Identifying talented track and field athletes: exploring the impact of relative age effect in Spanish national athletics federation training camps

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**Abstract**

This study examined the existence of relative age effects (RAEs) in Spanish National Athletics Federation (RFEA) training camps between 2006 and 2013. Overall, 1,334 selected athletes at U15 years (cadet) and U17 years (juvenile) were compared against 27,711 licenced but unselected athletes for the same age groups. The results highlighted the influential role of the RAE on the selection process of athletes who participated in track and field training camps. Specifically, while RAEs were evident consistently across both cadet and juvenile categories, effects were stronger for males and those athletes at U15 level. When specifically comparing selected with unselected licenced athletes, clear RAE was evident except for the older (U17) female category. These results have implications for participation in athletics and also for biased selection to talent camps of those young people born earlier in the selection year. As such, many young talented young athletes may have diminished chances of becoming elite athletes despite their talents and efforts due to their date of birth. As a result, consideration of the existence and impact of RAEs for the talent identification and development system would likely be advantageous for the long-term goals of RFEA.

**Keywords:** Age Distribution, Selection Bias, Adolescent, Age Factors

**Introduction**

**Relative Age Effect in Sport**

Talent identification and development systems underpin elite sport success across the world today. Being able to identify talent effectively and provide the right resources at the right time is crucial for continued success. Equally, minimising unnecessary and early disengagement from sport helps to maintain an active population and also avoids the potential loss of late developing talent ([Cobley, Baker, Wattie, & McKenna, 2009](#_ENREF_13)). With the aim of providing equal opportunities, fair competition and to minimise maturational differences in school and sport alike, children and adolescents are traditionally grouped by annual chronological age ([Helsen, van Winckel, & Williams, 2005](#_ENREF_28)). This, in theory, will allow young people to train and compete with others who are similar physically, mentally and emotionally promoting equality throughout the system.

However, annual chronological age grouping systems mean that each year, assuming the cut-off date remains unchanged (as is common), certain youngsters born on or close to the ‘selection date’ are anything up to one year older than other children in their age group. This has been shown to provide many physical, emotional and psychological advantages ([Barnsley, Thompson, & Barnsley, 1985](#_ENREF_6); [Cobley *et al.,* 2009](#_ENREF_13); [Morrison, Smith, & Dow-Ehrensberger, 1995](#_ENREF_36)). When maturational differences are also considered, young people with a combination of being relatively younger and later maturing will have even greater challenges, which may make it impossible to compete with older, early maturers ([Musch & Grondin, 2001](#_ENREF_38)).

[Barnsley *et al.*, (1985](#_ENREF_6)) termed this phenomenon the ‘relative age effect’ (RAE) and this effect is most often shown to be present by the existence of a disproportionate number of ‘successful’ athletes being born within the first three months of the selection year. The rationale for this effect most cited, is that those older athletes are likely to be physically more mature and advanced than those who are younger. This would appear to be particularly advantageous in most strength based sports, although not all sports ([Baxter-Jones, 1995](#_ENREF_8)). This is supported by [Sherar, Baxter-Jones, Faulkner, & Russell (2007](#_ENREF_42)) who showed that selected hockey players were more mature, taller and heavier than their unselected peers and in the main were born between January and June (oldest in the selection year), suggesting the interaction between biological maturity and RAE.

**What is the Impact of RAE?**

Social agents (coaches, directors and parents) can influence the development of RAEs through the nature of initial selection or enrolment ([Gutierrez, Pastor, Gonzalez, & Contreras, 2010](#_ENREF_25)). For example, in a sport structure where there is a high competition for places or a competitive system that requires ‘performance selection’ of some sort, RAE is likely to be facilitated, particularly when a short term view of performance capability dominates the selection criteria ([Barnsley & Thompson, 1988](#_ENREF_5); [Barnsley et al., 1985](#_ENREF_6); [Jimenez & Pain, 2008](#_ENREF_30); [Pierson, Addona, & Yates, 2014](#_ENREF_39)). In fact, it has been shown to be quite typical for coaches and scouts who search for young talent to look for physical characteristics, such as speed, power and physical size as a sign of talent ([Furley & Memmert, 2016](#_ENREF_22)).

