HOSTED BY

ELSEVIER

CrossMark

Available online at www.sciencedirect.com

ScienceDirect

Journal of Sport and Health Science 3 (2014) 273–278

www.jshs.org.cn

Original article

The relative age effect has no influence on match outcome in youth soccer

Donald T. Kirkendall

Center for Learning Health Care, Duke Clinical Research Institute, Durham, NC 27715, USA

Received 30 April 2014; revised 5 June 2014; accepted 3 July 2014
Available online 31 July 2014

Abstract

Purpose: In age-restricted youth sport, the over-selection of athletes born in the first quarter of the year and under-selection of athletes born in the last quarter of the year has been called the relative age effect (RAE). Its existence in youth sports like soccer is well established. Why it occurs has not been identified, however, one thought is that older players, generally taller and heavier, are thought to improve the team's chances of winning. To test this assumption, birth dates and match outcome were correlated to see if teams with the oldest mean age had a systematic advantage against teams with younger mean ages.
Methods: Player birth dates and team records ($n = 5943$ players on 371 teams; both genders; U11−U16) were obtained from the North Carolina Youth Soccer Association for the highest level of statewide youth competition.
Results: The presence of an RAE was demonstrated with significant oversampling from players born in the 1st *vs.* the 4th quarter (overall: 29.6% *vs.* 20.9% respectively, $p < 0.0001$). Mean team age was regressed on match outcomes (winning %, points/match, points/goal, and goals for, against, and goal difference), but there was no evidence of any systematic influence of mean team age and match outcomes, except possibly in U11 males.
Conclusion: Selecting players based on physical maturity (and subsequently, on age) does not appear to have any systematic influence on match outcome or season record in youth soccer suggesting that the selection process should be focused on player ability and not on physical maturation.

Keywords: Match outcomes; Relative age effect; Soccer; Youth sport

1. Introduction

Youth sports should be an opportunity for young players to improve their skills, increase their tactical awareness, gain physical and psychological fitness, and, most importantly, have fun playing a game with others of similar abilities. Unfortunately, youth sports like soccer have become so organized that parents, coaches, administrators, and players strive to move up from recreational play to the more competitive travel teams. Each year, the goals are to play with and against better players, be taught by better coaches, and to play in more competitive matches and leagues. Next year, the cycle repeats itself.

One question that probably should be asked (but has not to my knowledge) is what do the selecting coaches look for at these annual auditions. Perhaps the coaches are looking at each player's skills, inherent physical characteristics (e.g., speed) or other less objective features like "soccer intelligence", "coach-ability", or potential. The selection process is to serve what purpose? Are coaches trying to find players who fit their "style" and want to try and develop them to be successful in the next age group or do they look for players who will give them the best opportunity to win now? While "travel team" coaches have yet to be surveyed about their prioritization of selection criteria, the prevailing thought is that winning is at the core of the selection process, whether decisions are made consciously or unconsciously.

E-mail address: Donald_kirkendall@yahoo.com
Peer review under responsibility of Shanghai University of Sport.

http://dx.doi.org/10.1016/j.jshs.2014.07.001

Most youth leagues are set up according to age with arbitrary cutoff dates in order to minimize developmental differences between age and ensure more equitable competition.[1] When combined with a coach's preoccupation with winning, this well-intentioned policy has resulted in players being selected who, on some level, appear to be older relative to their similar aged peers; they are early maturers. The assumption is that the interaction of skill, tactical understanding, cognitive ability, maturity, physical stature, and more has a greater probability of being found in the oldest players in each age grouping. The most widely recognized proxy being height.[2,3]

This favoritism toward selecting players born early in the birth year has been termed the relative age effect (RAE). It was first identified in the Canadian hockey and was hypothesized to play a role in success in hockey, defined as playing in the National Hockey League.[4] There have been subsequent descriptions of an RAE in most team sports like basketball,[5] volleyball,[6] soccer,[7−14] baseball,[15] *etc*. The presence of an RAE in individual sports is not as ubiquitous, but is apparent in skiing (downhill and Nordic),[1] tennis,[16] archery (JH Williams, personal communication), and, oddly, National Association for Stock Car Automobile Racing (NASCAR).[17] Individual esthetic sports (dance, gymnastics, figure skating, diving)[1] seem less prone to an RAE. The selection process that results in an RAE has been reported in North America, Asia, Europe, Africa, and South America. Interestingly, the RAE was reversed in African U-17 teams.[18]

