



The Beginning of Senior Career in Team Sport Is Affected by Relative Age Effect

Corrado Lupo¹, Gennaro Boccia¹, Alexandru Nicolae Ungureanu¹, Riccardo Frati², Roberto Marocco² and Paolo Riccardo Brustio^{1*}

¹ NeuroMuscularFunction Research Group, School of Exercise & Sport Sciences, Department of Medical Sciences, University of Turin, Turin, Italy, ² School of Exercise & Sport Sciences, SUIISM, University of Turin, Turin, Italy

OPEN ACCESS

Edited by:

Miguel-Angel Gomez-Ruano,
Polytechnic University of Madrid,
Spain

Reviewed by:

Fábio Angioluci Diniz Campos,
Instituto Federal Goiano (IF Goiano),
Brazil
Jon Irazusta,
University of the Basque Country,
Spain

Antonio García De Alcaraz
Serrano,
University of Almería, Spain

*Correspondence:

Paolo Riccardo Brustio
paoloriccardo.brustio@unito.it

Specialty section:

This article was submitted to
Movement Science and Sport
Psychology,
a section of the journal
Frontiers in Psychology

Received: 18 April 2019

Accepted: 11 June 2019

Published: 26 June 2019

Citation:

Lupo C, Boccia G,
Ungureanu AN, Frati R, Marocco R
and Brustio PR (2019) The Beginning
of Senior Career in Team Sport Is
Affected by Relative Age Effect.
Front. Psychol. 10:1465.
doi: 10.3389/fpsyg.2019.01465

Many previous studies in national team sports did not report evidence about relative age effect (RAE) in senior categories. This study aimed for the first time to determine if the RAE may specifically affect the early, but not the late, phase of senior career in elite team sports. A total of 3,319 birthdates (basketball: $n = 642$; rugby: $n = 572$; soccer: $n = 1318$; volleyball: $n = 337$; water polo: $n = 450$) of elite senior players were analyzed. Senior players with an age lower or equal to the 25^o percentile of age were considered as *early phase* players while the others as *late phase* players. Separate Poisson regression models were applied to investigate the RAE in each sport (overall, and for *early phase* and *late phase* subgroups). Considering the overall sample, players born close to the beginning of the year were 1.57, 1.34, 2.69, 1.48, and 1.45 times more likely to reach first and second Italian division of basketball, rugby, soccer, volleyball, and water polo respectively, than those born in the last part of the year. RAE was present in all *early phase* subgroups. Differently, in the *late phase* subgroups the RAE was present only in soccer. Data highlighted a bias in the selection of senior teams, which may limit the chance to identify talented players born late in the second part of the year. Italian sport federations should promote the talent development of relatively younger players by equally promoting the joining of young players to senior teams.

Keywords: talent identification, biological age, team sports, physical maturation, RAE

INTRODUCTION

In sport context, birthdates are usually chosen to gather sport categories of adolescents and young athletes. Literature reported that in youth teams' relatively older players (i.e., athletes born close to cut-off date of selection) and relatively younger players (i.e., athletes born far away to cut-off date of selection) may present large differences in physical and psychological maturation (Cobley et al., 2009; Lovell et al., 2015). As consequence, relatively older players are advantaged in sport performance if compared with relatively younger players (Cobley et al., 2009) and have more probabilities to be selected by coaches and talent scouts (Lovell et al., 2015; Furley and Memmert, 2016; Sarmiento et al., 2018). This leads to an over-representation of athletes born close to selection date. This phenomenon is recognized with the name of Relative Age Effect (RAE) (Barnsley et al., 1985; Musch and Grondin, 2001; Boccia et al., 2017).

