2	1	1	8.61 (ns)

*Non-responders and those no longer playing soccer

Table 3. Characteristics (means and standard deviations) of players born in 1990 (n=50, 13 years) by birth quarter and results of MANOVAs and estimated effect sizes (η^2). All players were measured and tested within a two week interval in April 2004.

	Birth Quarters									
	1st (n=14)		2nd (n=16)		3rd (n=11)		4th (n=9)			
Variables	M	SD	M	SD	M	SD	M	SD	F	η^2
Chronological Age, yrs	14.2	0.1	13.9	0.1	13.6	0.1	13.4	0.1	252.36[a]	0.94
Skeletal Age, yrs	14.3	1.0	14.6	1.1	14.2	1.2	14.1	0.8	0.52	0.03
SA/CA ratio	1.01	0.07	1.05	0.08	1.05	0.09	1.05	0.06	1.06	0.06
Height, cm	160.3	8.0	163.4	9.2	158.5	9.7	156.5	7.8	1.36	0.08
Predicted adult ht, cm	171.0	6.0	173.7	5.6	172.7	7.7	172.8	4.7	0.53	0.03
% Predicted adult height	93.7	2.3	94.0	3.2	91.8	2.2	90.6	2.6	4.26[b]	0.22
Weight, kg	51.9	10.5	54.0	9.2	48.6	11.2	48.9	9.6	0.82	0.05
Sum Skinfolds, log n	3.56	0.49	3.60	0.45	3.43	0.36	3.59	0.36	0.40	0.03
Functional Capacities:										
Shuttle run, s	18.9	0.9	18.9	1.3	18.6	0.7	19.0	0.9	0.27	0.02
Counter move jump, cm	30.6	6.0	30.5	4.1	29.9	3.4	30.9	5.3	0.08	0.01
Sprint, s	7.97	0.40	7.88	0.39	7.85	0.28	7.92	0.47	0.23	0.01
Yoyo endurance run, m	2323	957	2170	1024	2396	816	2191	791	0.17	0.01
Soccer Skills:										
Ball control, log normal	3.62	0.73	3.31	1.02	3.30	1.13	3.70	0.73	0.61	0.04
Dribbling speed, s	13.2	0.7	13.5	0.9	13.6	1.0	13.7	1.2	0.60	0.04
Passing, n	21.2	2.0	20.1	3.5	20.4	2.6	20.7	3.1	0.39	0.03
Shooting, pts	6.6	2.6	9.0	3.5	8.4	2.0	7.9	3.2	1.78	0.10
Goal Orientation										
Task	4.23	0.44	3.96	0.86	4.30	0.39	4.14	0.43	0.88	0.05
Ego	2.04	0.63	1.76	0.53	1.55	0.32	2.00	0.72	1.91	0.11
Potential, coach evaluation	3.29	1.07	3.06	1.18	3.27	1.10	2.56	1.50	0.81	0.05

[a]$p<0.001$, [b]$p=0.01$

Table 4. Distributions of players born in 1990 (n=50, 13 years) by maturity status based on SA and percent predicted adult height and by stage of pubic hair at baseline (April 2004) and by playing status in 2006 and in 2014 within birth quarter, and results of Chi square analyses

		Birth Quarters				
		1st (n=14)	2nd (n=16)	3rd (n=11)	4th (n=9)	χ^2
Maturity status at 13 years						
Skeletal:	Late	2	1	1	0	
	On time	11	8	5	6	
	Early	1	7	5	3	7.04 (ns)
% Adult height	Late	0	0	0	0	
	On time	8	7	8	7	
	Early	6	9	3	2	3.74 (ns)
Pubertal:	PH 2	2	4	4	3	
	PH 3	8	5	2	6	
	PH 4	4	6	5	0	
	PH 5	0	1	0	0	11.39 (ns)
Subsequent playing status						
2006	Dropout	2	6	5	1	
	Club	9	5	5	7	
	Elite	3	5	1	1	8.58 (ns)
2014	NR+NLP*	11	14	10	5	
	Regional	3	2	0	4	
	National	0	0	1	0	10.33 (ns)

*Non-responders and those no longer playing soccer