In an attempt to determine factors that influence player selection and retention, numerous papers have explored a multitude of variables. Coaches may be looking for differences in performance characteristics like endurance, speed, *etc*., between players born early (first quarter) *vs.* later (last quarter) in the birth year hoping that the older player will have superior performance in all the fitness variables. But the only difference Figueiredo and colleagues[19] found in 11−14-year boys was in endurance. Maybe the coaches are trying to choose players with the highest skill level. The same project showed no difference in dribbling, passing, shooting skills[19] and that has been reported elsewhere.[20] A main difference between players selected for more advanced teams early (i.e., early maturers) *vs.* younger (late maturers) that has been reported is physical maturation (as height and mass) and the accompanying performance factors known to be influenced by muscle mass (sprinting, explosive power).[21] When the smaller players are not selected, they do not have the advantage of better coaching, teammates, and competition[22] and as a result fall behind in skill performance[23] and are more likely to drop-out of the sport.[22,24,25] This pattern is not consistent with the goal of developing all players in youth sports.

While the RAE and the reported differences or similarities within an age group are most apparent during adolescence, its presence is less apparent in adulthood amongst professionals. It appears that late maturers continuing in the game eventually catch up (physically, physiologically, emotionally) with their early maturing counterparts[26] and on a couple levels have more successful careers in terms of professional longevity and salary.[27]

These findings may reflect a conscious or unconscious desire by the selecting coach to select players who offer the best opportunity to win resulting in the RAE. What is interesting is that despite this issue being recognized and studied for nearly 30 years, there are no reports that say whether the process used to select participants for a team actually results in better team performance where performance or success is defined as variables like winning percentage or points per match. If the selection process as currently conducted works as intended, "older" teams would have a better record than the "younger" teams. Reported here are data that show the presence of an RAE in youth soccer in the US and the lack of any correlation between team age and team performance.

2. Methods

The US Youth Soccer Association is one of the governing bodies that regulate youth soccer. Each US state has an affiliated youth soccer association that governs youth soccer on the local level. The North Carolina Youth Soccer Association (NCYSA) oversees competitive soccer at the recreational (U5−U18 plus adults), Challenge (1st level of travel soccer requiring an audition, U10−U18), and Classic (highest level of travel soccer, also U10−U18) for both males and females. In North Carolina, the boy's scholastic season is August through November and the girl's scholastic season is February through May. Players are restricted from playing on both a club and a school team, so the seasons of interest were fall 2010 (females) and spring 2011 (males), the seasons of most participation.

The NCYSA provided the database on Classic players for the competitive year 2010−2011. The database was de-identified for name, player ID, address, and other identifying data. What was retained was a database that contained each player's birth month, birth date, birth year, competitive age group (i.e., U12, U14, *etc.*), gender, and team name for the age groups with the greatest participation (U11−U16). The competitive year cutoff for North Carolina (as defined by US Youth Soccer) begins at August 1 and ends at July 31. Each player's birth month and year were recoded to the 1st quarter through the 4th quarter of the birth year. Players who were "playing up" (e.g., a U12 age player on a U13 age team) were coded as the 5th quarter and then excluded from analysis.

The NCYSA posts the season's records on its website. A database was developed that contained each team's name, age group, gender, matches won, matches lost, matches drawn, goals for, and goals against. From this, winning percentage (wins/total number of matches), win + draw percentage (wins + draws/total), goal difference (GF-GA), and points, based on the traditional 3 points for a win and 1 point for a draw.

In order to correlate team age with team performance, a statement of team age needed to be developed. Within each competitive age group, August 1 was recoded as "1", August 2 was recoded as "2", *etc*., through July 31 recoded as "366".

A team's mean age was then determined and added to the database of team record.

