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Relative age effect in French alpine skiing : problem and solution

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Keywords : Ski; Relative age effect; Performance; Maturity, Talent Identification

Objectives: To identify the potential bias of the relative age effect (RAE) in French alpine skiers and to propose a mathematical correction adjustment for such a bias.

Methods: All performances and birthdates of skiers on the national and international circuit were collected from the 2004 up to 2019. A goodness-of-fit chi-square test and the residuals were used to study distribution of birth trimesters in youth competitors. A linear relationship between the distribution of performances and the months obtain a calibration coefficient allowing to rebalance the performance by considering the effect of RAE.

Results: Individuals born at the beginning of the year are over-represented in the elite young selections in all disciplines for both genders. A coefficient based on the relationship between month of birth and performance adjusts individual performance and cancels out the effect of RAE.

Conclusion: The RAE is present in French alpine skiing. We present a method allowing to consider the effect of the RAE in the performances realized in each gender and discipline. This method allows coaches to have a more objective opinion on performance and to reduce selection bias.

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39 Introduction

40 The relative age effect is defined as a bias that advantages individuals born close to the
41 age-group cut-off in the cohort entry (eg school tests, sports competitions) (Helsen,
42 Winckel, and Williams 2005). The relative age effect has been a subject studied in many
43 fields including education since Freyman (Freyman 1965) and Armstrong (Armstrong
44 1966) in the 1960s. The tendency of better success of the individuals born at the beginning
45 of the year in the school environment has been confirmed in other studies. For example,
46 Aune and al. showed a relative age effect in the Norwegian numeracy test for 5th, 8th,
47 and 9th graders, an effect more remarkable among boys than girls (Aune et al. 2018).
48 Cogley and al. (Cogley et al. 2009) studied the relative age effect in 657 pupils (aged 11–
49 14) at a secondary school in North England. He found that older children (born in the first
50 two trimesters) were more represented in gifted and talented programs.

51 In sports, a 2018 study on the talent selection in 70 different sports, concerning 18,859
52 young Swiss athletes showed a moderate effect of relative age in athletics and
53 synchronized swimming, as well as a slight effect but significant in tennis, volleyball,
54 football and alpine skiing among girls (Romann et al. 2018). The RAE has been shown
55 for both genders in young American football players (Tribolet et al. 2018), rugby and
56 cricket (McCarthy, Collins, and Court 2016) and potentiated with the level of
57 performance (Leyhr et al. 2021). Finally, Raschner and al. showed a relative age effect
58 for both girls and boys at the 2012 Winter Youth Olympic Games across all disciplines
59 investigated (Raschner, Müller, and Hildebrandt 2012). Individuals who won medals
60 were relatively older than their non-medalist counterparts. This bias results from an
61 earlier maturity with higher performances for those born in the first months of a same
62 year, the classification by age group favoring the performance of relatively older athletes
63 (Helsen et al. 2000).

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64 Maturity is defined as the stage in which an organism is found which has reached its full
65 development. Regarding performance, we will talk about the development of physical,
66 physiological or cognitive faculties. This link between development and performance has
67 been studied and theorized (Berthelot 2012; Berthelot et al. 2019; Moore 1975) by a bi-
68 phasic function of progression and decline. Depending on the determinants of sports
69 performance, this maturity can be achieved at different ages. For example, maturity in
70 chess, with a cognitive dominance, is reached at the age of 31, while in 100 meters
71 athletics, with a physical dominance, is reached at the age of 25. The determinants of
72 performance vary depending on the sport and therefore also the phases of development
73 and therefore the effects of RAE (Till et al. 2014).
74 This relative age effect generates long-term effects. Brustio and al. looked at the RAE to
75 adulthood in world athletics (Brustio et al. 2019). They first of all confirmed the presence
76 of bias in all disciplines in the youth categories (under 18 and under 20). They also
77 identified an relative age effect that persisted into adulthood in some disciplines, notably
78 throwing events. Likewise, Gennaro Boccia and al have shown that being relatively born
79 earlier in the year can confer an advantage throughout men's careers in throwing events
80 (Boccia, Cardinale, and Brustio 2021). Conversely, MacCarthy et al showed a reversal of
81 the RAE advantage (McCarthy, Collins, and Court 2016). Although relatively young
82 professional rugby and cricketer players were less likely to be selected into their
83 respective national academy systems, they were more likely to advance to senior national
84 teams. McCarthy and Collins (McCarthy and Collins 2014) confirm this "reversal" of the
85 RAE in rugby. This reversal effect has been called the "underdog" effect (Gibbs, Jarvis,
86 and Dufur 2012). Finally, de la Rubia et al showed a relative age effect still present in the
87 adult male and female categories in international handball (de la Rubia et al. 2021).

Other studies have demonstrated the existence of the RAE among international skiers (Baker et al. 2014). Analyses of 1,474 ski jumpers, 7,501 cross-country skiers, 15,565 alpine skiers, 4,179 snowboarders and 713 Nordic combined athletes revealed significant RAE for most of these disciplines for all genders. But no published study has investigated French alpine skiing. Since each country has its own system of talent identification, previous studies may not be simply extrapolated to the French alpine skiing system. The presence of RAE in skiing was global and having not changed over the past 10 to 15 years (Steidl-Müller et al. 2019), it is useful to focus on this phenomenon in French alpine skiing specifically. In addition, no solutions regarding the RAE in alpine skiing have been proposed.

