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The reverse relative age effect in professional soccer: an analysis of the Brazilian National League of 2015

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ABSTRACT

Research question: The relative age effect (RAE) has been examined in several sports, proposing that athletes born in the initial months of each year have an advantage in development compared to those born in the final months. Recent studies reveal a reverse RAE whereby players born at the end of the year reach the adult category with better technical quality, salary and career length than the other players. We analyze whether there is a reverse relative age effect, assessing the influence on the market value and sports performance of soccer players.

Research methods: We test the hypotheses on a dedicated dataset of 601 professional Brazilian soccer players that participated in the Brazilian National League in 2015. Brazil is the largest exporter of soccer players to the top leagues and teams. Data were analyzed using multivariate statistics and the Pearson chi-square test.

Results and findings: We found a reverse relative age effect in relation to the players' sports performance, but not in relation to their market value.

Implications: Players born in the last months of the year had better sports performance. We contribute to a better understanding of the reverse effect of relative age, accounting for individual characteristics and career trajectory, with potential implications for better decisions by soccer coaches and managers regarding how soccer players are selected and developed.

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Reverse relative age effect; Brazilian soccer; players' market value; players sport performance

Introduction

In sports, players are divided into different categories based on their age. This division into age groups aims to make competitions fairer by grouping players with similar levels of physical and mental development (Grossmann & Lames, 2013). However, although dividing players into age groups seems fair, several studies have shown that there are significant differences in the development of young players born in different months of the same year (e.g. Poli, Ravenel, & Besson, 2015a). We call the relative age effect (RAE) the effect of the differences in the development between players in the same group, or category. In many sports, the effect is that coaches more often select those players born at the beginning of

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the year, as talented, and comparatively less players born at the end of the year, which tend to be considered as less skilled (Vincent & Glamser, 2006).

The influence of the RAE in different sports at the youth level is well established (Helsen, Winckel, & Williams, 2005; Musch & Grondin, 2001; UEFA, 2016), but some pioneering studies have raised the possibility that a 'relative age effect reversal' may exist in the long run. That is, some scholars are inquiring into the possibility that those players born at the end of the year may have an advantage in comparison to the players born at the beginning of the year. Some studies have explored a RAE reversal by comparing performance indicators such as salaries (Ashworth & Heyndels, 2007), first choices in drafts (Baker & Logan, 2007), career length (Gibbs, Jarvis, & Dufur, 2012; Grossmann & Lames, 2013; Steingröver, Wattie, Baker, & Schorer, 2016), games played and points scored (Deaner, Lowen, & Cobley, 2013), selection at senior level (Coutts, Kempton, & Vaeyens, 2014; McCarthy, Collins, & Court, 2015).

A possible RAE reversal seems reasonable and may be observed when comparing the youth and adult categories. First, the influence of relative age differences benefiting those born in the beginning of the year tends to decrease as players mature mentally and physically (Gibbs et al., 2012; McCarthy & Collins, 2014). Second, for instance, in soccer, the majority of the players in the youth categories are born in the initial months of the year and only a small percentage of players are born in the final months (Rabelo et al., 2016). However, contrary to likely expectations in the adult categories we count a larger percentage of younger cohort professional soccer players than accounted for by the youth drafts (Ashworth & Heyndels, 2007; Coutts et al., 2014). This opens the possibility of investigating whether soccer players born in the final months may be more skilled, or have higher technical ability than those players born in the initial months (McCarthy & Collins, 2014). Thus, the puzzling question is whether the soccer players born at the end of the year and that tended to be neglected in the younger categories, being less often selected for teams, arrive at the adult category with advantageous attributes, on average, than the players born in other months. This is the reversal of the RAE.

In this study, we scrutinize whether a reverse RAE exists in professional soccer players, by assessing specifically the soccer players' market value and sports performance. These two parameters are proxies for technical quality and should probably be the most relevant for managers and coaches in the selection, hiring, and promotion of players in high-performance sports. Empirically, we delimited our scope to Brazilian professional soccer players. Moreover, Rabelo et al. (2016) have found an RAE in Brazilian soccer, where there is a majority of soccer players born in the first two quarters of the year, but there are no studies, to the best of our knowledge, on a possible reverse relative age effect pertaining to Brazilian athletes generally, or soccer in particular. Using the empirical context of Brazilian soccer entails a contribution in that Brazil is the largest exporter of soccer players to the most valuable teams and leagues worldwide (Poli, Ravenel, & Besson, 2015b).

The study makes a contribution to the study of age effects. The vast majority of the existing studies explore the RAE but we complement the extant research on the RAE reversal. Research on an RAE reversal has studied the effect on such aspects as the salaries (Ashworth & Heyndels, 2007; Fumarco, Gibbs, Jarvis, & Rossi, 2017), likelihood of being drafted (Baker & Logan, 2007; Coutts et al., 2014), career length (Gibbs et al., 2012; Grossmann & Lames, 2013; Steingröver et al., 2016), and performance (Deaner et al., 2013). We

add to this research by examining the effects on the market value of the player and their sports performance. We thus also contribute to existing empirical estimations. We account for an array of both specific characteristics of the players (e.g. the players' tactical sector, dominant foot) and their professional career (e.g. club mobility and the initial club where each player started a professional career), which enables us to more clearly observe the influence of a reverse RAE in the market value and sports performance.

