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Developmental contexts, depth of competition and relative age effects in sport: A database analysis and a quasi-experiment

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Abstract

Improving learning environments requires an understanding of biases and restrictions of current environments. The widely used policy of grouping youth into 'age groups' for education and sport promotes a persistent and pervasive developmental disadvantage known as the 'relative age effect'. This investigation documents two studies examining the potential role of depth of competition in promoting relative age effects in sport. In Study 1, we considered effects across 49 European countries (*N* = 189,411) and their relationship with depth of competition. There were significant effects in 38 countries but they did not seem to be related to depth of competition as measured by UEFA club ranking, league, ratio of national to international players or inhabitants per country. Study 2 used a quasi-experimental approach to consider a linear relationship between the number of participants in a sport, the number of spots on a sports team and the size of relative age effects. Results did not support a linear relationship between these variables but provided some evidence of non-linear interactions. Collectively, these results indicate that the relationships between competition variables and the size of relative age effects are more complex than previously hypothesized.

Keywords: Annual age-grouping, expertise, talent, handball, football

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When considering optimal learning environments, attention is normally drawn to factors that facilitate an individual's learning such as quality of instruction or the availability and accessibility of learning aids. However, more general factors can be equally if not more influential and the contexts in which learning occurs can have a significant impact on skill acquisition and development. For example, learning contexts can be influenced positively or negatively by constraints such as policies, resources and environmental characteristics. One factor, which has been found to significantly influence the learning environment and the context for athlete development is 'relative age'. Relative age, referring to the chronological differences between individuals within annually age-grouped cohorts, is an influential constraint on attainment in both education and sport (Baker, Schorer, & Cobley, 2010; Cobley, Baker, Wattie, & McKenna, 2009; Schorer, Wattie, & Baker, 2013; Wattie, Schorer, & Baker, 2015). Its consequences, known as relative age effects (RAEs), are associated with a number of developmental outcomes. In sport, these discrepancies have been shown in team activities such as soccer (Augste & Lames, 2011; del Campo, Vicedo, Villora, & Jordan, 2010; Delorme, Boiché, & Raspaud, 2010a, 2010b; Helsen, Hodges, Van Winckel, & Starkes, 2000; Helsen, Starkes, & Van Winckel, 1998; Helsen, Van Winckel, & Williams, 2005; Musch & Hay, 1999; Verhulst, 1992; Vincent & Glamser, 2006; Williams, 2010), handball (Schorer, Baker, Büsch, Wilhelm, & Pabst, 2009; Schorer, Baker, Lotz, & Büsch, 2010; Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009), and rugby (Abernethy & Farrow, 2005; Till et al., 2010), with an over-representation of relatively older athletes. These findings extend across developmental stages (Brewer, Balsom, Davis, & Ekblom, 1992; Helsen et al., 2005; Schorer, Cobley, et al., 2009; Wattie, Cobley, & Baker, 2008), but seem to be most pronounced in adolescent athletes (Cobley et al., 2009).

What makes these effects so intriguing and relevant when discussing optimal learning environments is that RAEs are not the result of naturally endowed superior abilities. These effects are driven by a more favourable alignment between the characteristics of relatively older youth and the demands of their developmental environment (see Wattie, Schorer, & Baker, 2014). Importantly, these effects are largely driven by the arbitrary 'cut off' or 'selection' dates used to define age groups. Indeed, when selection dates have been changed in the past, RAEs have shifted so that the newly relatively older athletes are advantaged, while the formerly relatively older are no longer over-represented (see Helsen, Starkes & Van Winckel, 2000). Based on the range of descriptive data provided over the past three decades, there have been several mechanisms proposed as causes of RAEs. In general, these focus on the influence of maturational differences (e.g., Barnsley & Thompson, 1988) such as greater height and weight found in relatively older cohorts compared to their relatively younger counterparts. Because relatively older players are chronologically older, they have greater maturation at any given time, particularly during childhood and adolescence (Hirose, 2009; Sherar, Baxter-Jones, Faulkner, & Russell, 2007; Till et al., 2010). Therefore, as a result of the learning context created by selection dates, which generate relative age differences, children can appear to have different levels of ability and potential to acquire skill. In sport, relative age differences can subsequently result in different opportunities for selection, as well as access to better coaching, instruction, practice and competition (see Cobley et al., 2009; Musch & Grondin, 2001).