In other sports, solutions have been proposed to consider the RAE. In the National Hockey League, reducing the age groups; changing the annual limits for age groups; or to delaying the selection and identification processes beyond the stages of puberty and maturation have been tested (Barnsley and Thompson 1985). Nolan and Howell have shown that these biases have persisted in hockey despite the available option for adjusting this bias (Nolan and Howell 2010). Another study in basketball (de la Rubia Riaza et al. 2020) proposed to evaluate the athlete on her/his performance in the long-term and not the immediate results only. They suggested to take into account the maturation of the athlete rather than the age groups, and to design models of evaluation of young athletes accounting for other parameters (psychology, emotional intelligence, cognitive skills, etc.). These methods include development parameters linked to maturation, but none has presently been validated that would more precisely detect future talent. Romann and Cobley proposed a linear correction in sprint athletics (Romann and Cobley 2015). They showed that a relative age difference of nearly one year resulted in expected average performance differences ranging from 10.1% to 5.3% among Swiss junior sprinters.

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113 Other corrective adjustment procedures were constructed from the regressed relationship
114 between chronological age and objective performance measures of swimming (Abbott et
115 al. 2021, 2020; Cobley et al. 2019). A practical solution proposed by Helsen et al in soccer
116 (Helsen et al. 2021) makes it possible, based on a longitudinal study examining secular
117 changes in biological maturation in Belgian boys, to determine an appropriate
118 developmental allocation date by knowing the anthropometric characteristics of the
119 individual. Its new classification based on this allocation date and not its chronological
120 date, makes it possible to cancel the RAE.

121 A systematic review (Webdale et al. 2020) identified ten independent solution to RAE
122 types from sixty-three peer-reviewed publications between 1980 and 2018. Six of these
123 solutions were “technical and policy-based”. This relates to modifying the age structures,
124 correcting performance by a coefficient, achieving player quotas and making categories
125 by anthropometric parameters. Three proposed solutions were pedagogical and
126 informational focusing above all on pedagogical training to raise awareness of the RAE
127 bias. They highlight the difficulty of applying the different methods proposed and that
128 the implementation of these solutions has the potential to affect both positively and
129 negatively the career and life outcomes of participants. The recommended solutions seem
130 difficult to implement quickly because they require substantial changes in sports
131 organizations.

132 Therefore, we aimed to 1) determine the relative age effect in French alpine skiers in
133 young age groups and adulthood, and 2) recommend a method to consider the RAE. We
134 hypothesized that a relative age effect is present in both genders among French alpine
135 skiers and that a proper regression method could provide a robust solution to compensate
136 for this effect.

Methods

Studied population

Inclusion criteria

The population studied included all male and female French alpine skiers having participated in at least one competition in Giant Slalom (GS), Slalom (SL) and Super Giant Slalom (SG) between the age of 13 up to 30 from the 2004/2005 season up to the 2018/2019 season.

Exclusion criteria

Downhill (DH) performances have been included for adult categories only. (DH is not a discipline practiced in youth categories).

Sample description

The studied population consisted of 21348 individuals ,7672 women (36%) and 13661 men (64%).Among these competitors, 2793,1917,1162 individuals participated to the national U14, national U16 championship and international U18 championship respectively. The distribution of performance and age for each category and gender are presented in the table .

Data source

The performance data on the national and international circuit as well as dates of birth were available on the website of the French Ski Federation: <http://www.ffs.fr/ski-alpin/competitions/resultats>. Alpine skiing performance is quantified using FFS (French Ski Federation) points. The number of points scored on the day of the competition depends on the overall level of the race and the time achieved in relation to the winner of the race : $(\frac{T_x}{T_0} - 1) \cdot F$, with T_x the runner's time in seconds, T_0 the winner's time in seconds

and F a discipline dependent factor. The data regarding of participation in elite youth competitions is private internal data that of the French Ski Federation made available for this study.

Data analysis

The age group categories in alpine skiing are determined according to the skiers' year of birth. The U14 category is made up of skiers born in year $y - 14$ and $y - 13$ for the season $y - 1/y$. The U16 category is made up of skiers born in year $y - 16$ and $y - 15$ and category U18 is made up of skiers born in year $y - 18$ and $y - 17$. For example, a skier born in 2006 will be in the U14 category for the 2018-2019 season. An individual can be present in several categories if he has competed for several years. For Every year, there are two French (FFS) youth elite championships in U14 and U16 categories and one youth elite international (FIS : International Ski Federation) championships in U16 category. Only skiers selected by their regional committees in each category (U14, U16) participated in these competitions.

Identifying the relative age effect

To have a large sample size in each group and a higher statistical power, birth dates of participants in the elite young competitions (U14 and U16 FFS, U16 FIS) were categorized into trimesters (*January, February, March: Q1, April, May, June: Q2, July, August, September: Q3, October, November, December: Q4*). A Chi-squared test of adequacy was used to compare the distribution of birth trimesters with the distribution of birth trimesters for the entire French population over the study period. Historical public data for the entire French population were obtained from the INSEE (Institut national de la statistique et des études économiques): <https://www.insee.fr/fr/statistiques/serie/000436391>. In the presence of a global effect,

Haberman residuals (Haberman 1973) were calculated and compared to the quantiles of the normal distribution (of order 0.1,0.05,0.01) to determine the birth trimester over or under represented. These residuals represent the standardized deviation between the observed and expected values. They asymptotically follow a standard normal distribution. In the absence of a relative effect of age, the distribution of trimesters of birth is assumed to follow the distribution of the general French population, therefore a rejection of the null hypothesis of homogeneity will identify a relative age effect.

Relative age effect in adulthood

The homogeneity test was performed on the birth trimesters of individuals present on the international circuit (FIS) in adulthood (between 22 and 30 years) in GS, SG, SL and DH. The FIS circuit is the highest level of alpine skiing in the world. If the distribution of birth trimesters does not follow the French distribution, the relative age effect is present in adulthood.