Subsequently, those children who are selected at early stages - in many cases those born early in selection year ([Barnsley *et al.,* 1985](#_ENREF_6); [Cobley, Abraham, & Baker, 2008](#_ENREF_12)) - are likely to benefit from an increase in self-efficacy, perceived competence, and motivation, which encourages them to improve their skills in comparison with younger peers ([Helsen *et al.,* 2005](#_ENREF_28)). Indeed, Bloom’s ([1985](#_ENREF_9)) work highlighted that the ‘perception of potential’ is an important trigger for the transition into higher development stages. Other advantages include more opportunities for more and better quality training (such as training camps organized by federations) and competition. Consequently their advantage is perpetuated over relatively younger players ([Wattie, Cobley, & Baker, 2008](#_ENREF_51)). This of course can then be detrimental for the motivation of those children disadvantaged by RAE ([Musch & Grondin, 2001](#_ENREF_38)) and can generate negative experiences such as frustration which may eventually lead to drop out of sport ([Hollings, Hume, & Hopkins, 2014](#_ENREF_29)) and a subsequent reduction of the talent pool ([Brewer, Balsom, & Davis, 1995](#_ENREF_11); [Delorme, Boiche, & Raspaud, 2010a](#_ENREF_19); [Gould & Maynard, 2009](#_ENREF_23); [Jimenez & Pain, 2008](#_ENREF_30)). Given the potential for cumulative benefits of selection, and related self (de)selection, it is not surprising that there is some evidence to suggest differences continue into elite and professional competition ([Delorme *et al.,* 2010a](#_ENREF_19)).

One problem for talent development systems that are perpetuated by RAE, is that anthropometric and physical variables or performance at age group levels are not highly predictive of performance at the elite level ([Barreiros, Cote, & Fonseca, 2014](#_ENREF_7); [Till *et al.,* 2010](#_ENREF_47); [Vaeyens, Gullich, Warr, & Philippaerts, 2009](#_ENREF_48)). Consequently, an approach that emphasises the importance of these qualities at developmental stages is highly likely to be sub optimal and unfair for those young athletes who develop at a slower pace because their talent needs more time to emerge (Martindale, Collins, & Daubney, 2005; [Simonton, 1999](#_ENREF_44)).

**To What Extent Do RAEs Exist?**

There can be distinct disadvantages to RAE, so it is important to understand how prevalent it is. With this in mind two reviews have been carried out. [Musch and Grondin (2001](#_ENREF_38)) showed that the majority of research had been carried out in soccer and ice hockey and showed strong effects of RAE. Although interestingly, while RAE effects are apparent through most age groups, [Helsen, Starkes, & Van Winckel (1998](#_ENREF_27)) found that effects didn’t emerge until the age of 12 years. Also, with increasing age into adulthood effects were found to weaken (c.f., Musch and Grondin, 2001). [Barnsley *et al.*, (1985](#_ENREF_6)) supported this and showed that RAE is more likely to occur between the ages of 10 and 19 which indicates that the active maturation process may have a profound effect on the development of relative age effects. When other team sports are considered, the picture is more equivocal. For example, in baseball and cricket RAEs have been found, but in basketball and American football no RAEs are observed while in volleyball and handball, RAEs are dependent on moderating variables such as age. Interestingly, at the time of Musch & Grondin’s ([2001](#_ENREF_38)) review very few individual sports had been examined.

Cobley *et al.,* completed a meta-analytical review in 2009 which included 38 studies between 1984 and 2007 and re-examined 253 samples across 14 sports and 16 countries. The overall conclusions revealed small, consistent prevalence of RAE through the literature, with age, skill level and sport context acting as mediating variables. The implications are quite profound, and they concluded that the youngest performers within any annual age groups were less likely to participate from under 14 years of age; less likely to participate in representational teams between 15-18 years and less likely to become elite athletes in the sport contexts examined. However, it is important to note that only 2% of the overall sample was female and over 75% of the sample was in the context of ice hockey (32.5%), soccer (30%) and basketball (13%), with under 1% being from individual sports.