Although age-related factors are critical antecedents of RAEs, they are also underpinned by other, more global factors, which can influence the developmental contexts. Some researchers (Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009; Musch & Grondin, 2001) have proposed that depth of competition is an important influence on whether an environment perpetuates RAEs or not. Put simply, the more players competing for a finite number of places on teams or a single team, the more likely that the characteristics of relatively older youth may appear to optimally align with environmental and task demands, and the stronger the size of the effect. Daniel and Janssen (1987) originally made this proposition when associating the integration of early competitive programming in Canadian ice-hockey, such as talent streaming and structured tiers of proficiency, with the first appearances of RAEs during the late 1980s. To add, Wattie, Baker, Cobley, and Montelpare (2007) associated increasing RAE prevalence with increased competition due to general population and sport participation growth in Canada. In their study of Canadian ice-hockey, they tracked the existence of RAEs among males who played in the National Hockey League. Their results replicated findings by Daniel and Janssen (1987) indicating that RAEs manifested in the NHL during the late 1980s. A similar line of results was revealed for German soccer by Cobley, Schorer and Baker (2008). More recently, Schorer et al. (2009) demonstrated that RAE prevalence in German handball was directly influenced by other factors associated with competition. They identified an increase in RAEs with increasing competition level (i.e., regional and national talent squads), which was attenuated across gender groups. As effect sizes were larger for males than for females they reasoned that such a difference could be related to the number of participants involved in the sport development system. Further, they noted that variations in league calibre, playing position and handedness supported the conclusion that depth of competition was a key mechanism driving RAEs. In a similar study, Loffing and colleagues (2010) showed that RAEs were diminished in smaller populations (i.e., effects were observed in right-handers but not left-handers presumably because left-handers are less common). However, these relationships were largely speculative and require further investigation. The aim of the present studies was to investigate the assumption that developmental contexts with higher competition lead to greater RAEs.

To achieve this aim we used two different approaches. In study 1, we investigated RAEs in adult international soccer in Europe by analysing a large international data set. While RAEs are expected in adult soccer (Cobley, Schorer, et al., 2008; Helsen et al., 2000; Helsen et al., 1998; Helsen et al., 2005), the size of these effects might be influenced by several factors. For example, in European soccer the most skillful players tend to congregate in the highest leagues, independent of country. Therefore, the depth of competition between European leagues, which have different reputations and standards of play, has been varied since the Bosman ruling (see Antonioni & Cubbin, 2000; Ericson, 2000), which allowed every team to utilize as many foreign players as desired. Different estimates of depth of competition within and between leagues are considered in this study. In Study 2, we focused on a youth developmental stage and administered a quasi-experimental approach to evaluate changes in competition and their effects on RAEs in German handball. More specifically, we investigated whether reducing the number of spots available at a specific selection level (i.e., changing the depth of competition) influenced the size of RAEs. Together, both studies give new insights into how depth of competition affects RAEs.

Study 1

The aims of this study were *first* to replicate RAEs found in European Junior national teams (Helsen et al., 2005) and adult league football (Jimenez & Pain, 2008; Vaeyens, Philippaerts, & Malina, 2005) as well as European elite adult soccer. *Second*, we wanted to investigate whether differences in the size of RAEs between different leagues were related to UEFA rankings of the countries, the number of inhabitants within each country, the ratio of native and foreign players per league, or the league level within each country. All four variables could influence the depth of competition in the leagues and therefore, if the assumption noted in previous research (Cobley, Schorer, et al., 2008; Daniel & Janssen, 1987; Schorer, Cobley, et al., 2009; Wattie et al., 2007) is correct, higher magnitude RAEs should be found as depth of competition increases. UEFA rankings represent success of the country in the league over the last five years. Naturally, countries with higher scores are more attractive to players, because they win more international championships such as the UEFA Champions League or the UEFA Europe League. The influence of the number of inhabitants on development of expertise has previously been demonstrated by birthplace effect studies (Baker & Logan, 2007; Baker, Schorer, Cobley, Schimmer, & Wattie, 2009; Côté, MacDonald, Baker, & Abernethy, 2006; MacDonald, Cheung, Côte, & Abernethy, 2009). Additionally, a study by Schorer et al. (2009) on handball noted differences in RAEs between native and international players. A higher number of international players may reflect the attractiveness of a league to players of the highest calibre and can therefore also be considered an estimate of depth of competition.

Methods

Player data were obtained from an open internet source (www.eufo.de). For the 1998/99 to 2008/09 seasons, we obtained birth and nationality data for 189,411 players from 49 European countries. Players were drawn from the first league for most of the countries. For some countries there were also data for the first, second, third, and fourth leagues. To test RAEs, the relative age for all players - national and international - was determined by coding the birthdates of players born in and after 1981 into one of four categories based on the date used by international league soccer to classify players into age groups: Quartile 1 (Q1) = January - March; Quartile 2 (Q2) = April - June; Quartile 3 (Q3) = July - September; and Quartile 4 (Q4) = October - December. For players born in and before 1980 a different cut-off date (e.g., 1st August) was applied (Cobley, Schorer, et al., 2008). Therefore, players categorized in Quartile 1 were born between August to October (Q2: November - January; Q3: February - April, & Q4: May – July). While this has been done successfully in previous work (Cobley, Schorer, et al., 2008), the current study considers 49 different countries. The soccer organizations for all 49 countries were contacted by email and/or phone to verify the cut-off dates; however, only 18 responded. Within the responding countries, 17 confirmed the cut-off dates used here, while the other had traditionally used the 1st of August. Because so few of the federations (1 of 18) reported a different cut-off date and considering the FIFA requirement that all teams use the 1st of January as the cut-off date for international tournaments, we decided to use January 1st for subsequent analyses. Additionally, the UEFA league ranking for each country and the number of inhabitants per country were retrieved from an open internet source (www.wikipedia.de), which previous studies have shown to be a reliable source of this type of information (Giles, 2005).