Rellocation RAE solution

The method was developed for the U14, U16 and U18 categories, individuals of the same category were separated by their year of birth y (first year) and $y + 1$ (second year). Each skier is represented only once per season, characterized by his best performance achieved. For each year, the dates of birth have been categorized into months of birth (January to December). At each age, a linear regression was performed between the month of birth and the skier best performance (in FFS points). If the slope coefficient α is significantly different from 0, it is used as a calibration coefficient to rebalance the effect of relative age. We calculated the “adjusted” points for each individual i :

$$Ptscorr_j^i = Pts_i - \alpha_j * k$$

with j : age, k : Birth trimester

These adjusted points allow to compare several skiers independently of their month of birth. The categories being composed in 12-month range, the coefficients will adjust the performance within each of the group (1st and 2nd year). For example, the U14 1st year and the U14 2nd year will have two distinct coefficients, and will allow each individual to be compared with regard to his category (1st or 2nd year). We used a cross validation method to check the robustness of our method. We cut our sample into two parts, one accounting randomly for 75% of the sample data, and another part with 25%. The 75% made it possible to calculate the calibration coefficients at each age category. Then, the calibration coefficients was applied on the remaining 25% data sample. The RAE bias is considered to be annulated cancelled out if the previous positive linear relationship between performance and month of birth on this “test” sample was now absent.

Results

Identifying the relative age effect

The birth trimesters of participants in elite youth competitions does not follow the distribution of the entire French population (proportion (%) = 24.4, 25.0, 26.1 24.4) (Figure 1) ($p < 0.05$). A relative age effect was identified in all youth competitions for both genders. Skiers born in the first trimester are over-represented in all categories. (proportion (%) = 33.3, 31.7, 34.6, 27.1, 30.7, 29.2 for men’s U14 ; women’s 14 ; men’s U16 ; women’s U16 ; men’s U18 and women’s U18 respectively , $p < 0.01$). Skiers born at last trimester are underrepresented (proportion (%) = 16.7, 17.3, 15.8, 18, 16.6, 18.6 for men’s U14 ; women’s 14 ; men’s U16 ; women’s U16 ; men’s U18 and women’s U18 respectively, $p < 0.01$)

The proportion observed in each discipline (GS, SG and SL) are represented in the Supplementary figures. A different distribution of the French population is present in all

disciplines (GS, SG and SL) for national competitions (FFS). The first and second trimesters are overrepresented and the 3rd and 4th trimesters are underrepresented in all men's and women's disciplines for U14 competitions. In U16, the 4th trimester is underrepresented in all disciplines for both genders, and the first trimester is overrepresented in SG and SL.

Relative age effect in adulthood

Figure 2 shows an imbalance in the distribution of the birth trimesters among adult skiers as well compared to the French population. Individuals born in the first trimester are overrepresented in men GS (proportion=29.4% $p<0.05$), GS female (35.2% $p<0.01$), SG male (proportion=29.7% $p<0.05$), SG female (proportion=41.7% $p<0.01$), SL male (proportion=28% $p<0.1$), SL female (proportion=34.7% $p<0.01$) and DH women (proportion=47.5% $p<0.01$). Individuals from the last trimester are underrepresented in GS male (proportion=20.5% $p<0.1$), GS female (proportion=18.9% $p<0.1$), SG female (proportion=16.7% $p<0.1$), SL male (proportion=20.8% $p<0.1$), SL female (proportion=16.5% $p<0.1$) and DH women (proportion=12.5% $p<0.1$).

Rellocation RAE solution

The methodology allowing performance to be adjusted by the relative age effect developed in all categories for both genders in alpine skiing is presented for the densest category in terms of the number of performances achieved, the male GS. A linear relationship between performance and month of birth for each category in Giant Slalom is illustrated in Figure 3. In each age category, the slope coefficient is different from 0 (3.27, 2.73, 2.09, 1.88, 2, 1.47 for men's U14 1st and 2nd year ; women's 14 1st and 2nd year; men's U16 1st and 2nd year; women's U16 1st and 2nd year; men's U18 1st and 2nd year and women's U18 1st and 2nd year). This coefficient represents the potential

gain in points for each additional birth month at each age in male GS. Calibration coefficients as well as the confidence intervals are summarized in Figure 4 for each category, gender and discipline.

After correcting the performance / age relationship using the calibration coefficient, the RAE was considered in Figure 5 (\forall age j : $\alpha_j = 0$, $p > 0.05$). All the confidence intervals of the performance averages for each month of birth follow the linear trend with a zero slope, except for the month of October for the U16 first year category.

Figure 6 also includes the calibration coefficients obtained with the methodology presented for women (bottom) also and for the disciplines SG, GS and SL (in column).

For each category (on the vertical axis) is represented the calibration coefficient as well as its confidence interval delimited by the two bars. If the value 0 (represented by the horizontal bar) is within the confidence interval, the assumption that the calibration coefficient is equal to 0 is not rejected. A null calibration coefficient means that the month of birth has no influence on performance. All the calibration coefficients for the U14 categories (1st and 2nd year) are significantly different from 0. Conversely, 4 coefficients are significantly different from 0 in U18 1st year and 1 in U18 2nd year.

Discussion

This study shows a relative age effect in all disciplines and age categories among French alpine skiers. It also demonstrates that this effect lasts until adulthood in the international FIS circuit, with a higher proportion of individuals born at the beginning of each year. Based on such findings we propose a solution to adjust for this effect via a calibration coefficient calculated for each event, age category, and gender. This option allows coaches or regional selectors compare performances in a fairer way of several skiers born in different months of the same year.

Several studies have investigated the relative age effect in other sports (Cobley et al. 2019; de la Rubia Riazza et al. 2020; Helsen, Winckel, and Williams 2005; Nolan and Howell 2010; Tribolet et al. 2018). This work is the first one to quantify RAE in French alpine skiing disciplines. Development between 13 and 18 years has already been studied in other studies (Bottollier et al. 2020). The strong physical component of alpine skiing, with important energy needs partly explains why relatively older individuals find themselves advantaged in performance. The link between physical and cognitive abilities and RAE exists (Huertas et al. 2019) but some studies do not observe it (Carling et al. 2009). It also depends on the selection criteria developed to reach the high level in the different sports.