The RAE has been successively observed in several individual (Cobley et al., 2018; Kearney et al., 2018; Brustio et al., 2019) and team sports. In the latter sport area, this phenomenon has been especially investigated in soccer (Fumarco and Rossi, 2015; Gonzalez-Villora et al., 2015; Sierra-Diaz et al., 2017; Brustio et al., 2018; Rada et al., 2018), basketball (Arrieta et al., 2016;

Rubajczyk et al., 2017; Steingrover et al., 2017; Ibanez et al., 2018), and rugby union (Till et al., 2010; McCarthy et al., 2016; Jones et al., 2018), but also in other team sports such as volleyball (Campos et al., 2016) and water polo (Barrenetxea-Garcia et al., 2018). Despite the pervasiveness of RAE in youth sport teams, controversial results were found at senior professional level (Delorme et al., 2009; Romann et al., 2018). For example, large RAE was found in soccer (Gonzalez-Villora et al., 2015; Brustio et al., 2018), while small or negligible RAE was observed in other sport teams such rugby league (Delorme et al., 2009; Till et al., 2010; Jones et al., 2018), basketball (Delorme et al., 2009; Werneck et al., 2016; López de Subijana and Lorenzo, 2018), volleyball (Campos et al., 2016) and water polo (Barrenetxea-Garcia et al., 2018). A discrepancy in RAE at senior professional level may also emerge in relation to the countrywide. For example, in a nationwide analysis of most popular sports in Switzerland (Romann et al., 2018), despite authors found an overall RAE in male athletes, RAE associated to single sports reported substantial differences. Similarly, Delorme et al. (2009) showed in French male professional players a different pattern in RAE according to the sport teams considered. Specifically, a significant RAE was observed only in ice-hockey while only a trend was detected in handball and rugby union but not in basketball, soccer or volleyball. Interesting, a different trend was observed in female professional players, where RAE was found to be small or not present at all (for an extensive review and meta-analysis see Smith et al., 2018). Indeed, the social context, the level of competition, the popularity, and number of active participants may affect the presence of RAE (Musch and Grondin, 2001). The paucity of studies focused on RAE of different team sports in the same countrywide is evident, and further studies are strongly needed.

New evidences underlined a reversal RAE at senior professional level, where relative younger players may have the greatest potentiality for a later success (McCarthy et al., 2016; Till et al., 2016). In other words, it is possible that relative younger players may have the chance to be identified and selected at senior professional level at late stage of their career. Accordingly, as previously suggested, it is possible that RAE magnitude may differ in the early and late phase of professional senior career (Brustio et al., 2018). Indeed, it is likely to hypothesize that only the first years of senior career may be affected by the RAE. This would mean that the relatively older athletes (i.e., those born close to the selection date) may be advantaged in entering the senior teams. Despite this sensible hypothesis, previous studies, focusing on RAE at senior level, investigated the senior teams without differentiating between the athletes in the first years of senior career and the others (Delorme et al., 2009; Till et al., 2010; Werneck et al., 2016; Jones et al., 2018; López de Subijana and Lorenzo, 2018).

Thus, the aim of this study was to quantify the prevalence and magnitude of RAE in male Italian context at professional senior level (i.e., first and second division), focusing on basketball, rugby (i.e., rugby union, 15 players each team), soccer, volleyball, and water polo, which are the most popular team sports in Italy¹. In

addition, RAE was separately quantified for players competing in the early (*early phase* players) and later (*late phase* players) stage of their senior career in order to determine if the RAE in senior team may be influenced over time.

MATERIALS AND METHODS

Design

Birthdates of 3,319 male athletes were collected from the first and second Italian division of basketball, rugby, soccer, volleyball and water polo for the 2017–2018 seasons. Date of birth was obtained from different sources such as TransferMarkt database for soccer players and web sites of clubs for the other sports. Data collection has been performed at the end of the season, when the teams' rosters are consolidated after eventual players moving among different clubs. All players included in the rosters of senior teams were considered in this analysis regardless of the age.

Procedure

A total of 642 (mean age = 25.6 ± 5.6 years), 572 (mean age = 24.2 ± 4.5 years), 1318 (mean age = 25.0 ± 5.0 years), 337 (mean age = 25.6 ± 5.5 years), and 450 (mean age = 25.6 ± 6.3 years) male elite players were analyzed in basketball, rugby, soccer, volleyball, and water polo, respectively. The 18, 7, 9, 4, and 24 % of the subjects in basketball, rugby, soccer, volleyball, and water polo, respectively aged less than 18 years. Players' names were removed from the data set. Since our data are based on anonymous resources, no informed consent was requested. This study was approved by the local ethics committee of the University of Turin (Italy) and conducted in accordance with the declaration of Helsinki.