It is important to not assume RAEs would automatically transfer in the same manner to females and individual sports ([Wattie *et al.,* 2014](#_ENREF_53)). For example, research focused on these populations have shown that RAEs can be weaker or even non-existent in female sports ([Wattie, Baker, Cobley, & Montelpare, 2007](#_ENREF_50)) and in sports such as golf, figure skating and gymnastics RAEs have been shown not to exist or have a different quartile dominance (e.g., more Q4 or Q2) (e.g., Baker, Janning, Wong, Cobley, & Schorer, 2014; Cote, Macdonald, Baker, & Abernethy, 2006; Hancock, Starkes, & Ste-Marie, 2015). However, in sports such as swimming, tennis, cross country skiing, ski jumping, alpine skiing, snowboarding and Nordic combined RAEs have been found ([Baker *et al.,* 2014](#_ENREF_3); [Müller, Hildebrandt, & Raschner, 2015](#_ENREF_37); [Musch & Grondin, 2001](#_ENREF_38)).

**Do RAEs Exist in Track and Field?**

In line with the dearth of information on individual sports, few studies exploring RAEs have been undertaken in track and field. Interestingly, [Hollings *et al.,* (2014](#_ENREF_29)) and [Medic, Young, Starkes, Weir, & Grove (2009](#_ENREF_35)) provided evidence for RAEs in athletics in a performance context, while [Wattie *et al.*, (2014](#_ENREF_53)) found an underrepresentation of relatively older participants at recreational level. More specifically, [Hollings *et al.,* (2014](#_ENREF_29)) explored RAE within performances at the World Youth Championships and World Junior Championships and found significant RAE overall, with a stronger effect in male athletes in comparison to female athletes, and a stronger effect for 16 and 17 year olds in comparison to 18 and 19 year olds. They also concluded that the 2-year age category used for grouping competitors in these athletics championships exacerbated the impact of RAE on performance. [Medic *et al.,* (2009](#_ENREF_35)) examined RAE across 5 year age groupings rather than the traditional annual age grouping system investigated in most RAE studies. They discovered younger masters athletes were advantaged across these categories, more so for males than females.

While there is some investigation of RAE in the track and field context, no studies appear to have examined the existence of RAEs through age group talent training camps. This is important because selection in track and field is potentially more objective, results driven and grounded in normative performance standards ([Hollings *et al.,* 2014](#_ENREF_29)), which aligns to one of the most cited mechanisms of RAE, advanced maturation and physical development. As such, track and field may be particularly susceptible to RAE. Given the clear negative consequences of RAE through a development system, it is of particular interest to explore it.

In Spain, the Spanish National Athletics Federation (RFEA) hold training camps (TC) for boys and girls who have been identified as talented for track and field events, mainly those who have achieved gold medals at the national youth championships. These training camps cover 4-years age ranges and are held each year in Easter, summer and Christmas for both male and female athletes. The national government awards financial support to RFEA to help the development of potential through talent identification and development programmes. Athletes selected for training camps will have the opportunity to be trained by experienced coaches. This may significantly influence the progression of athletes and if RAE exist, reduce opportunity for those athletes born late in the competitive year ([Delorme *et al.,* 2010a](#_ENREF_19)). It is important to note that part of this budget is invested in these training camps to help produce talented athletes who are capable of representing Spain at senior international track and field events. Given the potential for track and field to be susceptible to RAEs, in combination with the long term goals of Spanish athletics, it would seem important to investigate further.

In summary, based on the impact of RAEs in the development of youth talented athletes, the following research question was developed: Do RAEs influence the selection process of the athletes participating in TCs organized by RFEA? The aims of the current study are: 1) To examine the existence of RAE in track and field athletes selected to take part in official TC, 2) To examine gender differences on RAEs in TC organized by national federation.

**Methods**

**Participants**

Date of birth of 1,334 athletes (n=700 males; 634 females) who had been selected to TC organized by RFEA throughout 2006-2013 were collected from the official published lists for each TC. Verification of date of birth was undertaken by the RFEA against the RFEA athletes’ database. With the purpose of comparing selected athletes with all licensed athletes, the birthdates of all athletes affiliated to the RFEA of these categories (n=27,711) during the period studied were collected from the federation database.

**Design**

To examine RAEs, athletes’ birthdates were categorised according to the cut-off date of 1st of January, which is the international cut-off date for track and field. Quartile 1 (Q1) consisted of those born in the three months immediately after the selection date (1st January) and so on for the remaining months comprising the annual-age group (i.e., Q2-Q4). Category was coded regarding their age in two-level nominal categorical variable: (1) U15 years (cadet) and (2) U17 years (juvenile). Due to significant differences between sexes identified in previous studies (e.g. Baker, Schorer, & Cobley, 2010), gender was considered separately. This study was conducted in accordance with the revised ethical declaration of Helsinki and was approved by the Ethics Committee of the University of Extremadura.

