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Original Article

RELATIVE AGE EFFECT ON NATIONAL BASKETBALL TEAMS AROUND THE WORLD: ANALYSIS BY SEX, AGE, LOCATION AND WORLD RANKING

EFEITO DA IDADE RELATIVA EM SELEÇÕES NACIONAIS AO LONGO DO MUNDO: ANÁLISE POR SEXO, IDADE, CONTINENTE E POSIÇÃO NO RANKING MUNDIAL

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RESUMO

Este estudo teve como objetivo verificar a presença do efeito da idade relativa (EIR) em uma amostra mundial de basquete, considerando sexo, idade (jovem e adulto), posição no ranking mundial da FIBA e região da FIBA. Os dados de data de nascimento foram extraídos do site oficial de acesso aberto da FIBA e agrupados de acordo com o mês de nascimento e estratificados em trimestres como janeiro a março (Q1), abril a junho (Q2), julho a setembro (Q3), e outubro a dezembro (Q4). Testes de qui-quadrado foram utilizados para identificar possíveis discrepâncias na frequência de nascimentos entre os trimestres, e a razão de chances foi calculada entre o número de datas de nascimento no Q1 vs. Q4. A amostra foi composta por 8.664 atletas (3.889 mulheres e 4.775 homens), representando 140 países, desde sub-14 até categorias adultas. O EIR esteve presente em todos os fatores de análise, exceto nos jogadores da Oceania. As discrepâncias mais proeminentes foram mostradas por equipes masculinas, equipes sub-14 e sub-15, equipes de alto escalão mundial da FIBA e equipes da FIBA Américas. Na categoria adulta, embora ainda presente, o EIR apresentou tendência de reversão. Houve uma sobre representação de atletas nascidos no início do ano, independentemente do fator de análise, embora as causas do EIR permaneçam obscuras.
Palavras-chave: esporte coletivo; seleção de talentos; análise de desempenho.

ABSTRACT

Purpose: This study aimed to verify the presence of relative age effect (RAE) in a worldwide basketball sample, considering gender, age (youth and adult), FIBA World ranking position, and FIBA region. Methods: Date of birth data was extracted from the FIBA official open-access website and was grouped according to the month of birth and stratified into quarters such as January to March (Q1), April to June (Q2), July to September (Q3), and October to December (Q4). Chi-square tests were used to identify possible discrepancies in the frequency of births among trimesters, and the odds ratio was calculated between the number of birthdates in Q1 vs. Q4. Results: The sample consisted of 8664 athletes (3889 female and 4775 male), representing 140 countries, from U14 to adult categories. RAE was present in all analysis factors, except for Oceania players. The most prominent discrepancies were shown by male teams, U14 and U15 teams, FIBA world top-ranking teams, and FIBA Americas teams. In the adult category, although still present, RAE showed a trend to be reversed. Conclusions: There was an overrepresentation of early-born athletes, regardless of the factor of analysis, although the causes for RAE remain unclear.
Keywords: team sports; talent selection; performance analysis.

Introduction

Basketball performance demands physical, athletic, and behavioral player attributes[1], which are determined by environmental (influences from coaches, family, friends), task (physical and athletic demands of the sport), and organismic constraints (the individual qualities of humans). In the latter case, the date of birth has been playing a prominent role[2]. Briefly, an individual born in January is at least 300 days ahead in the physical development process, compared to someone born in December of the same year. This phenomenon is known as the relative age effect (RAE)[3], and it has been a growing concern among sports scientists[4-6].

Considering that, in general, the youth categories are standardized by year of birth, athletes born at the beginning and at the end of the year compete together, although they may present profound differences in terms of physical attributes, such as height, for example. In fact, Derlome e Raspaud[7] identified that in youth categories height is one of the top-valued criteria for player selection. Moreover, height and wingspan, besides power, agility, and speed, discriminated between drafted and undrafted professional basketball players[8]. Although the population in the USA showed an increase in height since the 1940s, the average height among NBA players was substantially higher in the same period[9], even surpassing football, baseball, and ice hockey players[10]. Thus, it is hard to pass on the opportunity to select an already more physically developed young player to join the team, especially above-average tall players, since height is a nontrainable characteristic, and no one can rule out the possibility of a relatively older player meeting this criterion.

