Relative age effect in elite swimmers in U14 Czech Championship

Michal Bozděch[1], Adrián Agricola[2], Adam Křehký[2], Petr Schlegel[2], Jiří Zháněl[1]

[1]*Faculty of Sport Studies, Masaryk University, Brno, Czech Republic*
[2]*Faculty of Education, University of Hradec Králové, Hradec Králové, Czech Republic*

Abstract

PURPOSE *The issue of the Relative Age Effect (RAE) has been studied in the theory of sports for more than 30 years. Most studies concentrate on team sports, while the area of some individual sports like swimming can be considered still underexplored.*
METHODS *The aim of our study was to verify the RAE in young elite swimmers (n = 198) who participated in Czech Republic U14 Championship (1) in male and female samples (2) according to swimming disciplines and distances (3) and performance (times in individual disciplines) between individual quartiles / semesters of birth. The analysis was performed with the use of adequate statistical (chi-square test, Kruskal-Wallis H test, Mann-Whitney U test) and effect size (effect size w index, eta-square test, effect size r index) tests.*
RESULTS *The results showed a different intensity of RAE sex-differences (male: w = 0.033; female: w = 0.006). In the division by the swimming disciplines and swimming distances, statistically significant values with large effect size were found in males in 50 m freestyle, 200 m individual medley, 100 m butterfly and 200 m butterfly. However, this did not apply for girls. Analysis of differences in performance showed a significant difference between the dependent variables (sex, distance, discipline) by different independent variables of quartile / semester of birth with large effect size only in cases of male 100 m breaststroke and female 200 m individual medley.*
CONCLUSIONS *The issue of RAE should be circulated among the coaches working with youth, athletes, sports organizations, but also parents of athletes in order to avoid the termination of actively spent time or drop-outs.*

Key words: *birthdate, performance, sport, swimming, sex, adolescence*

INTRODUCTION

In the field of sports sciences, the Relative Age Effect (RAE) term refers to the deviation of the distribution in birthdates of selected athletes from the normal distribution in the population (Delorme, Boiché & Raspaud, 2010). This means that the birthdates for a selected sample of athletes are not distributed proportionally, as are the birthdates for a corresponding segment of normal population, i.e. approximately evenly throughout the year. A higher frequency of athletes is, on the contrary, cumulated at the beginning of the selected time period (year, season), which means that athletes born at the beginning of the year/season are represented more often in the selected sample than athletes born in later months (Agricola, Zháněl & Hubáček, 2013; Lames, Augste, Dreckmann, Görsdorf & Schimanski, 2008). This fact can significantly affect the level of physical and performance preconditions in previously born athletes, especially in youth categories and, in particular, during the period of puberty, when the differences in anthropometric, resp. motor characteristics get even deeper (Cobley, Baker, Wattie & McKenna, 2009; Lames et al., 2008; Nykodým, Bozděch, Agricola & Zháněl, 2020).

In general, most studies have confirmed RAE mainly in youth categories and in top-level / elite sports (Cobley et al., 2009). The main interest of the authors of RAE studies in sports is mostly focused on team sports, especially ice hockey (Bezuglov et al., 2020; Fumarco, Gibbs, Jarvis & Rossi, 2017; Nykodým et al., 2020) and soccer (Götze & Hoppe, 2020; Li et al., 2020; Roberts et al., 2020). However, we can find numerous RAE studies also in some individual sports, for instance in tennis (Moreira, Lopes, Faria & Albuquerque, 2017; Ulbricht, Fernandez-Fernandez, Mendez-Villanueva & Ferrauti, 2015; Wendling & Mills, 2018) and skiing (Bjerke, Lorås, Vorland & Pedersen, 2020; Müller, Gonaus, Perner, Müller & Raschner, 2017; Steidl-Müller, Hildebrandt, Raschner & Müller, 2019). On the other hand, we record only a small number of RAE studies in some (mainly individual) sports including swimming. Nevertheless, we can state from the conclusions of available studies that the existence of RAE has been proven in most cases in elite junior male and female swimmers, similarly as in other sports (Baker, Schorer & Cobley 2010; Cobley et al., 2009; Lames et al., 2008). We know from the conclusions of various studies that the occurrence of RAE in swimming is less frequent in girls / females than in boys/males (Baker et al., 2010; Cobley et al., 2009; Romann, Rössler, Javet & Faude, 2018) and the approximate age of 12–13 can be marked as the period of its strongest influence; later the RAE effect gradually and irregularly weakens, it may disappear completely, or so called reverse RAE may appear (Cobley et al., 2018, 2019). However, this does not mean that the relatively older swimmers achieve better specific performance (time in a given discipline) than their relatively younger peers (Costa et al., 2013). Based on the assessment through effect size tests, we can state that RAE is more pronounced with a higher level of performance, especially in the categories of 13–15 years (Cobley et al., 2019). Some studies have demonstrated RAE also in senior categories (Ferreira et al., 2017), which is usually the result of drop-out of swimmers already in junior categories and age bias environment.