**Data analysis**

Frequencies were obtained for quartiles. Differences among relative age quartiles were considered using asymptotic Chi-square goodness-of-fit against an assumed equal distribution. The same statistical procedure was also carried out using weighted mean scores observed for the corresponding population of athletes affiliated to the RFEA, following previous recommendations ([Delorme et al., 2010a](#_ENREF_19)).

The effect size ω for the Chi-square tests was calculated, as proposed by [Wattie, Schorer, & Baker (2015](#_ENREF_52)). Odds ratios (ORs) and 95% confidence intervals (95% CI) were calculated for relative age quartile distribution for the total sample and according to gender, as proposed by [Cobley et al. (2009](#_ENREF_13)). Statistical significance was considered when p<0.05. The statistical package SPSS v.20 for MAC (IBM, New York, USA) was used for the statistical analysis, however the effect size was assessed using G\*Power 3.1.9.2.

**Results**

Table 1 presents the relative age quartiles for selected athletes including both genders and age groups. For both genders and all age groups, significant differences were observed between the numbers of entries by relative age quarter (p < 0.05). Analysing the descriptive data by individual quarters, it is possible to notice a higher number of athletes born in the 1st (33.4 ± 6.7%) or in 2nd quarter (30.9 ± 2.1%) of the year and very few in the last quarter (15.9 ± 6.1%).

Table 2 presents the relative age quarter distribution for the whole population of licensed athletes during the period 2006-2013 in cadet and juvenile categories. This population is used as reference to calculate the expected distribution.

For both genders and all age groups, significant differences were observed between the number of entries by relative age quarter (p < 0.05) in licensed athletes during the aforementioned period. It is observed that a high number of athletes was born in the 1st (28.3 ± 2.2%) or in 2nd quarter (26.9 ± 0.9%) of the year in comparison with a fewer number in the last quarter (21.4 ± 1.9%).

Differences between the observed distribution and the theoretical expected distribution are displayed in Table 3. The results reflect a classical RAE with an over-representation of athletes born in Q1 (19.8 more, as mean, in comparison with theoretical expected distribution) and Q2 (12.9 more, as mean, in comparison with theoretical expected distribution), especially in the first quartile, and an under-representation of athletes born in Q3 (12.8 less, as mean, in comparison with theoretical expected distribution) and Q4 (19.8 less, as mean, in comparison with theoretical expected distribution). While a positive difference is observed in athletes born in Q1, a negative difference is noticed in Q4, except for juvenile female with a negative difference in Q1 (1.7 less compared with theoretical expected athletes) and a positive difference in Q4 (0.5 more compared with theoretical expected athletes).

The descriptive OR of the current findings revealed that the likelihood of being selected for taking part in a training camp is higher for an athlete of the first quarter than for one of the last quarter. Cadet males showed the higher likelihood (OR=7.43; χ2 = 83.59; p < 0.001; ω = 0.65) in comparison with cadet females (OR=2.49; χ2 = 23.02; p < 0.001; ω = 0.32) and juvenile males (OR=2.79; χ2 = 20.21; p < 0.001; ω = 0.38). This phenomenon is not statistically significant in female juvenile athletes (OR=1.16; χ2 = 0.33; p = 0.567; ω = 0.05).

Also, there is a higher likelihood for a cadet male athlete of the Q1 than for those born in Q2 (OR=1.45; χ2 = 3.99; p = 0.046; ω = 0.12) and Q3 (OR=3.42; χ2 = 39.41; p < 0.001; ω = 0.41) and cadet female athletes of the Q1 compared with Q3 (OR=2.53; χ2 = 23.78; p < 0.001; ω = 0.33). The ORs and the corresponding χ2 for each quarter according to gender and category are presented in Table 4.