Hancock et al.[11] proposed a theoretical model to explain RAE in sports based on previous theories (see the Pygmalion, Galatea, and Mathew effects), explaining that players who develop faster could be favored by coaches, fulfilling early the coaches' expectations, and reaching better outcomes. However, based on Raudenbush[12] findings, it is possible to assume that in the long run, this coach-athlete relationship could fail to keep improving performance if the early selection criteria were biased for size, not tactical, technical, or cognitive skills. Hence, RAE is more likely to be found in youth categories, but not necessarily among adults[5].

Some aspects still demand clarification. For instance, it is not clear whether RAE happens in female teams the same way it happens in male teams[13, 14]. Evidence suggests that during a competition, the best-ranked teams tend to present RAE [5]. However, this seems to be valid for short-term periods, i.e., relative to winning games or the final standing, but not for long-term performance. Also, most studies analyze a single or just a few competitions, making data restricted to a small number of countries. This way, so far it has not been possible to determine whether RAE is a worldwide basketball phenomenon or just limited to some countries or regions.

Therefore, we aimed to verify the presence of RAE in a worldwide basketball sample. Our strategy was to analyze data of players from their respective national teams that took part in FIBA championships, considering gender, age (youth and adult), FIBA World ranking position, and FIBA region.

Methods

Data Collection and Organization

The main idea was to use data from national team athletes, as they went through a double selection process, first to play basketball itself, and then to represent the country in an international level competition. Date of birth data was extracted from the FIBA official open-access website (https://www.fiba.basketball/). In the "events" tab, it is possible to access the websites of the championships held by FIBA, which provide information on the age, body mass, height, and date of birth of each athlete registered in the competition. Birth dates were stored in a spreadsheet for later analysis (Figure 1). All championships occurred from 2012 to 2023. Studies based on open-access data do not require research approval by an ethics committee according to the Brazilian National Council of Health (Resolution No. 510, published on April 7, 2016). Still, all procedures were carefully conducted under the Declaration of Helsinki, especially regarding the rights to privacy and confidentiality of participants' personal information.

Figure 1. Data collection process flowchart.
Source: Authors

The data was grouped according to the month of birth and stratified into quarters such as January to March (Q1), April to June (Q2), July to September (Q3), and October to December (Q4). To meet the specific objectives of the study, the data were reorganized according to sex (male and female), age group (Under-14, Under-15, Under-16, Under-17, Under-18, Under-20, and Adult), FIBA World Ranking, stratified into five tiers determined by quintiles, and FIBA Regions (FIBA Africa, FIBA Americas, FIBA Asia, FIBA Europe, and FIBA Oceania).

Data Analysis

Chi-square tests were used to identify possible discrepancies in the frequency of births among trimesters.

The United Nations Statistics Division open-access website was used to collect data on the worldwide births per month to determine reference values of each quarter birth frequency, considering the years 2013 to 2023 span and comprehending over 250 million births (https://data.un.org/Data.aspx?d=POP&f=tableCode%3a55). Based on these data, the relative birth frequency was 24.4%, 24.5%, 26.3%, and 24.7%, from the first to the fourth quarters, respectively.

All group analyses were conducted two-fold, with within and between analysis approaches. The within approach analyzed the frequency of birth among quarters in the same category (chi-square goodness of fit test), considering the reference proportion, while the between approach compared the distribution between group categories (chi-square test of independence). For age groups, the analyses considered subsequent categories, hence U-14 was compared to U-15, U-15 was compared to U-16, and so on (Figure 2). Adjusted residuals with Bonferroni correction were considered statistically significant if $\leq$-2.0 or $\geq$ 2.0[15]. The W coefficient was calculated as a measure of the χ^2 effect size. W coefficient was determined as the square root of "χ^2 divided by the total number of frequencies". Cut-off points for data interpretation were established as $\leq$0.1 small, 0.1–0.3 medium, and >0.3 large effect, as suggested by Cohen[16].

