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# Relative age effect in elite Brazilian athletes in different combat sports: an observational study

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## Abstract

**Background** The relative age effect (RAE) suggests that, due to maturity, young athletes born in the first quartiles of the year may have advantages over those born in the last quartiles of the year. Thus, it is important to evaluate the RAE in different sports and to consider the particularities of the subdivisions of the sports categories.

**Objective** To analyze the RAE in the top 20 of the Brazilian rankings in different combat sports.

**Methods** Observational study that analyzed the national databases for the year 2019 (from categories U-11 to U-18) made publicly available by the Brazilian confederations of karate, taekwondo and fencing. We obtained data on date of birth, age category and body weight of all modalities, type of fencing competition weapon (Epee, Foie and Saber) and type of karate modality (kumite and kata) from the top 20 places in each ranking. The final sample consisted of 1,486 athletes (Age: $14.2 \pm 2.3$. Male—53.2%. Female—46.8%). To identify the RAE, we performed a contingency analysis and compared the results between the sexes within the same sport.

**Results** There was RAE in the U-11, U-12, U-15 and U-17 fencing categories ($p < 0.05$), being higher in the female categories ($p < 0.05$). The RAE was higher for males in the Epee test, and similar between the sexes for the Saber and Foie tests. In karate, RAE occurred in categories U-14 and U-16 ($p < 0.05$), being higher in males ($p < 0.05$). The RAE was similar between the sexes in the kumite modality ($p < 0.05$). There was no RAE for the kata modality in karate ($p > 0.05$) and for the Taekwondo categories ($p > 0.05$).

**Conclusion** The results showed the existence of a relative age effect in elite athletes ranked (top 20 places in each ranking) only for the sport of fencing and karate kumite.

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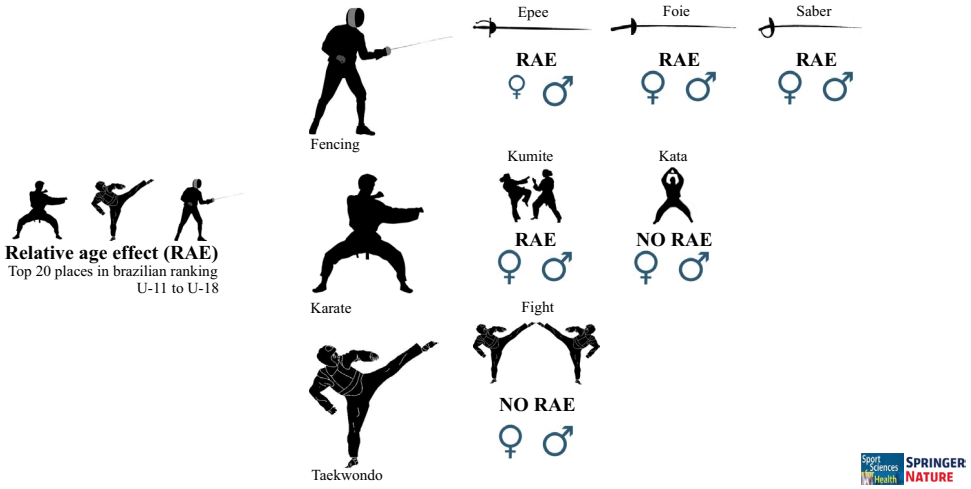
**Graphical abstract**




**Keywords** Relative age · Biological maturation · Maturity · Sport · Athlete

## Introduction

The relative age effect (RAE) is a phenomenon based on the argument that, within the same sport category, older athletes born in the first quartiles of the year (i.e., from January to June) may have possible advantages over younger ones born in the last two quartiles of the year (i.e., from July to December) [1, 2]. This possible advantage can generate two problems that deserve attention from professionals who work in the selection and development of sports talents, early abandonment and selection bias [3]. The understanding of the cause that generates RAE is still in doubt in the literature, but there is some evidence as modalities that demand more physical development such as strength and potency [4, 5] and the male category [3] point to the emergence of the RAE much more frequently. However, even today it is clear that the RAE varies according to the sport (its internal divisions), age category, sex and culture/region, making increasingly detailed and regional investigations necessary for a better understanding of this phenomenon.

