Sports Coaching

Relative age effects in elite Brazilian track and field athletes are modulated by sex, age category, and event type

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Abstract - Aim: This study investigated the Relative Age Effect (RAE) in Brazilian track and field athletes based on sex, age category (U-16, U-18, U-20, U-23 and senior), and event type (sprints/hurdles, middle distance, long-distance, jumps, throws). **Methods:** Data from 2.259 male and 1.776 female elite track and field athletes, ranked top-50 in events held by the Brazilian Track and Field Confederation in 2019 were analyzed. To determine RAE athletes were divided into four quarters based on their months of birth, considering January 1st the cut-off date. The influence of sex, age category, and event types in the pervasion of RAE in Brazilian track and field athletes was assessed through Chi-squared tests. **Results:** Athletes born closer to the cut-off date were more frequent than athletes born further from this date were in male youth categories. This effect reduced as categories increased, even reversing in the senior category. Finally, RAE was more frequent in events in which athletic performance relies more on strength, speed, and power, which is the case of sprints/hurdles, jumps, and throws. **Conclusion:** RAE is particularly prevalent in young male Brazilian track and field athletes, which indicates that many potentially talented athletes are overlooked in youth tryouts because they were born months away from the cut-off date. Policies that reduce the disadvantages faced by relatively younger athletes are warranted in order to avoid the loss of potential sports talents.

Keywords: athletics, track and field, talent identification, talent selection.

Introduction

Grouping children and adolescents according to their year of birth is a strategy widely used in most sports systems to provide equal opportunities and experiences (e.g., training and competition) among young athletes during their early stages of development[1,2]. This is supposed to allow young athletes to train and compete under similar conditions of performance. However, research has indicated that one possible consequence of this grouping system is an over-representation of relatively older athletes (i.e. born in the first months of the selection year) in many sports teams, due to greater physical and cognitive development (maturation-selection hypothesis)[1]. Since relatively older athletes are more prone to be seen as talented by coaches[3], they are more likely to be favored in terms of selection for higher tiers of competition, access to better training structures, and more experienced coaches, thus being more likely to succeed in the early stages of the sport[4]. This phenomenon is known as the Relative Age Effect (RAE) and refers to performance and selection inequalities existent due to the annual age-grouping system in youth sports[1,2,3].

The existence of RAE and its extent in a given sports context results from the interaction of many factors, as proposed by Wattie et al. theoretical model[3]. These authors proposed that RAE could be interpreted based on the interaction of three constraints: individual, task, and environmental. Individual constraints refer to athlete's individual qualities, such as sex, height, body composition, maturational status, and so on. Environmental constraints relate to the sport's popularity, its policies, and physical environment, among others. Finally, task constraints concern the sports specificity, its competitive level, and the physical capabilities that are more important for success (i.e. strength, speed, and power). According to the specificities of a given sport context, it is expected that each of these constraints will interact to different degrees, contributing to the pervasiveness (or not) of the RAE[3].

Even though RAE is a widespread phenomenon in team sports[5,6,7], its investigation in track and field athletes is still scarce. Given the negative consequences of this selection bias through the long-term development system[4], it is important to further investigate the factors that modulate the occurrence of RAE. In Wattie et al.[3] constraints-based model, sex, and age categories are considered individual constraints that might determine the occurrence of RAE. Studies carried out in the track and field context have demonstrated that higher magnitude effects are present in male contexts and that these effects are usually smaller in women[8,9,10]. Regarding age categories, there is evidence that the magnitude of the effects decreases as age categories increases[9-12]. Of note, in some cases relatively younger athletes are even over-represented in the senior categories ("reversal of advantage")[13,14], as some athletes can increase their competitiveness and overcome their chronological limitations by developing skills related to sports context (i.e., technical and tactical performance) to compete with their pairs who were born earlier in the year[15,16]. However, it is important to note that the "reversal advantage" hypothesis was usually found in team sports[7,13,16], and further understanding this phenomenon in the track and field context is necessary.

Additionally, the type of event (a task constraint) may also affect RAE occurrence. According to Wattie et al. model[3] and the maturation-selection hypothesis[1], track and field athletes might be potentially prone to RAE given that performance measures relies mainly on physical performance. In other words, it seems reasonable for coaches to select those athletes with more developed physical characteristics, especially in those types of events that require more strength, speed, and power (i.e., task constraints). Accordingly, previous investigations in the track and field context reported that RAE seems to be modulated by the type of event investigated, with greater effects in sprints, jumps, and throws events[8,10,17]. Regarding the aforementioned results, it is important to note that most of these investigations were conducted in European countries, where track and field is a more widespread sport than in Brazil. Thus, whether these findings apply to the Brazilian track and field context remains a topic to be addressed.