As mentioned above, we still do not find a sufficient number of studies in some sports to analyse the issue of RAE in individual disciplines, age categories or performance levels which prevents a comprehensive understanding of RAE in the specific sport.

Since the conclusions of our detailed literary research imply that one of these sports is also swimming, we decided to turn our attention to this problem. The aim of our study was to find whether there existed any RAE: (1) in male and female participants of 2019 Czech swimming Championship in the U14 category, (2) in the division according to swimming disciplines and distances (3) and in relation to the performance between individual quartiles or semesters of birth, based on the times achieved in individual disciplines.

METHODS

Participants

The participants of the presented descriptive research were swimmers (male n = 94; female n = 104) who participated in the Czech U14 Summer Masters Swimming Championship in Zlín (50 m pool) in 2019. Czech Masters Swimming Championship are organized by the Czech Swimming Federation (ČSPS) according to the valid rules of the FINA international swimming federation, adjusted for the situation of the Czech Republic. The condition of qualification is participation at regional Championship; for long distance swimming, at long-distance swimming regional pupil Championship, eventually participation in the Czech Long-Distance Swimming Cup (hereinafter referred to as qualifying races). At the Czech Masters Swimming Championship, the swimmers can compete only in the disciplines in which they have raced in qualifying races; and only in six disciplines. A maximum of 32 swimmers can participate in 50 m, 100 m, 200 m and 400 m disciplines; maximum of 24 swimmers in 800 m and 1500 m. Admission of a competitor to the race depends on qualifying time; the number of swimmers from one club is not limited.

Procedures

Research variables (n = 26) consisted of 5 swimming disciplines (freestyle [FS], backstroke [BAS], butterfly [BF], breaststroke [BRS], individual medley [IM] and 6 different distances (50 m, 100 m, 200 m, 400 m, 800 m, 1500 m) by sex (male, female). As a categorical variable we chose, with regard to our research objective, dates of birth divided by quarters (Q_i) into Q_1 (January through March), Q_2 (April through June), Q_3 (July through September) and Q_4 (October through December), see Table 1–3, or divided by semesters (S_i) into S_1 (January through June) and S_2 (July through December), see Table 4.