RAE has been previously analyzed in several sports, including combat sports such as karate, judo and taekwondo [6]. In combat sports where wrestling takes place, categories are divided by sex, year of birth and subcategories by body weight [7]. In addition, some combat sports confederations use the leveling given by belt colors to prioritize the level of learning in the athlete's training process [8]. The division of subcategories by the athletes' weight makes competition fairer in relation to the impacts of blows [4, 5].

However, there are combat sports that do not use bodyweight subcategories. In fencing, for example, the subcategories are according to the type of weapon used (i.e., Epee, Foie and Saber) [9, 10]. As in fencing, in karate, one of its modalities (i.e., kata) does not consider weight subdivisions in competitions [8]. Karate is basically divided into kumite, which is the modality of fighting a real opponent, and kata, which concerns a predetermined presentation of movements, where the athlete who performs the best presentation wins [8]. The kata modality is divided only by sex and chronological age, while the kumite modality is subdivided by sex, chronological age and body weight [11]. Unlike taekwondo, which, although it has display modalities similar to kata, subdivides its categories by weight and gender [12].

Previously, when analyzing the rankings of combat sports from the Olympic Games held in London 2012 and Rio de Janeiro 2016, Campideli et al. [13] did not find a consistent presence of RAE. This can be justified by the subdivision of weight in the categories, which apparently makes the competition fairer between the athletes [14]. However, the authors of the present study are aware that the RAE in combat sports that do not use weight subdivisions such as fencing and the Kata modality in karate has not yet been investigated in athletes of both sexes. In addition, the analysis of younger categories, where RAE is more prevalent [5], seems to be interesting to better elucidate this phenomenon in combat modalities.

The present study aimed to analyze the RAE in the top 20 of the Brazilian national rankings of different combat sports. The study hypothesized that, due to the non-use of subdivisions by body weight, the RAE would appear among the top 20 in the ranking of fencing and karate kata modality, and that it would not appear in taekwondo combat sports and

kumite modality in karate that use subdivisions of categories by body weight.

## Methods

The present study analyzed the Brazilian national rankings of the year 2019 of different combat sports, the total sample was formed by fencing, karate and taekwondo athletes being composed of the first 20 athletes in the ranking of their respective modalities (type of fight) categories (U-11–U-18) and subcategories (Weight: karate kumite and taekwondo. Age: fencing and karate kata. Weapon used: fencing), totaling 1486 athletes of both sexes (Average age: $14.2 \pm 2.3$, 53.2% male, 46.8% female. Distributed in 405 fencing athletes, 498 karate athletes and 583 taekwondo athletes). It is important to state that the rankings for the years 2020 and 2021 were not considered due to the interference of the COVID-19 pandemic in the calendar of national-level sports competitions that had to be canceled or adjusted to occur with a reduced number of athletes.

The databases are publicly available in the sports confederations and can be consulted online (fencing: https://cbesgrima.org.br/; Karate: https://www.karatedobrasil.com/ and Taekwondo: https://cbtkd.org.br/). Thus, the fact of using public databases exempts the present study from analysis by a local ethics committee. In addition, the present study followed the STROBE guidelines for observational studies [15].

### Procedures and data acquisition

Initially, the respective websites of the national sports entities responsible for each modality analyzed in the present study (fencing, karate and taekwondo) were accessed. For karate and fencing, when the data provided were incomplete regarding dates of birth, emails were sent to the sports entities explaining the particularities of the study and requesting the data omitted in the rankings. For Taekwondo, it was not necessary to request additional data by e-mail. Finally, the data were gathered in the U-11, U-13, U-15 and U-17 fencing categories; Karate U-14, U-16 and U-18; Taekwondo U-12, U-15 and U-18. It is important to point out that in the present study, we used up to the 20 first placed in the ranking of each category, and that the number of athletes in the ranking varied from 5 to 20 subjects depending on the body weight range (which varied between sports from − 30 to + 78 kg).