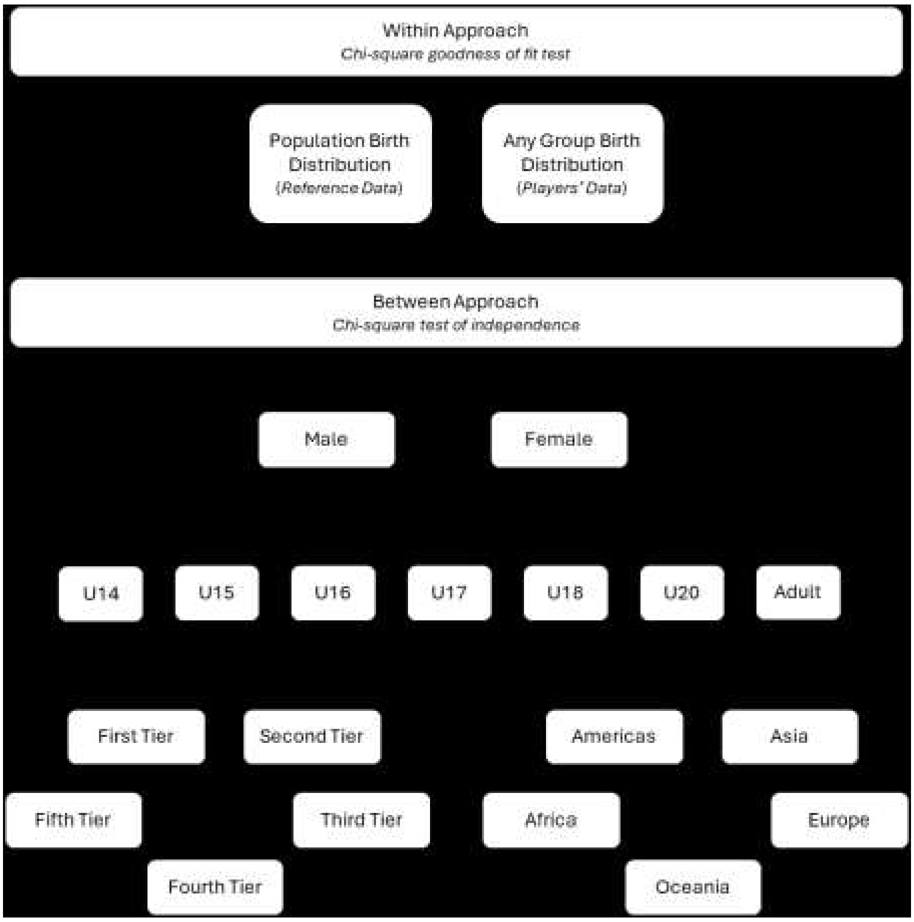

Figure 2. Flowchart of the data analysis process.
Source: Authors

Odds ratios (OR) between the number of births in the first and the last quarters were also calculated as the effect size[17], and interpretation cut-off points were established as no effect if OR = 1.0, weak association if OR < 3.0, and strong association if OR ≥ 3.0[18].

All statistical procedures were conducted by SPSS 24.0 (IBM, EUA), adopting 0.05 as the significance level.

Results

Overall Analysis

The sample consisted of 8664 athletes (3889 female and 4775 male), representing 140 countries. Analysis of the group as a whole revealed that the distribution of birth dates of basketball players who took part in several FIBA championships did not follow the reference distribution ($\chi^2(3) = 165.918$; $p < 0.001$), with a W coefficient of 0.14 (medium effect size). Without any shadow of a doubt, there were a greater number of athletes born in the initial months compared to the final months of the year. Q1 had a relative frequency of 10 percentage points higher than Q4, with an OR of 1.5 (1.4 to 1.6; weak association) (Figure 3).

Gender Group Analysis

There was an unbalanced number of births throughout the year in both female and male athletes [$\chi^2(3) = 46.118$; $W = 0.11$ and $\chi^2(3) = 129.126$; $W = 0.16$, respectively; $p < 0.001$ and medium effect size for both]. Gender comparison showed statistical difference [$\chi^2(3) = 9.760$; $p < 0.021$], with males presenting a lower prevalence of athletes born in the last trimester (adjusted residuals of 2.6) compared to females. The OR showed weak association in both genders, with 40% and 60% more chances for an athlete to be born in the early than in the late months of the year [OR = 1.4 (1.2 to 1.6) and 1.6 (1.4 to 1.8), for female and male, respectively) (Figure 3).