Statistical analysis

Research data were analysed using adequate methods of descriptive (absolute and relative frequency, median, lower and upper quartile) as well as inference (chi-square test, Kruskal-Wallis H test and Mann-Whitney U test) statistics and effect size tests (effect size w index, eta-square test and effect size r index). Chi-square goodness of fit test (χ^2) was used to verify the differences between the expected and observed birthdate distributions. The expected distribution was determined by days in Q_i: Q_1 = 90/365.25 (24.6%); Q_2 = 91/365.25 (24.9%); Q_3 = 92/365.25 (25.2%); Q_4 = 92/365.25 (25.2%). Threshold values for small (w = 0.10), medium (w = 0.30), large (w = 0.50) effect were used to assess the effect size (ES) w index (Cohen, 1988). The significance of the differences between the independent variable (Q_i) and dependent variables (sex, swimming styles, and race distance) was assessed using Kruskal-Wallis H test and eta-squared effect size test (η^2), together with 95 % confidence interval (CI). The threshold values for η^2 (Cohen, 1988) are small ($\eta^2 = 0.01$), medium ($\eta^2 = 0.06$) and large ($\eta^2 = 0.14$) effects. Mann-Whitney U test was used in case if independent variables (Q_i) contained less than 5 swimmers; in these cases, we chose semesters (S_i) instead of the Q_i independent variables. To assess effect size, we used effect size r index for Mann-Whitney U test, which can be interpreted as a small (r = 0.10), medium (r = 0.30), or large (r = 0.50) effect (Cohen, 1988). All the values of ES indexes (w, η^2, r) smaller than small effect were marked as trivial (Cohen, 1988) and we transformed them into the Common Language Effect Size, (CLES), for their better interpretability and generalizability (Cohen, 1988; Dunlap, Cortina, Vaslow, & Burke, 1996; McGraw & Wong, 1992). Statistical calculations were performed using licensed IBM SPSS Statistics for Windows software (IBM Corp, Armonk, New York, USA, v. 25.0). The threshold at $\alpha = 0.05$ was chosen as the level of statistical significance.

RESULTS

Table 1 contains the results of an analysis of birthdate distribution and the evaluation of RAE for the whole research group and its effect on sex. Table 2 further includes analyses of birthdate distribution and an assessment of the level of RAE effect for individual research variables, performed with the use of test in terms of statistical significance and magnitude of effect size. The following Table 3 and 4, however, do not give the numbers of frequencies as in the case of Table 1 and 2, but the final times of the competitors [MM:SS.SS]. This made it possible to verify the presumption whether the relatively older swimmers performed better, in the form of better time, because of their biological advantage.

Table 1. Differences between the Expected and Observed Distribution of Swimmers' Birthdate

Sex	Birthdate quarters				n	χ^2	p	W
	Q_1 (%)	Q_2 (%)	Q_3 (%)	Q_4 (%)				
Male	35 (37.23)	22 (23.40)	22 (23.40)	15 (15.96)	94 (100%)	9.846	0.020	0.033
Female	28 (26.92)	27 (25.96)	25 (24.04)	24 (23.08)	104 (100%)	0.385	0.943	0.006
Total	63 (31.82)	49 (24.75)	47 (23.74)	39 (19.70)	198 (100%)	6.600	0.086	0.013

Note: Q_{1-4}: quarter of birth; χ^2: chi-square goodness of fit test; w: effect size w index (Cohen's w)

Table 2. Differences between the Expected and Observed Distribution of Swimmers' Birthdates in Sex, Distance and Discipline