## Statistics

### Contingency analyses

To identify the effect of relative age, we performed a contingency analysis using the chi-square ($\chi^2$) goodness-of-fit test. Thus, we considered as "Base column" the data of the quartiles of birth, as "Rows of data" the sex [male and female], the category [Fencing: U-11, U-13, U-15 and U-17. Karate: U-14, U-16 and U-18. Taekwondo: U-12, U-15 and U-18]. For the fencing and karate modalities, we performed the analysis of the grouped events [Fencing: Epe, Foie and Saber. Karate: kumite and Kata.] and segregated [by weapon type, by fighting an opponent and kata]. For taekwondo and kumite category of karate, we weighted the weight of the analyses with the values of the variable "category by body weight". For fencing and karate kata category, we weighted the weight of the analyses by the variable "ranking position" [from 1st to 20th place]. The effect size for the $\chi^2$ test analyses was verified by "Cramer's V" considering the magnitude: small: 0.06–0.17; medium: 0.18–0.29; and large: > 0.29 [16]. We used the Likelihood Ratio (L-Ratio) test to assess the probability of the relative age effect occurring in the total sample and in the categories stratified by age and sex, to interpret the L-Ratio we used the magnitude [17]: Values between 0 and 1 reduce the probability [0.1–0.19: large decrease, 0.2–0.49: moderate decrease, 0.5–0.99: slight decrease and 1: neutral probability]; values > 1 increase the probability [1.1–1.9: neutral probability, 2–4.9:slight increase, 5–9.9: moderate increase and ≥ 10: large increase].

### Data normality

Chronological age data are described as mean, standard deviation. The other data are described in absolute frequency and percentage. The normality of the database was tested by the Kolmogorov–Smirnov and *Z* score tests for asymmetry and kurtosis (− 1.96 to 1.96).

### Comparisons

The difference in the relative age contingency between the sexes [male and female] was verified through the "*U*" test of "Mann–Whitney", the size of the effect was verified by the "Rho" of Spearman and the magnitude adopted was: small: 0.10–0.29; medium: 0.30–0.49; broad: 0.50–0.79; very broad: ≥ 0.80 [16]. All above-mentioned were performed using open source software R (version 4.0.1; Foundation for Statistical Computing®, Vienna, Austria) considering the significance of $p < 0.05$.

**Table 1** Sample characterization

| Categories | Participants (*N*) | | Chronological age (years) | | Tests | Participants by tests (*N*) | |
|---|---|---|---|---|---|---|---|
| | | | Fencing | | Fencing | | |
|  | Male | Female | Male | Female | | Male | Female |
| U-11 | 52 | 52 | 10.5 ± 0.9 | 10.9 ± 0.7 | Epee | 80 | 77 |
| U-13 | 52 | 52 | 11.7 ± 1.2 | 12.8 ± 0.7 | Foie | 78 | 73 |
| U-15 | 56 | 43 | 14.3 ± 0.7 | 14.9 ± 0.5 | Saber | 62 | 35 |
| U-17 | 60 | 38 | 16.0 ± 0.9 | 16.5 ± 0.6 | – | – | – |
|  | Karate | | | | Karate | | |
| U-14 | 99 | 63 | 13.0 ± 1.7 | 12.9 ± 1.6 | Kumite | 242 | 152 |
| U-16 | 96 | 64 | 15.2 ± 1.5 | 15.1 ± 1.4 | Kata | 34 | 50 |
| U-18 | 101 | 75 | 17.0 ± 1.7 | 17.0 ± 1.8 | – | – | – |
|  | Taekwondo | | | | Taekwondo | | |
| U-12 | 85 | 52 | 10.6 ± 0.8 | 10.7 ± 0.8 | – | – | – |
| U-15 | 110 | 146 | 14.0 ± 0.9 | 13.7 ± 0.9 | – | – | – |
| U-18 | 80 | 110 | 16.4 ± 0.9 | 16.6 ± 1.0 | – | – | – |

N absolute number. ± mean and standard deviation. U-11 under-11 category, U-12: under-12 category, U-13 under-13 category, U-14 under-14 category, U-15 under-15 category, U-16 under-16 category, U-17 under-17 category, U-18 under-18 category

## Results

Table 1 describes the sample characterization regarding chronological age, and the sample distribution in relation to the number of participants by sex (male and female), age category (U-11–U-18) and type of test (Fencing: by weapons used; Karate: kumite and kata).

Table 2 shows the effect of relative age by age categories (U-11–U-18). Thus, an effect of relative age on fencing was identified in the U-11 (both sexes), U-12 (female), U-15 (both sexes) and U-17 (female) categories. In the U-11 (Rho 0.55, 95% CI 0.40; 0.67, $p = 0.001$) and U-15 (Rho 0.60, 95% CI 0.55; 0.79, $p = 0.02$) categories in fencing the effect of relative age was higher in females compared to males. There was also an effect of relative age in Karate in the U-14 (both sexes) and U-16 (both sexes) categories. In addition, in the U-16 category (Rho 0.75, 95% CI 0.60; 0.87, $p < 0.001$) the relative age effect was higher in males than in females. For Taekwondo, there was no effect of relative age in any of the analyzed categories.

