European Journal of Sport Science
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tejs20

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Aldo M. Costa [a b c], Mário C. Marques [a b], Hugo Louro [b d], Sandra S. Ferreira [e] & Daniel A. Marinho [a b]

[a] Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal
[b] CIDESD, Research Centre in Sports, Health and Human Development, Covilhã, Portugal
[c] CICS-UBI, Health Sciences Research Center, Covilhã, Portugal
[d] Sports Science, Institute of Rio Maior, Rio Maior, Portugal
[e] Department of Mathematics and Center for Mathematics, University of Beira Interior, Covilhã, Portugal
Published online: 13 Nov 2012.

European Journal of Sport Science, 2013
Vol. 13, No. 5, 437–444, http://dx.doi.org/10.1080/17461391.2012.742571

ORIGINAL ARTICLE

The relative age effect among elite youth competitive swimmers

ALDO M. COSTA[1,2,3], MÁRIO C. MARQUES[1,2], HUGO LOURO[2,4], SANDRA S. FERREIRA[5], & DANIEL A. MARINHO[1,2]

[1]*Department of Sports Sciences, University of Beira Interior, Covilhã, Portugal,* [2]*CIDESD, Research Centre in Sports, Health and Human Development, Covilhã, Portugal,* [3]*CICS-UBI, Health Sciences Research Center, Covilhã, Portugal,* [4]*Sports Science, Institute of Rio Maior, Rio Maior, Portugal,* [5]*Department of Mathematics and Center for Mathematics, University of Beira Interior, Covilhã, Portugal*

Abstract
The aim of this study was to analyse the relative age effect (RAE) in competitive swimming. The best 50 Portuguese swimmers (12- to 18-year-olds) for the main individual swimming pool events of both genders were considered. Analysis was conducted on 7813 swimming event participants, taking account of respective swimmer birth dates and the Fédération Internationale de Natation points gained. Differences in the distribution of birth dates by quarter year were determined using the Chi-square. A one-way analysis of variance ANOVA was used to test for differences measured in points between individuals by quarterly birth year intervals. A two-way analysis of variance ANOVA was also conducted to test the interaction between gender and seasonal birth date with regard to performance. The results show an inequitable distribution ($p < 0.01$) of birth dates by quarter for almost all age groups and both genders. However, the distribution of birth dates by quarter for each considered swim event shows that RAE seems to exist only for 12-year-old females and 12- to 15-year-old males. Analysing mean swimming performance, post-hoc results ($p < 0.01$) show no consistency in RAE. Higher performance occurs among older swimmers only in 100 m butterfly (female 1998, 1st $\neq$ 2nd quarter, $p = 0.003$). The results also show no interaction between gender and seasonal birth date ($p < 0.01$). Findings of this study show that a higher number of swimmers, particular males, are born in the first two quarters of the year, although there is mostly no effect of seasonal birth date on performance differences within the top 50 swimmers.

Keywords: *Swimming, relative age effect, chronological age, age groups*

Introduction

The difference of age among individuals in the same grade grouping is referred as relative age effect (RAE) (Barnsley, Thompson, & Barnsley, 1985). The literature is fairly abundant in studies on this topic, principally relating to school achievement, reporting that relatively younger students present more academic problems than their older classmates (Bell & Daniel, 1990; Davis, Trimble, & Vincent, 1980; Dickinson & Larson, 1963; Hauck & Finch, 1993). In fact, students born shortly after the cut-off birth date are almost 1 year older than late-born students in their respective age group (Musch & Grondin, 2001).

This relative age difference, which is typical of most public primary schools in the world, seems to be associated with significant variations in cognitive development (Morrison, Smith, & Dow-Ehrensberger, 1995). This possibly explains why discussion of this issue persists (apart from academic interest), since parents may question whether their child is ready to attend school.

