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# Relative age effects in Swiss talent development – a nationwide analysis of all sports

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**ABSTRACT**
Relative age effects (RAE) generate consistent participation inequalities and selection biases in sports. The study aimed to investigate RAE across all sports of the national Swiss talent development programme (STDP). In this study, 18 859 youth athletes (female N = 5353; mean age: 14.8 ± 2.5 y and male N = 13 506; mean age: 14.4 ± 2.4 y) in 70 sports who participated in the 2014 competitive season were evaluated. The sample was subdivided by sex and the national level selection (NLS, N = 2464). Odds ratios (ORs) of relative age quarters (Q1-Q4) and 95% confidence intervals (CI) were calculated. In STDP, small RAE were evident for females (OR 1.35 (95%-CI 1.24, 1.47)) and males (OR 1.84 (95%-CI 1.74, 1.95)). RAE were similar in female NLS athletes (OR 1.30 (95%-CI 1.08, 1.57)) and larger in male NLS athletes (OR 2.40 (95%-CI 1.42, 1.97)) compared to athletes in the lower selection level. In STDP, RAE are evident for both sexes in several sports with popular sports showing higher RAE. RAE were larger in males than females. A higher selection level showed higher RAE only for males. In Switzerland, talent identification and development should be considered as a long-term process.

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**KEYWORDS**
Youth sports; talent selection; athletic development; maturation

## Introduction

The phenomenon of relative age effects (RAE) is well-known in youth sports. Children and adolescents are commonly pooled into annual age groups to account for developmental differences and, thus, to allow for more equal inter-individual opportunities for being successful in a particular sport. There remains, however, a potential gap of up to 12 months in chronological age between individuals. RAE is defined as the overrepresentation of chronologically older participants within one selection year relative to their chronologically younger counterparts. This effect occurs during the early development of youth athletes (Cobley, Baker, Wattie, & McKenna, 2009; Musch & Grondin, 2001). RAE may lead to a biased view of the potential of children in a particular sport as early-born athletes may have advanced physical and cognitive abilities compared to their late-born opponents and are, therefore, more likely be identified as more talented (Cobley et al., 2009; Delorme, Boiché, & Raspaud, 2010; Gil et al., 2014; Hancock, Adler, & Côté, 2013; Wattie, Schorer, & Baker, 2015). Consequently, these children may have a higher chance of being selected for representative teams or talent centres and may receive more comprehensive future training. It has been shown in youth soccer and basketball players that those who are born late in the selection year are more likely to drop out of these sports than players who are born early in the selection year (Delorme et al., 2010; Delorme, Chalabaev, & Raspaud, 2011).

In a comprehensive meta-analytical review, Cobley et al. (2009) reported a consistent risk for RAE, which is apparent across a variety of different sports. These authors presented data on RAE in 14 different sports (ice hockey, volleyball, basketball, American football, Australian rules football, baseball, soccer, cricket, swimming, tennis, gymnastics, netball, Rugby Union and golf) for male and female athletes from 4 years of age to the senior professional level. Most studies were conducted in soccer and ice hockey. The largest RAE were found in basketball and soccer. RAE were present in all age categories and increased with age until late adolescence. In adult athletes, the RAE were lower, comparable to (pre)pubertal children. Further, RAE were apparent in all levels of play. Whereas the RAE were marginal at the lowest levels, they increased with higher representative levels. However, on the elite level, the effect size decreased to values of lower competitive levels. Meanwhile, data on RAE in other sports, such as alpine skiing (Müller, Hildebrandt, & Raschner, 2015), handball (Schorer, Cobley, Busch, Brautigam, & Baker, 2009) and athletic sprinting (Romann & Cobley, 2015) are available, confirming the presence of RAE in these sports as well.

Data on RAE in the above-mentioned meta-analysis were, however, not consistent between studies, and evidence for some sports is based on only small samples. Particularly, for female athletes, the number of available studies is limited and

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Supplemental data for this article can be accessed here

data are inconsistent. For instance, Delorme et al. (2010) found RAE in French female soccer players, particularly in the youth age categories. Interestingly, there was also an inverse RAE in drop-outs who were overrepresented in the second half of the selection year and underrepresented in the first half. In contrast, Vincent and Glamser (2006) observed marginal RAE among female youth soccer players, whereas in their male counterparts the RAE was clearly larger. The authors discussed complex interactions of biological and maturational differences with socialization influences as possible reasons for these sex differences. Goldschmied (2011) reported no RAE in elite level female soccer, basketball and handball players. This report, however, was not published in a peer-reviewed scientific journal, is based on a limited number of players and contains data from three different countries and seasons. Overall, the inconsistent evidence on RAE in females warrants further research in this population (Delorme et al., 2010).