Table 3 presents the results in Fencing (different weapons) and Karate (kumite and kata) by types of events. Thus, in Fencing, an effect of relative age was pointed out in the Epee test for categories U-11 (both sexes), U-13 (female) and U-17 (both sexes). In the Epee test for the U-11 category, the relative age effect was higher in males than in females (Rho 0.38, 95% CI 0.30; 0.45, $p = 0.04$). The effect of the relative age in the Foie test was pointed out for the U-11 (female), U-13 (female) and U-15 (female) categories. For the Saber test, there was an effect of relative age for the categories U-11 (both sexes), U-13 (both sexes), U-15 (both sexes) and U-17 (female). In addition, there were no differences between the sexes for the Saber test in the U-11, U-13 and U15 categories. For the Kumite no Karate test, there was an effect of relative age in the U-14 (both sexes) and U-16 (both sexes) categories, there were no differences between the sexes in relation to the greater occurrence of the relative age effect. For the Kata test, there was no effect of relative age.

## Discussion

The present study analyzed the relative age effect in the top 20 of the Brazilian national rankings of different combat sports. The initial hypothesis of the study was that due to the non-use of subdivisions of categories by body weight, the relative age effect would appear among the top 20 in the ranking of fencing and karate kata, and that it would not appear in taekwondo and karate kumite that use subdivisions of categories by body weight. Thus, to test the hypothesis, we weighted the contingency analyses by body weight category and by the order of placement in the ranking. Thus, the initial hypothesis of the present study was

**Table 2** Results of the contingency analysis of the effect of relative age on age categories

| Sex | Fencing | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Q1 | | Q2 | | Q3 | | Q4 | | $\chi^2$ | *p* | *V* | L-Ratio |
| | *N* | % | *N* | % | *N* | % | *N* | % | | | | |
| | U-11 | | | | | | | | | | | |
| Male | 29 | 56 | 12 | 24 | 09 | 17 | 02 | 03 | 15.6 | 0.04* | 0.15 | 5.6 |
| Female | 18 | 35 | 15 | 29 | 06 | 11 | 13 | 25 | 42.2 | 0.006* | 0.28 | 8.7 |
| | U-13 | | | | | | | | | | | |
| Male | 17 | 33 | 11 | 22 | 17 | 33 | 07 | 12 | 12.3 | 0.07 | 0.11 | 3.1 |
| Female | 42 | 81 | 06 | 11 | 01 | 02 | 03 | 06 | 43.7 | 0.0005* | 0.30 | 9.2 |
| | U-15 | | | | | | | | | | | |
| Male | 22 | 40 | 17 | 31 | 11 | 20 | 06 | 09 | 12.4 | 0.02* | 0.12 | 6.3 |
| Female | 13 | 31 | 15 | 34 | 10 | 24 | 05 | 11 | 30.2 | < 0.001* | 0.27 | 9.6 |
| | U-17 | | | | | | | | | | | |
| Male | 16 | 27 | 18 | 30 | 16 | 27 | 10 | 16 | 14.8 | 0.1 | 0.09 | 3.7 |
| Female | 12 | 30 | 10 | 27 | 07 | 19 | 09 | 24 | 33.4 | 0.0002* | 0.25 | 9.4 |
|  | Karate | | | | | | | | | | | |
| | U-14 | | | | | | | | | | | |
| Male | 28 | 27.5 | 27 | 27 | 19 | 19 | 25 | 26.5 | 10.2 | 0.01* | 0.25 | 9.1 |
| Female | 27 | 43 | 12 | 20 | 03 | 05 | 21 | 32 | 12.5 | 0.01* | 0.22 | 9.3 |
| | U-16 | | | | | | | | | | | |
| Male | 28 | 29.5 | 30 | 31.5 | 27 | 28.5 | 11 | 10.5 | 15.4 | 0.001* | 0.33 | 9.0 |
| Female | 14 | 23 | 7 | 11 | 24 | 38 | 19 | 30 | 5.2 | 0.02* | 0.30 | 8.8 |
| | U-18 | | | | | | | | | | | |
| Male | 29 | 29.3 | 31 | 30.8 | 25 | 24.8 | 16 | 18.1 | 2.8 | 0.4 | 0.12 | 3.3 |
| Female | 30 | 40 | 19 | 25.5 | 14 | 19 | 12 | 15.5 | 3.1 | 0.4 | 0.10 | 3.6 |
|  | Taekwondo | | | | | | | | | | | |
| | U-12 | | | | | | | | | | | |
| Male | 20 | 23.6 | 20 | 23.6 | 23 | 27.5 | 22 | 25.3 | 0.97 | 0.8 | 0.08 | 2.4 |
| Female | 16 | 31 | 10 | 20 | 13 | 24.5 | 13 | 24.5 | 0.95 | 0.8 | 0.05 | 1.7 |
| | U-15 | | | | | | | | | | | |
| Male | 35 | 32 | 37 | 34 | 18 | 15 | 20 | 19 | 4.5 | 0.2 | 0.14 | 1.5 |
| Female | 40 | 27.4 | 37 | 25.4 | 30 | 20.4 | 39 | 26.8 | 3.0 | 0.2 | 0.12 | 1.5 |
| | U-18 | | | | | | | | | | | |
| Male | 18 | 22.5 | 25 | 31.3 | 22 | 27.4 | 15 | 18.8 | 6.7 | 0.08 | 0.9 | 0.1 |
| Female | 23 | 21 | 22 | 20 | 29 | 26.5 | 36 | 32.5 | 7.0 | 0.08 | 0.11 | 0.3 |