Sex	Distance	Discipline	Birthdate quarters				n	χ^2	p	w
			Q_1 (%)	Q_2 (%)	Q_3 (%)	Q_4 (%)				
M	50	FS	14 (45.16)	8 (25.81)	8 (25.81)	1 (3.23)	31 (100%)	10.625	0.014	0.585
M	100	FS	14 (43.75)	7 (21.88)	7 (21.88)	4 (12.50)	32 (100%)	6.750	0.080	0.459
M	100	BAS	11 (34.38)	8 (25.00)	7 (21.88)	6 (18.75)	32 (100%)	1.750	0.626	0.234
M	100	BF	16 (50.00)	11 (34.38)	4 (12.50)	1 (3.13)	32 (100%)	17.250	0.001	0.734
M	100	BRS	8 (34.78)	4 (17.39)	7 (30.43)	4 (17.39)	23 (100%)	2.167	0.539	0.307
M	200	FS	10 (31.25)	5 (15.63)	10 (31.25)	7 (21.88)	32 (100%)	2.250	0.522	0.265
M	200	BF	13 (40.63)	11 (34.38)	6 (18.75)	2 (6.25)	32 (100%)	9.250	0.026	0.538
M	200	IM	13 (40.63)	7 (21.88)	10 (31.25)	2 (6.25)	32 (100%)	8.250	0.041	0.508
M	200	BAS	11 (34.38)	6 (18.75)	6 (18.75)	9 (28.13)	32 (100%)	2.250	0.522	0.265
M	200	BRS	10 (31.25)	9 (28.13)	9 (28.13)	4 (12.50)	32 (100%)	2.750	0.432	0.293
M	400	FS	13 (40.63)	6 (18.75)	5 (15.63)	8 (25.00)	32 (100%)	4.750	0.191	0.385
M	400	IM	9 (29.03)	10 (32.26)	7 (22.58)	5 (16.13)	31 (100%)	1.875	0.600	0.246
M	1500	FS	6 (26.09)	6 (26.09)	4 (17.39)	7 (30.43)	23 (100%)	0.833	0.841	0.190
F	50	FS	9 (28.13)	11 (34.38)	7 (21.88)	5 (15.63)	32 (100%)	2.500	0.475	0.280
F	100	FS	11 (34.38)	8 (25.00)	9 (28.13)	4 (12.50)	32 (100%)	3.250	0.355	0.319
F	100	BAS	10 (31.25)	11 (34.38)	7 (21.88)	4 (12.50)	32 (100%)	3.750	0.290	0.342
F	100	BF	11 (34.38)	7 (21.88)	3 (9.38)	11 (34.38)	32 (100%)	5.500	0.139	0.415
F	100	BRS	7 (21.88)	7 (21.88)	9 (28.13)	9 (28.13)	32 (100%)	0.500	0.919	0.125
F	200	FS	11 (34.38)	7 (21.88)	8 (25.00)	6 (18.75)	32 (100%)	1.750	0.626	0.234
F	200	BF	8 (25.00)	10 (31.25)	3 (9.38)	11 (34.38)	32 (100%)	4.750	0.191	0.385
F	200	IM	7 (21.88)	9 (28.13)	8 (25.00)	8 (25.00)	32 (100%)	0.250	0.969	0.088
F	200	BAS	11 (34.38)	8 (25.00)	8 (25.00)	5 (15.63)	32 (100%)	2.250	0.522	0.265
F	200	BRS	7 (21.88)	6 (18.75)	11 (34.38)	8 (25.00)	32 (100%)	1.750	0.626	0.234
F	400	FS	11 (34.38)	7 (21.88)	10 (31.25)	4 (12.50)	32 (100%)	3.750	0.290	0.342
F	400	IM	7 (21.88)	9 (28.13)	9 (28.13)	7 (21.88)	32 (100%)	0.500	0.919	0.125
F	800	FS	6 (25.00)	5 (20.83)	6 (25.00)	7 (29.17)	24 (100%)	0.333	0.954	0.118

Note: M: male; F: female; FS: freestyle; BAS: backstroke; BF: butterfly; BRS: breaststroke; IM: individual medley; Q_{1-4}: quarter of birth; χ^2: chi-square goodness of fit test; w: effect size w index (Cohen's w)

Table 3. Differences between Swimmers' Time according to Quarters of Birthdate in Sex, Discipline and Distance