Methodological confounding through differences in the talent identification and development systems between countries or country-specific popularity of a particular sport may also affect results. Cohort studies analysing large homogeneous samples of youth athletes over a variety of different sports from a single country are rare. In most studies with large nationwide samples, only a limited number of different sports (in most instances a single sport) were analysed (Delorme et al., 2010, 2011; Romann & Fuchslocher, 2013). It has been suggested that the popularity of a particular sport, the number of active participants, the importance of physical development and the competitive level affect the existence of a RAE (Musch & Grondin, 2001). There is evidence supporting these hypotheses. For example, Delorme and Raspaud (2009) showed that no RAE is present in shooting sports, i.e. a sport in which physical capabilities are of minor relevance for sports performance. Similarly, it has been shown that in sports with weight categories, RAE are not present (Albuquerque et al., 2012; Delorme, 2014). Weight categories may counterbalance maturational and physical differences between young athletes within age categories and, thus, may prevent the occurrence of RAE. Altogether, important questions remain, for instance, whether RAE are indeed consistent through all sports or whether there are inverse RAE in some sports as late-born talented age-groupers might tend to change to specific sports with fewer competitive demands and less rivalry. The analysis of RAE within a national talent development programme including all selected youth athletes of all organised sports, may facilitate to answer such questions within a homogenous talent development context.

The aim of the study was to investigate the RAE in all organized sports based on a countrywide Swiss database where youth athletes (7 to 20 years of age), who were selected into a nationwide talent programme, were registered. It was hypothesized that overall RAE are apparent in sports with high rates of participation and high selection pressure (e.g. soccer, alpine skiing), whereas sports with less public attention and fewer participants (e.g. fencing, curling) do not necessarily show RAE or even inverse RAE. As Olympic sports are usually more popular, include more participants and show a high competitive level already in young athletes, RAE should be more pronounced in Olympic as compared to Non-Olympic sports. Furthermore, it was expected that there are more pronounced RAE in male as compared to female youth athletes and that RAE are less pronounced in sports with weight categories.

## Methods

### *Participants*

The Swiss system of talent identification, selection and development is based on three levels of performance (Figure 1) (Romann & Fuchslocher, 2013). The first level is a nationwide extracurricular programme called "Jugend und Sport" (J + S), which is offered to all young children and adolescents aged 5 to 20 years. The second level is the national Swiss talent development programme (STDP) within J + S in 70 different sports starting at the age of 7 years. All Swiss youth athletes in the STDP (N = 18 859; female N = 5353; age: 14.8 ± 2.5 y and male N = 13 506; age: 14.4 ± 2.4 y) who participated in the 2014 competitive season were included in the present analysis. Athletes in STDP are selected by the national talent selection instrument (PISTE), which includes six major assessment criteria (competition performance, performance tests, performance development, psychological factors, athlete's biography and biological development) and a number of sub-components (e.g. resilience, anthropometry, achievement motivation) (Fuchslocher, Romann, & Gulbin, 2013). Licensed coaches perform the practices in this programme, and the athletes are expected to train more than 400 hours per year. J + S and Swiss Olympic jointly established this cut-off criterion. The third level is the subgroup of the national level selection (NLS). In the PISTE process, athletes with the potential to successfully perform in national and international competitions are selected in the NLS.

### *Procedures and data analysis*

Anonymised information on participant's age, sex, date of birth and sport disciplines was retrieved from the database of J + S (Swiss Federal Office of Sport, 2015). The study was approved by the institutional ethical review board of the Swiss Federal Institute of Sport.

In Switzerland, the cut-off date for all sports is January 1$^{st}$. The athletes were categorized into four relative age quarters (Q) according to their birth month independently of birth year (i.e., Q1 = January to March; Q2 = April to June; Q3 = July to September; and Q4 = October to December). The observed birth-date distributions were calculated for every relative age quarter. The expected birthdate distributions were obtained from the actual corresponding distributions (1994–2009) as the number of live births registered with the Swiss Federal Office of Statistics. The relative age quarters of the Swiss population were as follows: Q1 = 24.5%; Q2 = 25.2%; Q3 = 26.1%; and Q4 = 24.2%. Sports were categorized into Olympic and Non-Olympic sports and for clarity, into large (25 largest sports according to the number of involved athletes for each sex separately; sports with more than 43 selected athletes for females and more than 74 selected athletes for males on the STDP level) and small sports (lower number of athletes in STDP). The reason for this categorisation is a higher participation, more funding and more scientific support for Olympic sports (Swiss Olympic Association, 2017). Data of the latter are presented in the supplementary files only.