N absolute number of participants, % percent, $\chi^2$ contingency coefficient, V effect size by "V" Cramer, L-Ratio likelihood ratio, U-11 under-11 category. U-12 under-12 category, U-13 under-13 category, U-14 under-14 category, U-15 under-15 category, U-16 under-16 category, U-17 under-17 category, U-18 under-18 category, Q1 first quartile, Q2 second quartile, Q3 third quartile. Q4 fourth quartile

partially confirmed through the main findings that pointed out that in all fencing events in most categories the RAE occurred and that, unlike the initial thought, most of the kumite categories in karate occurred the RAE, being more predominant in males. In addition, in the kata modality of karate and taekwondo, RAE did not occur in any category.

It was identified that in fencing the RAE occurred for both sexes, being higher in the female categories U-11, U-12, U-15 and U-17. However, when segregating the sample by type of weapon used, for the most disputed event in the modality (Epee) the RAE was higher in the male U-11 category, while in the other events the RAE was similar in both sexes in the U-categories-11, U-13, U-15 and U17

**Table 3** Results of the contingency analysis of the effect of relative age in the weapon categories in fencing and in the kumite and kata categories in karate

| Sex | Fencing–Epee | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | | Q2 | | Q3 | | Q4 | | $\chi^2$ | $p$ | $V$ | L-Ratio |
| | $N$ | % | $N$ | % | $N$ | % | $N$ | % | | | | |
| | U-11 | | | | | | | | | | | |
| Male | 13 | 65 | 05 | 25 | 01 | 05 | 01 | 05 | 32.1 | < 0.001* | 0.36 | 9.7 |
| Female | 06 | 30 | 07 | 35 | 01 | 05 | 06 | 30 | 23.6 | 0.005* | 0.32 | 9.5 |
| | U-13 | | | | | | | | | | | |
| Male | 07 | 35 | 03 | 15 | 10 | 50 | 00 | 00 | 10.2 | 0.1 | 0.05 | 3.6 |
| Female | 11 | 55 | 05 | 25 | 01 | 05 | 03 | 15 | 20.1 | < 0.001* | 0.20 | 9.8 |
| | U-15 | | | | | | | | | | | |
| Male | 04 | 20 | 05 | 25 | 05 | 25 | 06 | 30 | 9.6 | 0.051 | 0.09 | 3.7 |
| Female | 03 | 15 | 08 | 40 | 09 | 45 | 00 | 00 | 8.7 | 0.06 | 0.02 | 4.7 |
| | U-17 | | | | | | | | | | | |
| Male | 02 | 10 | 08 | 40 | 09 | 45 | 01 | 05 | 23.1 | 0.049* | 0.19 | 6.1 |