Sex	Distance	Discipline	Time [MM:SS.SS]				n	H	p	η^2 (95 % CI)
			Q_1 [med (x_{25}-x_{75})]	Q_2 [med (x_{25}-x_{75})]	Q_3 [med (x_{25}-x_{75})]	Q_4 [med (x_{25}-x_{75})]				
M	100	BAS	1:11.09 (1:07:27–1:12.26)	1:11.07 (1:06.11–1:12.47)	1:08:00 (1:06:00–1:15:04)	1:10:03 (1:09:03–1:12:47)	32	0.306	0.959	0.096 (0.000–0.254)
M	200	FS	2:12.90 (2:10.20–2:16.60)	2:10.0 (2:04.7–2:11.6)	2:12.8 (02:09.8–2:15.2)	2:13.40 (2:10.50–2:17.00)	32	4.101	0.251	0.039 (0.000–0.150)
M	200	BAS	2:30.00 (02:26.00–02:36.00)	2:30.00 (2:22.00–2:40.00)	2:33.00 (2:21.00–2:40.00)	2:31.00 (2:28.00–2:37.00)	32	0.236	0.972	0.099 (0.000–0.259)
M	400	FS	4:42.00 (4:35.5–4:47.5)	4:37.00 (4:30.00–4:39.20)	4:33.00 (4:33.00–4:41.50)	4:43.50 (4:33.70–4:48.80)	32	5.931	0.115	0.105 (0.000–0.267)
M	400	IM	5:18.00 (5:11.50–05:36.50)	5:30.50 (5:17.50–5:42.30)	5:18.00 (5:09.00–5:28.00)	5:37.00 (5:16.50–5:43.69)	31	3.928	0.269	0.034 (0.000–0.137)
F	50	FS	0:29.00 (0:28.00–0:30.00)	0:30.00 (0:29.00–0:30.00)	0:29.00 (0:28.00–0:30.00)	0:30.00 (0:29.00–0:30.00)	32	0.903	0.825	0.075 (0.000–0.222)
F	100	BRS	1:23.00 (1:20.00–1:26.00)	1:23.00 (1:17.00–1:26.00)	1:22.00 (1:16.00–1:26.50)	1:22.00 (1:20.50–1:26.50)	32	0.225	0.973	0.099 (0.000–0.259)
F	200	FS	2:22.00 (2:16.00–2:27.00)	2:24.00 (2:21.00–2:24.00)	2:23.50 (2:17.80–2:27.80)	2:22.00 (2:20.50–2:25.80)	32	0.742	0.863	0.081 (0.000–0.232)
F	200	IM	2:35.00 (2:34.00–2:42.00)	2:41.00 (2:39.00–2:45.00)	0:02:36 (0:02:35–0:02:40)	0:02:41 (0:02:37–0:02:47)	32	6.973	0.073	0.142 (0.000–0.314)
F	200	BAS	2:40.00 (2:33.00–2:46.00)	2:39.00 (2:38.00–2:39.80)	2:39.00 (2:34.50–2:43.00)	2:43.00 (2:38.00–2:47.00)	32	2.336	0.506	0.024 (0.000–0.105)
F	200	BRS	3:04.00 (2:55.00–03:07.00)	2:58.00 (02:49.00–03:02.00)	2:58.00 (2:53.00–3:03.00)	03:05.00 (2:54.00–3:08.00)	32	3.250	0.355	0.009 (0.000–0.016)
F	400	IM	5:37.00 (5:22.00–5:59.00)	5:50.00 (5:40.00–5:56.50)	5:35.00 (5:26.50–5:46.00)	5:50.00 (5:46.00–5:59.00)	32	6.759	0.080	0.134 (0.000–0.305)
F	800	FS	10:13.00 (09:47.50–10:28.30)	10:32.00 (10:07.00–10:48.00)	10:00.00 (9:51.00–10:36.00)	10:32.00 (10:24.00–10:36.00)	24	4.121	0.249	0.040 (0.000–0.157)

Note: M: male; F: female; FS: freestyle; BAS: backstroke; BF: butterfly; BRS: breaststroke; IM: individual medley; Med: median; x_{25}: lower quartile, x_{75}: upper quartile; $Q_{1-4:}$ quarter of birth; H: Kruskal-Wallis H test; η^2: Eta-square test; CI: confidence interval

Although the Table 1 shows a gradual decrease in the number of both absolute and relative frequencies from Q_1 to Q_4 in all the above given variables (male, female, total), which indicates the existence of RAE, we calculated – assessing the values of chi-square goodness of fit test – that comparing the occurrence of expected and observed birthdate (in Q_i) showed a statistically significant deviation from the birthdate distribution only in male sample (χ^2 (3) = 9.846, p = 0.020, w = 0.033, ES = trivial).