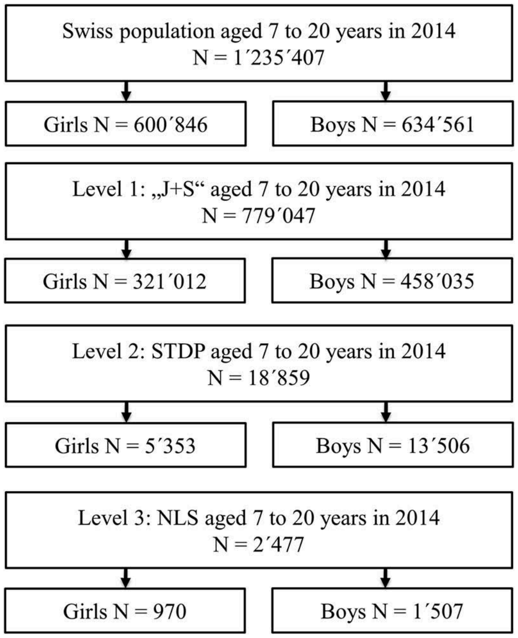


Figure 1. Overview of the different levels of selection in the Swiss organized sport system (J + S), the Swiss talent development programme (STDP) and the national level selection (NLS).

Based on these data, odds ratios (OR) with 95% confidence intervals (95% CI) were calculated between Q1/Q4 as commonly used in RAE studies (Cobley et al., 2009). A relevant RAE was assumed if the confidence interval of the OR did not include 1. The OR for the Q1 vs. Q4 comparison was interpreted as follows: OR < 1.22, 1.22 ≤ OR < 1.86, 1.86 ≤ OR < 3.00, and OR ≥ 3.00, indicating negligible, small, medium and large effects, respectively (Olivier & Bell, 2013). If the OR was < 1 and the confidence interval did not include 1, this finding was interpreted as an inverse RAE. As population-based data were analysed, inferential statistics were not applied (Gibbs, Shafer, & Dufur, 2012).

## Results

In total, 18 859 youth athletes (5353, 28% girls) between 7 and 20 years of age were included in the STDP in the year 2014 (Figure 1). Thirteen percent (N = 2477) of these athletes (female, N = 970; male, N = 1507) were included in the subgroup of NLS.

Tables 1 and 2 show the relative age quarter distribution of female and male youth athletes together with the odds ratios for athletes born in the first quarter vs. last quarter of the selection year for the 25 sports with the largest number of participants in Switzerland. Detailed data for all sports included in the STDP are shown in the appendices in the online supplementary material (Tables SI and SII).

In female athletes in the STDP (Table 1), medium RAE in track and field and synchronized swimming were observed. Small RAE were present in tennis, volleyball, soccer and alpine skiing. No relevant RAE were found in the NLS in female athletes.

In male athletes in the STDP (Table 2), track and field, soccer, shooting, basketball, ice hockey, field hockey and volleyball showed medium RAE. Small RAE were present in cross-country skiing, alpine skiing, tennis, swimming, handball and floorball. In athletes in the NLS, large RAE were found in tennis, rowing, soccer, alpine skiing and ice hockey and medium effects in basketball and handball.

When comparing small sports with the 25 biggest sports for male youth athletes, on average medium RAE were found in the 25 biggest sports for male athletes of the STDP and the NLS, small RAE in small sports of the STDP and inverse RAE in small sports in the NLS. The only single small sport with large RAE was trampoline (OR = 9.92 (95%-CI 1.27, 77.50)). In female youth athletes, no relevant RAE was present in small sports (see online supplementary Tables SI and SII).

The ORs for selected athletes born in the first quarter vs. the last quarter of the selection year are categorised for the STDP and the NLS for Olympic and Non-Olympic sports separately in Figure 2. Whereas there is medium RAE for Olympic sports in male youth athletes with larger RAE in the NLS, female sports and Non-Olympic sports merely showed small to negligible RAE.

As expected, no relevant RAE were found in sports with weight categories (judo, karate, wrestling, boxing; female, OR = 1.42 (95%-CI 0.87, 2.30); male, OR = 0.85 (95%-CI 0.64, 1.12)) in athletes in the STDP. In contrast, athletes in the NLS showed medium RAE in these sports (females, OR = 4.46 (95%-CI 0.96, 20.66); males, OR = 1.75 (95%-CI 0.84, 3.17)).

## Discussion

In this study, data on RAE are presented in a population-based approach comprised of all youth athletes who were registered in the Swiss talent development programme (STDP) in the year 2014. A large variability in RAE was found across different types of sports and between girls and boys. The main findings are (a) that in female athletes a small and in male athletes medium overall RAE were present, (b) that in male athletes the RAE were considerably larger in Olympic as compared to Non-Olympic sports and (c) that in male athletes the RAE were larger in athletes in the NLS as compared to the STDP. Small sports showed negligible to small RAE. In sports with weight categories, medium RAE were only present in the NLS athletes of both sexes.