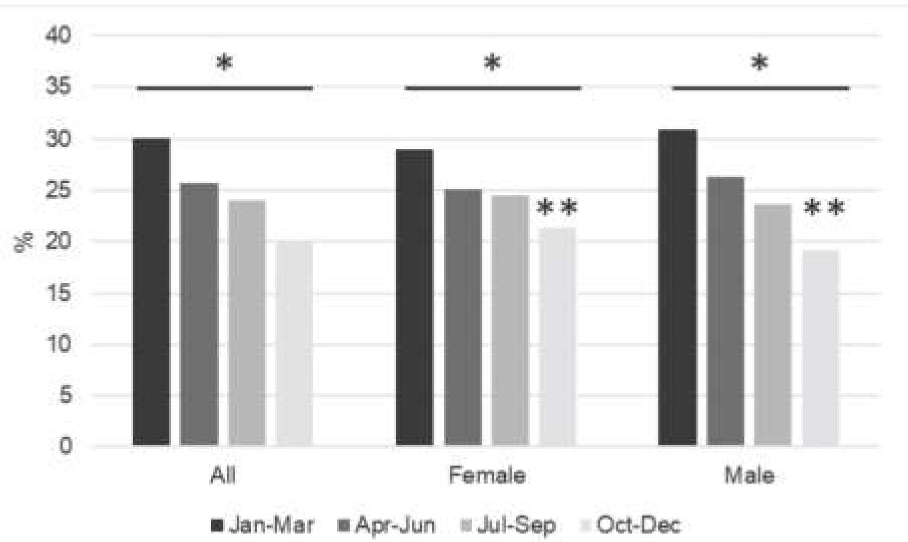

Figure 3. Quarterly distribution of birth dates for all, female and male athletes. * means within statistical difference (Chi-square; $p < 0{,}001$); ** means between genders statistical difference (adjusted residuals > 2.0).
Source: Authors

Age Group Analysis

The all-youth group (U-14 to U-20 players) presented a $\chi^2(3) = 312.947$ ($p < 0.001$), with each category's χ^2 ranging from 8.554 to 92.147 ($p < 0.05$ for all). Likewise, the adult category showed a statistical difference, although with a small effect size for χ^2 and almost no effect for Q1 vs. Q4. Overall, there were no differences between any subsequent youth age group categories (*p*-values ranging from 0.055 to 0.891), although adjusted residuals of 2.0 and 2.2 were found for the Q4 of U-16 in comparison to U-15 and U-17, respectively, and 2.0 for the Q2 of U-18 compared to U-17. On the other hand, the birth distribution in the adult category was statistically different from U-20 [$\chi^2(3) = 127.554$; $p < 0.001$], with adjusted residuals of -9.2, -6.4, -4.2, and 15.2 through the Q1 to the Q4, respectively. U-15 showed the strongest effect size for χ^2, and also for Q1 vs. Q4, indicating more than three times the number of athletes born in the initial months of the year compared to the final months. Moreover, almost two out of three U-15 athletes were born in the first semester, the highest proportion of all, though this number fell to roughly 52% among adult athletes (Table 1).

Table 1. Absolute and relative frequency, chi-square values, and effect sizes for the number of basketball players born per quarter in each aging group. Data presented as n (%).

	U-14	U-15	U-16	U-17	U-18	U-20	Adult
Q1	37 (30.8)	208 (38.2)	402 (35.5)	176 (32.9)	406 (31.4)	208 (32.1)	1167 (26.6)*
Q2	36 (30.0)	146 (26.8)	304 (26.9)	123 (23.0)	355 (27.4)*	170 (26.3)	1098 (25.0)*
Q3	31 (25.8)	126 (23.1)	249 (22.0)	129 (24.1)	303 (23.4)	147 (22.7)	1096 (25.0)*
Q4	16 (13.3)	65 (11.9)	177 (15.6)*	107 (20.0)*	231 (17.8)	122 (18,9)	1029 (23.4)*
χ^2	8.554	75.155	92.147	20.249	47.253	23.494	11.107
Df	3	3	3	3	3	3	3
P	0.036	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.011
W	0.27	0.37	0.28	0.19	0.19	0.19	0.05
OR	2.4	3.2	2.3	1.7	1.8	1.7	1.1
(IC95%)	(1.1-5.2)	(2.2-4.7)	(1.8-2.9)	(1.2-2.3)	(1.4-2.2)	(1.3-2.4)	(1.0-1.3)