The global relative age effect is probably due to the fact that selections at youngest ages are mostly made on the sole criterion of performance. Individuals in the same age category but months older have more time to further develop their physical, physiological and psychological characteristics (Helsen et al. 2000). Diry et al. (Diry et al. 2020) showed this dependence on maturity of physiological factors for rowing. Another study reinforced this hypothesis, showing that the relatively older male competitors were significantly taller and heavier than the younger competitors in youth winter Olympics (Raschner, Müller, and Hildebrandt 2012). Like in other studies, the RAE is exacerbated in the youngest categories and wanes in the proximity of the senior categories (Johnson, Farooq, and Whiteley 2017; Smith et al. 2018; Votteler and Höner 2017), with a greater presence of RAE in adulthood in men than in women (Boccia, Cardinale, and Brustio 2021). This persisting effect in senior categories can find explanations probably because the skiers selected in the young categories benefit earlier from more investment in trainings, more experienced trainers and training partners, and the knowledges about the elite circuits, which facilitates their access to the highest level in adulthood. We therefore

do not find here the so-called “underdog effect”, that is to say an inversion of the proportions of birth trimester in adulthood, yet present in different team sports such as rugby (McCarthy and Collins 2014) or basketball (de la Rubia Riazza et al. 2020). If this is not due to a statistical hazard, maybe team sports have more performance factors than alpine skiing which may lead to more subjective judgments from coaches which allow access even in late ages. Conversely, as in our study, we find a RAE in various individual disciplines, notably throws in athletics (Boccia, Cardinale, and Brustio 2021; Brustio et al. 2019). These individual sports have performance determinants closer to alpine skiing. Selection methods, which offer future benefits, may be carried out early in an athlete’s career, and leave little opportunity for new athletes.

The methods proposed so far (Barnsley and Thompson 1985) have not made it possible to reduce the biases linked to the RAE (Nolan and Howell 2010). These are indeed fair measures, but proposals such as reducing the ages for regrouping or setting up quota systems in elite selections are costly and difficult to implement from a logistical point of view on an entire population of young athletes. An interesting idea would be to carry out standardized and quantifiable physical, physiological, psychological and sociological tests at regular intervals to monitor, on multiple indicators, long-term performance (several years). However, unlike the method proposed in this study, this approach can be complex to set up and requires individual monitoring over the long term.

Our method is easy to set up and allows for a faster adaptation of institutional practice with regard to detection and selection of young people. This method is similar to what has been previously suggested in swimming sprint disciplines (Romann and Cogley 2015; Abbott et al. 2021, 2020; Cogley et al. 2019). The authors have used a linear regression between performance and chronological age to determine the potential gain in terms of performance according to the swimmer’s birth period. Their adjustment procedures

Obviously, performances do not progress linearly; it follows a double intertwined exponential (Berthelot et al. 2019), but for the sake of implementation simplicity, compensation can be approximated through a linear relation over a 12 months period. Both methods allow researchers and coaches to compare in an equivalent manner all the swimmers of the same category regardless of the month of birth. This has two main practical advantages: in the short term, individuals may have their performances rebalanced in a fairer way for their real age. In the long term, individuals who were previously unselected due to their period of birth may reintegrate into a long-term training program for young skiers and the paths of high performance and thus be able to more easily exploit their potential to reach the top level. The method is simple to apply, and could be integrated directly into the coaches monitoring tools, providing more accurate evaluation of the performance of young skiers.

Practical application

This study therefore makes it possible for the coaches and federal staff of young skiers to become aware of the presence of a relative age effect in French alpine ski. We show that it may be necessary to assess young athletes on potential performance and not current one only. Second, this study proposes a method to better compare skiers of different chronological ages, integrating the RAE in a given category. For example, if two skiers have similar performances but at different chronological age, the calibration coefficient method will give the youngest one a fairer evaluation, suggesting a higher potential in the future. The proposed method does not recommend selecting athletes with a best potential estimated by our model, it aims to provide this additional information to make a decision. The person using the decision support tool, i.e. the coach or federal staff for example, will then adjust these coefficients himself by his personal knowledge. It is therefore a first step towards correcting the bias of the RAE in French alpine skiing. Skiers may no longer

miss certain selections unfairly, while the federation can acquire a more accurate assessment of its young categories, that will better support long-term potentials by rebalancing the chances from the beginning.

Limitations and perspectives

The present study has two main limitations. First, the calibration equations depend on a performance dataset with a 15-year follow-up only. The volume of data is more important for the young categories and decreases over time. Hence, there is a greater uncertainty regarding the calibration coefficient in the adult ages. But the proposed method will get more precise as new data entries will increase the robustness of the model. In addition, the confidence interval of the coefficient makes it possible to add a nuance taking into account the sample size and the outliers. The second limitation of this study is that it only considers the age and performance variables to correct for the RAE. It would be interesting to take into account other factors allowing to calculate biological maturity (Mirwald et al. 2002) and its influence. It may therefore be worthwhile to include biological / biometrical variables of interest (height, seat height, leg length ...) or other parameters of ski, and compare the performances of skiers according to the progression of these variables also. The method is mainly based on easily retrievable performance and age data, it would be interesting to apply it to other sports whose performance is measured quantitatively.