**Discussion**

The findings of this study reinforced the previous research that RAEs exist in strength based sports ([Baker *et al.,* 2014](#_ENREF_3); [Hollings *et al.,* 2014](#_ENREF_29)). While RAEs existed across both U15 and U17 age groupings, stronger RAEs were evident at the U15 cadet level. Evidence of stronger RAE through pubertal phases is also supported in the literature ([Costa, Marques, Louro, Ferreira, & Marinho, 2013](#_ENREF_15)). Given the objective performance criteria used in athletics contexts to select athletes for talent development opportunities it seems likely to be a consequence of maturation and physical differences due to age differences ([Cobley *et al.,* 2009](#_ENREF_13); [Coelho *et al.,* 2010](#_ENREF_14); [Rebelo *et al.,* 2013](#_ENREF_40); [Wattie *et al.,* 2015](#_ENREF_52)). Additionally, this study provided evidence of gender differences in RAE amongst Spanish athletes selected for the RFEA training camps. In line with the findings of a recent study stronger RAEs were found in male athletes ([Hollings *et al.,* 2014](#_ENREF_29)), which is likely to be attributable to the interactive role of maturation differences and social influences. Interestingly, evidence of RAE disappeared in older selected females as compared to other liscenced athletes. However, RAE was identified consistently in the population of licensed young track and field athletes (selected or not). Given the RAE in age group athletics found here, it would be important to examine whether RAEs extended to senior athletes. Indeed, research has identified that the strength of RAE can decrease until adulthood and recent work has uncovered the possibility of a reversal effect of relative age where there is an over-representation of relatively younger athletes at senior level, even though there was an under-representation through the age groups (e.g. McCarthy & Collins, 2014).

A disproportionately large number of the Spanish athletes who were selected for the track and field training camps were born in the first two quarters of the selection year. A much lower percentage of selected athletes was born in the 3rd and 4th quarter. The results revealed significant RAEs for all participants in training camps apart from the juvenile female category. The RAE was stronger in males in comparison to females. In line with this finding, a recent study conducted with world-class track and field athletes also showed a stronger effect in males than females ([Hollings *et al.,* 2014](#_ENREF_29)). However, the gender differences may be due to a complex interaction of biological and maturational differences with socialization influences ([Vincent & Glamser, 2006](#_ENREF_49)). It is well known that girls start their maturity earlier than boys ([Tanner, 1981](#_ENREF_45)). In the present study, cadet females presented RAE between Q1 and Q4 and between Q1 and Q3, while juvenile females did not show statistical differences between quartiles. Those juvenile females were closer to physical maturation than cadet females. This similar physical status during juvenile stage between athletes born in different quartiles could be the origin of the reduction of RAE ([Malina, 1994](#_ENREF_31)). Also a social explanation is used to justify this result. The stereotypes used by the society could affect in terms of pressure to female athletes, who could drop out of the competitive sport ([Vincent & Glamser, 2006](#_ENREF_49)). This stereotype based on an ideal female body, opposite to physical characteristics needed for competitive sport, could be the reason for dropping out from sport and puberty is the stage where it is more likely to occur ([Shakib, 2003](#_ENREF_41)). Previous research has also noted a higher dropout rate in females born during the first half of the year. If an early physical development acts as an important advantage, it also acts as a social disadvantage for those that have won before and after a maturation process cannot ([Delorme, Boiche, & Raspaud, 2010b](#_ENREF_20)). Nevertheless, this interpretation remains speculative, and more research is needed to further examine and understand the complexities of RAEs across genders.

As recommended by D[elorme *et al.,* (2010a](#_ENREF_19)), this study used all licensed cadet and juvenile track and field athletes as a reference population. RAE was identified in selected athletes, as compared to unselected athletes. This represents a problem because being selected allows for competitive progression and opportunities for access to better resources and more opportunities for quality practice ([Helsen *et al.,* 1998](#_ENREF_27)). On the other hand, relatively younger athletes may be more likely to drop out from sport because of a potential false sense of being untalented or lack of opportunities ([Delorme, Chalabaev, & Raspaud, 2011](#_ENREF_21)), leading to an unwanted reduction in the talent pool and general participation levels ([Helsen *et* *al.,* 1998](#_ENREF_27)). [Musch and Grondin (2001](#_ENREF_38)) identified competition as a major factor for RAE to occur, thus training camps may need to base their talent identification programs on other elements rather than competition results.