The data were summarized using routine descriptive statistics. The presence of an RAE was tested using a chi-square goodness of fit. Birth quarter fractions were based on actual counts of calendar days within each quarter (0.251, 0.251, 0.249, 0.251 for the 1st through the 4th quarters, respectively) and were the expected distribution to test whether the fractional distribution of the players differed from this expected. Differences between birth quarters were determined using 95% confidence intervals. Relationships between the mean team age and team performance were determined using simple correlation methods (SAS JMP; Cary, NC, USA). A significance level of $p < 0.05$ was considered to be statistically significant.

3. Results

Auditions for the 2010–2011 season were held in the spring of 2010. After auditioning, players were selected or assigned to teams according to each club's policy. Once the actual competitive season began, which for females began about 4 months later and for males could have been 10 months later, some clubs would realign teams and the resulting team name may not have matched the initial team assignment after the audition. When an exact match for the team a player was originally assigned could not be found in the final season standings, that player was excluded from further analysis.

For the year 2010–2011, there were 12,411 players registered for Classic play on 890 U11–U16 teams for the analysis of an overall RAE by gender and age group. Table 1 outlines the final player counts, by age group and sex, used in the analyses. At this level of play, a significant departure from the expected distribution of birth quarters was seen for all age groups statewide in both males and females (Table 1). As the RAE is generally defined as an over sampling of players from the first quarter of the birth year and an under-sampling of players born in the last quarter of the birth year, the paired comparison of most interest is between the 1st and 4th quarters (Table 1). Of the 12 age groups listed, only one age group (U15 girls, $p = 0.052$) did not show this pattern.

After exclusion for unmatched team names and including only those teams where a team's final season record matched with team names in the player database, a final database was generated and contained 5943 players on 371 teams. When teams with end of season records could be matched exactly with their audition day team names, a similar distribution was apparent in all but the U14 (1996) boys (Table 2). Overall, there was no difference between the distribution of the subsample of boys and girls *vs.* the overall gender-specific distributions of the total sample.

Correlations of each team's average birth day (as a 1–366 number) with season outcomes are presented in Table 3. Of all the possible correlations, there were significant r values for only the U11 (1999) boys for win + tie percentage, goals against, and goal differential. Other than that pattern, only two other correlations were significant.

4. Discussion

The existence of an RAE in sport is well documented and the statewide data presented here offers more evidence of its presence. There are numerous reports that attempt to present reasons behind the existence of the RAE as well as solutions. In the absence of survey data that might provide some insights into the selection and assignment process, authors are left to

Table 1
Number of teams, players, and birth quarter distribution (%) by sex and birth year for North Carolina Classic registrants.

	No. of teams	No. of players	Birth quarter (%)				p value	Is 1st > 4th?
			1st	2nd	3rd	4th		
Female								
1994 (U16)	48	848	26.6	30.2	23.0	20.2	0.0003	Yes
1995 (U15)	61	1019	27.2	27.4	22.9	22.6	0.052	No
1996 (U14)	54	951	28.4	26.8	25.4	19.4	0.0004	Yes
1997 (U13)	70	1168	30.6	27.9	21.4	20.1	<0.0001	Yes
1998 (U12)	58	754	30.0	25.9	22.0	22.2	0.008	Yes
1999 (U11)	55	673	30.9	25.7	22.6	20.8	0.002	Yes
Overall	430	5413	28.9	27.4	22.9	20.8	0.0001	Yes
Male								
1994 (U16)	65	1177	29.0	26.2	23.7	21.2	0.002	Yes
1995 (U15)	71	1230	28.2	26.3	23.1	22.4	0.016	Yes
1996 (U14)	72	1276	27.3	26.5	24.5	21.7	0.026	Yes
1997 (U13)	80	1392	29.0	25.9	23.3	21.8	0.001	Yes
1998 (U12)	72	914	29.3	26.0	22.8	21.9	0.008	Yes
1999 (U11)	80	1009	31.8	24.4	21.5	22.2	<0.001	Yes
Overall	460	6998	29.0	25.9	23.2	21.9	<0.0001	Yes

Note: The columns "No. of teams" and "No. of players" are the number of teams and players, by age group and sex, in the analysis. The "Overall" rows are the sum of teams and players for females and males. For the "Birth quarter" columns, each cell in the Overall row represents the overall mean for each sex. p values represent the significance level when comparing mean birth quarter percentages.