Statistical comparisons were made using chi-square tests (SPSS 22.0); effect size and test power were calculated using G-Power 3.0.10 (Faul, Erdfelder, Lang, & Buchner, 2007). Given the large number of countries in the present analysis, previous work indicating only marginal differences in birth rates across the year in several countries (Cobley, Schorer, et al., 2008) and in line with considerable previous research in this area, comparisons were based on an equal distribution of births across months per year. To investigate the relations between RAE sizes and the four other moderators, an exploratory approach was chosen. While correlations between these were calculated, only the size of correlations was reported as a descriptive measure because reporting p-values was considered to be inadequate.

Results

In the first step, an overall analysis of the RAEs was conducted. As can be seen in Figure 1, significant RAEs were revealed, $\chi^2(3) = 17095.04$, $p < .01$, $w = .14$, and the effect sizes per country varied from .05 for Ireland and Iceland up to .28 for Armenia (Table 1). No significant RAEs existed for Ireland, Iceland, Macedonia, Luxembourg, Malta, San Marino, Estland, Moldawia, Kasachstan, Georgia, and Montenegro.

In the next step, the relation between effect sizes of RAEs and UEFA league ranking was investigated. As can be seen in Figure 2a, the correlation between these variables was small, $r = .15$. In a follow-up, we differentiated between effect sizes for different leagues within countries and related these to the UEFA league ranking per country. As seen in Figure 2b, no linear relation was observed for first, $r = -.05$, or second, $r = .03$, league per country. For third and fourth leagues, no relations were calculated, because there were not enough observations. Additionally, no clear trend was observed for differences between leagues per country. Out of the 19 countries where more than one league could be identified, 10 had higher effect sizes in the second league compared to the first league. From the remaining nine, seven had larger effects for first league and two had the same size effect. All of the differences between effect sizes for league 1 and for league 2 were rather small (below .10).

The ratio of national to international players showed no clear trends, $r = .04$ (Figure 2c). In most countries, more national than international players were found. In only five countries were more international players found.

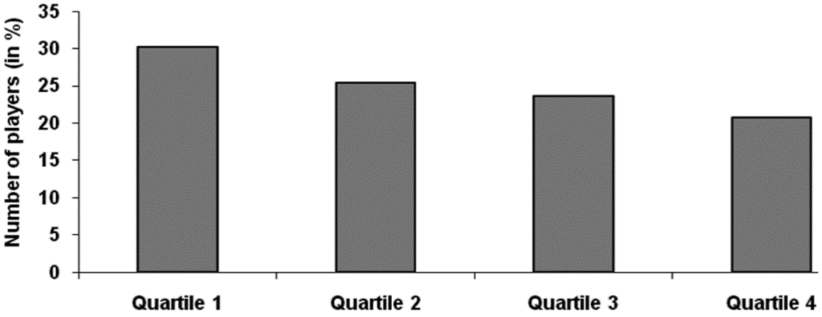


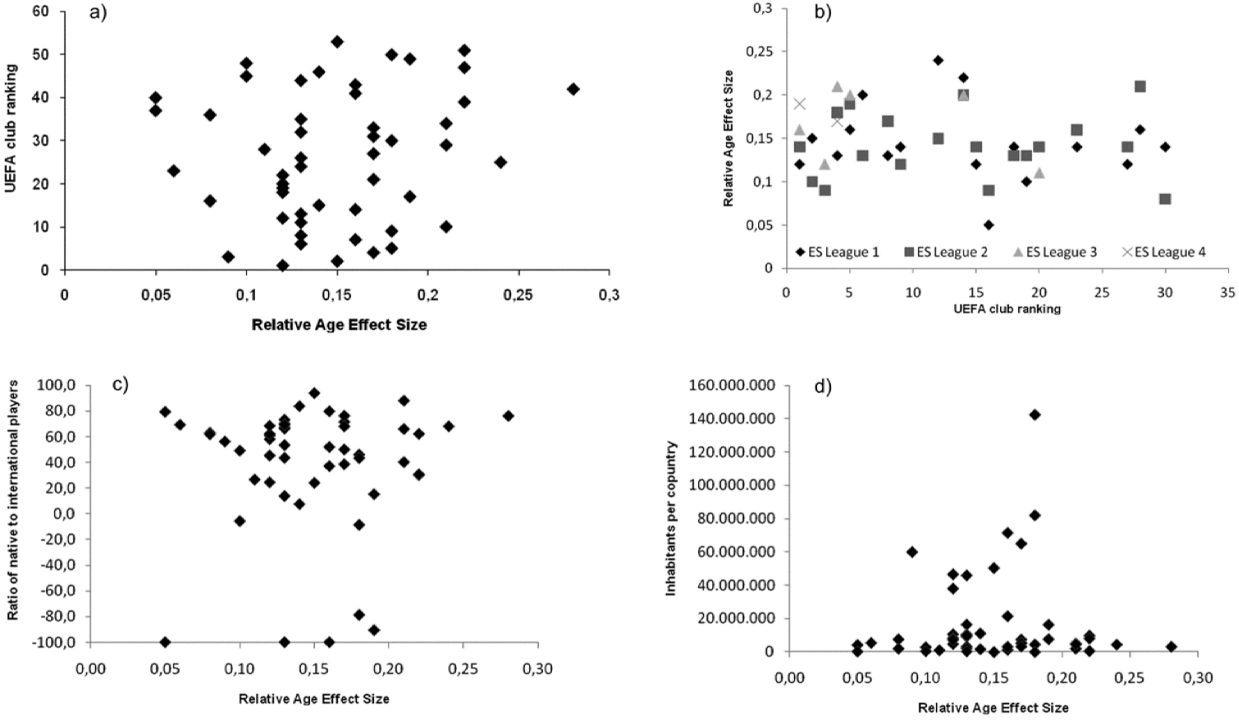
Figure 1:
Distribution of athletes (in percent) per quartile for all European Leagues (*n* = 189,411)