In Brazil, track and field is not as popular a sport as in most European countries, which is relevant when investigating the existence of RAE in this sports system. In the "soccer country", team sports (i.e. futsal, soccer, handball, basketball, and volleyball) are very popular with children and adolescents, which results in lower competition for spots in the few track and field clubs around the country. This low competition for spots may reduce the probability of occurrence and the magnitude of RAE in the Brazilian track and field selection context, since coaches have fewer options to choose from during youth selections, minimizing the risk of negative bias selection[1,18]. Previous research indicates this may be even more likely with females, due to less social support received by these athletes to engage in sports activities[2]. However, whether the low popularity of track and field in Brazil modulates RAE is speculative and needs to be investigated. If RAEs are indeed prevalent in the Brazilian track and field context, then improvements to the development and selection of talents system are warranted, aiming to reduce negative selection bias in this sporting context.

Recent investigations that focused on the talent selection and detection processes in track and field have brought some important insights that may relate to the prevalence of RAE in a given sports system. When analyzing the career trajectories of high-performance track and field athletes, Boccia et al.[19] found that top-level athletes reach their peak performance later than other athletes. Moreover, Kearney et al.[10] found low correlations between track and field athletes' performance in senior and youth categories. Together, these findings indicate that early sport success should not be the only factor considered by coaches during the selection processes. This is particularly relevant for coaches, as it is precisely when RAE is more pronounced (in the young categories) that selection processes usually take place[1]. Thus, athletes born closer to the cut-off date are more likely to perform better in lower categories, due to developmental advantages, while relatively younger athletes (potential talents) are more likely to be neglected. Indeed, evidence indicates that relatively younger athletes are less likely to be selected for higher tiers of competition, and show higher drop-out rates than relatively older athletes in youth sports[5], which makes these athletes less likely to reach higher tiers of competition. Thus, the loss of athletes at the grassroots levels is somehow troublesome, as it happens long before they have the chance to achieve their best performance levels[19]. This fact should raise the awareness of coaches and sport policymakers, as potential track and field talents may have been repeatedly disfavored due to their birthdates in RAE-prevalent sports systems.

The assessment of RAE in a given sport system may have great practical application, as it enables sport policymakers to propose policies that target the loss of potential sportive talents due to selection bias that arises from the age-grouping policies[4,11]. Therefore, it is essential to consider the multifactorial nature of the RAE phenomenon and the specificity of the Brazilian track and field context. The present study aimed to investigate the effects of relative age on elite Brazilian track and field athletes, according to sex, age category, and type of event. We hypothesized that the male context would favor RAE occurrence to a greater extent than the female one since deeper competition for spots is expected in male sports[8,9]. The magnitudes of RAE are expected to decrease as age categories increase, due to a decreasing influence of maturational factors[1,20]. Finally, we hypothesized that RAE would be more prevalent in sprints, jumps, and throws events, as relatively older athletes are more likely to present higher speed, power, and strength levels than their relatively younger peers[10,17].

Methods

Participants

The sample of this study was composed of 2,259 male and 1,776 female elite Brazilian track and field athletes of U-16 (M = 433; F = 400), U-18 (M = 644; F = 526), U-20 (M = 458; F = 343), U-23 (M = 312; F = 228) and/or senior (M = 412; F = 279) categories. The inclusion criteria were being ranked top-50 in at least one of the events held in 2019 by the Brazilian Track and Field Confederation, regardless of wind information.

Data collection and procedures

Data were obtained from the Brazilian Track and Field Confederation (CBAt) Official Website, according to 2019 rankings available at the official domain (www.cbat.org.br). Data collection was performed during January 2020. The information obtained included athletes' age category, event type, and the best result obtained in the year of 2019, as well as personal data such as birthdate, sex, and name. All data used in this study were reported anonymously. The organization of the data was based on our variables of interest: sex, event type, and age category. For statistical purposes events were grouped as follows: I) Sprints/ Hurdles (75 m, 100 m, 200 m, 250 m, 400 m, 100 m with hurdles, 110 m with hurdles, 300 m with hurdles, and 400 m with hurdles for males; and 75 m, 100 m, 200 m, 250 m, 400 m, 80 m with hurdles, 100 m with hurdles, 300 m with hurdles and 400 m with hurdles for females); II) Middle Distance (800 m, 1,000 m,1,500 m, 3,000 m, 1000 m steeplechase, 2,000 m steeplechase and 3,000 m steeplechase); Long Distance (5,000 m and 10,000 m); III) Jumps (long jump, triple jump, high jump, and pole vault); and 4) Throws (shot put, discus throw, javelin throw, and hammer throw).

The cut-off date for elite athletes participating in the Brazilian track and field championships is January 1st, therefore this was defined as the first month of the selection year, and served as a reference to classify athletes' birth dates into four quarters. The variables were then analyzed considering this organization, based on the quarter of the year the athletes were born. Some athletes were ranked in more than one age category and were only analyzed in the category in which they belong, according to their age in the category analysis. Athletes who were ranked in more than one event type were accounted once for each one of the event groups in the event analysis.

