

Research article

## Maturity Status Strongly Influences the Relative Age Effect in International Elite Under-9 Soccer

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### Abstract

The aim of the study was to assess the role of the relative age effect (RAE) and to investigate the influence of the biological maturity status on the RAE in international under-9 soccer. The birth dates of 222 male participants of the U9 Eurochampionship Soccer Tournament in Vienna in 2016 were analyzed and divided into four relative age quarters (Q1-Q4) and the biological maturity status was assessed with the age at peak height velocity (APHV) method. Based on the mean±standard deviation of the APHV, the athletes were divided into three groups of maturity: early, normal and late maturing. Chi-Square-tests were used to assess the difference between the observed and the expected even relative age quarter distribution and to evaluate the difference between the observed distribution of early, normal and late maturing athletes and the expected normal distribution. A univariate analysis of variance was performed to assess differences in the APHV between the relative age quarters. A RAE was present ( $\chi^2 = 23.87$ ;  $p < 0.001$ ;  $\omega = 0.33$ ). A significant difference was found in APHV between the four relative age quarters ( $F = 9.906$ ;  $p < 0.001$ ); relatively older athletes were significantly less mature. A significant difference was found between the distribution of early, normal and late maturing athletes and the expected normal distribution for athletes of Q1 (high percentage of late maturing athletes: 27%;  $\chi^2 = 17.69$ ;  $p < 0.001$ ;  $\omega = 0.46$ ) and of Q4 (high percentage of early maturing soccer players: 31%;  $\chi^2 = 12.08$ ;  $p = 0.002$ ;  $\omega = 0.58$ ). These findings demonstrated that the selection process in international soccer, with athletes younger than 9 years, seems to be associated with the biological maturity status and the relative age. Relatively younger soccer players seem to have a better chance for selection for international tournaments, if they enter puberty at an earlier age, whereas relatively older athletes seem to have an increased likelihood for selection independent of their biological maturity status.

**Key words:** Relative age effect, maturity status, under-9 soccer, talent development.

### Introduction

The *relative age effect* (RAE) is a well-documented phenomenon in youth sport (Cobley et al., 2009). This effect exists when the relative age quarter distribution represents a biased distribution among the four quarters with an overrepresentation of athletes born early in the selection year (Musch and Grondin, 2001). For example, among the under-15, under-16, under-17 and under-18 youth soccer players from 10 European countries, 43.4% were born in relative age quarter 1, and only 9.3% in the last relative age quarter (Helsen et al., 2005). Due to the system of classifying athletes by chronological age within one birth year, age

differences of up to twelve months are possible between athletes of the same competition category (Helsen et al., 2005). However, often broader age bands (e.g., two-year age bands or two constituent years) are used for classifying athletes in competition categories, which lead to greater age differences between athletes of the same competition category (Steingröver et al., 2017). These relative age advantages have led to the RAE phenomenon, which is present in diverse types of sport (Cobley et al., 2009). Schorer et al. (2013) underlined the necessity to differentiate between varying effects (constituent year vs. within-one-year) to better understand the mechanisms behind talent development. However, most studies in RAE research did not consider diverse age-cohorts.

A recently published review article demonstrated that the RAE is present in several age categories of national and international soccer (Sierra-Diaz et al., 2017). Gutierrez Diaz Del Campo et al. (2010) found a significant RAE among prepubescent youth soccer players from Spain (under-11 till under-18) selected for elite youth teams of clubs belonging to the Spanish Professional Football League; however, no difference was found between the relative age quarter distribution of the amateur players compared to the distribution of the Spanish population. Additionally, no significant influence of the age group the athletes compete in, their position on the pitch and the number of years they have spent in the category (U11-U18) was present. As a consequence, the authors concluded that the main cause of RAE in elite soccer seems to be the talent identification process. (Gutierrez Diaz Del Campo et al., 2010) Similar findings were revealed in prepubescent ice hockey (Hancock et al., 2013). However, at the youngest levels of international soccer, no study has been published, so far. Nevertheless, the existence of the RAE in several age categories in soccer indicates that the talent development system in this sport discriminates against relatively younger athletes and a lot of talents get lost because talent in a sport does not depend on the birth month (Lames et al., 2008).