This study is important, from a managerial perspective, to coaches and sports managers, contributing to improve talent detection, selection and promotion, calling attention to technical abilities instead of physical attributes. The coaches are directly responsible for the selection and maintenance of the players, who become one of the main products of the clubs, generating sports results on the pitch and commercial and financial results off the pitch (Hill & Sotiriadou, 2016). It is also important in helping to devise strategies to improve players' development, and in guiding the actions of sports federations and leagues to attenuate age unbalances in the age categories thus minimizing the influence of relative age effects.

Literature review and hypotheses

The relative age effect (RAE) refers to advantages individuals may have from small age differences, and have been studied in several sports. An RAE is more noticeable for players in the youth categories where even a few months in age difference may have substantial influence in the physical and mental maturity of the players (Gibbs et al., 2012), their ability to deal with stress, self-esteem, and motivation (Musch & Grondin, 2001). The RAE combines physical (Vincent & Glamser, 2006), cognitive, emotional, motivational and competitive factors (Musch & Grondin, 2001). The RAE is important because there is a tendency for coaches, during the identification and selection of new players, to draft the taller and stronger players (often those born in the beginning of the year), while the smaller and thinner players (possibly born in the end of the year – relatively younger) are often excluded from the teams.

The populations of early selected youth players and later successful adult players in senior elite sports are not identical but are widely disjoint populations (Güllich, 2014). Some studies (e.g. Musch & Grondin, 2001; Poli et al., 2015a) have shown that the RAE is more salient in younger categories until early adulthood, than in the adult categories. Players born at the end of the year and who are often deferred in sports selections, develop greater career stress, lower self-esteem, and burnout (Delorme, Chalabaev, & Raspaud, 2011). Moreover, players born at the end of the year that reach the professional level probably overcame more difficulties, grown more skilled and mentally stronger than the average players. This latter is referred to as the reverse RAE, and discussed in the following section.

The reverse relative age effect

There is some evidence that a reverse RAE may occur, at least in some instances. For example, Ashworth and Heyndels (2007) noted that the German soccer players born in the final months of each year had higher wage averages than those born in the early months. Baker and Logan (2007) also found a reversal of an RAE noting that ice

hockey players born in the final months of the year were more often chosen at the beginning of the drafts, as the first picks, and Gibbs et al. (2012) and Steingröver et al. (2016) found that the ice hockey players born in the later months of the year had longer careers. Deaner et al. (2013) further found that the players born in the final months were the most productive, based on the number of points scored and games played. In sum, these studies point to a reverse RAE on the long run, noting that players born in the last quarter of the year have some advantage in their adult career (McCarthy & Collins, 2014). Table 1 presents an overview of the studies pointing to a reverse RAE.

The evidence, however, is not conclusive on the existence of an RAE and reverse RAE. Steingröver et al. (2016) found inconclusive results in relation to the career length in basketball and soccer. In German handball, Schorer, Baker, Büsch, Wilhelm, and Pabst's (2009) study did not find a difference in height, weight or technical skills of players that they could attribute to relative age differences. Fumarco and Rossi (2018) concluded that Italian football players' born at the end of the year received lower salaries in comparison with the older peers.

Regarding the potential benefits of the reverse RAE, there are two possible advantages that the players born at the end of the year may hold in the adult category. First, the players

Table 1. Studies of RAE reversal.

Authors	Research question	Sample	Results
Ashworth and Heyndels (2007)	Did players born at the end of the cut-off date have higher salaries?	285 professional soccer players from the German Bundesliga	Goalkeepers and defenders born at the end of the cut-off date earn more. No difference found for attackers.
Baker and Logan (2007)	What is the influence of RAE and place of birth in the hockey draft?	1013 US and Canadian players selected in the NHL draft	Players born at the end of the year were selected before the majority
Gibbs et al. (2012)	The RAE only decreases or it also reverses in the professional categories?	1109 Canadian base hockey, drafts, professional and Olympic team	Highest proportion of players born at the end of the year and with longer careers
Deaner et al. (2013)	What is the influence of bias in the selection of talent (drafts)?	2736 Canadian professional hockey players (NHL)	Players born at the end of the year had higher games played and higher points scored
Grossmann and Lames (2013)	What impact does the RAE have on professionalizing players?	2438 male and female amateur and Bundesliga soccer players	Greater promotion for the professional teams and longer career for those born at the end of the year
Coutts et al. (2014)	What is the influence of the RAE on the drafts of adolescents and adults?	806 Australian professional football players	Higher selection of adolescents born at the beginning of the year and greater selection of adults born at the end of the year
McCarthy et al. (2015)	Is the reverse RAE an isolated case or a genuine effect in sports?	821 Rugby players and 668 adult Cricket players	Both sports had greater conversion of the talents born at the end of the year to the adult category
Steingröver et al. (2016)	Players born at the end of the year have longer career?	407 basketball players (NBA), 1028 hockey players (NHL) and 2380 American football players (NFL)	Longer career in the NHL, but not in the NBA or the NFL
Fumarco et al. (2017)	Players born at the end of the year have higher scoring and higher salaries?	8760 NHL player-season (2008–2016)	Players born in the last quarter of the year score more and have higher salaries than those born in the first quarter
Wrang et al. (2018)	How an RAE influences the selection in the senior level in Danish national handball?	244 handball players from Danish U19, U21 and senior national levels	Danish national senior level talent selection favors the relatively younger players