Note: Q1: Jan-Mar; Q2: Apr-Jun; Q3: Jul-Sep; Q4: Oct-Dec; df: degrees of freedom; *W*: Cohen's effect size for χ^2; OR (odds ratio): Q1 vs. Q4 effect size; * means statistically different from the previous age group, based on adjusted residuals.
Source: Authors

FIBA World Ranking Group Analysis

The distribution of birth dates was different from reference values no matter what FIBA World ranking tier, however the higher the tier, the higher the χ^2 effect size (*W* coefficient), highlighting that the first-tier ranked teams presented next to three out of five athletes born in the first semester. Nonetheless, all *W* coefficients revealed just medium effect sizes. No differences were found among third-, fourth-, and fifth-tier ranked teams. First- and second-tier teams showed more athletes born in Q1 than fourth- and fifth-tier teams, while also showing fewer athletes in Q4 than fourth-tier teams, with adjusted residuals ranging from 2.0 to 2.8 (Table 2).

Table 2. Absolute and relative frequency, chi-square values, and effect sizes for the number of basketball players born per quarter according to FIBA World ranking. Data presented as n (%).

	First-Tier	Second-Tier	Third-Tier	Fourth-Tier	Fifth-Tier
Q1	589 (32.4)*	533 (31.9)*	514 (29.7)	482 (28.3)	481 (28.0)
Q2	485 (26.7)	409 (24.5)	458 (26.5)	423 (24.8)	451 (26.3)
Q3	405 (22.3)**	410 (24.6)	409 (23.6)	416 (24.4)	433 (25.2)
Q4	338 (18.6)***	318 (19.0)***	350 (20.2)	382 (22.4)	352 (20.5)
χ^2	72.486	56.741	30.397	13.028	18.675
df	3	3	3	3	3
p	<0.001	< 0.001	< 0.001	0.005	< 0.001
W	0.20	0.18	0.13	0.09	0.10
OR	1.8	1.7	1.5	1.3	1.4
(IC95%)	(1.5-2.1)	(1.4-2.1)	(1.2-1.8)	(1.1-1.5)	(1.1-1.7)

Note:Q1: Jan-Mar; Q2: Apr-Jun; Q3: Jul-Sep; Q4: Oct-Dec; df: degrees of freedom; *W*: Cohen's effect size for χ^2; OR (odds ratio): Q1 vs. Q4 effect size; * means statistically different from the 4th and 5th tiers, based on adjusted residuals. ** means statistically different from the 5th tier, based on adjusted residuals. *** means statistically different from the 4th tier, based on adjusted residuals.
Source: Authors

FIBA Region Group Analysis

Except for Oceania, all FIBA regions showed an imbalance in the distribution of births among the four quarters of the year ($p < 0.05$; medium effect size). The percentage difference between Q1 and Q4 varied between 5.7% and 11.8%, depending on the FIBA region. The highest values for *W* and OR were found in FIBA Americas, but still a weak association (effect size). FIBA Americas presented the lowest number of athletes in Q4, but no statistical differences were found from other regions. On the other hand, FIBA Europe presented proportionally more athletes in Q2 than FIBA Africa, FIBA Americas, and FIBA Asia (adjusted residuals of 2.1, 2.4, and 2.4, respectively). Furthermore, FIBA Europe had over 57% of athletes born in the first semester, the highest value among all regions, while FIBA Asia presented the lowest value (almost 53%). FIBA Asia also showed more athletes in Q3 than FIBA Europe (adjusted residuals of 2.6; Table 3).

Table 3. Absolute and relative frequency, chi-square values, and effect sizes for the number of basketball players born per quarter in each FIBA region. Data presented as n (%).