Talent identification systems are often based on selection biases that confuse maturation for talent (Cobley et al., 2009). In this context, Cobley et al. (2009) proposed the *maturation-hypothesis* to explain RAE in sport: it can be assumed that the relative age of an athlete is related to his/her cognitive and physical maturation; thus, the favorable selection of relatively older athletes compared to relatively younger athletes is influenced by the maturational differences between them (Baker et al., 2014). The short-term consequences are that relatively older and earlier

maturing athletes seem to be more “talented” and are consequently selected, whereas relatively younger and less mature athletes are often excluded and drop out of sport (Müller et al., 2017; Romann and Cogley, 2015). As a consequence, the combination of a relatively older age and an advanced maturation positively influence the selection and thus, might lead to the RAE. Cogley et al. (2009) showed that this is especially true in sports with high demands on strength and power; in such sports, youth athletes who are above average in height and weight compared to non-athletes of the same age are favourably selected (Cogley et al., 2009). Additionally, Gil et al. (2014) revealed that 10-year-old Spanish youth soccer players of the four relative age quarters did not significantly differ in the biological maturity status from each other, which indicates that relatively younger, but nevertheless selected, youth soccer players can counteract their relative age disadvantage by an advanced biological maturity status. Furthermore, Deprez et al. (2013) and Müller et al. (2017) showed that among relatively younger national youth soccer players a high percentage of early maturing athletes were present, which indicates that relatively younger soccer players might only have a chance of selection if they were early maturing whereas relatively older athletes had a selection advantage independent of their maturity status (Deprez et al., 2013). However, it has to be considered that in both studies other extraneous variables that could have influenced the selection (e.g., training age, training quality, ...) were not controlled. Hancock et al. (2013) found a strong RAE in pre-pubescent female ice hockey players and hypothesized that physical maturation differences might not have as strong an impact on RAE as always thought, whereas cognitive factors might have a stronger impact which could be seen in prepubescence; alternative, small changes in annual growth are significant enough to produce RAE. Towlson et al. (2017) revealed that maturation and anthropometric characteristics appear to bias the allocation of players (especially for key defensive roles) already from an early development stage, whereas physical attributes do not influence the selection until latter stages of talent development. Johnson et al. (2017) showed that maturation status had an even 10-fold stronger influence on selection in elite youth soccer than the relative age. Therefore, the biological maturity seems to play a major role in the selection of youth soccer players. However, these studies were conducted only at national levels of youth soccer and conflicting results were found. It might be hypothesized that at an international level an even greater selection pressure is present

which might strengthen the selection bias of favorably selecting relatively older and early maturing athletes. However, this has to be investigated in order to fully understand the mechanisms behind the RAE in top-level international youth soccer with the goal of contributing to a fairer talent development in this sport.

Therefore, the aim of the present study was to investigate the association of the biological maturity status with the selection and consequently, the RAE among high-level international elite U9 soccer players who were selected for a European Youth Soccer Tournament.

## Methods

### Participants

In total, data from 222 male participants of the U9 Euro-championship Soccer Tournament in Vienna in 2016 were evaluated in the present study. Athletes of the birth year 2007 and younger were allowed to participate; however, only athletes born in 2007 participated in the tournament. In total, 40 teams from 18 nations participated in the tournament; however, data from 20 teams could be obtained because these teams agreed to participate in the study. The mean age of the study participants was 9.0 years (standard deviation:  $\pm 0.4$ ) and ranged from 8.5 to 9.5 years. Table 1 presents the anthropometric data (means and standard deviations) of the study participants.

### Procedures

The birth dates of all participants were collected and then divided into four relative age quarters according to their birth months. Because January 1<sup>st</sup> is used as the cut-off date for the competition categories in soccer, the months were split into the four relative age quarters as follows: January to March were categorized as relative age quarter 1 (Q1); April to June as quarter 2 (Q2); July to September as quarter 3 (Q3), and October to December as quarter 4 (Q4).