born in the final months may be more skilled than the average, since they were selected and maintained in the base categories, even when they had physical and maturational disadvantages (Ashworth & Heyndels, 2007; Grossmann & Lames, 2013). That is, these players possibly revealed better skills to overcome the difficulties of being among older players, which surpassed a relative age influence. This leads us to hypothesize that there is a reverse RAE such that those players relatively younger actually have higher technical quality, which increases their market value.

Hypothesis 1: Players born in the fourth quarter have higher market value compared to the players born in the other quarters.

The second possible advantage of the players born at the end of the year is related to the fact that younger players have always trained and played together or against older players. This is likely to result in better learning, a positive effect emerging from being in a more competitive environment (Ashworth & Heyndels, 2007). There is at least partial evidence for a peer effect and the players' sports performance. The research on ice hockey by Deaner et al. (2013) confirmed that those born in the fourth quarter had better sports performance, compared to the number of points scored and games played. Also in hockey, the studies by Gibbs et al. (2012) and Steingröver et al. (2016) noted that those players born in the last quarter had a longer career than their peers. That is, these players not only retired later, but they also continued to work longer on high-performance teams. However, in the same research by Steingröver et al. (2016), this effect was not been confirmed in basketball and American football. Moreover, other studies also show that there is a tendency for fourth-quarter-born talent to be revealed later for the professional sport, such as in the Australian football (Coutts et al., 2014), rugby and cricket (McCarthy et al., 2015). This means that during the youth categories these players passed discreetly through the training period, matured late and continued to develop into adulthood, surpassing in technical and physical quality the team pairs initially identified as talents (Gibbs et al., 2012). The conflicting evidence supports our following hypothesis.

Hypothesis 2: Players born in the fourth quarter have better sport performance compared to the players born in the other quarters.

Method

Sample

A total of 677 players participated in the Brazilian National League of 2015 – Series A. Our sample comprises 601 Brazilian players, after excluding 13 players for which there were no data on the market value, 4 for which we lacked information on the number of games in the career, and 59 foreigners. Our sample does not include foreign players to avoid the interference of variations such as changes in cut dates that divide the dates of each category, considering that in Brazil the cut date is always between December 31 and January 1. For instance, in the countries of the northern hemisphere, the cut dates are different. The school and sport year calendar begins in the middle of the year (August or September) and when the players start to play in national or international competitions, such as the UEFA or FIFA calendar, the date is changed to January 1. These differences are

likely to have influenced to some extent the findings of prior studies (see, for instance, Helsen et al., 2005; Simmons & Paull, 2001).

Of the 601 players in the sample, 183 players were born in the first quarter (30.4%), 180 in the second quarter (30%), 146 in the third quarter (24.3%) and 92 in the fourth quarter (15.3%). The average birth date of the sample in the annual calendar is June 7. The mean age was 26 years and 29 days, the minimum age was 17 years and 11 days and the maximum age was 42 years and 90 days, with a standard deviation of 4.69.

Data collection

The secondary data were collected from the website of Transfermarkt.de, which is the largest database in the world relating to football, with information on more than 600,000 players, clubs and coaches. The data has been used in several studies (e.g. Bryson, Frick, & Simmons, 2013; Franck & Nüesch, 2012; Herm, Callsen-Bracker, & Kreis, 2014; Scelles, Helleu, Durand, & Bonnal, 2014) and employed by football clubs for guiding the transfers of players and salary negotiations (Herm et al., 2014). Franck and Nüesch (2012) tested the accuracy and reliability of the Transfermarkt database concerning the estimates of market value, comparing the official data published by Kicker magazine (published real data of the market values of the transfers), specialized in soccer, with the estimates reported by Transfermarkt, finding a correlation of 0.89 between the two datasets.

It is worth pointing that the database does not include data regarding games or players involved in state, regional and friendly tournament matches. Moreover, regarding the total number of games played during the players' career only includes data on national leagues and cups, such as the Brazilian National League and Brazil Cup, and the international tournaments such as the South American Cup, *Libertadores* of America Cup, and FIFA Cups of national teams and clubs.