Conclusion

A relative age effect is present in all youth age categories of the French alpine skiing. In the French national ski teams, skiers born at the beginning of the year are over-represented compared to those born at the end of the year. This effect is also present in adulthood on the international elite circuit (FIS). We propose an easily implementable

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379 calibration method that corrects for such a bias. By adjusting the FIS points of each skier
380 according to their month of birth, it allows for a fairer and more accurate performance
381 evaluation. Ultimately, this tool could help rebalance the chances of reaching the highest
382 levels, regardless of the month of birth.
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Tables

Figures

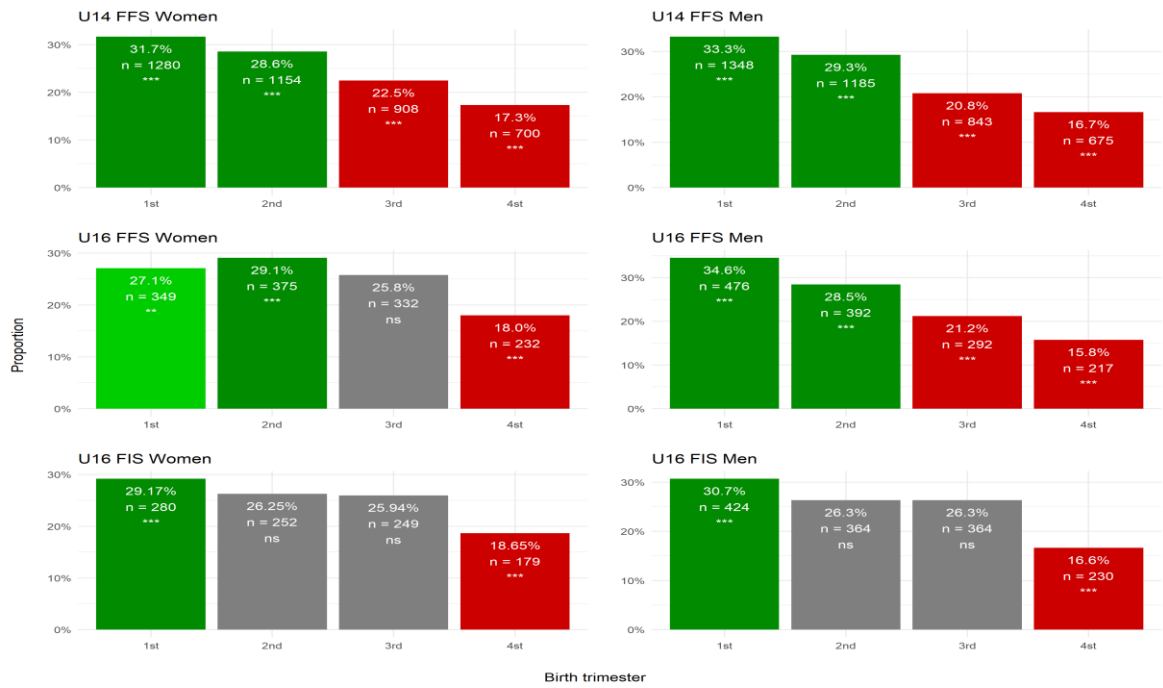


Figure 1: Distribution of proportions of female and male skiers according to their trimester of birth in French elite youth skiing competitions (U14 FFS, U16 FFS, U16 FIS). The stars indicate the level of significance level of the over or under representation of the corresponding trimester (* :0.1; ** :0.05, *** :0.01)



Figure 2: distribution of the birth trimester of participants in international competitions (FIS) in the senior category (U30). The stars indicate the level of significance level of the over or under representation of the corresponding trimester (* :0.1; ** :0.05, *** :0.01)

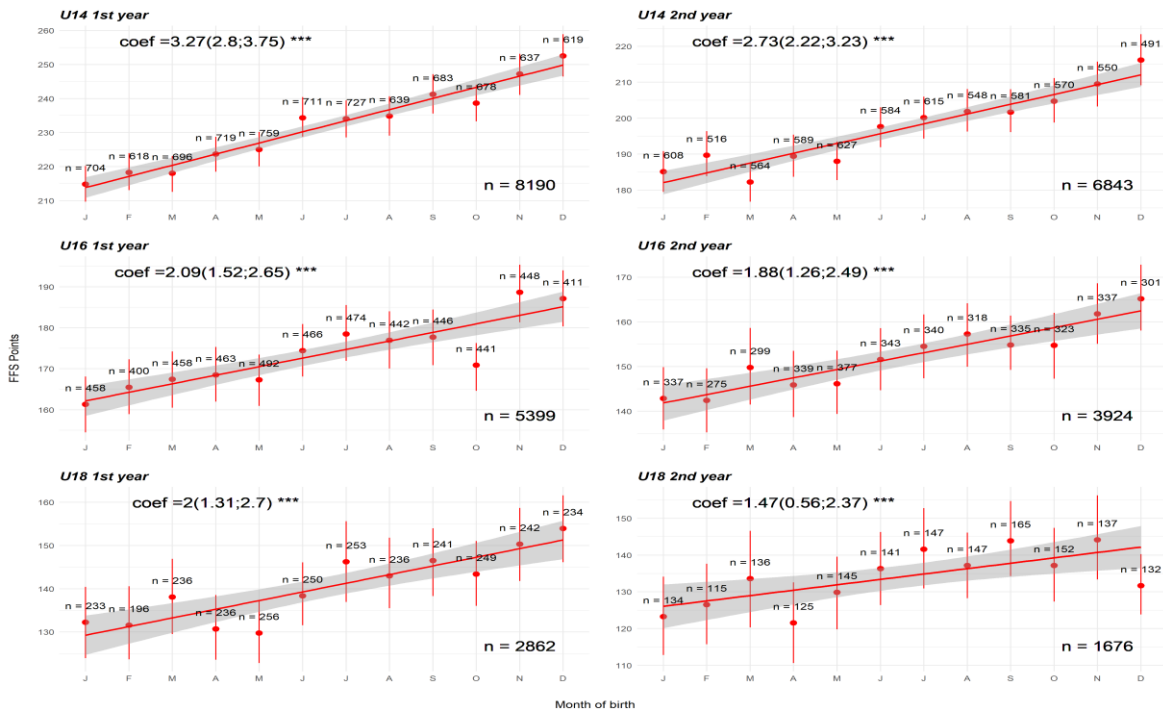


Figure 3: Performance (FFS points) according the month of birth and calibration coefficient (coeff) at each age in male Giant Slalom.