Statistical analysis

Athletes' frequencies were presented in absolute and relative values. A chi-square test (χ^2) was performed to compare the birthdates' distribution of athletes according to sex, event type, and age categories. For all analyses, the effect size (ω) of the chi-square tests was calculated. The observed distributions of athlete's birthdates on each quarter were compared with the expected frequencies, based on Brazilian reports from 1994 to 2005 (Brazilian Ministry of Health), similarly to Figueiredo et al[6]. Additionally, Odds Ratio (ORs) and 95% confidence intervals for Q1 versus Q4 and first semester versus second semester (1st:2nd) were calculated. Analyses were performed in the Statistical Package for the Social Sciences (SPSS), version 20.0 (Chicago, USA). The level of significance was 0.05. Whenever multiple comparisons between quarters were necessary, Bonferroni's corrections were performed. In these cases, the significance level was adjusted to 0.008.

Results

The results of the analysis of Brazilian track and field athletes' birthdates by sex and event revealed that the overall observed distribution was different from expected for males ($\chi2$ = 48.257; $p < 0.001$; ω = 0.15; OR - Q1:Q4 = 2; OR - 1st:2nd = 1.86), with athletes born in the first quarters of the year (Q1 and Q2) being more frequent than athletes born in the second semester were (Figure 1). There were no differences between female athletes ($\chi2$ = 1.659; $p > 0.65$; ω = 0.03; OR - Q1:Q4 = 1.29; OR - 1st:2nd = 1.28). Event types were evaluated separately, and the analysis of male athletes showed a skewed representation of athlete's dates of birth in sprints/hurdles ($\chi2$ = 17.135; $p < 0.002$; ω = 0.15; OR - Q1:Q4 = 2.05; OR - 1st:2nd = 1.98), middle distance ($\chi2$ = 9.887; $p < 0.02$; ω = 0.17; OR - Q1:Q4 = 2.14; OR - 1st:2nd = 1.55), jumps ($\chi2$ = 15.187; $p < 0.002$; ω = 0.17; OR - Q1: Q4 = 2.14; OR - 1st:2nd = 1.98) and throws ($\chi2$ = 11.812; $p < 0.008$; ω = 0.16; OR - Q1:Q4 = 2.03; OR - 1st:2nd = 2.09) events, but not in long distance events ($p = 0.58$; ω = 0.01). In all male events post hoc analysis indicated that athletes born in the first semester of the year were more frequent (Q1 and Q2) ($p < 0.006$). In the case of the female track and field athletes, the observed distribution of birthdates did not differ from expected distributions, regardless of the event type ($p > 0.45$).

The results of the analysis of Brazilian track and field athletes' birthdates by sex and age category revealed uneven birthdates distributions for males (Figure 2), specifically in U-16 ($\chi2$ = 39.383; $p < 0.001$; ω = 0.3; OR - Q1:Q4 = 3.75; OR - 1st:2nd = 3.15), U-18 ($\chi2$ = 19.527; $p < 0.001$; ω = 0.17; OR - Q1:Q4 = 1.71; OR - 1st:2nd = 2.23), U-20 ($\chi2$ = 15.431; $p < 0.002$; ω = 0.18; OR - Q1: Q4 = 2.3; OR - 1st:2nd = 2.14), and senior ($\chi2$ = 11.237; $p < 0.02$; ω = 0.17; OR - Q1:Q4 = 1.45; OR - 1st:2nd = 0.91) categories, but not in U-23 ($p = 0.38$). Post hoc analysis indicated that athletes born in the first semester of the year were more frequent than athletes born in the second semester were ($p < 0.05$) in U-16, U-18, and U-20 categories. On the other hand, athletes born in the Q3 ($p < 0.02$) were more frequent than athletes born in the