### *Key findings*

To the best of our knowledge, this is the first study analysing a complete sample of a nationwide talent development programme including all organized sports. Medium RAE were found over all 68 male sports in the STDP sample. The effect was clearly larger in the higher selection levels (NLS). This finding is supported by the literature, showing an increasing risk for RAE with higher levels of competition (Cobley et al., 2009). Several factors may increase the risk of RAE in a particular sport. For instance, RAE might be affected by the sport's popularity, the amount/rate of participation, the level of competition, higher selection pressure, early specialization and the expectations of coaches who are involved in the selection process (Cobley et al., 2009; Hancock et al., 2013; Wattie et al., 2015). Also, differences between late- and early-born athletes in cognitive, social, physical and maturational development might result in RAE (Musch & Grondin, 2001). For instance, Reed,

Table 1. Nationwide data of relative age effects in female youth athletes in the Swiss talent development programme (STDP) and in the national level selection (NLS) in the year 2014 for the 25 largest sports.

| | STDP | | | | | | NLS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sport | N | Q1 (%) | Q2 (%) | Q3 (%) | Q4 (%) | OR Q1 vs. Q4 (95% CI) | N | Q1 (%) | Q2 (%) | Q3 (%) | Q4 (%) | OR Q1 vs. Q4 (95% CI) |
| Soccer | 1042 | 27.6 | 26.2 | 27.7 | 18.4 | 1.49 (1.23, 1.79) | 121 | 20.7 | 29.8 | 36.4 | 13.2 | 1.55 (0.83, 2.90) |
| Volleyball | 557 | 29.3 | 27.5 | 24.2 | 19.0 | 1.53 (1.19, 1.95) | 45 | 33.3 | 35.6 | 15.6 | 15.6 | 2.13 (0.87, 5.21) |
| Alpine skiing | 412 | 31.6 | 24.5 | 22.3 | 21.6 | 1.45 (1.10, 1.90) | 61 | 37.7 | 23.0 | 19.7 | 19.7 | 1.90 (0.95, 3.82) |
| Swimming | 375 | 25.3 | 25.6 | 26.1 | 22.9 | 1.10 (0.82, 1.47) | 12 | 25.0 | 25.0 | 25.0 | 25.0 | 0.99 (0.20, 4.91) |
| Handball | 277 | 25.6 | 33.9 | 20.6 | 19.9 | 1.28 (0.90, 1.82) | 42 | 26.2 | 38.1 | 16.7 | 19.0 | 1.36 (0.55, 3.39) |
| Gymnastics artistic | 240 | 28.3 | 23.3 | 27.5 | 20.8 | 1.35 (0.93, 1.95) | 58 | 17.2 | 32.8 | 20.7 | 29.3 | 0.58 (0.27, 1.27) |
| Tennis | 201 | 29.9 | 26.9 | 23.9 | 19.4 | 1.53 (1.02, 2.29) | 34 | 29.4 | 17.6 | 26.5 | 26.5 | 1.10 (0.45, 2.71) |
| Athletics (track and field) | 183 | 31.7 | 29.0 | 23.5 | 15.8 | 1.98 (1.27, 3.10) | 29 | 27.6 | 37.9 | 17.2 | 17.2 | 1.59 (0.52, 4.85) |
| Basketball | 174 | 25.3 | 26.4 | 26.4 | 21.8 | 1.15 (0.74, 1.78) | 47 | 21.3 | 25.5 | 36.2 | 17.0 | 1.24 (0.49, 3.14) |
| Equestrian jumping | 163 | 26.4 | 28.2 | 20.2 | 25.2 | 1.04 (0.68, 1.60) | 38 | 28.9 | 21.1 | 21.1 | 28.9 | 0.99 (0.43, 2.29) |
| Figure skating | 148 | 21.6 | 23.0 | 33.8 | 21.6 | 0.99 (0.61, 1.62) | 21 | 33.3 | 14.3 | 38.1 | 14.3 | 2.31 (0.60, 8.95) |
| Cross-country skiing | 116 | 26.7 | 31.0 | 19.0 | 23.3 | 1.14 (0.68, 1.91) | 15 | 33.3 | 26.7 | 0.0 | 40.0 | 0.83 (0.25, 2.71) |
| Orienteering (running) | 111 | 21.6 | 25.2 | 27.0 | 26.1 | 0.82 (0.48, 1.41) | 11 | 18.2 | 27.3 | 36.4 | 18.2 | 0.99 (0.14, 7.04) |
| Synchronized schwimming | 104 | 27.9 | 29.8 | 27.9 | 14.4 | 1.92 (1.03, 3.58) | 42 | 26 | 28.6 | 33.3 | 11.9 | 2.18 (0.76, 6.28) |
| Judo | 84 | 28.6 | 25.0 | 25.0 | 21.4 | 1.32 (0.72, 2.44) | 13 | 23.1 | 46.2 | 30.8 | 0.0 | |
| Sports climbing | 81 | 35.8 | 17.3 | 21.0 | 25.9 | 1.37 (0.78, 2.41) | 13 | 23.1 | 15.4 | 30.8 | 30.8 | 0.74 (0.17, 3.32) |
| Rhythmic gymnastics | 73 | 28.8 | 23.3 | 30.1 | 17.8 | 1.60 (0.80, 3.21) | 33 | 33.3 | 30.3 | 21.2 | 15.2 | 2.18 (0.76, 6.28) |
| Shooting | 71 | 36.6 | 23.9 | 18.3 | 21.1 | 1.72 (0.91, 3.25) | 9 | 44.4 | 33.3 | 11.1 | 11.1 | 3.97 (0.44, 35.5) |
| Ice hockey | 67 | 26.9 | 29.9 | 17.9 | 25.4 | 1.05 (0.54, 2.04) | 26 | 26.9 | 23.1 | 23.1 | 26.9 | 0.99 (0.35, 2.83) |
| Badminton | 65 | 24.6 | 40.0 | 21.5 | 13.8 | 1.76 (0.78, 3.99) | 18 | 22.2 | 38.9 | 22.2 | 16.7 | 1.32 (0.30, 5.91) |
| Rowing | 57 | 29.8 | 29.8 | 24.6 | 15.8 | 1.87 (0.83, 4.21) | 13 | 7.7 | 30.8 | 38.5 | 23.1 | 0.33 (0.03, 3.18) |
| Karate | 53 | 26.0 | 21.0 | 36.0 | 17.0 | 1.54 (0.67, 3.57) | 17 | 29.4 | 0.0 | 58.8 | 11.8 | 2.48 (0.48, 12.8) |
| Synchronized skating | 50 | 30.0 | 26.0 | 24.0 | 20.0 | 1.49 (0.67, 3.31) | | | | | | |
| Snowboarding | 49 | 26.5 | 22.4 | 26.5 | 24.5 | 1.07 (0.49, 2.36) | 17 | 29.4 | 11.8 | 17.6 | 41.2 | 0.71 (0.22, 2.23) |
| Cycling mountainbike | 43 | 34.9 | 25.6 | 23.3 | 16.3 | 2.13 (0.87, 5.22) | 11 | 36.4 | 9.1 | 27.3 | 27.3 | 1.32 (0.30, 5.91) |
| **Total** | **4796** | **28.0** | **26.7** | **25.1** | **20.2** | **1.38 (1.26, 1.51)** | **746** | **26.5** | **27.3** | **26.4** | **19.7** | **1.34 (1.08, 1.65)** |