In sport, RAE has important implications, particularly in sporting disciplines with a strong focus on the resources of power and/or body size (swimming, basketball and soccer) (Malina, 1994). Indeed, the inter-individual variability of growth and biological maturation of young athletes leads, inevitably, to discrete sports performance. To mitigate such differences, almost all competitive sports are organised into age categories. Presumably, the participants are

Correspondence: A. M. Costa, Sports Science Department, University of Beira Interior, Rua Marquês D'Ávila e Bolama, Covilhã 6200-001, Portugal. E-mail: mcosta.aldo@gmail.com

grouped by chronological age to ensure developmentally equitable competition and opportunity (Medic, Starkes, & Young, 2007; Musch & Grondin, 2001; Vaeyens, Philippaerts, & Malina, 2005).

Despite this concern, RAE has been reported in a number of different sports. Doubtless for reasons of popularity, ice hockey and soccer have attracted more research attention. The ice hockey studies reported that players born in the early part of the cut-off date were not only more likely to play at higher levels but also less likely to drop out (Barnsley et al., 1985). In soccer, studies have tended to produce similar results, reporting that most professional players were born in the first quarter of the selection year (Brewer, Balsom, & Davis, 1995; Helsen, Williams, & Van Winckel, 2005; Vaeyens et al., 2005). However, some authors reported that RAE in soccer tends to accrue with increasing age (Musch & Grondin, 2001), while other studies disconfirm such data (Helsen, Starkes, & Van Winckel, 1998).

RAE has also been noticed in baseball (Grondin & Koren, 2000), rugby (Till et al., 2010) and tennis (Baxter-Jones, 1995; Dudink, 1994). For sports such as basketball (Daniel & Janssen, 1987) and gymnastics (Baxter-Jones, 1995), no significant RAE was reported. In sports such as swimming, the phenomenon seems to depend on age and categories (Baxter-Jones, 1995), but few studies have been conducted and then only upon male athletes. Moreover, in competitive swimming, the predicted optimal age for performance varies according to race distance, swimming technique and gender (Platonov & Fessenko, 1994; Silva et al., 2007b). Thus, we may hypothesise that RAE will also vary according to swimming pool events and by gender.

Therefore, the purposes of this study were twofold: (1) to analyse the existence of RAE in swimming, considering all competitive age groups and both genders; (2) to analyse the birth date distribution in both genders and the respective mean performance points for the main individual swimming events.

Methods

Subjects and experimental design

Officially archived data were collected on the top 50 Portuguese performance times and respective swimmer birth dates for the main individual swimming pool events in Portugal, taking into account both male and female competitive swimmers aged between 12 and 18 years old. To this end, retrospective data for 7813 participants were gathered from the official rankings website (swimrankings.net) of the European Swimming Federation (LEN), which also includes the Portuguese Swimming Federation official ranking data.

The study was conducted according to the recommendations of the local ethical committee and current Portuguese law and regulations.

Methodology

Swimmers (12- to 18-year-olds) were divided into age groups according to Portuguese Swimming Federation Rules: (1) cadet, males born in 1998; (2) infantile, born in 1997 or 1996 (males) and 1998 or 1997 (females); (3) juvenile, born in 1995 or 1994 (males) and 1996 (females); (4) junior, born in 1993 or 1992 (males) and 1995 or 1994 (females) and (5) senior, females born in 1993 and 1992. Because only 12- to 18-year-old swimmers were studied, female cadets and male senior were not included in the division of age groups. This age difference in the same age group is due to the LEN rules, which impose girls to be 2-years-old backward comparing to boys because of an earlier biological maturation.

The best performance times achieved during the year 2010 (1 January–31 December) were recorded for each of the following competitive events, with a maximum total of 50 entries for each event (long course swimming pool), gender and age group: front crawl (fc) – 50 m, 100 m, 200 m, 400 m, 800 m (females) or 1500 m (males); backstroke (bc), breaststroke (br) and butterfly (bf) – 100 m and 200 m; medley (md) – 200 m and 400 m. These performance times were then converted into points according to the international governing body of swimming (FINA) points table, which assigns point values to swimming performances (defined every year) – more for world class times and fewer for slower times. The conversion of times into FINA points enables comparison of performance amongst all swim events in a particular age group. Tis study also analysed times in seconds for each male and female swim event to ensure greater accuracy in swimmer performance, which allows for the possibility of adding and comparing data in further researches.