Table 2
Birth quarter distribution (%) by sex and birth year for North Carolina Classic registrants on verified teams.

	No. of teams	No. of players	Birth quarter (%)				p value	Differences?
			1st	2nd	3rd	4th		
Female								
1994 (U16)	20	362	26.5	29.6	23.5	20.4	<0.0001	1, 2 > 4
1995 (U15)	29	481	29.7	26.4	22.2	21.6	0.0225	1, 2 > 4
1996 (U14)	29	497	29.2	24.9	25.6	20.3	0.0002	1, 2, 3 > 4
1997 (U13)	34	570	32.1	28.2	20.2	19.5	<0.0001	1, 2 > 4
1998 (U12)	24	310	28.7	28.4	22.6	20.3	0.0049	1 > 4
1999 (U11)	27	341	30.5	25.2	21.4	22.9	0.0013	1 > 4
Overall	163	2561	29.5	27.1	22.6	20.8	<0.0001	1, 2 > 3, 4
Male								
1994 (U16)	26	481	29.3	28.5	24.3	17.9	0.0006	1, 2 > 4
1995 (U15)	36	629	30.8	25.4	22.4	21.3	0.0036	1 > 4
1996 (U14)	39	690	25.9	28.1	23.0	22.9	0.11	NS
1997 (U13)	45	786	29.1	26.6	24.2	20.1	0.002	1 > 4
1998 (U12)	29	380	32.4	23.2	23.9	20.5	0.0105	1 > 4
1999 (U11)	33	416	31.2	25.1	20.5	23.2	0.022	1 > 3
Overall	208	3382	29.8	26.2	23.1	21.0	<0.0001	1, 2 > 3, 4

Abbreviation: NS = not significant.

make assumptions about why coaches make their choices, the most obvious of which is that coaches select players that they feel will give them the best opportunity to win matches.

No doubt, the selection process varies from club to club and players are chosen or assigned to teams according to club philosophy. When players are evaluated for region-level representation or higher, the coaches usually have an evaluation tool to guide those evaluating players asking for opinions about technical elements (e.g., comfort with the ball, finishing, creativity), tactical elements (e.g., ball circulation, communication, positional awareness), and physical/psychological elements (e.g., competitive attitude, soccer speed, soccer fitness, work rate) (Sam Snow, US Youth Soccer; personal communication); player size is not a stated factor. The assumption is that if a coach has to choose between two players, the choice will usually favor the taller and/or heavier player.

There are a number of excellent studies that demonstrate the small degrees of difference in the various factors of fitness between players born early *vs.* late in the birth year[3,20,22,23,28–32] and that those born later in the birth year who continually fail to get selected drop out of sport more often than those born early in the year.[22,33] None address the assumption that teams of players born earlier in the birth year actually perform better than teams made up of players born later in the birth year.

Combining a database of birth month and year with the season ending records provided a look at whether that assumption actually resulted in a better record. From Table 3, it is obvious that simply having a team populated with players born earlier in the birth year is no guarantee of having a successful season as evidenced by the lack of a correlation between average team birth date *vs.* winning percentages and

Table 3
Summary of correlation coefficients between team average birth date with selected seasonal performance data.