In terms of assessing the effect size w index values, we can conclude that the influence of birthdate showed in male (w = 0.033, CLES = 0.51) as well as in female swimmers (w = 0.006, CLES = 0.50) a trivial effect (w_{diff} = 0.027). Which are the smallest differences of ES values, and therefore the most homogenous effect in our study.

Since, in terms of statistical significance, different levels of RAE effect were found between the sexes, it was important to find whether and how this RAE effect would be reflected also in the division by disciplines and distances (Table 2), or by swimmers' performance (Table 3 and 4).

The chi-square goodness of fit test was calculated comparing the occurrence of expected and observed birth dates (in Q_i). Uneven distribution of the dates of birth – i.e. the existence of RAE – was demonstrated in male swimmers using statistical significance in 4 of 13 cases (30.77 %;

2times in BF, once in FS and IM). In female swimmers, we found statistically insignificant differences in birthdate frequency, so in this case we rejected the existence of RAE.

The values of ES w index in male swimmers ranged from small ($w = 0.190$, CLES = 0.51) to large ($w = 0.734$, CLES = 0.61) effect ($w_{diff} = 0.544$) in 13 swimming disciplines, which is the largest difference of ES values in our study, and thus the most heterogeneous effect. More precisely, we found a large effect in two disciplines (15.38 %; FS and BF), medium effect in five disciplines (38.46 %; 2times in FS and once in BRS, BF and IM), small effect in 6 disciplines (46.15 %; 3times in FS, 2times in BAS, once in BRS) and trivial effect in two disciplines (15.38 %; FS and BF).

In female swimmers, the values of ES w index ranged from trivial ($w = 0.088$, CLES = 0.51) to medium ($w = 0.415$, CLES = 0.57) effect ($w_{diff} = 0.327$). More strictly, we found a medium effect in five disciplines (38.46%; 2times in FS and BF and once in BAS), small effect in seven disciplines (53.85 %; 2times in FS and BRS, once in BAS) and trivial effect in one discipline (7.69 %; IM).

After assessing the existence of RAE (Table 1 and 2), we were interested in whether there existed performance differences (times achieved in individual disciplines) between quartiles (Q_i) in individual swimming disciplines. In this case, there was not a statistically significant difference between the dependent variables (sex, distance, style). This means that there was not any statistical difference in swim time between swimmers born in different Q_i. Which can be interpreted that there is no difference between relatively older and younger swimmers in performance; not even in the groups where we confirmed the effect of RAE (Table 2). The values of ES η^2 index in male swimmers in 5 swimming disciplines reached medium ($\eta^2 = 0.034 – 0.105$, CLES = 0.56 – 0.61) effect ($\eta^2_{diff} = 0.071$). These are more homogenous ES values than in swimmers in Table 2.

In female swimmers, we found in 8 disciplines the values of ES η^2 index ranging from trivial ($\eta^2 = 0.009$, CLES = 0.53) to large ($\eta^2 = 0.142$, CLES = 0.62) effect ($\eta^2_{diff} = 0.133$), which were more homogenous results than in the case of female swimmers from Table 2. We found, more precisely, a large effect in one discipline (12.50 %; IM), medium effect in 4 disciplines (50.00 %; 2times in FS, once in BRS and IM), small effect in two disciplines (25.00 %; BAS and FS) and trivial effect in one discipline (12.5 %; BRS). As some research variables did not meet the conditions of Kruskal-Wallis H test (more than 5 swimmers in group [Q_i]), the following Table 4 contains the results of Mann-Whitney U test, which we used to assess the categorial variable of birth semester (S_i) instead of birth quartile (Q_i).

The results of Mann-Whitney U test in male swimmers showed that the difference between the achieved times for S_1 and S_2 variables were statistically significant in two cases (BF and BRS, both on 100 m distance); once in case of girls (100 m BAS). In other cases, we did not prove any differences between times.