As shown in Table I, a total of 7813 participation entries (4081 for males and 3732 for females) were included in the study sample. Each of these entries represents swimmer performance ranked in the top 50 for each swimming event under study. It should be noted that the number of entries is higher than the actual number of swimmers, since there are swimmers who form part of the top 50 ranking in more than one event. This also means that the number of entries for each swimmer is dependent on the total number of athletes who currently compete in Portugal in each age group category.

Table I. Frequency of birth dates by quarter for male and female swimmers and all age groups.

				Observed frequency										
				1st quarter		2nd quarter		3rd quarter		4th quarter				
	Age group	Birth year	No. of entries	*N*	%	*N*	%	*N*	%	*N*	%	Expected frequency	χ^2	*P*-value
Males	Cadet	1998	473	132	27.91	173	36.58	114	24.10	54	11.42	118.3	62.011	0.000
	Infantile	1997	650	223	34.31	200	30.77	140	21.54	87	13.38	162.5	69.372	0.000
		1996	649	210	32.36	230	35.44	144	22.19	65	10.02	162.3	102.686	0.000
	Juvenile	1995	650	218	33.54	192	29.54	151	23.23	89	13.69	162.5	58.369	0.000
		1994	634	201	31.70	166	26.18	144	22.71	123	19.40	158.5	21.028	0.000
	Junior	1993	586	167	28.50	153	26.11	137	23.38	129	22.01	146.5	5.863	0.118
		1992	439	146	33.26	125	28.47	74	16.86	94	21.41	109.8	27.998	0.000
Females	Infantile	1998	624	269	43.11	211	33.81	87	13.94	57	9.13	156.0	194.59	0.000
		1997	650	198	30.46	210	32.31	138	21.23	104	16.00	162.5	46.394	0.000
	Juvenile	1996	644	133	20.65	171	26.55	201	31.21	139	21.58	161.0	18.435	0.000
	Junior	1995	623	185	29.70	158	25.36	147	23.60	133	21.35	155.8	9.340	0.025
		1994	519	140	26.97	169	32.56	140	26.97	70	13.49	129.8	41.008	0.000
	Senior	1993	392	97	24.74	160	40.82	66	16.84	69	17.60	98.0	58.265	0.000
		1992	280	49	17.50	111	39.64	47	16.79	73	26.07	70.0	38.000	0.000

It should also be noted that age groups were organised according to cut-off birth dates that match the last day of the calendar year. The sports season begins on 1 October for the full range of the age groups, with an almost one-month break during August.

Statistical analysis

All data for this study were analysed using SPSS computer software for Windows (version 19.0). The study sample was organised by quarterly birth year intervals: 1st quarter – born between 1 January and 31 March; 2nd quarter – born between 1 April and 30 June; 3rd quarter – born between 1 July and 30 September; 4th quarter – born between 1 October and 31 December. Differences between the birth year intervals (frequency) observed and expected were determined using the Chi-square for all swimmers and participation entries. A one-way analysis of variance (ANOVA) was used to test for differences in seconds or points between individuals by quarter year. The Bonferroni test was used for post-hoc analysis when the F-ratio was significant. A two-way analysis of variance (ANOVA) was also used with quartiles and gender as factors and FINA points as dependent variables. Statistical significance was considered when $p < 0.01$.