Statistical Analyses

To explore the possible differences in RAE between *early phase* and *late phase* players, the whole sample of each sport was split in two subgroups on the basis of their age. Those senior players with an age lower or equal to the 25th percentile of age of the considered sport (i.e., the first quartile of players in terms of age) were considered as *early phase* players; the rest of sample was considered as *late phase* players. It is likely that *early phase* players (i.e., the younger players in the senior sample) were those in their first years of their adult career. In absence of the actual year of entering the senior team, the age of the player has been considered as the most sensible index to determine if a player is in the early or late phase of his adult career.

In Italy, the youth categories are based on calendar years, for which all young players born from 1st January to 31st December of a calendar year are grouped together. Thus, the birth week (W_B) and the time of birth (T_B) of each player were computed according to previous studies (Brustio et al., 2018, 2019; Doyle and Bottomley, 2018, 2019). W_B indicates the week of the year of player's birth while T_B indicates how far from the beginning of the year a player was born (range score between 0 and 1).

In line with recent studies on RAE (Brustio et al., 2018, 2019; Doyle and Bottomley, 2018, 2019; Rada et al., 2018), a separate Poisson regression was applied to investigate the RAE in each

¹<https://www.coni.it>

team sport following the formula $y = e^{(b_0 + b_1x)}$. Specifically, y represents the frequency of birth in a given week while x represents the T_B . Moreover, the Index of Discrimination (ID), which provided the relative odds of being selected for a player born in the first versus last week of the competition year (Doyle and Bottomley, 2018, 2019), was calculated as e^{-b_1} . Finally, likelihood ratio R^2 was computed (Cohen et al., 2013). All data were analyzed in MATLAB R2017b (Mathworks, Natick, MA, United States).

RESULTS

Figure 1 reports the scatter-plots of relative birth frequency by week, the red line in the **Figure 1** represents the best fit of the Poisson regression modeling the frequency of birth in a given week the T_B . **Table 1** shows the descriptive statistic of W_B and T_B , and the output of Poisson regression for each subgroup and sport. The **Table 1** shows that the players of each considered sport were born at beginning of the year (mean T_B range: 0.42–0.48). Moreover, players born close to the beginning of the year (i.e., in the first week of the year) were 1.57, 1.34, 2.69, 1.48, and 1.45 times more likely to reach first and second Italian division of basketball, rugby, soccer, volleyball, and water polo than those born in the last part (i.e., last week) of the year (see ID values).

The cut-off ages for discriminating *early phase* and *late phase* subgroups were: 19 years, for basketball and water polo; 21 years, for rugby and soccer; and 22 years, for volleyball. According to these scenarios, the results suggested that the amount of RAE

was greater in the *early phase* than *late phase* subgroup of players in each sport. In fact, the Poisson regressions were significant for *early phase* players in basketball ($p < 0.0001$; $R^2 = 0.19$), rugby ($p = 0.01$; $R^2 = 0.14$), soccer ($p < 0.0001$; $R^2 = 0.47$), volleyball ($p < 0.03$; $R^2 = 0.16$), and water polo ($p < 0.04$; $R^2 = 0.12$). Differently, Poisson regression was significant for *late phase* subgroups, only in soccer ($p < 0.0001$; $R^2 = 0.47$), but not in the other sports. The T_B indexes in all sports were lower in *early phase* compared to *late phase* subgroups (see **Figure 1**). In addition, coherently to the above-mentioned results, IDs indexes in all sports were greater in *early phase* compared to *late phase* subgroups (see **Table 1**).

DISCUSSION

The aim of this study was to examine the prevalence and magnitude of RAE at senior professional level in Italian team sports, discriminating male players in relation to *early* or *late phase* of career. For this purpose, the birthdates distribution of basketball, rugby, soccer, volleyball, and water polo players competing in the first and second Italian Championships was recorded. The main finding consisted of a large over-representation of players born close to the beginning of the calendar year in early, but not in late, phase of senior career. Soccer was an exception, showing that even *late phase* players presented evidence of RAE, despite smaller than *early phase*.