ES index r values in male swimmers in 8 swimming disciplines reached small ($r = 0.116$, CLES = 0.54) to large ($r = 0.576$, CLES = 0.70) effect ($r_{diff} = 0.460$). We found – more precisely – a large effect in one discipline (12.50 %; BRS), medium effect in three disciplines (37.50 %; BF, BRS and FS) and small effect in 4 disciplines (50.00 %; 2times in FS and once in BF and IM). ES r index values in female swimmers in 5 swimming disciplines reached trivial ($r = 0.060$, CLES = 0.52) to medium ($r = 0.351$, CLES = 0.61) effect ($r_{diff} = 0.291$). We found – more precisely – a medium effect in one discipline (20.00 %; BAS), small effect in two disciplines (40.00 %; FS and BF) and trivial effect also in two disciplines (40.00 %; BF and FS).

DISCUSSION

Based on the results of the presented study, we cannot describe the RAE influence in the examined group as unambiguous because the level of its effect depends very much on the nature of dependent variable. Similar conclusions were reached also by Buhre and Tschernij (2018) due to

Table 4. Differences between Swimmers' Time according to Semesters of Birthdate in Different Sexes, Distances and Disciplines

Sex	Distance	Discipline	Time [MM:SS.SS]		n_{s1}/n_{s2}	U	p	r
			S_1 [Med (x_{25}-x_{75})]	S_2 [Med (x_{25}-x_{75})]				
M	50	FS	0:28.10 (0:26.90–0:28.30)	0:27.30 (0:27.10–0:27.80)	22/9	79.0	0.384	0.156
M	100	FS	1:01.00 (0:59.00–1:02.00)	1:01.00 (1:00.00–1:02.00)	21/11	99.0	0.513	0.116
M	100	BF	1:09.10 (1:06.20–1:12.10)	1:04.30 (1:01.70–1:07.60)	27/5	25.5	0.029	0.385
M	100	BRS	1:11.50 (1:09.50–1:12.70)	1:14.00 (1:13.00–1:16.00)	12/11	21.5	0.006	0.576
M	200	BF	2:40.5 (2:33.30–2:52.50)	2:30.00 (2:22.30–3:00.00)	24/8	72.0	0.296	0.185
M	200	IM	2:28.30 (2:27.00–2:33.52)	2:28.30 (2:25.00–2:31.00)	20/12	103.0	0.507	0.117
M	200	BRS	2:52.00 (2:42.00–2:59.00)	2:56.00 (2:48.50–3:06.00)	19/13	73.5	0.055	0.340
M	1500	FS	18:46.50 (18:15.30–19:12.70)	18:18.00 (17:53.00–18:44.00)	12/11	40.0	0.109	0.334
F	100	FS	1:05.00 (1:03.00–0:01:06)	1:06.00 (1:03.00–1:07.00)	19/13	96.0	0.291	0.186
F	100	BAS	1:13.00 (1:11.00–1:16.00)	1:15.00 (1:14.00–1:17.00)	21/11	65.5	0.047	0.351
F	100	BF	1:15.00 (1:11.00–1:19.00)	1:17.00 (1:14.00–1:18.00)	18/14	117.0	0.732	0.060
F	200	BF	2:51.50 (2:47.00–3:00.30)	2:55.00 (2:53.00–3:01.00)	18/14	93.0	0.209	0.222
F	400	FS	5:01.50 (4:55.50–5:05.20)	5:01.50 (4:55.00–5:07.50)	18/14	117.5	0.747	0.057