Results

Table I shows the quarterly birth year intervals for both genders and by age groups (male and female, respectively). For both genders and almost all age groups, significant differences were observed between the number of entries by birth year quarter ($p < 0.01$). Junior male born in 1993 and female swimmers born in 1995 were the only exception, where there appeared to be a more equitable frequency of birth dates. Analysing the descriptive data by individual quarters, one can note a higher number of male athletes born in the 1st or in 2nd quarter of the year and very few in the last quarter. In females the data are not so consistent, although the 3rd and the 4th quarter are always the most under-represented (except for 1996 females).

Table II shows swimming performance (converted into FINA points) by quarter for both male and female swimmers, respectively, and for all the age groups considered. Results show that young male swimmers seem to be more susceptible to RAE. However, the post-hoc results appear to demonstrate a weak consistency of this phenomenon in Portuguese competitive swimming, particularly its effect on swimming performance (e.g. male 1992-3rd, 1993-4th, 1994-3rd and female 1992-4th, 1993-3rd and 1995-4th perform better than others born in the first half of the year).

Tables III and IV show the statistical significance analysis output for the differences between the birth year intervals (Table III) and performance points (Table IV) by quarter, for each swim event considered. One can note that the number of observed differences is higher in the younger swimmers, particularly for 12- to 15-year-old male swimmers and for 12-year-old female swimmers.

It is worth noting also (Table IV) that the variation in swimming performance by quarter occurs exclusively in 100 m bf and 200 m br: female 1998, 100Bf, 1st (362.9 points) $\neq$2nd (301.0 points), $p = 0.003$; female 1995, 200*Br*, 2nd (410.8 points) $\neq$ 4th (493.4 points), $p = 0.009$. However, one can note that in the 200Br higher performance does not occur among older swimmers.

The results also (Table IV) show an effect of gender on swimming performance in the younger age

Table II. Mean (M) (plus standard deviation [SD]) swimming performance points (FINA) by quarter for male and female swimmers and all age group, the respective gender effect and the interaction between gender and seasonal birth date with regard to performance.

		1st quarter		2nd quarter		3rd quarter		4th quarter			Between subjects effects	
Birth year	Gender	M	SD	M	SD	M	SD	M	SD	$P_{(1)}$	$P_{(2)}$ Gender	$P_{(3)}$ Gender × Quartiles
1998	M	250.42	38.93	250.12	44.70	250.40	41.56	227.63	46.29	0.004[c,e,f]	0.000	0.263
	F	390.04	76.25	384.35	57.54	370.00	80.97	369.61	83.62	0.060		
1997	M	355.39	59.13	339.36	68.12	338.82	65.37	320.43	80.99	0.000[a]	0.000	0.018
	F	439.68	76.49	437.93	84.49	414.63	61.22	434.34	74.42	0.015		
1996	M	420.52	70.71	412.20	71.35	399.26	69.68	379.09	68.27	0.000[c,e]	0.000	0.067
	F	476.74	55.73	481.96	88.63	473.25	63.71	470.78	83.80	0.556		
1995	M	464.17	74.07	470.20	72.06	461.92	70.15	447.17	79.15	0.524	0.000	0.022
	F	478.36	72.86	475.63	78.92	493.07	76.11	498.16	80.71	0.027		
1994	M	504.58	90.90	461.90	83.53	469.63	78.09	465.85	79.01	0.000[a,b,c]	0.710	0.000
	F	468.28	105.96	506.19	98.44	480.24	114.22	438.73	11.27	0.000[e]		
1993	M	493.38	95.50	480.54	72.29	495.63	104.10	498.22	97.22	0.368	0.000	0.009
	F	435.80	147.40	469.62	116.49	494.7	112.18	447.01	124.35	0.017		
1992	M	458.41	122.37	443.45	101.18	488.01	100.24	482.21	117.99	0.016	0.044	0.048
	F	495.90	77.89	483.23	117.96	460.02	107.14	505.47	120.16	0.157		