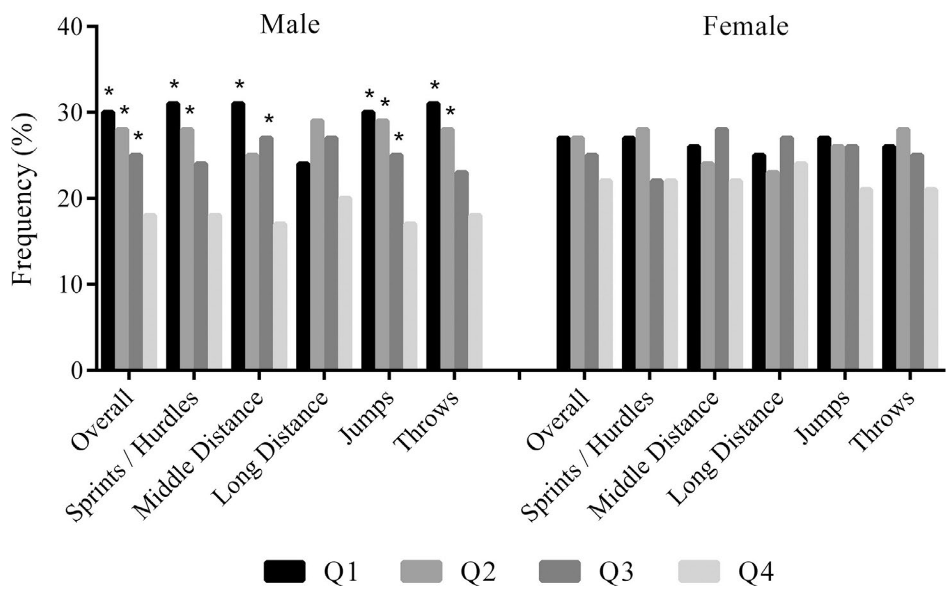

Figure 1 - Brazilian track and field athletes' quarters of birth organized by sex and event type. * means different from Q4.

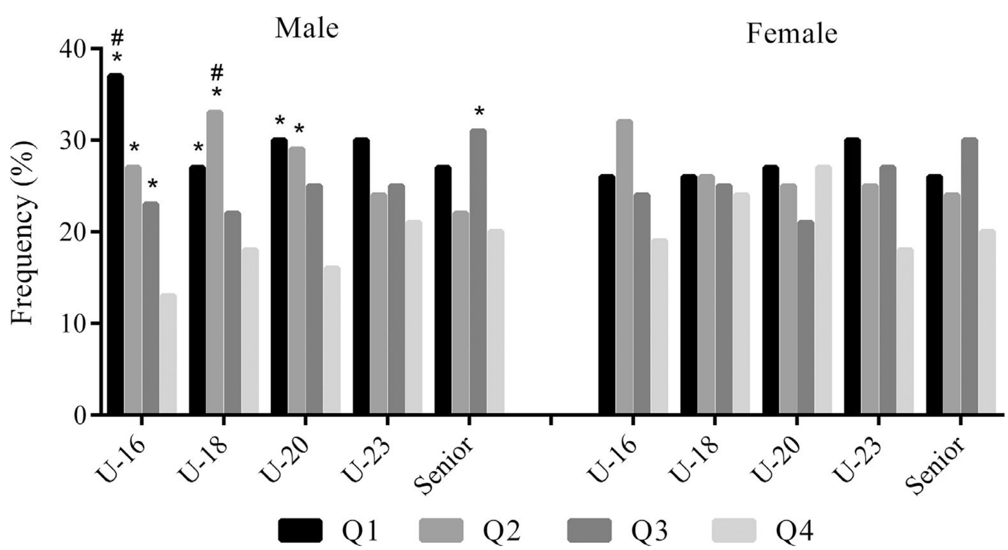

Figure 2 - Brazilian track and field athletes' quarters of birth organized by sex and age category. # means different from Q3; * means different from Q4.

other quarters in the senior category were. In female athletes, no skewed distributions were found in any category ($p > 0.05$).

The results of the analysis of male Brazilian track and field athletes' birthdates by age category and event type (Table 1) revealed uneven distributions in U-16, U-18, and U-20 and senior categories, but not in U-23. In U-16 skewed distributions were found in sprints/hurdles ($p < 0.001$; $\omega = 0.35$), jumps ($p < 0.03$; $\omega = 0.24$) and throws ($p < 0.01$; $\omega = 0.34$) events. In U-18 skewed distributions were only found in sprints/hurdles ($p < 0.02$; $\omega = 0.2$) events. In U-20 skewed distributions were only found in sprints/hurdles ($p < 0.01$; $\omega = 0.28$) events. Post hoc analysis showed different overrepresentations of athletes born in the first quarters (Q1 and Q2) of the year ($p < 0.006$). Meanwhile, in senior category skewed distribution was only found in throws ($p < 0.03$; $\omega = 0.31$) events. However, the post hoc analysis was not able to identify the differences ($p > 0.008$).

The results of the analysis of female Brazilian track and field athletes' birthdates by age category and event type (Table 2) revealed that observed distributions were like expected distributions in all event types in U-16, U-18, U-20, and U-23 ($p > 0.14$). Specifically, in the senior category a skewed distribution was found for throws ($p < 0.02$; $\omega = 0.46$), but not for the other events. However, the post hoc analysis was not able to identify these differences ($p > 0.008$).

Table 1 - Quarter of birth distribution of male Brazilian Track and field athletes' by age category and event.