The biological maturity status was assessed by the non-invasive method of calculating the *age at peak height velocity* (APHV) proposed by Mirwald et al. (2002). The equations include the following anthropometric characteristics that were assessed according to previously described procedures (Malina and Kozziel, 2014): body height (0.1 cm, Seca Portable Stadiometer, Hamburg, Germany), sitting height (0.1 cm, Seca Portable Stadiometer, Hamburg, Germany; sitting height table) and body mass (0.1 kg, Seca, Hamburg, Germany). The leg length (difference of body height and sitting height) and the actual chronological age

**Table 1.** Anthropometric data and age at peak height velocity of participants separated by relative age quarter and for the total sample. Data are means ( $\pm$ SD).

		Height [cm]	Weight [kg]	Sitting height [cm]	Age [yrs]	APHV [yrs]
<b>Total</b>	(n=222)	136.1 (6.2)	31.0 (4.5)	71.3 (3.2)	9.0 (.28)	12.8 (.33)
<b>Relative age quarter</b>	<b>Q1</b> (n=86)	137.1 (6.1)	31.3 (4.5)	71.7 (3.2)	9.3 (.07)	13.0 (.32)
	<b>Q2</b> (n=52)	137.5 (5.9)	32.2 (4.5)	72.2 (2.9)	9.1 (.08)	12.8 (.29)
	<b>Q3</b> (n=45)	134.6 (6.0)	29.8 (3.7)	70.1 (3.3)	8.8 (.07)	12.8 (.31)
	<b>Q4</b> (n=39)	133.9 (6.6)	30.1 (5.0)	70.4 (3.2)	8.6 (.07)	12.7 (.31)
<b>Biological maturity status</b>	<b>early</b> (n=36)	143.8 (4.7)	36.4 (3.0)	75.6 (2.0)	8.9 (.26)	12.3 (.14)
	<b>normal</b> (n=152)	135.8 (5.0)	30.9 (3.7)	71.2 (2.3)	9.0 (.27)	12.8 (.17)
	<b>late</b> (n=34)	129.6 (4.1)	25.8 (2.5)	67.1 (1.8)	9.2 (.26)	13.3 (.15)

APHV = age at peak height velocity; Q1-4 = relative age quarter 1-4

at the time of measurement were calculated. Based on the equations, the maturity offset as the time before or after individual peak height velocity (PHV) was then assessed. The predicted APHV could then be calculated as difference between chronological age and maturity offset. The validity of this method was previously confirmed (Müller et al., 2015) and the method is often used in studies among youth athletes (Deprez et al., 2013; Gil et al., 2014; Towlson et al., 2017). Based on previous studies (Sherar et al., 2007), the soccer players were then divided into three groups of maturity (late, normal and early maturing) based on the mean (M)  $\pm$  standard deviation (SD) of the APHV of the total sample (normal: APHV within M  $\pm$  SD; early: APHV < M - SD; late: APHV > M + SD). The validity of this classification was previously proven (Müller et al., 2015).

The study was performed according to the Declaration of Helsinki and was approved by the Institutional Review Board. Participants and coaches were informed of the study aims before written informed consent was provided.

### Statistical analyses

The differences between the observed and the expected relative age quarter distribution, chi<sup>2</sup>-tests ( $\chi^2$ ) were performed. The birth quarter distribution of all children from Germany, Switzerland and Austria born in the same birth year as the participants of the present study (2007) was considered as expected distribution (Q1: 24.1%; Q2: 24.2%; Q3: 27.1%; Q4: 24.6%). The effect size  $\omega$  was calculated for the  $\chi^2$ -tests (Sherar et al., 2007). Odds ratio (OR) and 95% confidence intervals (95% CI) were calculated (Cobley et al., 2009).

The normal distribution of the APHV was performed using Kolmogorov-Smirnov tests. The differences in APHV between the four relative age quarters were assessed by univariate analyses of variance (dependent variable: APHV; independent variable: relative age quarter). The variance homogeneity was assessed with Levene-Test and for post-hoc-tests, those of Scheffé were used. Additionally, the differences between the expected (normal) distribution of early, normal and late maturing athletes and the observed distribution (among each relative age quarter and for the total sample), were calculated by  $\chi^2$ -tests.

The level of significance was set at  $p < 0.05$ . All of the calculations were performed using IBM SPSS 23.0 (IBM Corporation, Armonk, NY, USA); the effect size was assessed using G\*Power 3.1.9.2 (University of Düsseldorf, Germany).