Notes: Q1 to Q4 = Quartile 1 to 4; OR = Odds ratio; 95% CI = 95% Confidence Interval.

Parry, and Sandercock (2016) suggested that social agents may contribute to RAE in English school sports. A recent study of German youth national football teams found RAE, but there were no relevant differences in anthropometric and performance characteristics between players of different relative age quarters (Skorski, Skorski, Faude, Hammes, & Meyer, 2016). Thus, physical or maturational differences might be of minor relevance for RAE on the highest performance level in an already highly selected population. An interesting finding is that male athletes in some NLS in sports with low participation rates showed inverse (not significant) RAE, i.e., a higher proportion of athletes was born in the last quarter of the year as compared to the first quarter of the year. It might be speculated that talented athletes, who were born late in the year, move from sports with high participation rates to those with lower participation rates in order to have the possibility to compete on a high performance level (Delorme, 2014).

In contrast to male sports, there were merely small RAE over all 63 female sports and no relevant difference between the STDP and the NLS. Previous data also revealed differences in RAE between girls and boys. For instance, Cobley et al. (2009) summarised the results of 38 studies published between 1984 and 2007 and found a larger OR (Q1 vs. Q4) of 1.65 (95%-CI 1.54, 1.77) in male athletes as compared to female athletes (OR 1.21 (95%-CI 1.10, 1.33)). Similarly, Raschner, Müller, and Hildebrandt (2012) observed a difference between males (OR 3.32) and females (OR 1.89) in more than 1000 athletes participating in the Youth Olympic Games 2012. Recently, Reed et al. (2016) reported data from more than 10 000 children participating at the London Youth Games and also found lower RAE in many sports for girls as compared to boys. Thus, these results are in line with the current evidence. Females generally mature earlier than their male peers and after peak height velocity differences in athletic performance are reduced or disappear (Vincent & Glamser, 2006). A possible additional explanation might be that the number of male athletes was 2.5 times the number of female athletes in the STDP. Further, the proportion of NLS athletes was about 11% boys and 18% girls. This reflects a larger pool for selection and a higher selection pressure in male athletes and may explain the difference in RAE between boys and girls. A further explanation for the smaller RAE in female youth athletes might be that changes in body shape, which are associated with early maturation (e.g. greater body mass per stature, shorter legs, wider hips, greater body fat) are disadvantageous for performance (Vincent & Glamser, 2006).