	Event	Q1 (Exp)	Q2 (Exp)	Q3 (Exp)	Q4 (Exp)	χ2	p	w	OR - Q1:Q4 95% IC	OR - 1st:2nd 95% IC
U-16	Sprints / Hurdles	55[d]	41[d]	30	17	18.10	<0.001	0.35	1.55	4.17
		(36.7)	(37.7)	(35.5)	(33.1)				0.95 to 2.54	2.55 to 6.83
	Middle Distance	17	11	12	5	5.51	0.14	0.35	4.85	2.71
		(11.5)	(11.9)	(11.2)	(10.4)				1.64 to 14.24	1.15 to 6.35
	Jumps	46[d]	42[d]	36	19	8.85	<0.03	0.24	3.09	2.56
		(36.7)	(37.7)	(35.5)	(33.1)				1.70 to 5.60	1.59 to 4.12
	Throws	41[d]	23	20	17	12.04	<0.01	0.34	3.37	3
		(25.9)	(26.6)	(25.1)	(23.4)				1.76 to 6.47	1.69 to 5.30
U-18	Sprints / Hurdles	67	85[c.d]	52	46	9.78	<0.02	0.2	0.71	2.4
		(64.2)	(65.9)	(62.1)	(57.9)				0.48 to 1.04	1.68 to 3.44
	Middle Distance	29	30	26	18	1.98	0.58	0.14	1.85	1.8
		(26.4)	(27.2)	(25.6)	(23.8)				0.95 to 3.58	1.03 to 3.12
	Jumps	43	55	43	29	5.04	0.17	0.17	1.64	1.85
		(43.6)	(44.8)	(42.2)	(39.3)				0.97 to 2.78	1.20 to 2.84
	Throws	37	40	21	23	6.81	0.08	0.24	1.87	3.06
		(31)	(31.9)	(30)	(28)				1.03 to 3.40	1.81 to 5.17
U-20	Sprints / Hurdles	46[d]	33	35	17	10.67	<0.01	0.28	3.65	2.31
		(33.6)	(34.5)	(32.5)	(30.3)				1.95 to 6.73	1.5 to 3.78
	Middle Distance	20	13	15	8	4.40	0.22	0.28	3.33	2.39
		(14.4)	(14.8)	(13)	(13)				1.33 to 8.29	1.12 to 5.10
	Long Distance	17	25	21	14	2.47	0.48	0.17	1.27	1.44
		(19.8)	(20.3)	(19.1)	(17.8)				0.58 to 2.79	0.76 to 2.71
	Jumps	34	30	20	16	6.35	0.10	0.25	2.7	3.16
		(25.7)	(26.4)	(24.8)	(23.1)				1.38 to 5.28	1.77 to 5.62
	Throws	22	32	22	18	3.01	0.39	0.18	1.29	1.82
		(24.1)	(24.8)	(23.3)	(21.8)				0.66 to 2.51	1.04 to 17
U-23	Sprints / Hurdles	28	26	29	25	0.40	0.94	0.06	1.16	1
		(27.7)	(28.5)	(26.8)	(25)				0.62 to 2.15	0.58 to 1.7
	Middle Distance	15	6	11	12	4.20	0.23	0.31	1.38	0.83
		(11.3)	(11.6)	(10.9)	(10.2)				0.56 to 3.4	0.36 to 1.92
	Long Distance	14	5	7	8	5.19	0.15	0.39	2.27	1.6
		(8.7)	(9)	(8.4)	(7.9)				0.80 to 6.39	0.61 to 4.17
	Jumps	19	17	16	9	2.67	0.45	0.21	2.61	2.07
		(15.7)	(16.1)	(15.1)	(14.1)				1.08 to 6.28	1.00 to 4.26
	Throws	17	21	14	13	1.43	0.70	0.15	1.41	1.98
		(16.7)	(17.1)	(16.1)	15				0.65 to 3.1	1.01 to 3.86
Senior	Sprints / Hurdles	27	16	27	24	4.27	0.23	0.21	1.17	0.71
		(24.1)	(24.8)	(23.3)	(21.8)				0.62 to 2.23	0.40 to 1.26
	Middle Distance	23	23	28	15	3.11	0.37	0.19	1.72	1.14
		(22.8)	(23.5)	(22.1)	(20.6)				0.83 to 3.54	0.63 to 2.06
	Long Distance	10	20	19	12	4.29	0.23	0.26	0.8	0.93

(*continued*)

Table 1 - continued

	Event	Q1 (Exp)	Q2 (Exp)	Q3 (Exp)	Q4 (Exp)	χ2	p	w	OR - Q1:Q4 95% IC	OR - $1^{st}:2^{nd}$ 95% IC
		(15.7)	(16.1)	(15.1)	(14.1)				0.32 to 1.9	0.46 to 1.9
	Jumps	22	14	23	18	3.00	0.39	0.19	1.31	0.77
		(19.8)	(20.3)	(19.1)	(17.8)				0.63 to 2.69	0.40 to 1.45
	Throws	30	16	30	15	8.72	<0.03	0.31	2.49	1.04
		(23.4)	(24)	(22.6)	(21.1)				1.23 to 5.01	0.58 to 1.86

Q1-Q4, birth quarter; (Exp), expected distribution; χ2, chi-square; p, level of significance; ω, effect size; OR - Q1:Q4, odds ratio from Q1 to Q4; OR - $1^{st}:2^{nd}$ odds ratio from 1^{st} semester to 2^{nd} semester; U-16, Under 16; U-18, Under 18; U-20. Under 20; U-23, Under 23; c, different from Q3; d, different from Q4.