Variables

The two dependent variables were the market value and the sports performance of the soccer players. The *market value* of the players should reflect, at least to some extent, the quality of the players (Ashworth & Heyndels, 2007) such that better players have greater market value. Bryson et al. (2013), Herm et al. (2014) and Scelles et al. (2014) have used the market value as a proxy for the technical quality of the athletes. The market values are provided in Euros by Transfermarkt.de for all players. The market values of the players are assessed in December, immediately after the end of the Brazilian National League of 2015. The market values are based on estimations that consider the player's age, recent sports performance, career experience and the interest of teams in hiring him (Bryson et al., 2013).

The market value estimates made available by transfermarkt.de are made in country-specific forums with the participation of 190,000 site users (Bryson et al., 2013). Market value estimates are constantly revised based on the recent performance of each player and the rumors of transfers between clubs. It is important to note that the estimates reflect the current timing of each player, even when the player has not yet been transferred to another club (Herm et al., 2014). A similar procedure of using a large forum is followed

for defining other characteristics of each player, such as the tactical position and the dominant foot. All data are subject to final approval from the experts who manage transfermarkt.de before being included in the database (Herm et al., 2014; Scelles et al., 2014) and made publicly available.

The soccer players' *sports performance* was measured by the total number of games in the career to date of each player. Similar proxy for sports performance was also used by Franck and Nüesch (2010) and by Deaner et al. (2013). Data for this variable were collected from Transfermarkt. For those Brazilian players that were in foreign teams and played abroad, we considered only the number of games played in the national league, the national cup and the official international tournaments. This measure is appropriate because players that played more in official games are likely to be the best performers (Franck & Nüesch, 2010) and thus are more often selected by the coaches. These players also have fewer absences due to such hazards as injuries and suspensions (Deaner et al., 2013).

The independent variable is the *birth quarter* of the soccer players. To test for a possible reverse RAE we coded the age of the players in quarters with the birth data available in Transfermarkt. The comparison was made between the fourth quarter and the other three quarters together, as several studies (e.g. Schorer et al., 2009) have shown that the RAE mainly affected those born in the fourth quarter, while those born in the second and third quarters tend to be less affected. We coded as 1 when the players were born in the fourth quarter (between October and December), and as 0 for those players born in all other quarters.

In measuring the birth date, we have followed extant RAE research and measured the birth dates of the players grouping then into quartiles (e.g. Baker & Logan, 2007; Gibbs et al., 2012). The grouping into quartiles aims at aligning the birth dates to the selection cut-off date in different sports (beginning, before the middle of the year, after the middle of the year and the end of the year from the cut-off date), and not the calendar year (McCarthy et al., 2015). In any instance, other studies have presented birth data in different forms, such as distinguishing only between the first and second semester of the year or separating in three periods of four months (e.g. Simmons & Paull, 2001). Yet other studies have presented the results in months, but ended up grouping in quartiles to facilitate discussion and comparison of data with previous studies (e.g. Helsen et al., 2005; Poli et al., 2015a).

We included a number of control variables to account for characteristics of the players, their career and the team played for. Data for these variables were collected from Transfermarkt.

We controlled for the *players' age* since it is likely to influence the soccer players' experience, physical condition and market value. That is, younger players in the early stages of their careers probably have a lower market value, and as they show better performance their market value increases (Scelles et al., 2014). Age is also influential in the number of games played during the career to date, since older players have a higher likelihood of having played in a larger number of games (Deaner et al., 2013). However, we may expect the relation between the players' age and value and performance to be nonlinear. Although age may translate into experience, as players' age their physical condition may decline and hence we used age in squared form.

We controlled for the *tactical sector* to account for the positions of the players in the team. Some positions may be more valued than others. For instance, in soccer, the average market value of the forwards is higher than of the defenders (Lucifora & Simmons, 2003). Taking RAE into account, Ashworth and Heyndels (2007), studying professional German soccer players, observed that defenders born in the fourth quarter had higher average salaries than those born in other quarters; they did not find a difference for forwards. Data on the tactical sector was collected from Transfermarkt.de, which is updated with the last performance of the players carried out through specific forums with the site users, then reviewed and finally approved by the site managers. We created four variables for the tactical sector: goalkeeper, defense, midfield, and forward, coded as 1 for players in the specific tactical sector, and as 0 otherwise – that is, if they play in other tactical sector. For instance, players that were goalkeepers were coded as 1, and all other as 0; similarly for the other 3 tactical positions. Goalkeeper was used as the base case.