This study reveals that Non-Olympic sports showed a lower risk for RAE than Olympic sports. It could be speculated that this is due to the greater attractiveness of Olympic sports as a result of their greater media presence and higher funding, whereas Non-Olympic sports are less popular and, hence, attract fewer young people (Fuchslocher et al., 2013; Swiss Olympic Association, 2017). A greater attractiveness might lead to larger pools of athletes in Olympic sports, which increases selection pressure (Musch & Grondin, 2001). This view is strengthened by the fact that only about 10% of the sample was involved in Non-Olympic sports, and the remaining athletes performed in Olympic sports. Interestingly, 12.4% of the Olympic sports athletes were selected to the NLS, whereas 21.6% of Non-Olympic athletes achieved the NLS, confirming the higher selection pressure in Olympic sports. Further, a higher professionalism in Olympic sports in general, as well as their talent selection instruments might be another underlying reason for an increased risk of RAE (Fuchslocher et al., 2013).

Table 2. Nationwide data of relative age effects in male youth athletes in the Swiss talent development programme (STDP) and in the national level selection (NLS) in the year 2014 for the 25 largest sports.

| | STDP | | | | | | NLS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sport | N | Q1 (%) | Q2 (%) | Q3 (%) | Q4 (%) | OR Q1 vs. Q4 (95% CI) | N | Q1 (%) | Q2 (%) | Q3 (%) | Q4 (%) | OR Q1 vs. Q4 (95% CI) |
| Soccer | 6010 | 35.9 | 27.8 | 20.9 | 15.3 | 2.33 (2.13, 2.54) | 217 | 48.8 | 23.0 | 17.5 | 10.6 | 4.57 (2.91, 7.18) |
| Ice hockey | 1501 | 33.3 | 26.9 | 23.3 | 16.5 | 2.01 (1.71, 2.35) | 226 | 38.9 | 28.8 | 23.0 | 9.3 | 4.16 (2.58, 6.69) |
| Handball | 601 | 29.8 | 25.6 | 24.5 | 20.1 | 1.47 (1.16, 1.85) | 66 | 36.4 | 22.7 | 24.2 | 16.7 | 2.16 (1.06, 4.42) |
| Alpine skiing | 580 | 30.7 | 27.4 | 24.3 | 17.6 | 1.73 (1.35, 2.22) | 74 | 40.5 | 27.0 | 23.0 | 9.5 | 4.25 (1.87, 9.68) |
| Tennis | 432 | 32.4 | 24.5 | 22.9 | 20.1 | 1.60 (1.22, 2.09) | 39 | 53.8 | 23.1 | 17.9 | 5.1 | 10.41 (2.44, 44.4) |
| Gymnastics artistic | 339 | 25.1 | 27.1 | 26.0 | 21.8 | 1.14 (0.83, 1.56) | 67 | 23.9 | 35.8 | 19.4 | 20.9 | 1.13 (0.55, 2.32) |
| Swimming | 335 | 30.1 | 25.7 | 23.9 | 20.3 | 1.47 (1.08, 2.01) | 21 | 28.6 | 14.3 | 14.3 | 42.9 | 0.66 (0.24, 1.86) |
| Floorball | 299 | 28.4 | 25.4 | 26.4 | 19.7 | 1.43 (1.02, 2.00) | 24 | 29.2 | 33.3 | 25.0 | 12.5 | 2.31 (0.60, 8.95) |
| Basketball | 273 | 31.9 | 28.9 | 23.8 | 15.4 | 2.05 (1.42, 2.98) | 60 | 38.3 | 33.3 | 13.3 | 15.0 | 2.53 (1.17, 5.48) |
| Judo | 250 | 20.4 | 24.4 | 29.6 | 25.6 | 0.79 (0.55, 1.14) | 23 | 30.4 | 30.4 | 26.1 | 13.0 | 2.31 (0.60, 8.95) |
| Volleyball | 223 | 29.6 | 30.0 | 24.7 | 15.7 | 1.87 (1.24, 2.82) | 34 | 32.4 | 32.4 | 17.6 | 17.6 | 1.82 (0.67, 4.92) |
| Athletics (track and field) | 179 | 35.8 | 25.7 | 24.0 | 14.5 | 2.44 (1.54, 3.86) | 34 | 26.5 | 35.3 | 23.5 | 14.7 | 1.79 (0.60, 5.33) |
| Water polo | 174 | 31.0 | 23.0 | 20.7 | 25.3 | 1.22 (0.82, 1.82) | 72 | 33.3 | 26.4 | 18.1 | 22.2 | 1.49 (0.79, 2.80) |
| Orienteering (running) | 164 | 22.0 | 25.0 | 25.6 | 27.4 | 0.79 (0.51, 1.23) | 12 | 0.0 | 16.7 | 41.7 | 41.7 | |
| Snowboarding | 163 | 27.0 | 20.2 | 25.8 | 27.0 | 0.99 (0.65, 1.51) | 20 | 35.0 | 15.0 | 40.0 | 10.0 | 3.47 (0.72, 16.71) |
| Badminton | 162 | 25.9 | 25.9 | 30.9 | 17.3 | 1.49 (0.92, 2.40) | 26 | 23.1 | 23.1 | 46.2 | 7.7 | 2.98 (0.60, 14.74) |
| Cross-country skiing | 160 | 28.8 | 31.9 | 23.1 | 16.3 | 1.75 (1.08, 2.84) | 22 | 36.4 | 27.3 | 22.7 | 13.6 | 2.64 (0.70, 9.97) |
| Cycling mountainbike | 109 | 27.5 | 29.4 | 25.7 | 17.4 | 1.57 (0.88, 2.79) | 29 | 37.9 | 20.7 | 20.7 | 20.7 | 1.82 (0.67, 4.92) |
| Sports climbing | 106 | 26.4 | 23.6 | 34.0 | 16.0 | 1.63 (0.89, 2.99) | 11 | 27.3 | 27.3 | 45.5 | 0.0 | |
| Shooting | 97 | 30.9 | 27.8 | 27.8 | 13.4 | 2.29 (1.19, 4.39) | 8 | 12.5 | 37.5 | 50.0 | 0.0 | |
| Field hockey | 95 | 28.4 | 26.3 | 30.5 | 14.7 | 1.91 (1.00, 3.65) | 49 | 28.6 | 24.5 | 22.4 | 24.5 | 1.16 (0.54, 2.50) |
| Karate | 87 | 21.8 | 26.4 | 16.1 | 35.6 | 0.61 (0.34, 1.08) | 22 | 31.8 | 27.3 | 13.6 | 27.3 | 1.16 (0.39, 3.44) |
| Table tennis | 86 | 22.1 | 36.0 | 20.9 | 20.9 | 1.05 (0.55, 2.00) | 22 | 22.7 | 36.4 | 13.6 | 27.3 | 0.83 (0.25, 2.71) |
| Rowing | 85 | 27.1 | 27.1 | 28.2 | 17.6 | 1.52 (0.79, 2.92) | 24 | 45.8 | 25.0 | 20.8 | 8.3 | 5.46 (1.21, 24.6) |
| Ski jumping | 74 | 33.8 | 13.5 | 24.3 | 28.4 | 1.18 (0.66, 2.11) | 10 | 20.0 | 10.0 | 30.0 | 40.0 | 0.50 (0.09, 2.71) |
| **Total** | **12,584** | **32.7** | **27.1** | **22.9** | **17.3** | **1.87 (1.76, 2.00)** | **1212** | **36.9** | **26.8** | **21.7** | **14.6** | **2.50 (2.10, 2.98)** |