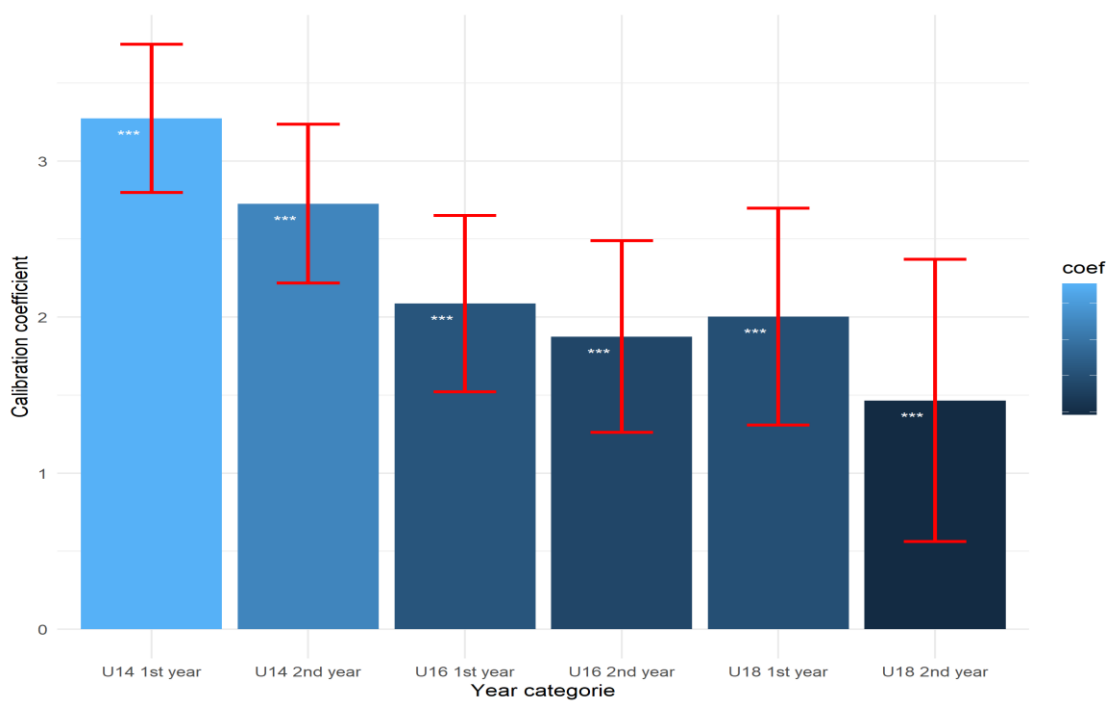


Figure 4: Calibration coefficient at each age in male Giant Slalom. The lighter the color, the higher the coefficient and the higher the relationship between month of birth and performance. The 95% confidence interval of the coefficients is delimited by the errors bar.

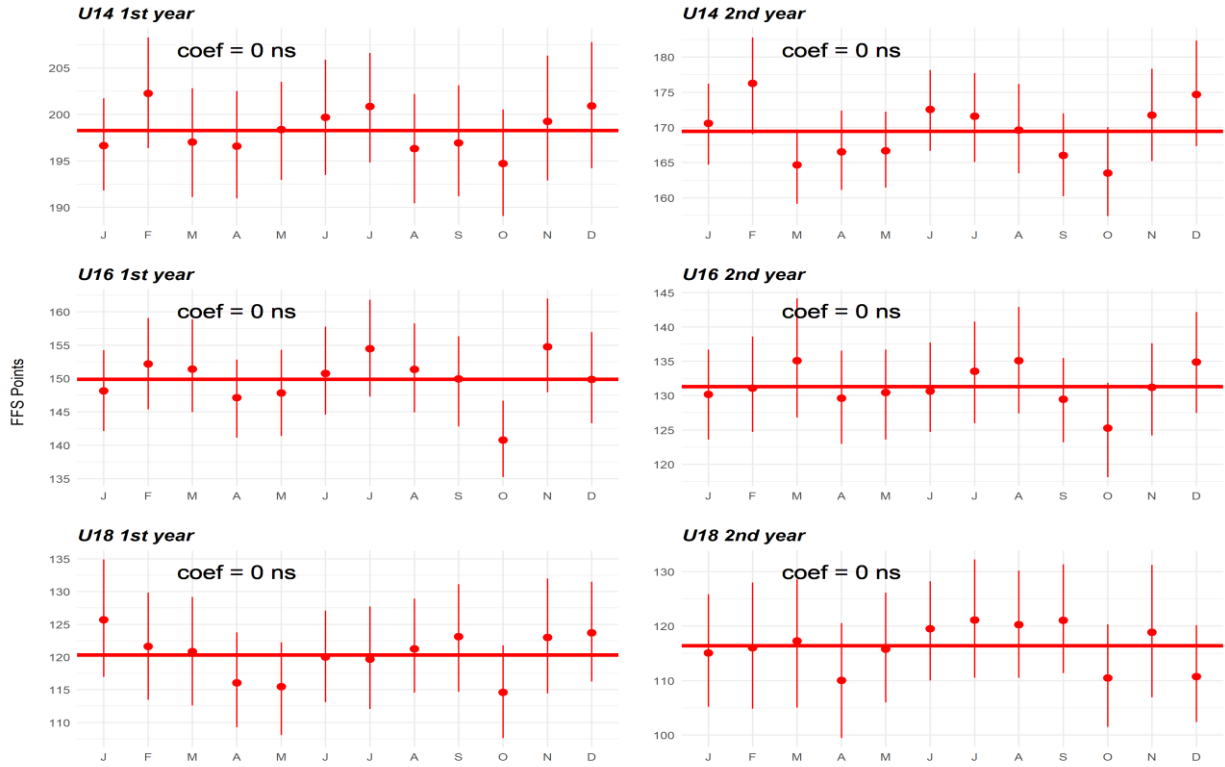


Figure 5: Performance (FFS points) according to the month of birth and calibration coefficient at each age in male Giant Slalom after performance correction