Table 2 - Quarter of birth distribution of female Brazilian Track and field athletes' by age category and event.

	Event	Q1 (Exp)	Q2 (Exp)	Q3 (Exp)	Q4 (Exp)	χ2	p	w	OR - Q1:Q4 95% IC	OR - $1^{st}:2^{nd}$ 95% IC
U-16	Sprints / Hurdles	32	46	28	29	4.24	0.24	0.18	1.13	1.87
		(34.6)	(35.7)	(33.6)	(31.2)				0.65 to 1.95	1.17 to 2.98
	Middle Distance	12	11	11	9	0.195	0.98	0.07	1.46	1.32
		(11)	(11.4)	(10.7)	(9.9)				0.57 to 3.74	0.58 to 2.98
	Jumps	36	39	38	22	3.643	0.3	0.16	1.86	6.42
		(34.6)	(35.7)	(33.6)	(31.2)				1.03 to 3.37	3.64 to 11.31
	Throws	23	30	20	14	4.114	0.25	0.22	1.87	2.42
		(23.3)	(23)	(21.6)	(20.1)				0.89 to 3.91	1.32 to 4.46
U-18	Sprints / Hurdles	50	53	46	43	0.213	0.98	0.03	1.22	1.33
		(49.2)	(50.8)	(47.7)	(44.3)				0.77 to 1.90	0.91 to 1.96
	Middle Distance	21	19	27	22	2.193	0.53	0.16	0.94	0.66
		(22.8)	(23.5)	(22.1)	(20.5)				0.48 to 1.81	0.37 to 1.17
	Jumps	35	35	32	35	0.527	0.91	0.06	1	1.09
		(35.1)	(36.2)	(34.1)	(35.6)				0.58 to 1.72	0.68 to 1.75
	Throws	29	30	24	25	0.44	0.93	0.06	1.22	1.44
		(27.7)	(28.6)	(26.8)	(24.9)				0.65 to 2.25	0.84 to 2.47
U-20	Sprints / Hurdles	23	19	19	26	2.784	0.43	0.18	0.84	0.87
		(22.3)	(23)	(21.5)	(20.1)				0.44 to 1.58	0.49 to 1.54
	Middle Distance	13	16	10	14	1.327	0.72	0.16	0.905	1.46
		(13.6)	(14)	(13.2)	(12.2)				0.39 to 2.08	0.70 to 3.03
	Long Distance	12	15	9	14	1.762	0.63	0.04	0.81	1.37
		(12.8)	(13.2)	(12.4)	(11.5)				0.33 to 1.97	0.62 to 3.02
	Jumps	23	17	21	19	1.199	0.75	0.12	1.29	1
		(20.5)	(21.2)	(19.9)	(18.5)				0.64 to 2.61	0.54 to 1.85
	Throws	21	19	14	19	1.51	0.68	0.14	11.97	1.46
		(18.7)	(19.3)	(18.1)	(16.8)				5.48 to 26.12	0.76 to 2.81
U-23	Sprints / Hurdles	26	18	13	13	5.372	0.15	0.28	2.59	2.86
		(17.9)	(18.5)	(17.4)	(16.2)				1.23 to 5.41	1.48 to 5.22

(*continued*)

Table 2 - continued

	Event	Q1 (Exp)	Q2 (Exp)	Q3 (Exp)	Q4 (Exp)	χ2	p	w	OR - Q1:Q4 95% IC	OR - 1st:2nd 95% IC
	Middle Distance	9	4	12	5	5.475	0.14	0.18	2.14	0.58
		(7.7)	(7.9)	(7.5)	(6.9)				0.66 to 6.82	0.22 to 1.55
	Long Distance	9	8	7	2	3.717	0.29	0.37	6.35	3.56
		(6.7)	(6.9)	(6.5)	(6)				1.32 to 29.50	1.14 to 11.13
	Jumps	12	16	16	10	1.432	0.7	0.16	1.25	1.15
		(13.8)	(14.3)	(13.4)	(12.5)				0.49 to 3.17	0.54 to 2.46
	Throws	13	10	13	12	0.783	0.85	0.13	1.11	0.84
		(12.3)	(12.7)	(11.9)	(11.1)				0.45 to 2.74	0.38 to 1.88
Senior	Sprints / Hurdles	19	20	18	13	0.821	0.84	0.11	1.63	1.58
		(17.9)	(18.5)	(17.4)	(16.2)				0.76 to 3.49	0.83 to 3.0
	Middle Distance	14	14	15	9	1.122	0.77	0.15	1.76	1.36
		(13.3)	(13.7)	(12.9)	(12)				0.718 to 4.30	0.65 to 2.85
	Long Distance	13	8	21	17	7.573	0.06	0.36	0.69	0.3
		(15.1)	(15.6)	(14.7)	(13.6)				0.30 to 1.60	0.14 to 0.65
	Jumps	18	10	9	10	4.105	0.25	0.3	2.29	2.17
		(12)	(12.4)	(11.7)	(10.8)				0.92 to 5.67	0.95 to 4.94
	Throws	8	14	22	7	10.771	<0.02	0.46	1.16	0.57
		(13.1)	(13.5)	(12.7)	(11.8)				0.41 to 3.4	0.26 to 1.25