In line with this, some research has attempted not only to explain the influence of annual age grouping in sport but also to identify solutions ([Baker *et al.,* 2010](#_ENREF_4); [Cobley *et al.,* 2009](#_ENREF_13); [Delorme *et al.*, 2010a](#_ENREF_19); [Wattie *et al.,* 2008](#_ENREF_51); [Wattie *et al.,* 2015](#_ENREF_52)). Both selection criteria and technical solutions have been suggested by researchers. Changing the category system to a 15- or 21-month category system ([Grondin, Deschaies, & Nault, 1984](#_ENREF_24)) or shortening the selection period to 9 months as [Boucher and Halliwell (1991](#_ENREF_10)) have been proposed. Recently, a dynamic model showed that variation of the cut-off date between 1 January and 1 July annually, coupled with additional support to the age-disadvantaged children, led to 96% reduction in the RAEs ([Pierson *et al.,* 2014](#_ENREF_39)).

Furthermore, designing multiple squads based on multiple standards would give the opportunity for fair competition to children who lack in physical attributes but show a higher technical level ([Musch & Grondin, 2001](#_ENREF_38)). Athlete quotas or average ages of teams or squads have been suggested to ensure more equal distribution of opportunities ([Barnsley & Thompson, 1988](#_ENREF_5); [Helsen *et al.,* 1998](#_ENREF_27)). Indeed, RAEs often do not exist in sports where weight categories are utilised ([Albuquerque *et al.,* 2015](#_ENREF_1); [Delorme, 2014](#_ENREF_18)), so solutions around grouping children by maturation or physical characteristics have also been suggested ([Baxter-Jones, 1995](#_ENREF_8)). However, some of these potential solutions may pose significant challenges to successful implementation. Less challenging solutions for governing bodies may include delaying selection and representational sport until past puberty, or de-emphasising the need for coaches to produce junior ‘success’. Furthermore, raising awareness about the RAEs and their impact on the identification and development of athletes could help coaches mediate the impact of RAE ([Andronikos, Elumaro, Westbury, & Martindale, 2016](#_ENREF_2); [Cobley *et al.,* 2009](#_ENREF_13); [Musch & Grondin, 2001](#_ENREF_38)). However, it is clear that there is a dearth of research on the efficacy of potential solutions, so future research that investigates the success of applied interventions longitudinally would be valuable.

**Conclusions**

The purpose of the current study was to examine the existence of RAEs in track and field training camps. Overall, the results of the current study highlighted the influential role of the RAE on the selection process of athletes who participated in track and field training camps. This study demonstrated that while RAEs were evident consistently across both cadet and juvenile categories, effects were stronger for males and those athletes at U15 level. Indeed, RAE disappeared for older (U17) females. Thus, RAEs may significantly influence the likelihood of participating at training camps organized by the RFEA. This indicates that many talented young athletes are overlooked which may diminish their chances of becoming elite athletes despite their talents and efforts. As a result, changes in the talent identification and development system would likely be advantageous for the long term goals of RFEA. There are many potential solutions, however, awareness raising and education of technical coordinators, coaches, scouts, parents and athletes would seem to be an essential first step ([Sherar, Esliger, Baxter-Jones, & Tremblay, 2007](#_ENREF_43); [Till *et al.*, 2011](#_ENREF_46)). Additionally, re-focus on long-term development rather than current performances may also facilitate the reduction of RAEs and promote more effective talent development ([Martindale, Collins, & Abraham, 2007](#_ENREF_32)).

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**Tables**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 1. Frequency of birthdates by quarter for male and female and categories of selected athletes. | | | | | | | | | | | | | |
|  |  |  | Observed frequency | | | | | | | |  |  |  |
|  |  |  | Q1 | | Q2 | | Q3 | | Q4 | |  |  |  |
| Category | Gender | N Total | N | % | N | % | N | % | N | % | Expected frequency | χ2 | P-value |
| Cadet | M | 391 | 162 | 41.4 | 128 | 32.7 | 67 | 17.1 | 34 | 8.7 | 97.8 | 102.84 | < 0.001 |
| F | 407 | 145 | 35.6 | 115 | 28.3 | 73 | 17.9 | 74 | 18.2 | 101.8 | 35.80 | < 0.001 |
| Juvenile | M | 309 | 96 | 31.1 | 93 | 30.1 | 77 | 24.9 | 43 | 13.9 | 77.3 | 22.95 | < 0.001 |
| F | 227 | 58 | 25.6 | 74 | 32.6 | 43 | 18.9 | 52 | 22.9 | 56.8 | 9.00 | 0.029 |