Notes: Q1 to Q4 = Quartile 1 to 4; OR = Odds ratio; 95% CI = 95% Confidence Interval.

In line with existing evidence (Albuquerque et al., 2012; Delorme, 2014), no relevant RAE were found in sports with weight categories for male athletes in the STDP. Similar evidence has already been revealed in combat sports (Delorme, 2014). This phenomenon might be explained by a "strategic adaptation", which is a voluntary shift of children to another sports where their physical capacities will be less determining for performance. Albuquerque et al. (2012) also did not find RAE within Olympic taekwondo athletes over 12 years of age. He assumed that RAE are reduced or diminished in taekwondo due to its competitive categories (weight categories and belt level), which are determined by the level of technical skills. Thus, the younger athletes are less disadvantaged because of lower physical capacities. This system of categorization may act as a key against drop out of younger athletes.

### *Methodological considerations*

The obvious strength of the present study is that it analysed a complete countrywide data pool comprised of all selected youth athletes in Switzerland in 2014. Therefore, comparisons between sports are not affected by possible differences between countries in, for instance, the talent identification, selection and development systems or the popularity of particular sports. However, Switzerland is a small country with small samples available for analyses in several sports. Thus, the results in small sports should be interpreted with care and the generalizability to other countries is limited. Swiss sports federations are aware of the problems associated with RAE, and coaches are educated in this regard. Additionally the current approach to counter RAE on the national level, which was introduced in 2008, did not reduce the effect. In this approach, the RAE phenomenon was educated to coaches and the federations had to integrate bonus points for RAE disadvantaged athletes in the PISTE-selection process (Fuchslocher et al., 2013). In international professional football, it has been shown that awareness of the problem and 10 years of research did not solve the problem as well, indicating that RAE is a robust phenomenon and cannot easily be changed (Helsen et al., 2012).