Note: The data show the *p*-value 1, *P*(1), (ANOVA) for the differences in swim performance between individuals by quarter of birth. The gender effect and the interaction between gender and seasonal birth date with regard to performance is presented as *p*-value 2 and 3, *P*(2) and *P*(3), respectively. Statistical significance ($p < 0.01$) post-hoc analysis is present as following:
[a]1st quarter ≠2nd quarter.
[b]1st quarter ≠3rd quarter.
[c]1st quarter ≠4th quarter.
[d]2nd quarter ≠3rd quarter.
[e]2nd quarter ≠4th quarter.
[f]3rd quarter ≠4th quarter.

groups ($p < 0.01$). However, the interaction between gender and seasonal birth date for each swimming event performance was not significant ($p > 0.01$).

Discussion

Competitive swimming, like other sports disciplines, is organised according to standard 1-year-old categories, based on participant's chronological age. The purpose of relative age studies such as this is to identity advantaged and disadvantaged cohorts within these standard age group categories (Medic, Young, & Medic, 2011). Our key findings show an inequitable distribution ($p < 0.01$) of birth dates by quarter in just about all age groups and both sexes (Table I).

Indeed, a good number of the male top 50 Portuguese swimmers are born in the first two

Table III. Statistical significance output for the differences between the frequency of birth dates (*p*-value) by quarter for each male and female swim event.

	Male							Female						
	98	97	96	95	94	93	92	98	97	96	95	94	93	92
50Fc	0.181	0.137	0.751	0.350	0.104	0.641	0.137	0.212	0.440	0.398	0.423	0.193	0.082	0.523
100Fc	0.059	0.002	0.001	0.001	0.329	0.830	0.137	0.000	0.137	0.641	0.509	0.048	0.193	0.101
200Fc	0.008	0.036	0.016	0.012	0.350	0.181	0.321	0.000	0.137	0.019	0.678	0.451	0.543	0.413
400Fc	0.068	0.193	0.009	0.423	0.181	0.792	0.512	0.008	0.137	0.398	0.270	0.041	0.015	0.327
1500/800Fc	0.033	0.137	0.004	0.641	0.352	0.690	0.682	0.009	0.006	0.423	0.572	0.128	0.062	0.446
100Bc	0.036	0.009	0.112	0.003	0.868	0.641	0.238	0.001	0.423	0.451	0.308	0.715	0.021	0.089
200Bc	0.801	0.038	0.350	0.079	0.830	0.641	0.031	0.001	0.715	0.033	0.678	0.028	0.422	0.121
100Br	0.005	0.006	0.008	0.350	0.451	0.445	0.417	0.001	0.104	0.451	0.423	0.251	0.143	0.221
200Br	0.572	0.350	0.001	0.137	0.181	0.409	0.649	0.009	0.158	0.181	0.423	0.413	0.409	0.691
100Bf	0.451	0.038	0.237	0.079	0.112	0.572	0.316	0.000	0.068	0.207	0.509	0.335	0.034	0.067
200Bf	§)	0.090	0.104	0.253	0.264	0.630	0.464	0.000	0.014	0.036	0.762	0.843	0.172	0.370
200Md	0.063	0.003	0.001	0.253	0.451	0.868	0.572	0.000	0.253	0.792	0.715	0.036	0.249	0.179
400Md	0.025	0.193	0.003	0.350	0.112	0.753	0.801	0.000	0.059	0.868	0.913	0.072	0.269	0.905

Note: The data show the *p*-value (Chi-square) for differences between the frequencies of birth dates observed and expected.
Fc, front crawl; Bc, backstroke; Br, breaststroke; Bf, butterfly; Md, medley.
[§]There were not enough valid cases for processing.

Table IV. Statistical significance output for the differences between the swimming performance (FINA points) by quarter for swim event, the respective gender affect and the interaction between gender and seasonal birth date with regard to performance.