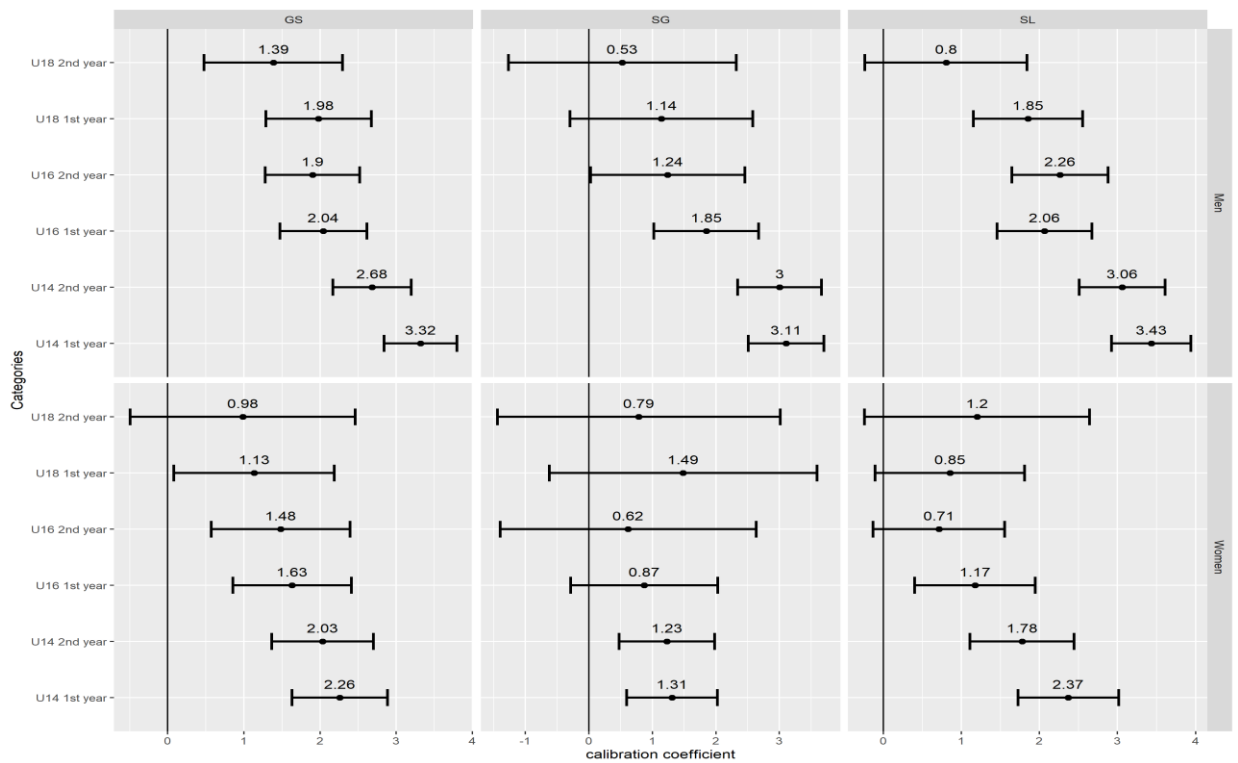


Figure 6: Calibration coefficient for all categories (in column) and for each gender (in line) in each category year. The horizontal axis is the calibration coefficient and the vertical axis is the year category. If the confidence interval (determined by the two horizontal bars) includes the value 0, the coefficient is not significantly different from 0

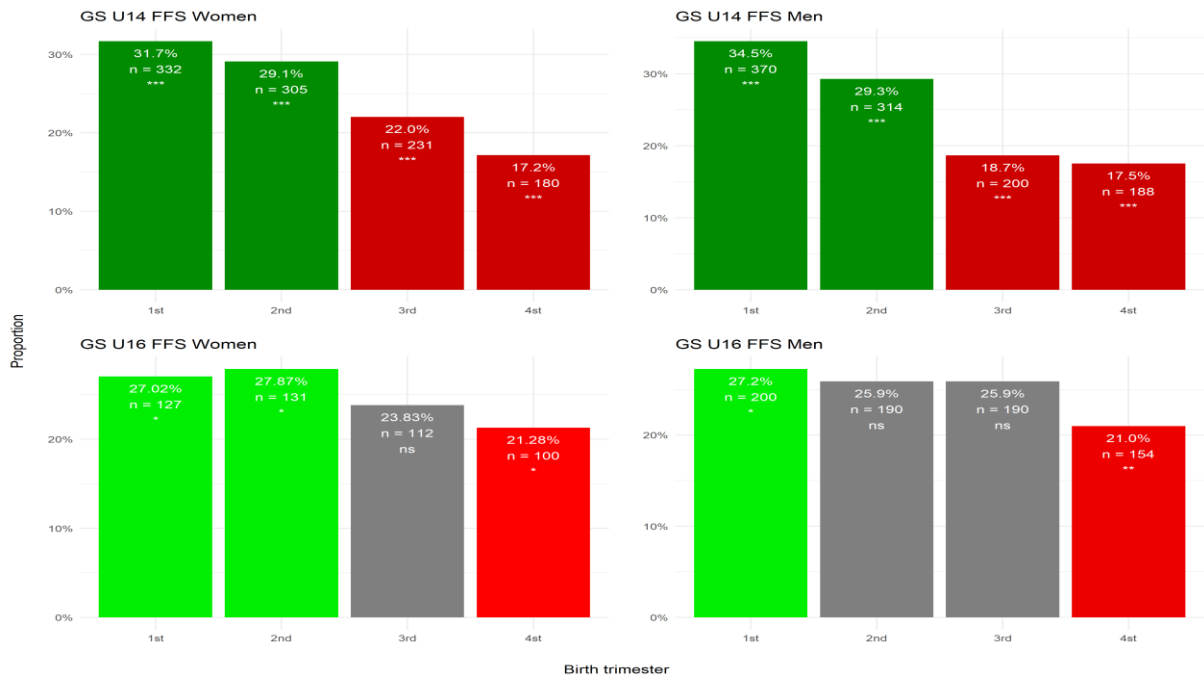


Figure 7: Distribution of terms of birth by category for elite youth competitions (FFS U14 above and FFS U16 below) and each gender (male on the right and female on the left) in GS