We also controlled for the *dominant foot* of the players – that is, with which foot they are able to play or are more proficient. Ambidextrous players tend to be more valued than single-footed players, and left-footed players to be more valued than right-footed (Bryson et al., 2013), and perhaps perform better. Data on the dominant foot was collected from Transfermarkt.de. This information is provided following the same criteria of tactical sector and market value, through specific forums with the site users, then reviewed and finally approved by the site managers. We created three dichotomous variables to account for the dominant foot: right foot, left foot and ambidextrous. For instance, measuring the left foot we assessed whether the players' dominant foot was the left, in which case we assigned a value of 1, and 0 otherwise (for right foot and ambidextrous). Right foot was used as the base case.

The *team* of the player was also accounted for. In the soccer leagues, there are tremendous differences in the investments made by teams in hiring players (Hall, Szymanski, & Zimbalist, 2002). Since we do not have accurate measures of the teams' values, and often players are bought and sold for undisclosed amounts, we categorized the teams into two groups, based on the average players' market value. Thus, eleven teams formed a group in which players have an average value of more than 1.5 million euros, while nine teams formed the second group, with average values of less than 1.5 million euros. We coded the team as a dummy variable, such that 1 – the player was in a team with an average value per athlete of over 1.5 million euros, and 0 – otherwise.

We controlled for the *mobility* of the player, which means the number of clubs each player played during their career to date. This is a count variable. Interestingly, players who moved frequently between clubs had average lower market values in comparison to those that stayed with the same team for longer periods of time (see also Velema, 2018).

We controlled for the *initial club* each player turned professional. This is important to account for the career of the players. Some players were promoted to the professional team in top clubs, where the environment tends to be more competitive, while other players started in smaller clubs where we may expect a lower influence of an RAE (Musch & Grondin, 2001). We coded the initial club as a dummy variable, with 1 if the player started his career in one of the clubs that played the first division, and 0 otherwise.

We also controlled for the number of years each player was in a foreign team (outside Brazil) during his career. We organized the data into three variables, considering the level of difficulty of the league: *Euro Top*, *Euro 2nd* and out of Euro. Euro Top

includes the teams in the first division of the 5 main leagues in Europe (England, Germany, Spain, Italy and France). This is a count variable for the number of years the player had in these teams. *Euro 2nd* refers to other European leagues out of the top five (e.g. Portuguese, Dutch, Irish, etc.). The variable is a count variable for the number of years. *Out of Europe* includes other foreign countries not European and not Brazil. Again, this was a count variable. Hence, the players that only played in Brazil were used as the base case.

Procedures of analysis

For the statistical tests, we conducted a multiple linear regression, which is appropriate given the dependent variables market value and sports performance. Additional analysis involved Pearson's non-parametric chi-square test to verify the adherence between observed data and expected data, used to compare frequencies between birth quarters.

Results

Table 2 shows the descriptive statistics and the correlations. Although some correlations are significant, they are not as high as to raise multicollinearity concerns, and the Variance Inflation Factor (VIF) is always below 3.7.

Table 3 presents the results of the testing of the hypotheses. We run a set of regressions for each dependent variable: market value and sports performance. Model 1 includes only the control variables, for market value. The team value is significant as could be expected. Model 2 tests hypothesis 1 proposing a positive relation between being born in the fourth quarter and the players' market value. The coefficient in model 2 is positive and in the predicted direction, but not significant. Hence, we cannot confirm a relation between the players' market value and their quarter of birth, in this sample of Brazilian professional soccer players.

Model 3 includes only the control variables for the dependent variable sports performance. Model 4 tests hypothesis 2 proposing a positive relation between reverse relative age and the sports performance. A positive and significant coefficient ($\beta = 0.60$, $p = 0.037$) confirms the hypothesis. Moreover, we obtained an R^2 accounting for 53.2% of the variability of sports performance. This result confirms the existence of an RAE reversal in Brazilian soccer, in which those born at the end of the year (and arguably disadvantaged during childhood and adolescence in relation to the cut-off date of the category), seem to have a better sporting career performance than those born in the other quarters.

We conducted a robustness test on the manner the relative age is measured. This is relevant because the majority of the studies use the birth quarters of the players, which could be perceived as a coarser measurement when finer-grained scales are also available (e.g. 12 months or 365 birth dates). That is likely because of the small magnitude of the effect, and justification for this downgrading was not provided in previous research. We did additional analyses testing for first versus each of second to fourth quarter individually which revealed no significant effect. In addition, we also tested for an RAE using the players' exact birth date (1–365 days) which, again, did not reveal a significant effect. These additional analyses are available as supplementary material (online).

Table 2. Descriptive and correlations matrix.