		98			97			96			95			94			93			92		
		$P_{(1)}$	$P_{(2)}$ G	$P_{(3)}$ G × Q	$P_{(1)}$	$P_{(2)}$ G	$P_{(3)}$ G × Q	$P_{(1)}$	$P_{(2)}$ G	$P_{(3)}$ G × Q	$P_{(1)}$	$P_{(2)}$ G	$P_{(3)}$ G × Q	$P_{(1)}$	$P_{(2)}$ G	$P_{(3)}$ G × Q	$P_{(1)}$	$P_{(2)}$ G	$P_{(3)}$ G × Q	$P_{(1)}$	$P_{(2)}$ G	$P_{(3)}$ G × Q
50*Fc*	M	0.946	0.003	0.108	0.060	0.000	0.700	0.270	0.000	0.255	0.485	0.000	0.609	0.557	0.000	0.976	0.251	0.022	0.692	0.733	0.642	0.775
	F	0.161			0.284			0.913			0.882			0.884			0.992			0.900		
100*Fc*	M	0.516	0.000	0.772	0.770	0.000	0.524	0.803	0.000	0.175	0.867	0.653	0.980	0.658	0.683	0.630	0.426	0.000	0.104	0.185	0.549	0.869
	F	0.608			0.114			0.157			0.945			0.400			0.129			0.758		
200*Fc*	M	0.909	0.000	0.611	0.520	0.000	0.668	0.255	0.000	0.186	0.970	0.113	0.375	0.535	0.045	0.191	0.282	0.020	0.906	0.963	0.012	0.834
	F	0.599			0.554			0.567			0.203			0.102			0.977			0.700		
400*Fc*	M	0.734	0.000	0.500	0.417	0.000	0.784	0.535	0.000	0.338	0.625	0.190	0.532	0.855	0.003	0.639	0.357	0.942	0.852	0.459	0.039	0.097
	F	0.505			0.379			0.056			0.488			0.714			0.905			0.084		
1500/ 800*Fc*	M	0.770	0.000	0.678	0.980	0.000	0.594	0.620	0.000	0.825	0.826	0.163	0.189	0.751	0.149	0.998	0.244	0.318	0.744	0.236	0.603	0.191
	F	0.590			0.325			0.204			0.211			0.831			0.846			0.106		
100*Bc*	M	0.688	0.000	0.922	0.454	0.000	0.844	0.310	0.000	0.313	0.633	0.065	0.489	0.202	0.669	0.956	0.601	0.013	0.098	0.970	0.480	0.470
	F	0.799			0.847			0.914			0.545			0.531			0.032			0.430		
200*Bc*	M	0.370	0.000	0.620	0.502	0.000	0.595	0.325	0.000	0.789	0.927	0.004	0.551	0.191	0.125	0.290	0.753	0.807	0.292	0.795	0.326	0.746
	F	0.752			0.446			0.952			0.557			0.462			0.116			0.807		
100*Br*	M	0.661	0.000	0.546	0.065	0.000	0.744	0.071	0.000	0.546	0.754	0.039	0.176	0.814	0.000	0.024	0.197	0.274	0.086	0.682	0.617	0.867
	F	0.116			0.761			0.684			0.069			0.023			0.484			0.922		
200*Br*	M	0.094	0.000	0.682	0.010	0.000	0.322	0.549	0.000	0.656	0.382	0.895	0.600	0.535	0.263	0.076	0.424	0.061	0.069	0.193	0.737	0.422
	F	0.382			0.262			0.683			0.007 d			0.263			0.168			0.298		
100*Bf*	M	0.010	0.000	0.033	0.402	0.000	0.667	0.714	0.000	0.796	0.818	0.555	0.947	0.578	0.425	0.106	0.125	0.020	0.776	0.682	0.918	0.180
	F	0.006 a			0.613			0.416			0.579			0.107			0.654			0.072		
200*Bf*	M	§	§	§	0.196	0.000	0.533	0.564	0.089	0.227	0.460	0.670	0.793	0.056	0.090	0.051	0.307	0.366	0.183	0.736	0.426	0.635
	F	0.430			0.977			0.079			0.992			0.128			0.395			0.866		
200*Md*	M	0.972	0.000	0.177	0.298	0.000	0.501	0.441	0.000	0.707	0.982	0.133	0.527	0.269	0.130	0.378	0.308	0.001	0.222	0.698	0.901	0.711
	F	0.319			0.812			0.367			0.238			0.297			0.358			0.945		
400*Md*	M	0.609	§	§	0.650	0.000	0.165	0.650	0.000	0.848	0.952	0.026	0.668	0.429			0.840	0.837	0.948	0.660	0.624	0.016
	F	0.240			0.284			0.676			0.496			0.876			0.974			0.214		