Considering the overall sample, evidence of RAE was found in each considered team sport. To quantify the RAE, we adopted the ID which consists in the relative odds of being selected

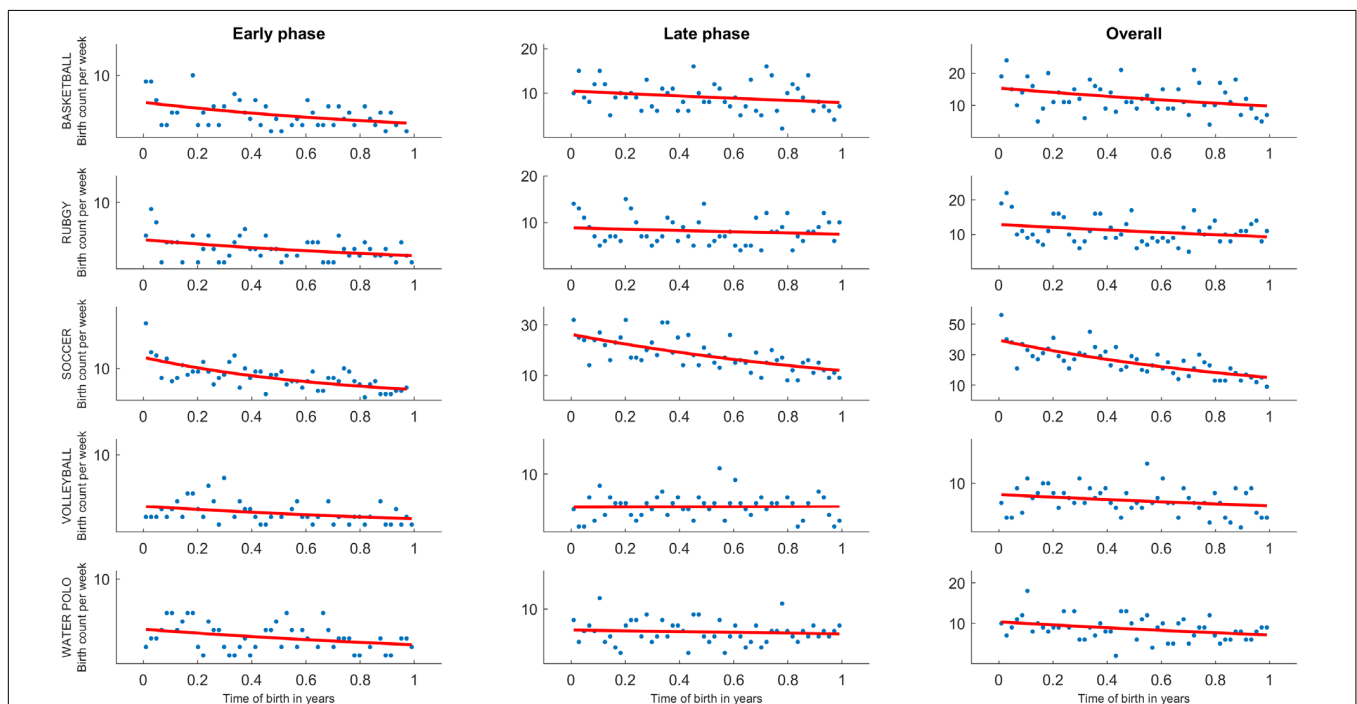


FIGURE 1 | Scatter-plots of birthdates reported for each team sport (i.e., basketball, rugby, soccer, volleyball, and water polo) in relation to the entire samples, and to the *early phase* and *late phase* career subgroups. The red line represents the best fit of the Poisson regression.

TABLE 1 | Poisson regression results in basketball, rugby, soccer, volleyball, and water polo.