Table 1:
Overview of birth quartile distributions per country and its inferential statistics

Countries	N	Q1	Q2	Q3	Q4	χ^2	p	ω	1- β
Albania	999	28.7	28.7	23.7	18.8	27.03	< .01	0.16	
Armenia	877	36.0	25.5	21.3	17.1	69.41	< .01	0.28	
Austria	8408	29.3	25.4	24.5	20.7	126.53	< .01	0.12	
Azerbaijan	917	33.9	20.0	25.3	20.8	44.90	< .01	0.22	
Belarus	3031	31.3	29.3	22.0	17.4	151.96	< .01	0.22	
Belgium	7264	29.6	25.4	23.5	21.4	106.06	< .01	0.12	
Bosnia	355	25.4	27.0	29.9	17.7	11.43	.01	0.18	
Bulgaria	2320	25.0	25.3	27.5	22.1	14.09	< .01	0.08	
Croatia	468	32.3	28.8	22.6	16.2	28.05	< .01	0.24	
Cyprus	2755	29.0	25.3	24.0	21.7	30.54	< .01	0.11	
Czech Republic	1229	30.3	24.6	22.5	22.7	19.51	< .01	0.13	
Denmark	5026	26.4	25.7	25.2	22.7	15.99	< .01	0.06	
England	19409	31.5	24.3	22.1	22.1	465.70	< .01	0.15	
Estonia	304	30.3	25.7	24.7	19.4	7.24	.06	0.16	0.83
Faeroese	1286	29.0	30.0	20.1	20.8	42.24	< .01	0.18	
Finland	3077	31.5	25.7	22.3	20.5	86.20	< .01	0.17	
France	12901	31.4	25.7	23.4	19.4	386.06	< .01	0.17	
Georgia	170	33.5	23.5	24.1	18.8	7.74	.05	0.21	0.86
Germany	34332	31.9	25.6	22.0	20.5	1049.30	< .01	0.18	
Greece	925	30.5	25.1	22.8	21.6	17.14	< .01	0.14	

Countries	N	Q1	Q2	Q3	Q4	χ^2	p	ω	1- β
Hungary	816	30.4	24.8	22.9	21.9	13.99	< .01	0.13	
Iceland	1543	26.8	25.3	24.0	23.8	3.62	.30	0.05	0.71
Ireland	248	23.0	26.2	25.4	25.4	0.58	.90	0.05	0.54
Israel	2632	29.3	25.3	24.7	20.7	39.33	< .01	0.12	
Italy	13619	27.9	24.6	26.0	21.6	116.42	< .01	0.09	
Kazakhstan	722	29.5	21.2	30.1	19.3	26.96	< .01	0.19	
Latvia	1511	30.2	25.6	22.6	21.5	27.60	< .01	0.13	
Lithuania	1414	28.4	28.3	21.6	21.7	25.54	< .01	0.13	
Luxembourg	395	28.1	21.3	25.8	24.8	3.84	.28	0.10	0.72
Malta	356	28.9	20.5	27.2	23.3	6.20	.10	0.13	0.78
Macedonia	415	23.6	28.0	23.1	25.3	2.36	.50	0.08	0.64
Moldova	263	28.9	27.8	25.5	17.9	7.77	.051	0.17	0.83
Montenegro	102	32.4	25.5	16.7	25.5	5.06	.17	0.22	0.74
Netherlands	1479	29.5	25.4	24.7	20.4	25.18	< .01	0.13	
Northern Ireland	1661	29.9	27.0	21.7	21.3	34.96	< .01	0.14	
Norway	5496	29.3	26.2	23.6	20.9	85.05	< .01	0.12	
Poland	1295	27.5	26.0	26.4	20.1	17.34	< .01	0.12	
Portugal	5750	29.4	25.9	24.4	20.3	98.56	< .01	0.13	
Romania	940	29.3	27.6	24.4	18.8	23.73	< .01	0.16	
Russia	6370	31.6	26.3	22.5	19.6	207.72	< .01	0.18	
San Marino	95	25.3	27.4	28.4	18.9	2.05	.56	0.15	0.63
Scotland	4669	33.0	25.3	23.0	18.7	201.63	< .01	0.21	
Serbia	536	31.0	26.3	22.9	19.8	14.76	< .01	0.17	
Slovakia	1614	30.7	27.5	21.7	20.1	48.03	< .01	0.17	
Slovenia	566	32.7	24.9	24.7	17.7	25.56	< .01	0.21	
Spain	11356	28.4	24.9	26.5	20.2	168.86	< .01	0.12	
Sweden	5604	29.5	25.7	24.6	20.3	96.45	< .01	0.13	
Swiss	2155	32.0	25.0	24.4	18.6	78.03	< .01	0.19	
Turkey	3805	29.8	25.7	25.7	18.8	96.17	< .01	0.16	
Ukraine	3969	30.0	25.3	23.8	20.8	70.27	< .01	0.13	
Wales	1962	28.6	25.0	21.5	24.9	19.97	< .01	0.10	