	Africa	Americas	Asia	Europe	Oceania
Q1	267 (30.5)	683 (31.3)	265 (29.1)	1175 (29.9)	214 (27.9)
Q2	209 (23.9)*	534 (24.5)*	214 (23.5)*	1073 (27.3)	202 (26.3)
Q3	214 (24.5)	542 (24.8)	245 (26.9)*	899 (22.9)	181 (23.6)
Q4	184 (21.1)	425 (19.5)	187 (20.5)	781 (19.9)	170 (22.2)
χ^2	17.319	61.811	13.192	81.701	5.002
df	3	3	3	3	3
p	0.001	< 0.001	0.004	< 0.001	0.172
W	0.14	0.17	0.12	0.14	0.08
OR	1.5	1.6	1.4	1.5	1.3
(IC95%)	(1.1-1.9)	(1.4-1.9)	(1.1-1.7)	(1.3-1.7)	(0.96-1.7)

Q1: Jan-Mar; Q2: Apr-Jun; Q3: Jul-Sep; Q4: Oct-Dec; df: degrees of freedom; *W*: Cohen's effect size for χ^2; OR (odds ratio): Q1 vs. Q4 effect size; * means statistically different from Europe, based on adjusted residuals.
Source: Authors

Discussion

The present study aimed to verify the presence of RAE in a worldwide basketball sample, considering gender, age, FIBA region, and FIBA World ranking position as factors of analysis. The main findings showed an overrepresentation of early-born athletes, regardless of the factor of analysis, although the causes remain unclear. The rationale for the uneven number of athletes born at the beginning versus at the end of the year is likely 3-fold. It could be a random effect, caused by nothing but just coincidence, with no relevant implications for talent selection. However, RAE, which seems to be associated with structured sports[19], was consistently found in the present sample with over 8600 athletes, representing 140 countries from all over the world, weakening the "random effect hypothesis".

RAE might also be a false positive event if the unbalanced birthdate distribution only mimicked the natural curve of births over the months ("population hypothesis"). Although data from the United Nations showed more worldwide births registered in the first quarter than in the last one, the difference among basketball players was greater than the population data, depreciating the population hypothesis. Hence, there is no reason to believe in an explanation other than that there is a bias in the talent selection process[20]. In light of this, Lopez de Subijana and Lorenzo[21] and Lupo et al.[20] call for a revision of the talent selection process, as late-born players have been receiving fewer opportunities to stand out.

As they are untrainable characteristics, body dimensions are very prominent in prospective basketball players, like height[8, 22] and wingspan[8, 22]. Delorme and Raspaud[7] showed in a French nationwide sample that early-born athletes were taller than late-born ones, supporting the premise of a biased talent selection. On the other hand, Garcia et al.[23] observed that height was not a clear factor of discrimination among early and late-born athletes in the U17, U19, and U21 FIBA World Championships.

Doncaster et al.[24] pointed out that RAE might be influenced by technical, psychological, and perceptual-cognitive, and not only by physical attributes. Notwithstanding, in the study of Lidor et al.[25], athletes associated their performance strengths with the physical pillar rather than the cognitive, emotional, and social pillars. It is intriguing, however, that these athletes felt that their date of birth did not influence their athletic development, and at the same time believe in having greater physical strengths than late-born athletes. Obviously, there is no doubt that male athletes are taller than female basketball players. Santos et al.[26] found a huge difference, with male athletes at the 50th percentile being higher than female athletes at the 95th percentile. Nonetheless, the height difference between early and late-born athletes must be better addressed further.

Male teams seem to be more likely to present RAE than female teams[3]. In the Italian National League, Lupo et al.[20] found an over-representation of early-born male athletes in the first years of their adult careers, while Brustio et al.[27] found only a small presence of RAE in female teams, even though early-born female athletes were more likely to reach 1st and 2nd division professional teams. Our data is consistent with this evidence since RAE was found in both genders, however, it was more prominent among male teams, especially when analyzing the last quarter's birth differences.

Likewise, Lidor et al.[25] found RAE among Israeli male teenage basketball players (14 to 18 years old), with almost twice the chance of an athlete being born at the beginning of the year compared to the end of the year. Furthermore, RAE was found in several young age groups in male and/or female teams, but mostly from European championships[28]. Hence, our worldwide data analysis brought an opportunity to comprehend the RAE phenomenon in a wide range of countries and regions. Our results indicate that RAE is a worldwide phenomenon, not just a local or regional phenomenon.