| Female | 07 | 40.6 | 04 | 24 | 03 | 17.7 | 03 | 17.7 | 19.8 | < 0.001* | 0.30 | 8.5 |
| | Fencing–Foie | | | | | | | | | | | |
| | U-11 | | | | | | | | | | | |
| Male | 08 | 41.5 | 05 | 26.5 | 05 | 26.5 | 01 | 5.5 | 16.0 | 0.06 | 0.20 | 3.2 |
| Female | 07 | 35 | 06 | 30 | 05 | 25 | 02 | 10 | 20.1 | 0.04* | 0.39 | 7.8 |
| | U-13 | | | | | | | | | | | |
| Male | 05 | 26.5 | 04 | 21 | 04 | 21 | 06 | 31.5 | 15.7 | 0.08 | 0.15 | 2;9 |
| Female | 19 | 95 | 01 | 05 | 00 | 00 | 00 | 00 | 34.5 | < 0.0001* | 0.40 | 8.9 |
| | U-15 | | | | | | | | | | | |
| Male | 08 | 40 | 07 | 35 | 05 | 25 | 00 | 00 | 13.2 | 0.051 | 0.17 | 3.3 |
| Female | 08 | 45 | 05 | 27.5 | 00 | 00 | 05 | 27.5 | 30.7 | < 0.001 | 0.36 | 9.2 |
| | U-17 | | | | | | | | | | | |
| Male | 10 | 50 | 07 | 35 | 00 | 00 | 03 | 15 | 17.3 | 0.07 | 0.12 | 3.2 |
| Female | 02 | 14 | 04 | 28 | 04 | 28 | 05 | 30 | 19.3 | 0.055 | 0.19 | 4.5 |
| | Fencing–Saber | | | | | | | | | | | |
| | U-11 | | | | | | | | | | | |
| Male | 08 | 62 | 02 | 16 | 03 | 22 | 00 | 00 | 19.5 | 0.02* | 0.32 | 9.3 |
| Female | 05 | 42 | 02 | 16 | 00 | 00 | 05 | 42 | 21.7 | 0.01* | 0.45 | 9.7 |
| | U-13 | | | | | | | | | | | |
| Male | 05 | 37 | 04 | 31 | 03 | 24 | 01 | 08 | 18.1 | 0.01* | 0.30 | 8.7 |
| Female | 12 | 100 | 00 | 00 | 00 | 00 | 00 | 00 | 22.0 | 0.001* | 0.33 | 9.0 |
| | U-15 | | | | | | | | | | | |
| Male | 10 | 63 | 05 | 31.5 | 01 | 5.5 | 00 | 00 | 19.3 | 0.002* | 0.29 | 9.8 |
| Female | 02 | 40 | 02 | 40 | 01 | 20 | 00 | 00 | 17.2 | 0.01* | 0.40 | 8.2 |
| | U-17 | | | | | | | | | | | |
| Male | 04 | 20 | 03 | 15 | 07 | 35 | 06 | 30 | 15.4 | 0.051 | 0.31 | 6.3 |
| Female | 03 | 50 | 02 | 35 | 00 | 00 | 01 | 15 | 16.8 | 0.04* | 0.42 | 7.8 |
| | Karate–Kumite | | | | | | | | | | | |
| | U-14 | | | | | | | | | | | |
| Male | 19 | 23.1 | 22 | 27.2 | 18 | 22.5 | 22 | 27.2 | 10.3 | 0.009* | 0.30 | 9.7 |
| Female | 18 | 40 | 07 | 16 | 02 | 04 | 18 | 40 | 11.6 | 0.005* | 0.25 | 9.9 |
| | U-16 | | | | | | | | | | | |
| Male | 24 | 31 | 25 | 32 | 21 | 27 | 09 | 10 | 13.5 | 0.001* | 0.32 | 10.0 |
| Female | 13 | 27 | 04 | 07 | 18 | 37 | 14 | 29 | 12.8 | 0.002* | 0.30 | 10.0 |
| | U-18 | | | | | | | | | | | |
| Male | 22 | 27 | 29 | 40 | 21 | 20.5 | 10 | 12.5 | 3.5 | 0.3 | 0.20 | 3.0 |