Variable	Mean	Std Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Quarter 4	0.153	0.360	1.000													
2. Market value	13.6819	0.993	0.067	1.000												
3. Sport performance	4.2816	1.198	0.054	0.635**	1.000											
4. Age Sq.	713.0670	259.672	−0.007	0.161**	0.673**	1.000										
5. Defense	0.32	0.469	−0.058	−0.041	0.006	−0.041	1.000									
6. Midfield	0.34	0.475	−0.044	−0.027	−0.013	0.029	−0.500**	1.000								
7. Forward	0.26	0.437	0.089*	0.082*	0.055	−0.081*	−0.407**	−0.424**	1.000							
8. Left Foot	0.220	0.414	−0.025	0.039	0.000	−0.069	0.104*	−0.044	−0.044	1.000						
9. Ambidextrous	0.028	0.166	0.095*	0.025	0.017	0.025	−0.054	0.067	0.015	−0.091*	1.000					
10. Team	0.491	0.500	−0.011	0.415**	0.170**	0.012	0.059	−0.015	−0.058	0.106**	−0.007	1.000				
11. Mobility	5.057	3.539	0.014	0.074	0.501**	0.625**	−0.036	−0.005	0.104*	0.007	0.014	−0.166**	1.000			
12. Initial Club	0.551	0.498	−0.062	−0.066	−0.012	−0.075	−0.024	0.039	−0.022	−0.014	−0.048	0.124**	−0.128**	1.000		
13. Top Euro	0.416	1.572	−0.019	0.136**	0.314**	0.374**	−0.082*	0.084*	0.028	0.016	0.073	0.129**	0.207**	0.073	1.000	
14. Euro 2nd	0.350	1.101	−0.036	0.155**	0.241**	0.226**	−0.101*	0.021	0.089*	−0.011	0.159**	0.081*	0.215**	0.083*	0.044	1.000
15. Out of Euro	0.293	1.021	−0.045	−0.014	0.189**	0.316**	−0.107**	0.014	0.148**	−0.036	−0.013	−0.050	0.335**	0.061	0.046	0.048

Note. Two-tailed Pearson correlations. $N = 601$.
*$p < 0.05$.
**$p < 0.01$.

Table 3. Regression results.

	Market value		Sports performance	
	Model 1	Model 2	Model 3	Model 4
Age sq	0.148 (0.007)**	0.147 (0.007)**	0.637 (0.000)***	0.636 (0.000)***
Defense	0.032 (0.654)	0.039 (0.590)	0.295 (0.000)***	0.302 (0.000)***
Midfield	0.055 (0.447)	0.061 (0.402)	0.263 (0.000)***	0.268 (0.000)***
Forward	0.156 (0.029)*	0.155 (0.030)*	0.343 (0.000)***	0.342 (0.000)***
Left foot	0.010 (0.796)	0.010 (0.780)	0.018 (0.528)	0.019 (0.509)
Ambidextrous	0.009 (0.803)	0.003 (0.944)	−0.012 (0.663)	−0.019 (0.509)
Team	0.415 (0.000)***	0.414 (0.000)***	0.170 (0.000)***	0.169 (0.000)***
Mobility	0.052 (0.309)	0.049 (0.334)	0.126 (0.001)**	0.123 (0.002)**
Initial Club	0.034 (0.367)	0.037 (0.331)	0.058 (0.047)*	0.060 (0.038)*
Euro Top	0.008 (0.852)	0.010 (0.811)	0.018 (0.560)	0.020 (0.516)
Euro 2nd	0.064 (0.100)	0.068 (0.080)	0.050 (0.097)	0.054 (0.072)
Out of Euro	−0.084 (0.039)*	−0.079 (0.050)	−0.075 (0.016)*	−0.071 (0.023)*
Intercept	12.605	12.572	0.976	0.936
Quarter 4		0.065 (0.080)		0.062 (0.027)*
R^2	0.225	0.229	0.542	0.546
R^2 adjusted	0.209	0.212	0.533	0.536
F-value	14.220	13.409	57.959	54.231
N	601	601	601	601

Note. The data presented are the Beta-coefficients. In parenthesis the *p* values.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

Additional analyses

To grasp a better understanding of how age and a reverse RAE may matter, we conducted additional analyses. First, regarding the frequency of players in the different age groups according to their quarter of birth. We classified the sample into age groups of 2 years (Figure 1). The chi-square test revealed a significant difference ($p = 0.03$) for the players 21–22 years old compared to the others; showing a larger number of players in the first