In the present study, the U14 and U15 teams had the highest discrepancy between the first and last quarters. Our results corroborate the study of Ribeiro Junior et al.[29] that noted Brazilian Youth National level teams had 48% early-born athletes versus only 8% late-born. The odds of an early-born U15 athlete being selected for the National team to represent his/her country in international competition were three times higher than a late-born in the present study. These odds were lower than the 7-fold found by Doncaster et al.[24] among athletes from a single Spanish club where half of the basketball players were early-born, and the 10-fold found by Kelly et al.[30] among English basketball athletes, but still worrisome. It is worth highlighting that, according to Lidor et al.[25], 14 and 18 years old are considered benchmark career turning points in the long-term perspective since they symbolize the transitional stage from developmental to specialization years and from youth to professional sports, respectively.

Gonçalves and Carvalho[31] stated that coaches' decision on talent selection during the developmental phase is triggered by aspects that tend to disappear during the specialization years. Hence, it is no surprise that the transition to the adult/senior/professional level showed a change in scenario since studies have been indicating no RAE in adult teams[32-36]. Our results showed the presence of RAE when considering all youth data as well as each of the age categories, with no differences observed between any consecutive age groups. That scenario changes for the adult group, which was statistically different from the U20, indicating a possible reversal of the RAE. Albeit adults still showed a more unbalanced birthdates distribution than the reference values (population data), effect size and odds ratio demonstrated a very small magnitude of RAE.

The fading of RAE when players reached the professional level was well-established in previous studies[21, 23, 24, 29, 30, 37]. Kalén et al.[37] identified that barely half of the male and female players selected for U15 National teams in Europe were selected for the U20. Besides, the U15 early-born players had 25% and 18% more chances to be selected for U20, for males and females, respectively. In Brazil, only 4% of athletes played at the national level at U15, U17, and U22, and less than 10% of more than 4700 athletes who played at least in one of those categories reached the professional level[29]. In England, almost 40% of the juniors were selected for the national team. This is the same percentage of professional basketball players that had been previously selected for junior national teams[21]. Altogether, these data strongly suggest a miss of critical aspects of the talent selection process, putting the plans of reaching the professional level in jeopardy.

So, why are there so many early-born athletes in youth basketball? The answer is likely that winning matters and the performance of relatively older players is expected to be better than their counterparts. Our study analyzed countries' long-term performance by their current position on the FIBA ranking. FIBA ranking is calculated based on the performance of each team in each championship played over an 8-year span (https://www.fiba.basketball/documents/rankingmen/howitworks). RAE was present in all five ranking tiers, but it was more prominent among the highest-ranked countries, indicating an association between RAE and better overall long-term performance.

Previous studies analyzed whether RAE might influence team and individual performance during specific championships or tournaments, sometimes comprehending several years or seasons. As regards the team performance, determined by championship ranking position, the best-ranked teams presented RAE in International U16 male[38], Brazilian U15 female[13], U20 European male[39], and Portuguese U14 and U16 male teams[40].

The effect of RAE on individual performance, determined by minutes played and efficiency indexes, was inconclusive. Early-born athletes were no better than late-born ones in the International U-16 Men Basketball Tournament[38] and in the U17 female and U21 male and female FIBA World Championship[23]. Furthermore, Gonçalves and Carvalho[31] analyzed data from U11 to U17 male and female Brazilian basketball players and found no relevant difference in aerobic fitness, anaerobic capacity, and muscle power between early and late-born athletes. On the other hand, relatively older male players played more minutes and had an all-around better performance in the U16, U18, and U20 European Basketball Championships[39]. Relatively older U18 male European players were better at some specific performance indexes depending on the playing position[41], and also covered longer distances and ran faster than relatively younger players[42]. Early-born male players were better at 3-point shots made (U17) and total points (U19), while early-born female players were better at assists (U19)[23].

Playing styles might differ among teams, countries, continents[43], and sex[44]. Zhai et al.[45] compared the individual performance of basketball athletes of different playing positions and found discrepancies whereas Madarane[46] identified differences in performance expressed as game-related statistics among FIBA regions. Therefore, it seemed important to analyze whether RAE would be different or more characteristic in some regions rather than others. Unfortunately, we failed to find studies comparing RAE in basketball among continents. The only one was Werneck et al.[36] which utilized data from the 2012 London Olympic basketball male and female tournaments and concluded that there was no RAE no matter the continent.

Leite et al.[47] analyzed the birthdates of the 2008 Beijing Olympics but aggregated all invasion/team sports data (basketball, handball, soccer, hockey, and water polo). This way, although there is no “basketball-only” data, their results indicated RAE in male South American invasion/team sports. However, as shown earlier, professional-level teams tend not to present RAE.