Q1-Q4, birth quarter; (Exp), expected distribution; χ2, chi square; p, level of significance; ω, effect size; OR - Q1:Q4, odds ratio from Q1 to Q4; OR - 1st:2nd odds ratio from 1st semester to 2nd semester; Category; U-16, Under 16; U-18, Under 18; U-20. Under 20; U-23, Under 23.

Discussion

This study investigated the pervasiveness of RAE among elite Brazilian track and field athletes according to sex, age category, and type of event. Given our current knowledge, this is the first study to investigate the RAE on elite Brazilian track and field athletes. Our findings indicated that sex is a strong RAE moderator in track and field since the effects were practically exclusive to male athletes. We also found that the effect reduces as age categories increase in youth male athletes, disappearing in the U-23 category and even reversing in the senior category. Finally, in the male context, an overrepresentation of relatively older athletes was found in events with more emphasis on speed, power, and strength (e.g., sprints, jumps, and throws). The overall magnitudes of RAE in our study are smaller than those of European track and field athletes[10,12]. These findings have relevant implications for the development of Brazilian track and field, especially for the process of identifying and selecting young athletes.

As expected, the magnitude of the RAE among elite track and field athletes was sex-dependent. The overrepresentation of relatively older athletes was observed in 5 out of 6 event groups in male athletes, while a similar distribution of athletes born between the quarters of the year was observed in all event groups in the case of female athletes. These findings are in line with previous research that indicated higher RAE in male athletes in track and field[12,17] and other sports[1,2]. Environmental constraints such as sports popularity, cultural norms, and performance demands may indicate less competition for spots in the female context, which relates to smaller RAE[2,21]. We found 27% fewer female athletes in the CBAt top-50 rankings compared to male athletes, which is in line with data from previous research in track and field[9,10] and other sports modalities[6]. This might indicate that female athletes experience less competition or have fewer training/competition spots available compared to male athletes, which could explain the absence of RAE in the female context of Brazilian track and field. Overall, small female participation in organized sports is a consistent finding in the literature and has been associated with less social support to engage in sports and less enjoyment during sports practice[2,22]. Nevertheless, it is imperative to investigate this phenomenon in the Brazilian track and field context, since specific social and cultural factors may also play an important role in low female sports participation.

The age category seems to be another important RAE modulator among elite track and field athletes. In our study, the age category analysis was performed independently for each sex. On male athletes, uneven distributions were found in U-16, U-18, and U-20 categories, but not in the U-23 category. In the senior category, our findings suggest reverse RAE. The analysis of youth categories showed an overrepresentation of relatively older athletes, that reduced as categories increased, even disappearing in the U-23. Our data were similar to previous studies on track and field athletes of different competitive levels, countries, and ages[8-11,17]. The "maturation-selection hypothesis" proposes that chronologically older children and adolescents are more likely to be physically mature[1,11], which may lead to performance advantages at youth sports. These advantages on basic anthropometric and physiological characteristics, however, tend to disappear as age increases, especially after the pubertal growth spurt[1,20]. This is believed to explain the reduction or loss of RAE in senior categories, which has also been reported in other contexts, such as the elite Italian male soccer[23]. Interestingly, an uneven distribution of birthdates was also identified in the male athletes of the senior category in our study. However, in this case, the post hoc analysis indicated that athletes born in the third trimester were the most frequent ones. This "RAE reversal" has been reported in senior elite sports, such as ice hockey[13] and soccer[7], and reinforces the idea that long-term athletic success is not dependent on the possible physical advantages of relatively older athletes[14]. It has been proposed that relatively younger athletes benefit from training and competing with physically advantaged relatively older peers[14,24]. This challenging environment may encourage younger athletes to work harder, be more motivated, and technically more skilled than their older peers[24]. For this reason, relatively younger athletes tend to be overrepresented in the senior category, where the initial physical advantages are not expected to play a central role anymore. Accordingly, our data showed that relatively older male Brazilian track and field athletes seem to be preferred in younger tiers selection processes, but this preference is reversed in the senior category.