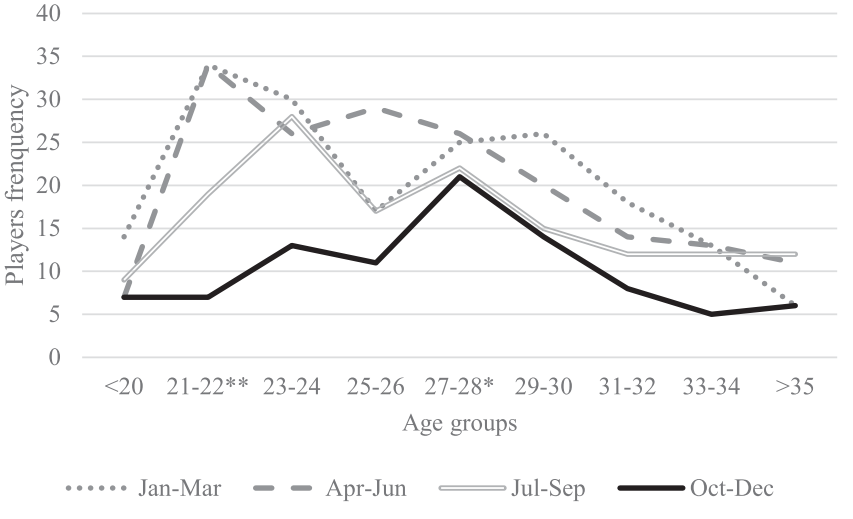

Figure 1. Frequency of players by age groups and quarters of birth. **$p < 0.05$, with the fourth quarter lower than expected (Relative age effect). *$p < 0.1$, with the fourth quarter higher than expected (Reverse effect).

three quarters of the year (from January to September) compared to those born in the fourth quarter.

For the age group of 27–28 years, the chi-square test showed only a marginal significance ($p = 0.058$) but it is indicative of a substantial increase in the frequency of players born in the fourth quarter compared to the other quarters. This may be evidence of the RAE reversal we theorized, although the older players in this sample do not surpass the remaining quarters in any age group. This may suggest that in this age group, the players are already fully formed, perhaps at the peak of their sports performance, and that there is late recognition of players neglected early in their professional career as put forth by Coutts et al. (2014) and McCarthy et al. (2015). A similar distribution was found in the study by Poli et al. (2015a) and the authors emphasized that there was a decrease in the RAE as age advances, but the frequency of players remains superior for the first quarters until the end of the career.

We also scrutinized the frequency of players relating the quarter of birth with the tactical sector (Table 4), since there is some evidence that an RAE may be more pronounced for some positions, or tactical sectors, than others (UEFA, 2016). A chi-square test showed a marginal significance only in the forward sector ($p = 0.059$). This finding sheds additional insight into the conflicting results in the studies by Lucifora and Simmons (2003) and Ashworth and Heyndels (2007) on the salaries received by players in different tactical sectors. We did not find any significant difference for players in the other tactical sectors related to their birth quarters. However, in a study with European players conducted by UEFA (2016), the results showed a higher frequency of players born in the first quarter only in the positions of goalkeepers and defenders, but not for forwards. That is, it seems that the physical and maturational advantages of the athletes are more enduring in the defensive positions of the game. While in the offensive positions, the technical requirement is greater than the physical, which opens greater possibilities for those born at the end of the year, as mentioned by Ashworth and Heyndels (2007). Thus, it is reasonable to conclude that defenders are benefited by the RAE, while forwards are benefited by the reverse RAE.

Furthermore, we examined the frequency of the dominant foot, comparing the players born in the fourth quarter with the other quarters (Table 5). The chi-square showed a significant difference ($p = 0.022$) only for the ambidextrous players, who were more frequent than expected in the fourth quarter. Although there is a low frequency of ambidextrous players in the sample (in fact, reflecting the reality since the majority of the players are single-footed), a third of these were born in the fourth quarter. Since ambidextrous players are capable of playing equally well with both feet, they are usually classified as excellent technical players and with greater ease to adapt to different tactical positions

Table 4. Frequency of players by tactical sectors.

Tactical Sectors	First to third Quarter (January–September)		Fourth quarter (October–December)		*p*-Value
Goalkeeper	37	6.2%	9	1.5%	0.422
Defense	171	28.5%	24	4.0%	0.244
Midfield	179	29.8%	27	4.5%	0.380
Forward	122	20.3%	32	5.3%	0.059$^{\tau}$
Total	509	84.7%	92	15.3%	0.096

$^{\tau}p < 0.06$.

Table 5. Frequency of players by dominant foot.

Dominant foot	First to third Quarter (January–September)		Fourth quarter (October–December)		*p*-Value
Right	381	63.4%	68	11.3%	0.263
Left	117	19.5%	18	3.0%	0.433
Ambidextrous	11	1.8%	6	1.0%	0.022*
Total	509	84.7%	92	15.3%	0.028*

*$p < 0.05$.

and sides of the field (Bryson et al., 2013). The higher proportion of ambidextrous players in the fourth quarter may be revealing of the suggestion put forth by Ashworth and Heyndels (2007) that those born in the fourth quarter can reach the adult category, despite the adversities, because they have better technical quality in comparison to players born in other quarters. This reinforces our proposal of a reverse RAE, whereby fourth-quarter players are more skilled than their peers and are able to survive in the unfavorable environment of the youth categories. In the other two cases, of the players with the right or left dominant foot, there was no difference in the frequencies expected across the tactical sectors.