Since we utilized data from several competitions, ages, years, countries, and continents, we were able to apply a much deeper analysis of this phenomenon. Our results revealed the presence of RAE in all continents, except for Oceania. It is important to emphasize that FIBA considers the three American continents as a single region for its operational sake. So, to respect the organization, there was no distinction among North, Central, and South America in the present study. FIBA Americas presented the highest values of early-born athletes. In the Americas, Asia, Africa, and Europe, the odds of an early-born athlete being selected to represent his/her country in an international level competition were 40% to 60% higher than a late-born athlete. Europe differs from the other regions in the relative number of athletes born in the second quarter of the year, but the first quarter was still their most marked.

This study has some limitations. Depending on the country, the sports competition calendar does not follow the year calendar, i.e., some countries do not consider the competition calendar from January 1st to December 31st. This peculiarity might alter the period of the year when the athletes could receive greater advantages for being selected. Notwithstanding, some of this information might be hard to find about some of the 140 countries analyzed. In addition, the FIBA calendar is defined as January to December, and that was the main reason we stratified data this way.

We also used the distribution of the number of births in each quarter of the year considering data from all countries in the aggregate as reference values, which may have disregarded some eventual discrepancies among countries. However, since the analyses were carried out for groups of countries or all countries simultaneously rather than for each country individually, we believe that the Worldwide reference values fitted the model more appropriately than each country reference.

We cannot write off the influence of maturity status on the youth talent selection protocols since it is well-documented that adolescents with advanced maturity status have better anthropometric and physical fitness profiles[48]. However, the prevalence of early-mature adolescents does not seem to be high enough to baffle the results of RAE. Toselli et al.[49] observed a biological maturity profile of 16%, 68%, and 16% in basketball players, and 19%, 68%, and 13% in non-athletes for early, on-time, and late maturity, respectively. Arede et al.[50] found 38% early and 62% average maturers while Gryko et al.[51] found that on-time maturers accounted for 97.7% of the 925 female Polish basketball players aged 13 years to 15 years old. The only exception seems to be the Brazilian basketball teams since early-matures represented 63% of the youth[31] and 75% of professional players[29]. Ribeiro Junior et al.[29] also emphasized that Brazilian basketball has been dealing with a chronic player selection bias concerning chronological age in the early stages of development.

Torres-Unda et al.[52] analyzed U14 teams that took part in a Mini Cup of the Spanish Basketball Clubs Association and found no difference in the age at peak height velocity among finalist, semi-finalist, and quarter-finalist teams. On the other hand, over 70% of finalist players were early-born, which might indicate a more relevant role of RAE in contrast to maturation status. Plus, although considered accurate, the maturity offset prediction based on peak height velocity has been shown to report a 6-month error of measurement[53]. Considering that youth competition categories are organized according to the birth year, an error of that magnitude does not support the maturation selection hypothesis for the overrepresentation of early-born athletes mentioned by Maciel et al.[54].

It is also important to point out that cognitive, emotional, social, and/or motor development may not necessarily depend on the biological maturation process, being more closely aligned with age and training experience[55]. In this sense, Maciel et al.[54] found that early-born U13 athletes had more experience since they took part in more games than late-born athletes within the same age category. Notwithstanding, there was a trend for late-born athletes to become more participative from the U15 onwards. Our data showed a relative decline in the number of early-born athletes throughout the aging groups, till it reached near balanced distribution of birthdates among quarters. This is consistent with the 'underdog hypothesis'[56], which states that a relatively younger player needs to embrace the challenge of competing against older counterparts to develop superior technical, tactical, and psychological skills over time[55-57]. As a consequence, a reversal of the RAE may occur, making the late-born career last longer, and contributing to the birthdate balance seen in senior categories[55]. As an example, Brazilian basketball teams showed RAE in U22, but not among 25-34 years players[58].

Conclusion

The relative age effect is a worldwide phenomenon in basketball teams, being more prominent among male, young, top-ranking, and American national teams. There was a trend to a reversal of RAE in the adult category. The determinant factors of RAE are still unclear and should be addressed in further investigations to allow for elaborating better strategies for talent selection and long-term development.

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