Birth year	Win%	Win + tie%	Pts/game	Pts/goal	GF	GA	GD
Female (fall 2010)							
1994 (U16)	0.06	0.23	0.12	−0.31	0.34	−0.19	0.33
1995 (U15)	0.00	0.01	0.00	−0.18	0.08	0.06	0.01
1996 (U14)	0.30	0.05	0.23	−0.36*	0.34	0.16	0.13
1997 (U13)	−0.11	0.02	−0.07	0.17	−0.10	0.19	−0.17
1998 (U12)	0.05	−0.06	0.0	0.0	−0.05	0.03	−0.05
1999 (U11)	−0.07	−0.14	−0.09	−0.33	0.01	0.18	−0.09
Overall	0.04	0.00	0.24	0.13*	0.10	0.90	0.00
Male (spring 2011)							
1994 (U16)	−0.27	−0.29	−0.29	−0.17	−0.28	0.21	−0.25
1995 (U15)	0.09	0.28	0.16	0.35*	−0.09	−0.10	0.02
1996 (U14)	0.12	0.02	0.09	−0.33	0.30	0.14	0.13
1997 (U13)	−0.20*	−0.21	−0.21	−0.15	−0.22	−0.09	−0.18
1998 (U12)	0.00	0.06	0.02	−0.21	0.26	0.19	0.06
1999 (U11)	−0.33	−0.38*	−0.37*	0.04	−0.38*	0.49*	−0.54*
Overall	−0.09	−0.02	−0.09	−0.04	−0.08	0.12	−0.12

*$p < 0.05$. Abbreviations: Pts = points; GF = goals for; GA = goals against; GD = goal difference.

scoring. The lack of any discernable pattern would seem to indicate there is no systematic benefit of having a team of early maturing players.

There were the occasional correlations between team age and some team performance (Table 3). Only for the U11 (1999) was there the appearance of a systematic impact of team age on outcome. This alone is curious because most reports indicate that the RAE is most evident around puberty, older than this age group. Of the significant correlations, probably the one of most interest or importance for any age group would be with the points per game. The variance in outcome accounted for by knowing a team's age (r^2) ranges from 0.04% to 14.4% in the boys and from 0.01% to 5.3% in the girls. Anderson and Sally[34] analyzed numerous factors that might influence outcome in professional league play and concluded that random chance accounts for half the information about match outcome making most any influence of team age on match outcome a minor factor. Based on the overall data, for each 30-day increase in mean team age, a team might gain 0.16 (5%) out of a possible 3 points per match.

Overall, an RAE was present across all ages in both male and female teams. The presence of the RAE in girls varies from some other reports that show little evidence[35−37] while others do show an RAE.[5,26,38] Most reports state that the effect is greatest in the years surrounding puberty; these distributions are consistent with other reports.

Solutions have been proposed, but none have seemed to gain any significant support by the soccer clubs. Changing the cutoff date, yearly rotation of cutoff dates, or changing the age grouping boundaries (e.g., from 12 to 9, 15, or 21 months)[39−41] have been criticized because each adds a layer of complexity with the frequent re-structuring based on age group.[2] Others have suggested a quota system that restricts the number of players born early in the birth year on each team,[42] grouping on height and weight,[16,43] or simply delaying audition-based competition until after puberty on the assumption that players do not reach their performance peak until their late 20's making identification of elite players in their early teen years unnecessary.[2] A simple solution that might prove to be logistically difficult is to group players in 6-month intervals, but the potential increase in the number of teams, support, and field space may, for some, make this an unlikely solution.

When discussing solutions, most papers emphasized raising the awareness of coaches about the existence of the RAE. Coaches may well be aware of the RAE, but as Helsen et al.[44] told us, 10 years of awareness (in Europe) has achieved little. Perhaps if coaches were alerted to the lack of evidence that shows having a team of early maturers wins more than teams made up of later maturers, the selection process might become more about the player's skills, tactical awareness, and performance and less about their size. One interesting note about size is that when two players collide and a foul is called, referees have a bias against the taller player,[45] making it possible that in the attempt to select a better (i.e., bigger, early maturing) team, the coach has a team that could well have more fouls called against them. While that referee bias is known, what affect that bias might have on outcome remains to be determined.

If the overall goal of youth sport is to help every player develop and become the best player possible, then an RAE would not exist, but its persistent presence shows that the selection process is either flawed or selecting coaches are using other parameters than skill, tactics, and fitness to select players. If the best solution is awareness of the problem, showing coaches that selecting players based on maturation within a particular birth year has no impact on seasonal outcome might be sufficient to convince coaches to focus more on each player's soccer performance and less on each player's size.

Acknowledgment

I would like to acknowledge Mark Moore (Deputy Director), Rachel Jones (Administrative Manager), and Kathy Robinson (Executive Director) of the North Carolina Youth Soccer Association for access to the data and season standings and to Sam Snow (Director of Coaching, US Youth Soccer) for his thoughtful insights. Dr. Kirkendall is a member of the FIFA Medical Assessment and Research Center.