Figure 2:
a) Relationship between relative age effect size per country (x-axis) and UEFA club ranking (y-axis). b) Relationship between relative age effect size per league level (x-axis) and UEFA club ranking (y-axis). c) Relationship between relative age effect size per country (x-axis) and ratio of national and international players in percent (y-axis). NOTE: Positive values reflect more native players and negative values more international players. d) Relationship between relative age effect size per country (x-axis) and inhabitants per country (y-axis)



Similarly, and as seen in Figure 2d, there was no linear relationship between the magnitude of RAE and the number of inhabitants in each country, $r = .04$. When separating countries (as the data in Figure 2d suggests) of more or less than 30 million inhabitants, two trends were identified. For countries with less than 30 million inhabitants, effect sizes seem to vary, but with no relation to the population. However, for countries with populations above 30 million there appears to be an increase of relative age effect sizes with a higher number of inhabitants (cf. Figure 2d). However, these effect sizes should be interpreted with caution, as they were still smaller than several countries with lower populations.

Discussion

The first aim of this study was to replicate RAEs across European elite adult soccer. There were significant effects for 38 out of 49 countries investigated, but generally only small overall effect sizes were found. The countries that did not show significant RAEs tended to be smaller countries with less prominent football leagues. The results from test power analyses present no clear picture, suggesting further investigations need to replicate this null-hypothesis.

Moreover, our assumption of January 1st as the most appropriate cut-off date for these analyses should be further validated. With the need for replication and validation in mind, the lack of RAEs might have been due to reduced intensity of competition as proposed by Musch and Grondin (2001), although other explanations exist including cultural differences between countries as well as football specific characteristics that might moderate this effect. For example, German soccer used to be often regarded as more athletic and forceful, while Spanish soccer is more tactical and technical. While these stereotypes are hard to classify and control, they might implicitly influence the developmental context and as a result influence the occurrence and maintenance of RAEs.

A second explanation might be that the competition factors affecting RAEs are not the same as those considered in this investigation. Interestingly, all four of the competition measures examined in Study 1 failed to show a clear relation to size of RAEs. This is surprising in the light of previous studies by Cobley et al. (2008), Daniel and Jansen (1987), Schorer et al. (2009), or Wattie et al. (2007). However, as Cobley et al. (2009) showed in their meta-analysis, RAE effect sizes are larger during adolescence. They also suggested that many variables like cultural values, developmental systems or selections interact to determine the effect sizes. It is plausible that the factors determining the depth of competition in youth are quite different from those at the adult or elite levels. We explore this issue in Study 2.

Study 2

As Musch and Grondin (2001) proposed, depth of competition might not directly determine the magnitude of the RAE, but it might create developmental contexts that are fertile ground for RAEs to occur. They defined competition as the number of spots available on a team compared to the number of players competing for these spots. This latter number depends on the popularity of given sports and/or by the amount of people eligible to play. Recently, a change in the talent development system for German handball provided the basis to investigate this issue more rigorously as a quasi-experiment. A change in the available spots for regional selection teams participating in the national team youth try-outs, 12 instead of 14 players, should hypothetically generate a greater depth of competition. With this in mind, the primary aim of Study 2 was to investigate the influence of changing depth of competition conditions on RAEs.

We hypothesized a linear relationship between the degree of competition and the size of RAEs. Our examination considered whether reducing the number of team members to be selected on a handball team (i.e., change in conditions) and accounting for possible increases in the number of athletes competing for places (Wattie et al., 2007) lead to inflated RAEs, thereby exacerbating participation and attainment inequalities.