Within the present investigation we were not able to investigate possible causal factors of the RAE (e.g., biological maturity status or physical performance). Additionally, the evolution of RAE in different age categories have not been analysed. Therefore, future research should focus on the underlying mechanisms behind the RAE and investigate differences of RAE between age categories and specific types of sports.

## Conclusions and practical implications

RAE are present in several sports in the talent development system of Switzerland, particularly in male youth athletes in Olympic sports on the highest selection level. This implies that talent and resources are being wasted, which is especially problematic for a small country like Switzerland. The present data support the detection of high-risk sports or groups of sports and, thus, a tailored implementation of preventive measures. Such measures,

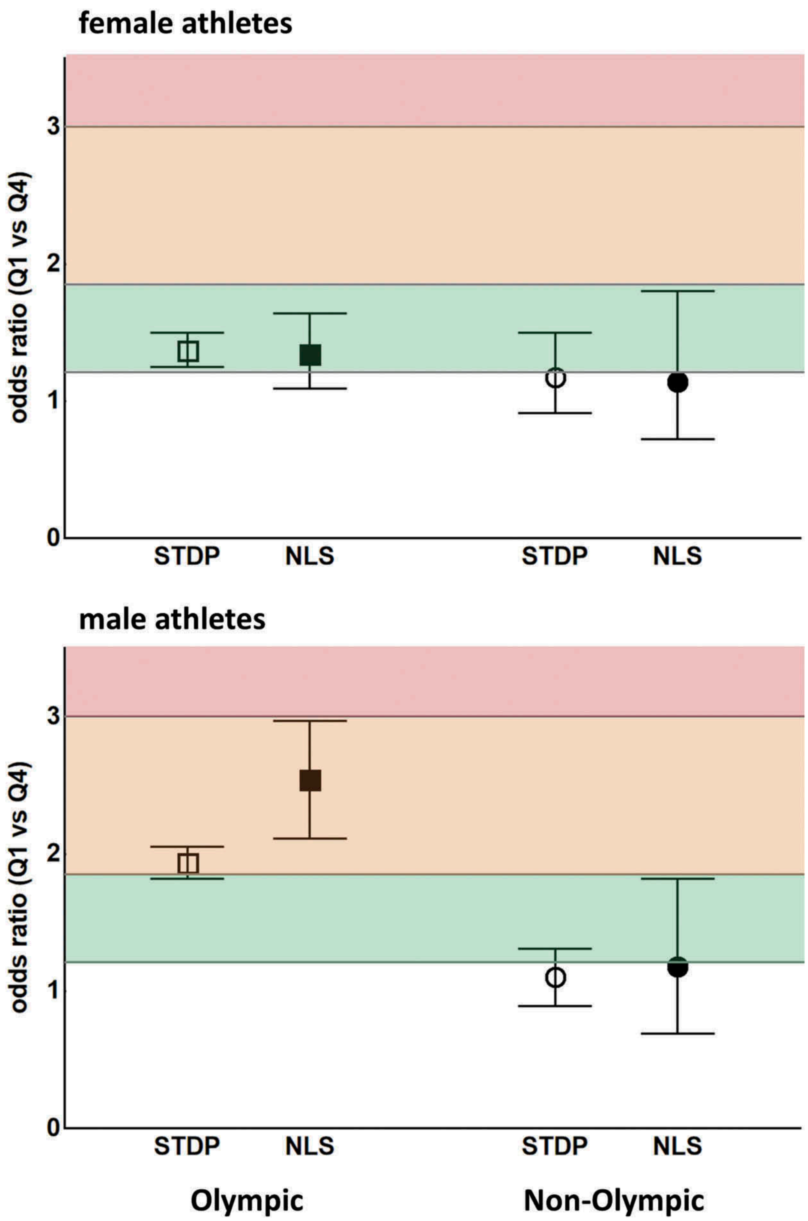


Figure 2. Relative age effects (RAE) in the Swiss talent development programme (STDP; regional to national level; open squares and circles) and the national level selection (NLS; national to international level; filled squares and circles; squares indicate Olympic sports, circles non-Olympic sports). Odds ratios (OR) for the frequency of athletes born in the first quarter of the year relative to athletes born in the last quarter of the year (females, upper panel; males, lower panel; the coloured bars indicate a large (red), medium (orange) and small (green) RAE).

which have been already described and discussed in literature, might include (a) improving coach education in sports at high risk of RAE, (b) building categories by biological age, weight or height (Musch & Grondin), (c) quotas of same RAE quarters, (d) rotating cut-off dates (Cobley et al., 2009) and (e) RAE correction factors in centimetre-gram-second sports (Romann & Cobley, 2015). As every selection increases RAE, selection as late as possible, at best after age at peak height velocity, may also contribute to reducing RAE. In Switzerland, talent identification, selection and development should be considered as a long-term process. Moreover, reducing RAE in the Swiss sport system would make long-term athlete development more legitimate and effective.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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