References

1. Baker J, Janning C, Wong H, Cobley S, Schorer J. Variations in relative age effects in individual sports: skiing, figure skating and gymnastics. *Eur J Sport Sci* 2014;**14**(Suppl. 1):S183−90.
2. Cobley S, Baker J, Wattie N, McKenna J. Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med* 2009;**39**:235−56.
3. Malina RM, Pena Reyes ME, Eisenmann JC, Horta L, Rodrigues J, Miller R. Height, mass and skeletal maturity of elite Portuguese soccer players aged 11−16 years. *J Sports Sci* 2000;**18**:685−93.
4. Barnsley RH, Thompson AH, Barnsley PE. Hockey success and birthdate: the relative age effect. *Can Assoc Health Phys Educ Recr J* 1985;**51**:23−8.
5. Delorme N, Raspaud M. The relative age effect in young French basketball players: a study on the whole population. *Scand J Med Sci Sports* 2009;**19**:235−42.
6. Okazaki FH, Keller B, Fontana FE, Gallagher JD. The relative age effect among female Brazilian youth volleyball players. *Res Q Exerc Sport* 2011;**82**:135−9.
7. Romann M, Fuchslocher J. Relative age effects in Swiss junior soccer and their relationship with playing position. *Eur J Sport Sci* 2013;**13**:356−63.
8. van den Honert R. Evidence of the relative age effect in football in Australia. *J Sports Sci* 2012;**30**:1365−74.
9. Ostapczuk M, Musch J. The influence of relative age on the composition of professional soccer squads. *Eur J Sport Sci* 2013;**13**:249−55.
10. Augste C, Lames M. The relative age effect and success in German elite U-17 soccer teams. *J Sports Sci* 2011;**29**:983−7.
11. Williams JH. Relative age effect in youth soccer: analysis of the FIFA U17 World Cup competition. *Scand J Med Sci Sports* 2010;**20**:502−8.
12. Gutierrez Diaz Del Campo D, Pastor Vicedo JC, Gonzalez Villora S, Contreras Jordan OR. The relative age effect in youth soccer players from Spain. *J Sports Sci Med* 2010;**9**:190−8.
13. Mujika I, Vaeyens R, Matthys SP, Santisteban J, Goiriena J, Philippaerts R. The relative age effect in a professional football club setting. *J Sports Sci* 2009;**27**:1153−8.
14. Helsen WF, van Winckel J, Williams AM. The relative age effect in youth soccer across Europe. *J Sports Sci* 2005;**23**:629−36.
15. Nakata H, Sakamoto K. Relative age effect in Japanese male athletes. *Percept Mot Skills* 2011;**113**:570−4.