No RAE was found in any age category among female athletes. These results are not similar to the findings from Kearney et al.[10] and Brazo-Sayavera et al.[12] with European track and field athletes, where an overrepresentation of relative older athletes was also reported for females. On the other hand, similar results were found in some categories by Brazo-Sayavera et al.[9], in a sample composed of Spanish youth female athletes. Our findings indicate that RAEs are not pervasive in any of the categories of Brazilian track and field female athletes. In addition to the depth of competition hypothesis, we speculate that these findings are related to the late talent selection process that is common in the Brazilian track and field context. Since performance development gradually decreases in females after the growth spurt[25], relatively older female athletes are less likely to be perceived as more talented due to maturation differences, causing RAE occurrence to decrease for this population[2,5]. This is because females usually mature earlier than males[20], and many female athletes undergo late selection processes (when the pubertal growth spurt is supposedly finished or at its end) in Brazil, which reduces the maturational differences between relatively younger and older athletes. Since the youngest category investigated in our study was the U-16, future research should investigate even younger age categories, as this could provide a further understanding of the RAE in the female Brazilian track and field context.

The event analyses according to the category in male athletes revealed uneven birthdates distributions in U-16, U-18, U-20, and senior. In the U-16, an overrepresentation of relatively older athletes was found for sprints/hurdles, jumps, and throws events. As age categories increased, this effect only remained in the sprints/hurdle's events, for the U-18 and U-20 categories. Overall, these findings indicate that the occurrence of RAE is greater in events that rely more on speed, power, and/or strength. This has also been reported by Hollings et al.[8] in Youth and Junior European elite athletes and by Brustio et al.[17] in World-Class track and field athletes. Hormone-dependent changes in height (skeletal tissue) and muscle mass during the puberty favor the relative youth athletes in track and field events where these aspects are determinant for performance[25]. This justifies the existence of RAE in the youngest categories of the sprints, jumps, and throws events, since the relatively younger athletes benefit from a "biased" view of their potential, as proposed in the maturation-selection hypothesis[1]. In the senior category, an uneven distribution was found for the throw's events, however, the post hoc analysis failed to identify this difference, and odds ratios between the semesters were very close (1.04).

When event types were analyzed according to the category in female athletes, even distributions were found for all event types in all categories, except for throwing events, in the senior category. In this case, the post-hoc analysis was not able to identify this difference, even though a seeming overrepresentation of athletes born in the second semester was found, as corroborated by the odds ratios. This finding, along with the ones in senior male throws suggests that the rationale behind selection processes in throwing events is unclear, which highlights the need for further investigation, preferably using a longitudinal approach that allows more athletes to be analyzed.

The RAE manifests itself in a complex way in Brazilian track and field, according to sex, categories, and event types. Our results showed a clear RAE in the male athletes, especially in younger categories. Thus, accounting for the RAE on the selection of male track and field athletes plays a key role to minimize the possible risk of losing potential talented young athletes due to the coaches' search for immediate performance. Since relatively older athletes are overrepresented in younger categories, potential talented athletes may be systematically overlooked, due to the transient disadvantages associated with their date of births in relation to cut-off dates[1]. This requires special attention from sports administrators, especially because previous research has shown that high performance in young categories does not predict sports success at high-level in track and field[10]. In addition, evidence indicates that RAE is not associated with competitive success in other elite sports modalities [16,26]. Thus, counter-RAE interventions such as educating sports stakeholders and coaches[4], reducing the age group's bandwidths[27], and the research and application of corrective adjustments in youth performance results[11] are some of the propositions to avoid potential talent loss in the male Brazilian track and field context.

This study has some limitations, such as not analyzing the events individually, due to the sample size available. This prevented us from drawing conclusions that are more specific to each of the events. Another limitation was the analysis of athletes that were present in rankings in a single year. Due to this limitation, it was not possible to verify changes over time regarding the effects of the RAE in the selection of Brazilian track and field athletes. Therefore, future research on the effects of relative age in Brazilian track and field athletes should analyze more athletes for longer periods than just one year. This longitudinal approach may allow a broader comprehension of the effects of RAE in the track and field context according to the specificity of each event.

Conclusion

In conclusion, RAE was found in the male Brazilian track and field athletes, whereas this effect was not prevalent in female athletes. Higher ORs for relatively older athletes were found in male athletes' youth age categories, especially in events in which performance is more affected by strength, speed, and power. Our results suggest that RAE affects talent selection in the younger categories of male track and field, which is confirmed by the overrepresentation of relatively older athletes in this context. However, when senior athletes were analyzed, the reversal of the effect was observed, as relatively younger athletes were more frequent than their relatively older peers were. This elucidates that many potentially talented athletes were lost along the talent development pathway, due to biased selection processes mediated by RAE. Now aware of this, coaches and sports administrators should employ specific policies to interventions to minimize the disadvantages experienced by athletes born further away from the cut-off dates in youth male track and field.

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