Additionally, we investigated whether there were any sex differences. Most studies of RAEs in sport have focused on male athletes and the few studies of female athletes sketch an inconsistent picture of RAEs in this group. For instance, Helsen et al. (2005) demonstrated consistent RAEs for male and female soccer players from the U18-European Championship while Vincent and Glamser (2006) found no effects among females in the US Olympic Developmental Program. In Switzerland, RAEs were observed among developmental levels of women’s soccer, but no RAEs were reported at elite national levels (Romann & Fuchslocher, 2011). Delorme and Rauspaud (2009) reported significant over-representations in the first two quartiles from ages 7 to 17 years for both female and male French basketball players. Schorer et al. (2009) revealed differences in effect sizes between male and female handball talents in regional selections, which were explained by the smaller number of female players compared to male players in German youth handball. These data suggest that the depth of competition varies for male and female athletes. Therefore, the second aim of this study was to investigate the effect of changing the depth of competition from the other end of the spectrum (i.e., by considering differences in number of athletes competing for a spot). By combining these two aims (i.e., reduction in spots for the selection team as well as different number of athletes participating in the sport), we investigate both competition factors simultaneously.

Methods

Player data were provided from the study by Schorer et al. (2009) and by new data collected during the national youth team try-outs for 20 regional squads in Germany (D-squads). Players’ age ranged between 13-15 years old. Until 2007, regional selections permitted 14 players in total to be selected from these try-outs. After 2008, regional teams (D-squads) were limited to 12 players (i.e., a 14.3% reduction) due to organizational constraints. For the 2001-2008 seasons, we obtained data for 1741 players. To test RAEs, the relative age for all players was determined by coding players’ birth-dates into one of four categories based on the date used by German handball federation to classify players into age groups: Quartile 1 (Q1) = January – March; Quartile 2 (Q2) = April - June; Quartile 3 (Q3) = July - September; and Quartile 4 (Q4) = October - December.

Additionally, data related to the number of living births (nLB) of the different federal states were obtained from the Statistical Institute of Germany for the years 1991-2000. This time period corresponded to the birth period of participants in this study. For two federal states there were three regional selections each. Therefore, the nLB was divided by three for these states. The mean nLB for the years 1991-2000 was then re-coded into three groups. Group 1 (small) consisted of federal states with less than 20,000 living births per year (*n* = 7). Group 2 (medium) was within the range of 30,000 to 45,000 (*n* = 5) and group 3 (large) was formed of regional selections whose nLB was above 65,000 (*n* = 3). The borders of these groups were chosen after an explorative analysis of the sizes for all federal states, which suggested these clusters.

Statistical comparisons were made using chi-square tests (PASW 18.0). Effect size and test power were calculated using G-Power 3.0.10 (Faul et al., 2007). As with previous research, comparisons were based on either an equal distribution of births across months per year (Cobley, Schorer, et al., 2008) or differences between distributions of different categorized regions or selections (Schorer, Cobley, et al., 2009).

Results

There are clear overall RAEs, $\chi^2(3) = 226.58$, $p < .01$, $w = .36$ (Figure 3), which remained significant for both the old, $\chi^2(3) = 163.89$, $p < .01$, $w = .35$, and new selection systems, $\chi^2(3) = 63.45$, $p < .01$, $w = .37$. Comparing the new and old selection systems revealed no significant differences in distributions, $\chi^2(3) = 4.39$, $p = .22$, $w = .05$, $1 - \beta = 51$.

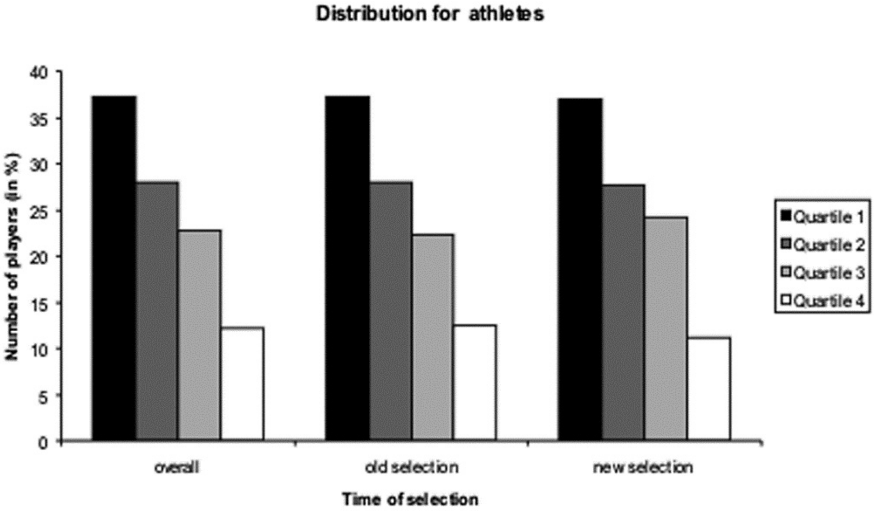


Figure 3:
Distribution of athletes (in percent) overall as well as for old and new selection systems separated

For all three different region sizes a significant RAE was revealed, small: $\chi^2(3) = 72.20$, $p < .01$, $w = .34$, medium: $\chi^2(3) = 78.86$, $p < .01$, $w = .34$, large: $\chi^2(3) = 80.12$, $p < .01$, $w = .43$ (Figure 4). These significant differences remained even when the old and new selection systems were differentiated for all six combinations, $\chi^2(3) > 14.78$, $p < .01$, $w > .30$.