*N total: Total number of participants. Q: Quarter*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 2. Frequency of birthdates by quarter for male and female and categories of total licensed athletes. | | | | | | | | | | | | | |
|  |  |  | Observed frequency | | | | | | | |  |  |  |
|  |  |  | Q1 | | Q2 | | Q3 | | Q4 | |  |  |  |
| Category | Gender | N Total | N | % | N | % | N | % | N | % | Expected frequency | χ2 | P-value |
| Cadet | M | 9097 | 2821 | 31.0 | 2547 | 28.0 | 2028 | 22.3 | 1701 | 18.7 | 2274.3 | 335.312 | < 0.001 |
| F | 9575 | 2790 | 29.1 | 2528 | 26.4 | 2202 | 23.0 | 2055 | 21.5 | 2393.8 | 136.421 | < 0.001 |
| Juvenile | M | 5740 | 1534 | 26.7 | 1489 | 25.9 | 1414 | 24.6 | 1303 | 22.7 | 1435.0 | 21.311 | < 0.001 |
| F | 3299 | 869 | 26.3 | 895 | 27.1 | 787 | 23.9 | 748 | 22.7 | 824.8 | 17.228 | 0.001 |

*N total: Total number of participants. Q: Quarter*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 3. Season of birth of selected athletes compared to whole population of licensed athletes as the theoretical distribution. | | | | | | | | | | | | |
|  |  | Q1 | | Q2 | | Q3 | | Q4 | |  |  |  |
| Category | Gender | N | ∆ | N | ∆ | N | ∆ | N | ∆ | Total | χ2 | P-value |
| Cadet | M | 162 | 40.8 | 128 | 18.5 | 67 | -20.2 | 34 | -39.1 | 391 | 42.463 | < 0.001 |
| F | 145 | 26.6 | 115 | 7.6 | 73 | -20.6 | 74 | -13.5 | 407 | 13.110 | 0.004 |
| Juvenile | M | 96 | 13.4 | 93 | 12.9 | 77 | 0.9 | 43 | -27.2 | 309 | 14.811 | 0.002 |
| F | 58 | -1.7 | 74 | 12.5 | 43 | -11.3 | 52 | 0.5 | 227 | 4.920 | 0.178 |

*Gen: Gender. Cat: Category. N total: Total number of participants. Q: Quarter.* ∆ difference between the observed distribution and the theoretical expected distribution.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 4.Descriptive odds ratios (OR) and corresponding χ²- and p-values and effect sizes across all relative age quarters – separated for category and gender. | | | | | |
| Sample | |  | Q1:Q2 | Q1:Q3 | Q1:Q4 |
| Cadet | Male  [n=391] | χ² | 3.99 | 39.41 | 83.59 |
| p value | 0.046 | <0.001 | <0.001 |
| ω  OR  [95% CI] | 0.12  1.45 [**1.09 to 1.95**] | 0.41  3.42  [**2.56 to 4.76**] | 0.65  7.43 [**4.95 to 11.14**] |
| Female [n=407] | χ² | 3.46 | 23.78 | 23.02 |
| p value | 0.063 | <0.001 | <0.001 |
| ω  OR  [95% CI] | 0.12  1.41 [**1.05 to 1.89**] | 0.33  2,53  [**1.83 to 3.50**] | 0.32  2.49  [**1.80 to 3.44**] |
| Juvenile | Male  [n=309] | χ² | 0.05 | 2.09 | 20.21 |
| p value | 0.827 | 0.149 | <0.001 |
| ω  OR  [95% CI] | 0.02  1.05  [0.74 to 1.47] | 0.11  1.36 [0.95 to 1.93] | 0.38  2.79 [**1.86 to 4.17**] |
| Female [n=227] | χ² | 1.94 | 2.23 | 0.33 |
| p value | 0.164 | 0.136 | 0.567 |
| ω  OR  [95% CI] | 0.12  0.71 [0.47 to 1.07] | 0.15  1.47 [0.94 to 2.29] | 0.05  1.16  [0.75 to 1.78] |

**Bold values indicate significance of odds ratio (of 95% CI does not include 1)**