		Basketball	Rugby	Soccer	Volleyball	Water polo
Overall	N	642	572	1318	337	450
	W_B	25 ± 15	25 ± 16	22 ± 14	25 ± 14	25 ± 15
	T_B	0.46 ± 0.29	0.48 ± 0.3	0.42 ± 0.28	0.47 ± 0.27	0.45 ± 0.29
	b_0	2.732	2.541	3.687	2.058	2.337
	b_1	-0.454	-0.294	-1.000	-0.392	-0.370
	ID	1.57	1.34	2.69	1.48	1.45
	R^2	0.12	0.07	0.6	0.07	0.11
p value	<0.0001	0.04	<0.0001	0.04	0.02	
Early phase	N	168	149	376	115	147
	W_B	23 ± 15	24 ± 16	21 ± 14	23 ± 15	23 ± 15
	T_B	0.42 ± 0.28	0.44 ± 0.30	0.39 ± 0.27	0.42 ± 0.28	0.43 ± 0.28
	b_0	1.714	1.457	2.581	1.243	1.415
	b_1	-0.866	-0.729	-1.333	-0.716	-0.611
	ID	2.38	2.07	3.79	2.05	1.84
	R^2	0.19	0.14	0.47	0.16	0.12
p value	<0.0001	0.01	<0.0001	0.03	0.04	
Late phase	N	474	423	942	222	303
	W_B	25 ± 15	26 ± 16	23 ± 14	26 ± 14	26 ± 15
	T_B	0.48 ± 0.29	0.49 ± 0.3	0.43 ± 0.28	0.49 ± 0.27	0.49 ± 0.29
	b_0	2.351	2.171	3.283	1.472	1.820
	b_1	-0.288	-0.152	-0.829	0.037	-0.145
	ID	1.33	1.16	2.29	0.96	1.12
	R^2	0.06	0.02	0.47	0	0.01
p value	0.07	0.37	<0.0001	0.87	0.56	

W_B , week in which players born; T_B , time of birth; ID, Index of Discrimination.

for an athlete born in the first versus the last week of the calendar year (Doyle and Bottomley, 2018, 2019). In this study, the IDs ranged from 1.34 to 2.69 underlined the presence of RAE in all considered team sports. Thus, the present results showed a different pattern in senior Italian context compared to International ones, where RAE was small or negligible as observed in basketball (Delorme et al., 2009; Werneck et al., 2016; López de Subijana and Lorenzo, 2018), rugby league (Till et al., 2010), volleyball (Campos et al., 2016) and water polo at senior level (Barrenetxea-Garcia et al., 2018). On the other hand, it possible that the proportion of players with less than 18 years (overall mean = 12%) in analyzed teams may partially influence the results contradicting previous results in senior teams and in accordance with other studies which describe RAE in European National Teams (Arrieta et al., 2016). However, as outlined before, controversial results may arise in relation to the countrywide, because the social context, the level of competitiveness, the popularity, and number of active participants affect the magnitude of RAE (Musch and Grondin, 2001; Cobley et al., 2009; Wattie et al., 2015). Thus, this finding should be considered specific to Italian context and cannot be generalized to other countries. Some speculations could be provided to more deeply interpret the results of the present study. The team sports of our study may be considered as highly physical demanding sports, where strength and power represent a substantial role. Since physical maturation is related to muscular strength, endurance, and speed, and is important to obtain successful performances (Musch and Grondin, 2001;

Cobley et al., 2009), relatively older players could be more favored than younger counterparts. Moreover, soccer, basket, rugby, and water polo are invasion sports and characterized by physical contacts, where higher muscular strength and body dimensions are directly favorable. Differently, despite volleyball is not an invasion sport, greater body dimension and physical capabilities can be favorable as well. This can explain the fact that also volleyball presented RAE values in line with the other sports, even if it is not an invasion sport. Beyond the physical aspect, the influence of social agents such as parents, coaches or the athletes themselves, especially at the beginning of the careers, may amplify RAE (e.g., best coaches, facilities, equipment, higher self-expectations) (Hancock et al., 2013). Furthermore, also environmental factors, such as birthplace, may positively impact on athletes' development and increase the opportunity to obtain success in sport (Côté et al., 2006).

Soccer is the sport more affected by RAE (Table 1). Players born near the cut-off date of selection are nearly three times more likely to play in the first or second division. The larger RAE in soccer may be related to the fact that soccer is the most popular sport in Italy. In fact, the high professionalism of the first and second division can be associated to a more severe player selection in comparison with other team sports. Moreover, the greater attractiveness of soccer compared to other sports in term of media presence and higher funding (Romann et al., 2018) might explain the larger RAE in soccer. In other words, we may speculate that the relative inferior popularity and number of active participants of basketball, rugby, volleyball, and water

polo in Italy, and consequent more opportunities to be selected in elite teams may have minimized the RAE. As consequence, even though soccer can benefit from a huge number of players, its talent selection seems to risk more than other team sports to lose valuable elite players only because of a late physical maturation occurring during the youth phase of career. Therefore, it could be hypothesized a paradoxical phenomenon, where an effective and trivial talent selection is developed in minor team sports and soccer, respectively.