Discussion and concluding remarks

The extant literature is abundant in observing an RAE (e.g. Musch & Grondin, 2001; Poli et al., 2015a) and in confirming some effects of relative age (e.g. Rabelo et al., 2016). The scrutiny of a possible reverse RAE has been less frequent and we contribute to that debate. Our argument is that the players born in the last quarter of the year would have greater technical quality than those players born in other quarters; and assessed the possible effect of the reverse RAE against two measures: the players' market value and their sports career performance. Thus, we have tested a reverse RAE proposing that the players born in the fourth quarter of the year would have higher market value and greater performance than those players born in all other quarters. Empirically, we constructed a dedicated dataset on the Brazilian professional soccer players.

Our argument has rested on the rationale that if players born in the fourth quarter reach the professional category despite the probable odds against them, then it is probable that these players demonstrate higher technical quality than other players. These players overcame the adversities of the youth categories where they played with and against older players (Ashworth & Heyndels, 2007). Moreover, these players, that had reduced chances of being selected into youth teams, may have developed unaffected by the possible dysfunctional effects of talent development systems (e.g. early specialization, early reinforcement of intensified practice, injury, paternalism, etc.).

This study contributes conceptually to the debate on a possible reverse RAE, and more broadly to studies scrutinizing the age effects. Our findings confirmed an influence on the players' sports performance. This is interesting and reinforces the findings of Deaner et al. (2013) that analyzed professional hockey and found evidence of higher sports performance of the players born in the fourth quarter, both in relation to the number of games in their career and the number of goals scored. Until now, only the studies by Deaner et al. (2013) and Fumarco and Rossi (2018) had examined such effects for sports performance, but in ice hockey. Moreover, this is the first study to estimate the market value of the

players in relation to the RAE reversal. However, our findings did not confirm an effect on the players' market value, which is somewhat contrary to the results of Ashworth and Heyndels (2007), where they found that German soccer players born in the fourth quarter tend to have a higher salary.

Our study showed that in the 27- and 28-year-old age group, there was a high frequency of players born in the fourth quarter, higher than expected for the sample (Figure 1). This represents a late insertion of players born in the final of the year who were passed over at the beginning of their career over those born at the beginning of the year, which means that it is the football market correcting managers' decision-making in the professionalization of young players. We also showed a higher concentration of attacking players (Table 4) and ambidextrous players (Table 5) for those born in fourth quarter compared to the other quarters, which may be related to the higher technical quality of the players.

There are also practical/managerial implications for sports managers in three main areas. First, our findings may help to improve talent detection, selection, and promotion. Considering that players born at the end of the year tend to be less valued by the clubs, evidence that they perform better in the long term is important to change how team managers and coaches select players. Coaches should focus more on the athletes' technical and tactical development, and suffer less pressure for results (Grossmann & Lames, 2013) which will allow them to make longer-term decisions.

Second, sports managers and coaches may act to foster the players' development. For example, to accelerate the development of those born at the beginning of the year by exploiting the peer effect, promoting young players to the above categories in an intentional strategy of players' development. Identical actions may be deployed for those born at the end of the year, to hold them for more time in youth teams allows them to play with younger players from the beginning of the year. This should improve the evaluation of the fourth-quarter players' technical skills.

Third, for the sports federations and leagues, it is relevant to understand the unbalances created by the age groups and divisions. Some managerial actions should be taken to minimize the influence of the RAE on the young players and the reverse RAE in the long run. Some actions may include, a variation of the cut-off date for each year, for example, alternating between January and July, which would allow athletes born in the second half to be the oldest in the category the following year (Musch & Grondin, 2001). A recommendation may be to organize the youth leagues with just one year of birth for each category (maximum of 12 months) and not with two years (see also Helsen et al., 2005). Although the RAE is known in the scientific world, most grassroots coaches do not know the subject. Therefore, this theme should be part of coach training courses (Grossmann & Lames, 2013; UEFA, 2016).

Limitations and future research

This study has limitations worth noting. For instance, although we controlled for age, the relationship between age and performance and market value is not linear. This makes it difficult to individually identify variations in players' performance and market value. As a consequence, we do not know who of the lower-performing and lower-value younger players remain lower-performing and lower-value players and who are just 'not yet high-performing and/or not yet high-value' players. Moreover, we sampled 601 Brazilian

professional soccer players who participated in the Brazilian National League of 2015. This was a scope decision that avoided dealing with different rules and regulations across countries and time. Nonetheless, we acknowledge that generalizations to other countries and sports need to be cautious. Additional studies extending to other countries and other sports, comparing practices and institutional regulations are warranted.

We also have limitations pertaining to the data. We assessed the players' sports performance by the number of games played during their career to date. More sophisticated measures of the technical fundamentals, such as the number of goals scored, right and wrong passes, goal assists, fouls committed and suffered, among others, may be employed. In additional, a far larger number of effects may account for differences in the players' performance and market value that future studies may account for. For instance, while we have included a number of controls for the career, future research may delve further in tracking the career of the players, in a longitudinal study, considering players' playing/selection status during young age and during adult age. This would then allow analysis of early and late-born players longitudinally regarding the development of their performance through youth and adulthood. This would be a more stringent approach to investigate the reversal of the RAE.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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