Note: The data show the *p*-value 1, *P*(1) (ANOVA) for the differences in swim performance between individuals by quarter of birth. The gender effect (G) and the interaction between gender and seasonal birth date with regard to performance (G × Q) is presented as *p*-value 2 and 3, *P*(2) and *P*(3), respectively. Statistical significance ($p < 0.01$) of post-hoc analysis is present as following:
[a]1st quarter ≠ 2nd quarter.
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[c]1st quarter ≠ 4th quarter.
[d]2nd quarter ≠ 4th quarter.
[§]There were not enough valid cases for processing.
Fc, front crawl; Bc, backstroke; Br, breaststroke; Bf, butterfly; Md, medley.

quarters of the year. We also noticed a small number of swimmers born in the 3rd and 4th quarter in nearly all groups. However, in females the data are not so consistent. Therefore, considering only the male swimmers, our results seem consistent with other studies that examined birth dates in elite athletes from several sports but particularly in swimming (Baxter-Jones, 1995). RAE seems evident even among master swimmers (Medic et al., 2007). Indeed, the odds of a master swimmer participating in the championship during the first constituent year of any 5-year-old category seem more than two times greater than the odds of that athlete participating during the fifth constituent year (Medic et al., 2011).

According to some authors (Barnsley et al., 1985) the most successful athletes tend to continue longer in practice because they are well rewarded for their efforts and may thus be encouraged to continue. Instead, late born athletes within a standard age category and, in particular, late-maturing athletes, are more likely to experience failure and frustration, resulting in lower personal expectations of success which may in turn lead to a higher likelihood of quitting. Indeed, Delorme, Boiché, and Raspaud (2010a) found not only a higher dropout rate among female soccer players born late in the competitive year but also a larger proportion of beginners born early in the competitive year. Thus, if a biased frequency among the whole population already exists, it is likely that such asymmetry would also occur among the elite (Delorme, Boiché, & Raspaud, 2010b). In a sense our results add weight to that assumption although we have no data concerning this issue. Hence, further studies are needed to investigate whether early dropout is a circumstance somehow related to the inevitable differences in maturational development of young athletes.

The age-grouping system in sports (based on chronological age) inevitably results in advantage for those who are older (Thompson, Barnsley, & Stebelsky, 2011). Thus, older athletes are generally taller, stronger and better coordinated: precisely those attributes regarded as decisive for success in various sports including swimming (Silva et al., 2007a). Critical is the fact that the variation in skeletal age in adolescents of a given chronological age may exceed 2 years (Malina, Chamorro, Serratosa, & Morate, 2007). However, differences in physical maturity may only partially explain RAE. If physical maturity was the only reason for this phenomenon, one would expect a more equitable distribution of birth dates for older male and female swimmers. According to our results, except for junior male swimmers, this does not seem to be the case. In fact, it has been argued that the underlying cause of RAE results from the combined influence of physical, cognitive, emotional, biological and sociological factors (Musch & Grondin, 2001). However, this multifactorial influence is not entirely clear in the literature (Cobley, Schorer, & Baker, 2008). For the most part, studies on RAE are purely observational and do not show the relationship between this phenomenon and the factors identified as potential causes (Sherar, Baxter-Jones, Faulkner, & Russel, 2007). Musch and Grondin (2001) also argue that despite the obvious importance of physical maturity, surprisingly few studies have been conducted to demonstrate the relationship between given physical development and RAE, using anthropometric and specific physical performance parameters. This is beyond question an important target of future research.