The most interesting result of this study was that in basketball, rugby, volleyball, and water polo, the RAE was present only in *early phase* subgroup (IDs ranged = 1.84–2.38) but not in the *late phase* subgroup (IDs ranged = 0.96–1.33). This finding highlights that, in these sports, relatively younger players may still suffer the initial disadvantage undergone in youth career (Cobley et al., 2009) during their *early phase* of adult career (McCarthy et al., 2016; Till et al., 2016). In soccer, the results presented the same trend but with even more pronounced RAE. Indeed, the ID was extraordinarily large in *early phase* subgroup (ID = 3.8) and lower, but still large, in *late phase* subgroup (ID = 2.3). Taken together, the present findings show that the relatively older soccer players (i.e., those born close the beginning of the year) are facilitated in entering the senior professional teams. Moving from youth to senior team is a delicate passage in players' careers. However, it seems that the relatively older players have early chances to join the senior teams compared to the relatively younger players. Anyway, for relatively younger players, further opportunities to play with senior team should be offered to optimize the process of talent development. However, it is known that the excessive research of immediate successes in youth categories could prevent the promotion of long-term talent development, leading coaches to select youth players with more mature physical characteristics (Lovell et al., 2015; Furley and Memmert, 2016; Sarmiento et al., 2018).

This study presents some limitations. The study considered the whole roster of the selected teams. Hence, it included also foreign players as well as players with less than 18 years. These aspects could potentially influence the observed RAE and the cut-off age used to categorize *early phase* and *late phase* players. Moreover, the present study did not investigate the possible causal factors of RAE, such individual performance during a season (e.g., total minutes and number of the match played) or individual characteristics (e.g., physical fitness performance, physical maturation, and anthropometrical measures) which may better describe the phenomenon. Additionally, the present study focused on male competitions only. Due to the possible small effect of RAE in female sport contexts (Smith et al., 2018), future studies are needed to investigate this phenomenon in the *early* and *late* phase of female players' career. Finally, the present study considered only one year of completion (e.g., 2017–2018

season). Furthermore, studies are needed to investigate the RAE considering the starting age of the players in elite teams as well as the phenomenon longitudinally.

CONCLUSION

At senior professional level, a large over-representation of players born close to the beginning of the year is evident in all popular Italian team sports. However, this trend significantly emerged for the *early phase* of players' career, whereas it was weaker for the *late phase*, which was significant only in soccer. Therefore, these data suggested that relatively older players have more chances to join senior teams especially at the beginning of their adult career.

To limit the negative RAE consequence, Italian sport federations should provide different solutions to advantage all athletes with different time points of development (Hurley et al., 2001; Romann and Cobley, 2015; Mann and van Ginneken, 2017; Haycraft et al., 2018). Since results of present study showed that the RAE is more evident in the early phase of players' career, practitioners should try to find solutions to support athletes in the transition from youth to senior teams. Taking in mind that even relatively younger players can reach top-level senior competition, team sports coaches should consider the later development trajectories of youth athletes. Thus, they should promote the talent development of the relatively younger players by equally promoting the joining of young players to senior teams.

DATA AVAILABILITY

The datasets generated for this study are available on request to the corresponding author.

AUTHOR CONTRIBUTIONS

CL, GB, and PRB conceptualized and supervised the study and wrote the original draft of the manuscript. All authors investigated the study, wrote, reviewed, and edited the manuscript. PRB carried out the formal analysis. CL acquired the funding.

FUNDING

All the funding regarding the realization of this study were received internally to the authors' organization (CL's Departmental funding; Department of Medical Sciences, University of Torino, Turin, Italy). There was no additional external funding received for this study.

REFERENCES

Arrieta, H., Torres-Unda, J., Gil, S. M., and Irazusta, J. (2016). Relative age effect and performance in the U16, U18 and U20 European basketball championships. *J. Sports Sci.* 34, 1530–1534. doi: 10.1080/02640414.2015.1122204

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Birthdate and performance: the relative age effect. *Can. J. Hist. Sport Phys. Educ.* 51, 23–28.