**Table 3** (continued)

| Sex | Fencing–Epee | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | | Q2 | | Q3 | | Q4 | | $\chi^2$ | *p* | *V* | L-Ratio |
| | *N* | % | *N* | % | *N* | % | *N* | % | | | | |
| Female | 24 | 42 | 15 | 24 | 12 | 21 | 07 | 13 | 3.3 | 0.3 | 0.19 | 3.5 |
| | Karate–Kata | | | | | | | | | | | |
| | U-14 | | | | | | | | | | | |
| Male | 09 | 50 | 05 | 29 | 01 | 04 | 03 | 17 | 0.00 | 1.0 | 0.0 | 0.2 |
| Female | 09 | 50 | 05 | 29 | 01 | 04 | 03 | 17 | 0.00 | 1.0 | 0.0 | 0.3 |
| | U-16 | | | | | | | | | | | |
| Male | 04 | 25 | 05 | 30 | 06 | 35.5 | 02 | 9.5 | 3.5 | 0.3 | 0.1 | 3.6 |
| Female | 01 | 05 | 03 | 20 | 06 | 40 | 05 | 35 | 3.3 | 0.3 | 0.1 | 2.8 |
| | U-18 | | | | | | | | | | | |
| Male | 07 | 37 | 02 | 15.5 | 04 | 23 | 06 | 34.5 | 1.4 | 0.7 | 0.0 | 1.5 |
| Female | 06 | 36 | 04 | 22.1 | 02 | 11.9 | 05 | 30 | 1.3 | 0.7 | 0.1 | 1.3 |

N absolute number of participants, % percent, $\chi^2$ contingency coefficient, V effect size by "V" Cramer, L-Ratio likelihood ratio, U-11 under-11 category, U-12 under-12 category, U-13 under-13 category, U-14 under-14 category, U-15 under-15 category, U-16 under-16 category, U-17 under-17 category, U-18 under-18 category, Q1 first quartile, Q2 second quartile, Q3 third quartile, Q4 fourth quartile

(Saber) or appeared only for females in the U-11, U-13 and U-15 (Foie) categories. These findings differ from the literature, where Musch and Grondin [4], Cobley et al. [5] and Albuquerque et al. [7] verified through meta-analysis the authors identified that the RAE was significantly higher in categories males compared to females. Previously Romann and Fuchslocher [9] analyzed the RAE in the rankings of female fencing categories in Swiss youth sports and in the Swiss National Talent Development Program (TDP). The authors found significant RAE for the Swiss youth sports ranking and inverse RAE (i.e., more athletes in the last two quartiles of the year) for the TDP Ranking. The authors did not consider the male categories and found similar results for alpine skiing, tennis, athletics and snowboarding, suggesting that regardless of the competitive level for the female categories, the occurrence of RAE does not maintain a pattern of occurrence.

In karate in the U-16 category, the RAE was higher for males. According to Goldschmied [18], this can be explained by the fact that the mechanism of biological maturity occurs earlier in female subjects than in males, and the variability of maturation stages is significantly lower in female subjects compared to males, the male sex. Furthermore, in young male athletes, the accumulation of lean body mass is significantly greater in advanced maturation stages compared to their late peers, while in females this difference in lean body mass occurs to a lesser extent between the stages of maturation [19, 20]. Thus, according to Almeida-Neto et al. [21], having an advantage in the total volume of lean body mass, can infer a physical advantage in relation to the levels of muscle strength and power in male athletes at an advanced stage of maturation in relation to their peers in a delayed maturation stage.

Another justification for the RAE being higher in males than in females is that during the process of training talent in sport, in general, the competitive level among male athletes is considered higher compared to female athletes [4]. It is noteworthy that during the training of athletes in combat sports, due to discrimination and machismo, male athletes are more encouraged to remain in the sport than female athletes [22, 23], this may also influence the higher RAE in male samples.

In karate, when segregating the sample by type of test, the present study identified that the RAE remained only for the kumite modality in both sexes. There was no RAE for the kata modality. According to Arriaza [24], as a sport, the kumite modality is more popular among karate practitioners. In this sense, Musch and Grondin [4] state that more popular modalities with higher concentrations of competitors can increase the probabilities of RAE. Another justification for this finding is that although a fight against a real opponent is not carried out, in the kata modality of karate, the technical level of the movement sequences is very high at national and international level, and the judges are judicious in relation to the performances which demands attention to the smallest details on the part of the competitors [25]. This characteristic of karate competitions makes practitioners prefer to compete in the kumite modality, characterized by demanding a balanced use of anaerobic power and a less accurate technical rigor due to the basic objective being centered on touching the opponent's body to score [24, 25].