16. Baxter-Jones AD. Growth and development of young athletes. Should competition levels be age related? *Sports Med* 1995;**20**:59–64.
17. Abel EL, Kruger ML. A relative age effect in NASCAR. *Percept Mot Skills* 2007;**105**:1151–2.
18. Williams JH. Relative age effect in youth soccer: analysis of the FIFA U17 World Cup competition. *Scand J Med Sci Sports* 2009;**20**:502–8.
19. Figueiredo AJ, Goncalves CE. Coelho E Silva MJ, Malina RM. Youth soccer players, 11–14 years: maturity, size, function, skill and goal orientation. *Ann Hum Biol* 2009;**36**:60–73.
20. Malina RM, Ribeiro B, Aroso J, Cumming SP. Characteristics of youth soccer players aged 13–15 years classified by skill level. *Br J Sports Med* 2007;**41**:290–5.
21. Coelho E, Silva MJ, Figueiredo AJ, Simões F, Seabra A, Natal A, et al. Discrimination of U-14 soccer players by level and position. *Int J Sports Med* 2010;**31**:790–6.
22. Figueiredo AJ, Goncalves CE, Coelho E, Silva MJ, Malina RM. Characteristics of youth soccer players who drop out, persist or move up. *J Sports Sci* 2009;**27**:883–91.
23. Rebelo A, Brito J, Maia J, Coelho E, Silva MJ, Figueiredo AJ, et al. Anthropometric characteristics, physical fitness and technical performance of under-19 soccer players by competitive level and field position. *Int J Sports Med* 2012;**34**:312–7.
24. Delorme N, Chalabaev A, Raspaud M. Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand J Med Sci Sports* 2010;**21**:120–8.
25. Pierson K, Addona V, Yates P. A behavioural dynamic model of the relative age effect. *J Sports Sci* 2014;**32**:776–84.
26. Schorer J, Cobley SP, Busch D, Brautigam H, Baker J. Influences of competition level, gender, player nationality, career stage and playing position on relative age effects. *Scan J Med Sci Sports* 2009;**19**:720–30.
27. Schorer J, Wattie N, Baker JR. A new dimension to relative age effects: constant year effects in German youth handball. *PLoS One* 2013;**8**:e60336. http://dx.doi.org/10.1371/journal.pone.0060336.
28. Carling C, Le Gall F, Malina RM. Body size, skeletal maturity, and functional characteristics of elite academy soccer players on entry between 1992 and 2003. *J Sports Sci* 2012;**30**:1683–93.
29. Figueiredo AJ, Coelho E, Silva MJ, Cumming SP, Malina RM. Size and maturity mismatch in youth soccer players 11- to 14-years-old. *Pediatr Exerc Sci* 2010;**22**:596–612.
30. Malina RM, Cumming SP, Kontos AP, Eisenmann JC, Ribeiro B, Aroso J. Maturity-associated variation in sport-specific skills of youth soccer players aged 13–15 years. *J Sports Sci* 2005;**23**:515–22.
31. Malina RM, Eisenmann JC, Cumming SP, Ribeiro B, Aroso J. Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. *Eur J Appl Physiol* 2004;**91**:555–62.
32. Philippaerts RM, Vaeyens R, Janssens M, Van Renterghem B, Matthys D, Craen R, et al. The relationship between peak height velocity and physical performance in youth soccer players. *J Sports Sci* 2006;**24**:221–30.
33. Delorme N, Chalabaev A, Raspaud M. Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand J Med Sci Sports* 2011;**21**:120–8.
34. Anderson C, Sally D. *The numbers game: why everything you know about soccer is wrong*. New York: Penguin Books; 2013.
35. Vincent J, Glamser FD. Gender differences in the relative age effect among US olympic development program youth soccer players. *J Sports Sci* 2006;**24**:405–13.
36. Nakata H, Sakamoto K. Sex differences in relative age effects among Japanese athletes. *Percept Mot Skills* 2012;**115**:179–86.
37. Goldschmied N. No evidence for the relative age effect in professional women's sports. *Sports Med* 2011;**41**:87–8.
38. Delorme N, Boiche J, Raspaud M. Relative age effect in female sport: a diachronic examination of soccer players. *Scand J Med Sci Sports* 2010;**20**:509–15.
39. Barnsley RH, Thompson AH, Barnsley PE. Hockey success and birthdate: the relative age effect. *Can Assoc Health Phys Educ Recr J* 1985;**51**:23–8.
40. Boucher J, Halliwell W. The Novem system: a practical solution to age grouping. *Can Assoc Health Phys Educ Recr* 1991;**57**:16–20.
41. Hurley WJ, Lior D, Tracze S. A proposal to reduce the age discrimination in Canadian minor hockey. *Can Publ Policy* 2001;**37**:65–75.
42. Barnsley RH, Thompson AH. Birthdate and success in minor hockey: the key to the NHL. *Can J Behav Sci* 1988;**20**:167–76.
43. Musch J. Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev Rev* 2001;**21**:147–67.
44. Helsen WF, Baker J, Michiels S, Schorer J, Van Winckel J, Williams AM. The relative age effect in European professional soccer: did ten years of research make any difference? *J Sports Sci* 2012;**30**:1665–71.
45. van Quaquebeke N, Giessner SR. How embodied cognitions affect judgments: height-related attribution bias in football foul calls. *J Sport Exerc Psychol* 2010;**32**:3–22.