Barrenetxea-Garcia, J., Torres-Unda, J., Esain, I., and Gil, S. M. (2018). Relative age effect and left-handedness in world class water polo male and female players. *Laterality* 24, 259–273. doi: 10.1080/1357650X.2018.1482906

- Boccia, G., Rainoldi, A., and Brustio, P. R. (2017). Relative age effect in males, but not females, undergraduate students of sport science. *Sport Sci. Health* 13, 349–353. doi: 10.1007/s11332-017-0364-7
- Brustio, P. R., Kearney, P. E., Lupo, C., Ungureanu, A. N., Mulasso, A., Rainoldi, A., et al. (2019). Relative age influences performance of world-class track and field athletes even in the adulthood. *Front. Psychol.* 10:1395. doi: 10.3389/fpsyg.2019.01395
- Brustio, P. R., Lupo, C., Ungureanu, A. N., Frati, R., Rainoldi, A., and Boccia, G. (2018). The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie A. *PLoS One* 13:e0196253. doi: 10.1371/journal.pone.0196253
- Campos, F. A. D., Stanganelli, L. C. R., Rabelo, F. N., Campos, L. C. B., and Pellegrinotti, Í. L. (2016). The relative age effect in male volleyball championships. *Int. J. Sports Sci.* 6, 116–120.
- Cobley, S., Abbott, S., Dogramaci, S., Kable, A., Salter, J., Hintermann, M., et al. (2018). Transient relative age effects across annual age groups in national level Australian swimming. *J. Sci. Med. Sport* 21, 839–845. doi: 10.1016/j.jsams.2017.12.008
- Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005
- Cohen, J., Cohen, P., West, S. G., and Aiken, L. S. (2013). *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*. New York, NY: Routledge.
- Côté, J., Macdonald, D. J., Baker, J., and Abernethy, B. (2006). When “where” is more important than “when”: birthplace and birthdate effects on the achievement of sporting expertise. *J. Sports Sci.* 24, 1065–1073. doi: 10.1080/02640410500432490
- Delorme, N., Boiche, J., and Raspaud, M. (2009). The relative age effect in elite sport: the French case. *Res. Q. Exerc. Sport* 80, 336–344. doi: 10.1080/02701367.2009.10599568
- Doyle, J. R., and Bottomley, P. A. (2018). Relative age effect in elite soccer: more early-born players, but no better valued, and no paragon clubs or countries. *PLoS One* 13:e0192209. doi: 10.1371/journal.pone.0192209
- Doyle, J. R., and Bottomley, P. A. (2019). The relative age effect in European elite soccer: a practical guide to poisson regression modelling. *PLoS One* 14:e0213988. doi: 10.1371/journal.pone.0213988
- Fumarco, L., and Rossi, G. (2015). *Relative Age Effect on Labor Market Outcomes for High Skilled Workers—Evidence from Soccer*. Available at: <http://www.bbk.ac.uk/management/docs/workingpapers/WP9.pdf> (accessed January 18, 2019).
- Furley, P., and Memmert, D. (2016). Coaches’ implicit associations between size and giftedness: implications for the relative age effect. *J. Sports Sci.* 34, 459–466. doi: 10.1080/02640414.2015.1061198
- Gonzalez-Villora, S., Pastor-Vicedo, J. C., and Cordente, D. (2015). Relative age effect in UEFA championship soccer players. *J. Hum. Kinet.* 47, 237–248. doi: 10.1515/hukin-2015-0079
- Hancock, D. J., Adler, A. L., and Cote, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352
- Haycraft, J. A. Z., Kovalchik, S., Pyne, D. B., Larkin, P., and Robertson, S. (2018). The influence of age-policy changes on the relative age effect across the Australian rules football talent pathway. *J. Sci. Med. Sport* 21, 1106–1111. doi: 10.1016/j.jsams.2018.03.008
- Hurley, W., Lior, D., and Tracze, S. (2001). A proposal to reduce the age discrimination in Canadian minor hockey. *Can. Public Policy* 27, 65–75.
- Ibanez, S. J., Mazo, A., Nascimento, J., and Garcia-Rubio, J. (2018). The relative age effect in under-18 basketball: effects on performance according to playing position. *PLoS One* 13:e0200408. doi: 10.1371/journal.pone.0200408