In a study that sought to analyze the RAE in categories from U-9–U-14 in athletes from multiple sports, Gil et al.

[6] did not find the presence of RAE in any male karate category. However, they found an RAE reverse for the female U-11 karate category. We emphasize that, unlike the present study, Gil et al. [6] analyzed karate only in a general way without considering the division by modalities (kumite and kata), in addition to considering all the athletes in the ranking, while the present study used only the top 20 in each category and weighted the analyses by body weight categories. The difference in the characteristics of each study may explain the different responses, demonstrating that the investigation, depending on how it is carried out, may or may not have RAE. Suggesting that as competitiveness increases, the likelihood of RAE increases.

Regarding the U-12, U-15 and U-18 taekwondo categories, no significant RAE was found. Converging and complementing the study by Albuquerque et al. [26], who analyzed the RAE in the ranking of Olympic taekwondo athletes and did not find significant results, our study did not find RAE in well-ranked athletes in the basic categories in Brazil. The fact that taekwondo is an unpopular combat modality among striker's fights (i.e., which use punches and kicks), may corroborate that the modality is sought after by subjects who have not been able to stand out in more popular sports such as karate. According to the Brazilian karate and taekwondo confederations in the year 2021, Brazil had more than one million athletes affiliated with karate and about thirty thousand athletes affiliated with taekwondo [12, 26]. In this sense, the lack of popularity of taekwondo can balance the chances of success of athletes who choose that sport regardless of the quartile of the year in which the athlete was born [27].

Based on the approach carried out, we emphasize that the present study has as a strong point the fact that when considering subcategories by weapons in fencing and by modality in karate (kumite and kata) the patterns of occurrence of RAE change among the top 20 in the Brazilian national ranking. However, the present study has, among its limitations, the fact that it did not analyze the top 20 athletes in the national rankings of karate, fencing and taekwondo from other countries, which makes it impossible to infer whether the findings are representative at a global level. In this way, we encourage the production of similar studies that seek to analyze the RAE among the top 20 athletes in the combat sports rankings in different countries [28].

Considering that the RAE is based on the chronological age of birth of young athletes, to significantly reduce the RAE in combat sports, we suggest that national entities seek to consider biological maturation during the process of sports training, selection and orientation of young talents in combat sports. Extending this possibility to the division of categories based on the stages of biological maturation, something similar to the Bio-bading [29–31]. In this way, athletes could compete in categories divided according to Bio-bading ("biological age"), with subcategories divided by belt color (technical level) and by body weight (body profile). This can prevent the loss of young sporting talent and strengthen the youth ranks of national-level combat sports.

## Conclusion

It was concluded that the effect of relative age is a variable present to be considered in the elite athletes that make up the Brazilian ranking only in the sports modalities of fencing and kumite in karate. Especially in the female categories (ages between 11 and 17 years old) in fencing, and in the male categories (ages between 14 and 16 years old) in the kumite modality of karate, where they present even more expressive relationship values, not showing any result in athletes of the same age. Ranked in taekwondo. In this way, we can consider relative age as an important variable to be observed in the selection processes, which can influence several other physical variables, since within the same category, depending on the difference in the athlete's month of birth, we can have individuals in different maturation stages. In addition, the top ranked athletes generally receive more structure and sponsorship to maintain training and proceed to the Olympic level, and that there is an unequal distribution in birth dates, which can lead to a possible selection bias.

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**Data availability** The data used in the present study are publicly available on the platform https://figshare.com, under https://doi.org/10.6084/m9.figshare.15183846.

## Declarations

**Competing interests** The authors declare no competing interests.

**Conflict of interest** Nothing to declare.

**Ethical approval** The databases are publicly available in the sports confederations and can be consulted online (fencing: https://cbesgrima.org.br/; Karate: https://www.karatedobrasil.com/ and Taekwondo: https://cbtkd.org.br/). Thus, the fact of using public databases exempts the present study from analysis by a local ethics committee.

**Informed consent** This study used publicly available databases, so formal consent from the participants is notrequired for the study design. In addition, sports confederations receive prior consent from participants to maketheir data available in open access rankings.

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