One of the purposes of this study was to address the hypothesis that RAE would differ according to swimming event and sex. Concerning gender differences, the literature is sparse since most studies were conducted using male-only subjects. As mentioned before, our data (Table I) suggest the existence of RAE particularly in males when the quarterly birth date intervals are taken into account. However, its impact on each swimming event performance (Table III) reveals a lower consistency and generality of RAE existence in Portuguese swimming. Indeed, the distribution of birth dates by quarter for each swim event shows that RAE is only pronounced in 12- to 15-year-old male swimmers in a few random competitions but without any clear pattern. As for girls, this phenomenon seems evident only for the youngest (12-year-old) swimmers. However, it seems important to note the lack of data for swimmers (under 12-years-old), particularly girls, which is a limitation of this study. Nevertheless, our results lead us to agree with Baxter-Jones (1995), who pointed to the earlier maturation of girls and the higher variance of the maturity status of boys as possible causes for a stronger RAE among male athletes. One of the main reasons may be due to consistent male advantages with increasing age in terms of physical growth and hormonal status. On the contrary, females show some inconstant effects with increasing age in terms of favourable physical growth but not hormonal development regarding body composition, strength and endurance development (Malina, Bouchard, & Bar-Or, 2004). In girls, after 12-years-old, RAE is still randomly visible in some swim events ($p < 0.05$, $p < 0.01$) but is probably due to more causes in addition to biological maturation, namely psychological factors (Sherar et al., 2007), training experience and competition level (Musch & Grondin, 2001). Indeed, the age-grouping system for girls leads to early increased competition level. As such, a 12-month variation in training experience (an extensive period proportionate to age, particularly for 12-year-old swimmers) will have a fairly substantial effect. Such reasoning also enables us to suppose that the quarterly variation in swimming performance does not occur in fc events because this technique is always in highest demand for training purposes (Table IV).

Because most swimmers rapidly specialise in a particular swimming technique, analysing this phenomenon in each competitive event is much more accurate than the analysis of RAE on mean swimming performance. In this sense, our Table IV data cast doubt on the consistency and generality of RAE on swimming performance rather than supporting the RAE hypothesis. Indeed, it seems now clear that RAE is negligible on real swimming performance, restricted only to the 100 m bf (12-year-old females).

The results (Tables II and IV) also show an effect of gender on swimming performance in the younger age groups (12–14 years); this result is to an extent expected due to: (1) the existence of significant gender differences in swimming performance; (2) age differences in the same age group due to the LEN rules, which require girls to be classed 2 years ahead of boys because of earlier biological maturation. We also observed that the interaction between gender and quarter is essentially non-existent for each competitive event (Table IV, $p < 0.01$).

We may summarise our results by saying that wider age differences (1st vs. 2nd half year of birth) are associated with significant differences in performance as far as wider performance ranges are concerned (top 50 or not), while this effect is not consistently revealed where smaller age differences (quarters) and smaller performance ranges (variation within top 50) are concerned.

Conclusion

The present findings suggest that, within a standard 1-year-old category, the top 50 Portuguese swimmer rankings include an inequitable distribution ($p < 0.01$) of birth dates by quarter. Indeed, a higher number of swimmers are born in the 1st or in the 2nd quarter of the year, although such consistency is only visible among males. This suggests that RAE can influence selection and progression in elite competitive swimming, particularly in males. However, there is mostly no effect of seasonal birth date on performance differences within the top 50 swimmers. The few exceptions may well be within coincidence.

Selection procedures should be used to help ensure equitable age groups, recognising that relative age differences and an earlier maturation stage can both affect performance. It is to be hoped that the results shown here will further the efforts of individuals and organisations to minimise this problem.

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