- Jones, B. D., Lawrence, G. P., and Hardy, L. (2018). New evidence of relative age effects in “super-elite” sportsmen: a case for the survival and evolution of the fittest. *J. Sports Sci.* 36, 697–703. doi: 10.1080/02640414.2017.1332420
- Kearney, P. E., Hayes, P. R., and Nevill, A. (2018). Faster, higher, stronger, older: relative age effects are most influential during the youngest age grade of track and field athletics in the United Kingdom. *J. Sports Sci.* 36, 2282–2288. doi: 10.1080/02640414.2018.1449093
- López de Subijana, C., and Lorenzo, J. (2018). Relative age effect and long-term success in the Spanish soccer and basketball national teams. *J. Hum. Kinet.* 65, 197–204. doi: 10.2478/hukin-2018-0027
- Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., and Cobley, S. (2015). Soccer player characteristics in English lower-league development programmes: the relationships between relative age, maturation, anthropometry and physical fitness. *PLoS One* 10:e0137238. doi: 10.1371/journal.pone.0137238
- Mann, D. L., and van Ginneken, P. J. (2017). Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *J. Sports Sci.* 35, 784–790. doi: 10.1080/02640414.2016.1189588
- McCarthy, N., Collins, D., and Court, D. (2016). Start hard, finish better: further evidence for the reversal of the RAE advantage. *J. Sports Sci.* 34, 1461–1465. doi: 10.1080/02640414.2015.1119297
- Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516
- Rada, A., Padulo, J., Jelaska, I., Ardigò, L. P., and Fumarco, L. (2018). Relative age effect and second-tiers: no second chance for later-born players. *PLoS One* 13:e0201795. doi: 10.1371/journal.pone.0201795
- Romann, M., and Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS One* 10:e0122988. doi: 10.1371/journal.pone.0122988
- Romann, M., Rossler, R., Javet, M., and Faude, O. (2018). Relative age effects in Swiss talent development - a nationwide analysis of all sports. *J. Sports Sci.* 36, 2025–2031. doi: 10.1080/02640414.2018.1432964
- Rubajczyk, K., Swierko, K., and Rokita, A. (2017). Doubly disadvantaged? The relative age effect in Poland’s basketball players. *J. Sports Sci. Med.* 16, 280–285.
- Sarmiento, H., Anguera, M. T., Pereira, A., and Araujo, D. (2018). Talent identification and development in male football: a systematic review. *Sports Med.* 48, 907–931. doi: 10.1007/s40279-017-0851-7
- Sierra-Diaz, M. J., Gonzalez-Villora, S., Pastor-Vicedo, J. C., and Serra-Olivares, J. (2017). Soccer and relative age effect: a walk among elite players and young players. *Sports* 5:E5. doi: 10.3390/sports5010005
- Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8
- Steingrover, C., Wattie, N., Baker, J., Helsen, W. F., and Schorer, J. (2017). The interaction between constituent year and within-1-year effects in elite German youth basketball. *Scand. J. Med. Sci. Sports* 27, 627–633. doi: 10.1111/sms.12672
- Till, K., Cobley, S., Morley, D., O’Hara, J., Chapman, C., and Cooke, C. (2016). The influence of age, playing position, anthropometry and fitness on career attainment outcomes in rugby league. *J. Sports Sci.* 34, 1240–1245. doi: 10.1080/02640414.2015.1105380
- Till, K., Cobley, S., Wattie, N., O’Hara, J., Cooke, C., and Chapman, C. (2010). The prevalence, influential factors and mechanisms of relative age effects in UK Rugby League. *Scand. J. Med. Sci. Sports* 20, 320–329. doi: 10.1111/j.1600-0838.2009.00884.x
- Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9
- Werneck, F., Coelho, E., de Oliveira, H., Júnior, D. R., Almas, S., de Lima, J., et al. (2016). Relative age effect in Olympic basketball athletes. *Sci. Sports* 31, 158–161. doi: 10.1016/j.scispo.2015.08.004

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright © 2019 Lupo, Boccia, Ungureanu, Frati, Morocco and Brustio. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.