Comparisons between distributions for all three regions revealed no significant differences within the old selection system, but there were significant differences in distributions between small and large regions in the new selection system, $\chi^2(3) = 8.77$, $p = .03$, $w = .25$, but not between small and medium or between medium and large regions.

Considering only the female players, a medium size RAE was revealed (Table 2); the effect size (around .30) was also revealed for the old selection system within the two smaller region sizes and increased slightly for regions with nLB over 65,000. While there were significant RAEs for the new selection system for the female players, it varied by region size. For small region sizes, RAEs failed to reach significance, but on a descriptive level the percentage of players from the first and second quartiles was much higher than for both others. The effect size for this distribution was small. For medium region sizes, clear RAEs were found with a medium size effect. This increased further for large region sizes with a large effect size.

For the male players, no differences were revealed. There were significant medium size effects for all players, even when differentiated between new and old selection systems and for the three different region sizes.

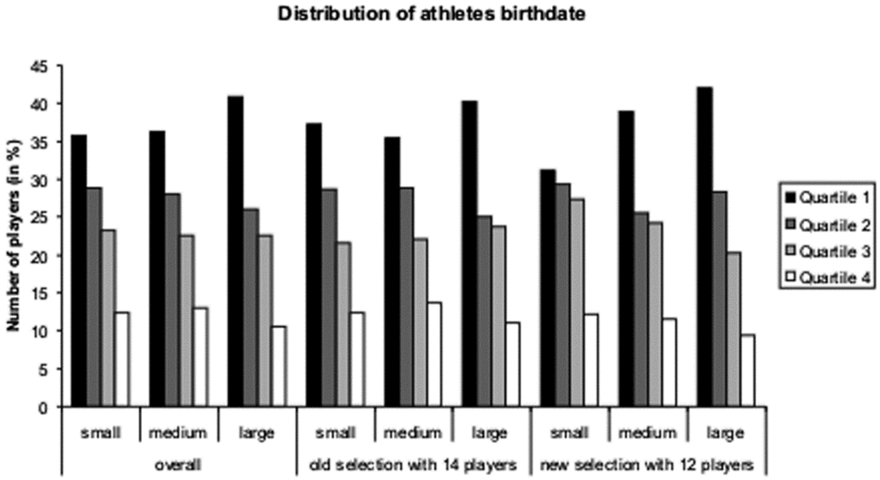


Figure 4:
Distribution of athletes (in percent) overall as well as separated for old and new selection systems differentiated for sizes of handball region

Table 2:
Birth quartile distribution and inferential statistics as a function of sex, time of selection and region size (RS)

		N	Q1	Q2	Q3	Q4	Inferential statistics
Female	Total	845	34.7	29.1	23.0	13.3	$\chi^2(3) = 86.39, p < .01, w = .32$
Old system (12 players)	overall	606	33.5	29.4	23.1	14.0	$\chi^2(3) = 52.20., p < .01, w = .29$
	RS 1	214	33.6	30.4	20.6	15.4	$\chi^2(3) = 18.41, p < .01, w = .29$
	RS 2	238	29.8	31.9	24.4	13.9	$\chi^2(3) = 18.64, p < .01, w = .28$
	RS 3	154	39.0	24.0	24.7	12.3	$\chi^2(3) = 21.95, p < .01, w = .38$
New system (14 players)	overall	239	37.7	28.5	22.6	11.3	$\chi^2(3) = 34.96, p < .01, w = .38$
	RS 1	83	27.7	33.7	24.1	14.5	$\chi^2(3) = 6.49, p = .09, w = .27$
	RS 2	84	38.1	25.0	25.0	11.9	$\chi^2(3) = 11.52, p = .01, w = .37$
	RS 3	72	48.6	26.4	18.1	6.9	$\chi^2(3) = 26.89, p < .01, w = .61$
Male	Total	896	39.5	26.7	22.7	11.2	$\chi^2(3) = 147.06, p < .01, w = .40$
Old system (12 players)	overall	677	40.5	26.6	21.6	11.2	$\chi^2(3) = 120.26, p < .01, w = .42$
	RS 1	239	40.6	27.2	22.6	9.6	$\chi^2(3) = 46.84, p < .01, w = .44$
	RS 2	300	40.0	26.3	20.3	13.2	$\chi^2(3) = 46.16, p < .01, w = .39$
	RS 3	137	41.6	26.3	22.6	9.5	$\chi^2(3) = 28.69, p < .01, w = .46$
New system (14 players)	overall	220	36.4	26.8	25.9	10.9	$\chi^2(3) = 29.20, p < .01, w = .36$
	RS 1	81	34.6	24.7	30.9	9.9	$\chi^2(3) = 11.49, p < .01, w = .37$
	RS 2	73	39.7	26.0	23.3	11.0	$\chi^2(3) = 12.20, p < .01, w = .40$
	RS 3	66	34.8	30.3	22.7	12.1	$\chi^2(3) = 7.82, p = .05, w = .34$