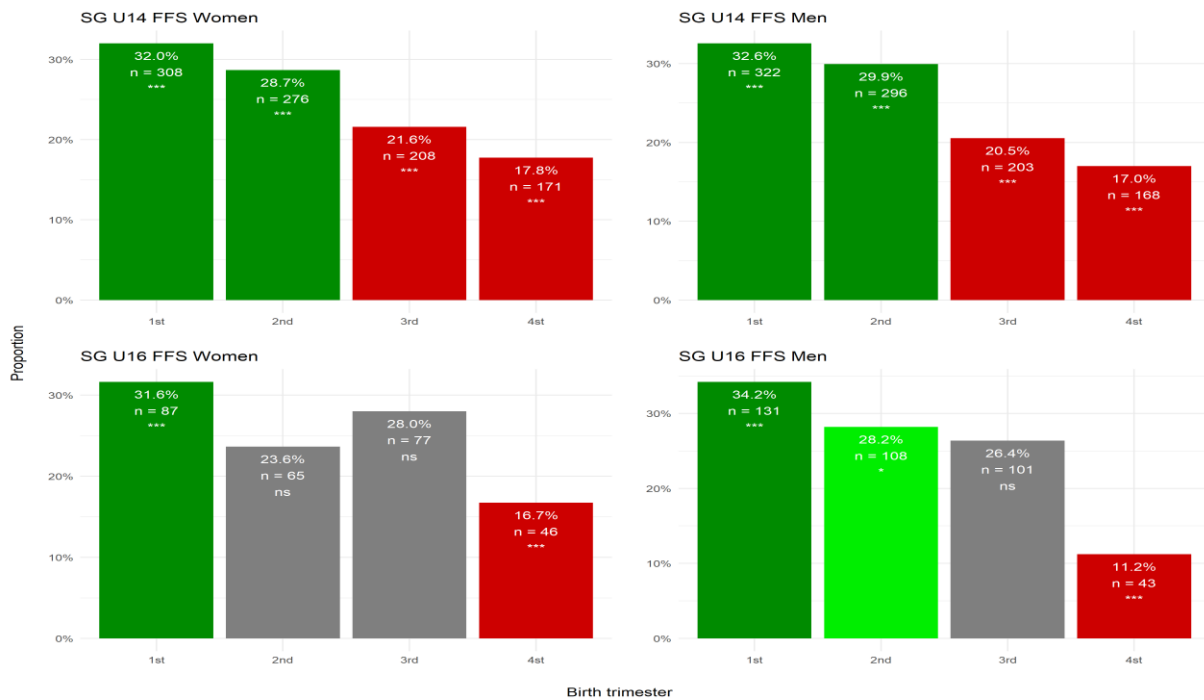


Figure 8: Distribution of terms of birth by category for elite youth competitions (FFS U14 above and FFS U16 below) and each gender (male on the right and female on the left) in SG

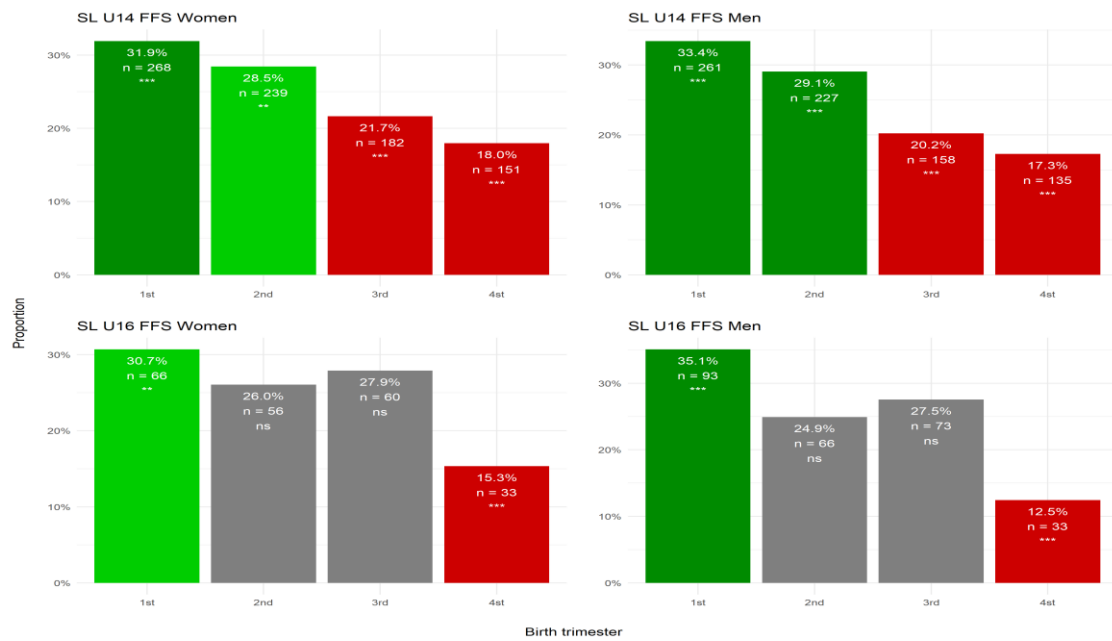


Figure 9: Distribution of terms of birth by category for elite youth competitions (FFS U14 above and FFS U16 below) and each gender (male on the right and female on the left) in SL