Note: M: male; F: female; FS: freestyle; BAS: backstroke; BF: butterfly; BRS: breaststroke; IM: individual medley; Med: median; x_{25}: lower quartile; x_{75}: upper quartile; S_i: semester of birth; U: Mann-Whitney U test; r: effect size r index; CI: confidence interval

inconclusive evidence of RAE occurrence in elite Swedish swimmers. Although there are significantly less academic studies dealing with RAE issue in female/girls than number of studies dealing with male/boys, it is clear – despite this disparity – that the level of RAE in female/girl sample is lower (or none) than in the case of males/boys, which is also valid in all comparable sports (Cobley et al., 2009; Smith, Weir, Till, Romann & Cobley, 2018). We reached similar conclusions as well for our research group in most of the examined variables, like Cobley et al. (2018) in the group of Australian swimmers or Costa et al. (2013) in Portuguese swimmers. Most common reasoning explaining this trend is a lower competition in the membership base (so the coaches cannot give preference to the temporarily biologically more mature girls) and earlier completion of the adolescence process in girls in comparison with boys (Baxter-Jones, Helms, Maffulli, Baines-Preece & Preece, 1995). The only conclusion we found that the RAE was higher in female swimmers than in the group of males was in Ferreira et al. (2017) study, where the authors had found a larger and statistically significant RAE effect in the group of female Olympic swimmers, but a statistically insignificant RAE effect in the male group. The authors of this study did not find any other relationship between birthdates (in Q_i) and winning medals or distribution of athletes by continents (with the exception of Asia). These findings confirm the hypothesis that the RAE effect is most evident during adolescence and then gradually and irregularly weakens (Cobley et al., 2018; Ulbricht et al., 2015). However, we can find examples when RAE is also evident in Swimming Masters age categories, which is usually caused by a progressive increase of the RAE influence during each decade of life (Medic, Young, Starkes, Weir & Grove, 2009) and thus a possible drop-out of relatively younger athletes in junior categories, where each subsequent age category created a stronger environment of age bias because of the departure of relatively younger athletes.

During our extensive literary research, we had not found a study which would deal with the effect of RAE in various disciplines (n = 6), distances (n = 6) and sex (male, female), which – in our case – consisted of a total of 26 different research variables. If we compare our results with Australian U16 swimmers (Cobley et al., 2018), we find that the ES values of our research group were comparable (small ES) 2times for the same variables (male 200 m breaststroke, female 50 m freestyle); 3times we found higher ES values (male 400 m freestyle, male 100 m breaststroke, female 400 m freestyle) and 3-times significantly higher ES values (male 50 m freestyle, female 200 m breaststroke, female 200 m breaststroke). These differences in ES values ranged from small-large to trivial-medium ES. Also in comparison with Abbott et al. (2020), our results in female swimmers in a similar age category (U16) reached higher ES values in 100 m as well as 200 m breaststroke (trivial-small ES). However, the differences disappeared when comparing ES with the group of TOP 25 % female swimmers (small-small ES).

As Cobley et al. (2018) monitored the effect of RAE in several age categories (U13 to U19), we can state, based on their results, that the most obvious effect of RAE was in younger swimmers and its intensity both in boys and girls gradually and irregularly decreased. We can conclude then that the period with the greatest RAE influence is about the age of 12. Similar conclusions were reached also by Costa et al. (2013) for elite Portugal swimmers. One explanation of this phenomenon may be that swimmers' growth curve indicates swimmers as early matures, compared to other young gymnastic, soccer, and tennis athletes (Baxter-Jones et al., 1995).

CONCLUSIONS

Our recommendation for practice are similar to the recommendations of other authors (Baker et al., 2010; Cobley et al., 2009, 2018; Smith et al., 2018), i.e. focus on the prevention of the struggles of late-born children and the protection from possible discontinuation of active spending of leisure time. Awareness of RAE issues should be spread among the coaches working with (not only talented) youth athletes themselves (e.g. in the form of workshops), representatives of sports organizations (who can modify the sports system), but also parents of athletes. This should be spread along with the emphasis on the information that relatively older individuals have only a temporary biological advantage, which does not guarantee them an excellent performance after the completion of the process of adolescence. This way, the drop-out of relatively younger athletes at the beginning of their adolescence process should be reduced (first wave of drop-out caused by RAE) as well as the drop-out of relatively older athletes after the period of adolescence who, in turn, lost the temporary biological advantage resulting from their date of birth (second wave of drop-out caused by RAE).

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