Discussion

Contrary to our proposition, overall RAEs remained stable within both selection systems regardless of the changes determining the number of players selected in handball. This seems surprising given the large number of studies (e.g., Cobley, Schorer, et al., 2008; Daniel & Janssen, 1987; Schorer, Cobley, et al., 2009; Wattie et al., 2007) proposing that competition increases RAEs. One possible explanation for the present finding comes from Schorer et al. (2009), who showed that RAEs are manifested differently in the adult context based on the demands of specific positions. For example, it may be that such a two player reduction, in an adult context, leads to a strategy whereby players in 'wing' positions are not selected at try-outs. As revealed by Schorer et al. (2009) for German handball, this might lead to smaller RAEs because these positions demand less height. However, because the aim of player development is to have 'all-around' players at this age and knowing that taller players have an advantage, it seems reasonable to choose bigger athletes during this stage of selection. Nonetheless, this remains speculative and needs to be investigated in future studies.

Considering the nLB categories and selection systems, we found the strength of RAEs was affected by changes in competition. While RAEs in the new selection conditions were larger in regions with higher potential participants, RAEs declined in regions with lower birth rates. These differences appear linked to changes for female athletes. It was surprising that females with smaller number of participants had strong differences in effect size, while the male players seemed unaffected by the reduction of spots in the selection team and region size. If the size of RAEs increases with higher depths of competition then an additive model could be assumed. The results reported here suggest a more complicated interaction between these moderators. Additionally, this trend was not found in the old selection conditions (i.e., 14 players per team) suggesting the relationship between competition (reflected by number of player selections and number of potential participants per region) and RAEs is not linear, as proposed.

General discussion

One major finding from these studies is that there are several dimensions of competition interacting with RAEs. While a general competition hypothesis as proposed by Musch and Grondin (2001) seems plausible, the effect of varying levels of competition seems more complex, since different factors interact at any given time to determine the level of competition for spots on a given team. Currently, our understanding of these factors and their interaction is limited. Wattie et al. (2008) suggested researchers need to differentiate between aspects of competition to gain a better and more distinct understanding of their association with RAEs. One possible differentiation would be to consider competition factors arising from (1) popularity of the sport in general (i.e., competition factors that are outside or external to the sport), and (2) the selection mechanisms within the sport (i.e., factors internal to the sport). First, general participation can account for competition at a global level (i.e., number of players entering or involved in a sport system). Studies examining this level of competition would be Daniel and Jensen (1987), Wattie et al. (2007), and Schorer et al. (2009). However, a second level of competition could be at a more local level (e.g., selection for a team). Studies by Schorer et al. (2009) considering elite vs. near-elite, or the selection of youth for talent squads would fit into this category. Related to competition in the present study, region size and number of athletes participating in the sport would be considered as being *external* factors, whereas the number of available spots on a representative team would be considered an *internal* factor. Sex would be considered an external factor if differences in the total number of females/males generate sex specific variability in RAEs. Ideally, this type of analysis would be grounded in a sound theoretical framework such as Bronfenbrenner's Ecological Systems Theory (Bronfenbrenner, 2000; Bronfenbrenner & Ceci, 1994).

Although not directly tested in this study, it is reasonable to assume a degree of interaction among these factors. The descriptive changes in effect sizes within the new handball selection system for female players seem to support this notion. Future studies will need to carefully consider these points in their data analyses. It is also important to acknowledge that our two-level differentiation may not be sufficient to encapsulate the complexity of this interaction. This will be a point to consider in future investigations that strive to ascertain a better understanding of *how* competition influences the learning environment with respect to RAEs.

This study provides new evidence that the relationship between RAEs size and depth of competition is influenced by several moderators that interact in a non-linear fashion. Future research needs to investigate the interactions of the various mechanisms underpinning RAEs to facilitate a deeper understanding of these effects. This is important, especially as RAEs are considered to constrain general psychological and social development (Musch & Grondin, 2001). Likewise, understanding the underlying mechanisms will inform interventions and organizations motivated toward removing RAEs inequalities in sports or other areas (e.g., education). Therefore it will be necessary to build a comprehensive model of RAEs, based not only on the assumptions and relations tested by large datasets, but also by quasi-experimental or experimental designs (Wattie et al., 2014).

Taken together, both studies show how varying learning environments can influence long-term outcomes in a specific field. In our case, a simple well intended policy defining cut-off dates has a large influence on the probability of reaching the highest tiers within a sport. However, the processes behind the different magnitudes of RAEs, such as the influence of different types of competition, are much less understood. Among other topics, future research should consider the interactions among our variables in creating an optimal learning environment for athlete development.

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