### Results

A relative age effect was found for the total sample of U9 soccer players ( $\chi^2$  (3,  $n = 222$ ) = 28.08;  $p < 0.001$ ;  $\omega = 0.35$ ) with an over-representation of athletes born in Q1 and an under-representation of athletes born in the last relative age quarter. The relative age quarter distribution is presented in Figure 1. The descriptive OR and the corresponding  $\chi^2$  for each quarter are presented in Table 2. The OR calculations revealed significant differences between Q1 and all other quarters. The likelihood of selection for the Eurochampionship was 2.7 to 4.9 times higher for a soccer player of the first relative age quarter compared to the other quarters.

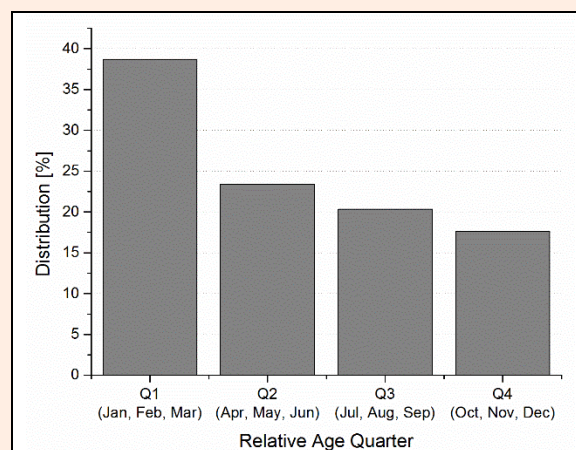


Figure 1. Relative age quarter distribution of the total sample.

Table 2. Descriptive odds ratio across all relative age quarters.

Quarter	Total		
	$\chi^2$	p	OR [95% CI]
Q1:Q2	8.377	.004	<b>2.73 [1.68, 4.45]</b>
Q1:Q3	12.832	<.001	<b>3.65 [2.19, 6.08]</b>
Q1:Q4	17.672	<.001	<b>4.86 [2.85, 8.30]</b>

Note: bolded values indicate significance of odds ratio (if 95% CI does not include 1). OR= odds ratio; CI = confidence interval

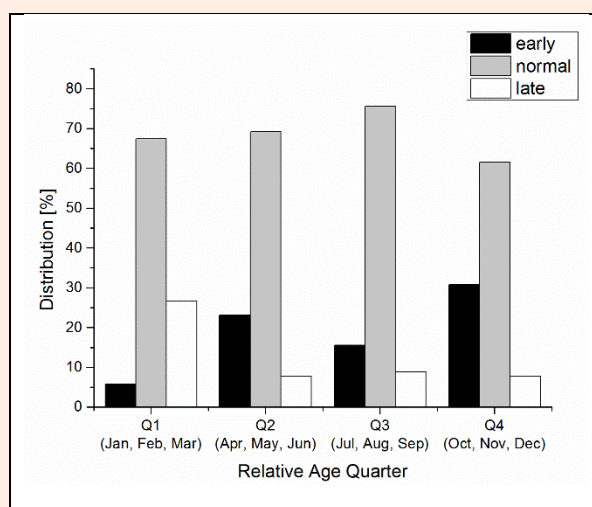


Figure 2. Distribution of early, normal and late maturing soccer players separated by relative age quarter

The univariate analyses of variance found a significant difference in APHV between the four relative age quarters ( $F(3,221) = 9.906$ ;  $p < 0.001$ ). Helmert-test revealed a significant difference between relative age quarter 1 and the other quarters ( $p < 0.001$ ). Post-hoc-tests revealed significant differences between relative age quarter 1 (mean APHV =  $12.96 \pm 0.3$ ) and Q2 (APHV =  $12.76 \pm 0.29$ ;  $p = 0.004$ ), as well as between relative age quarter 1 and Q4 (APHV =  $12.67 \pm 0.31$ ;  $p < 0.001$ ).

Most of the athletes were normal maturing (68.5%); 16.2% were early maturing and 15.3% were late maturing. The observed distribution of normal, early and late maturing athletes did not significantly differ from the expected

normal distribution ( $p = 0.077$ ). The distribution of early, normal and late maturing soccer players separated by relative age quarter is presented in Figure 2. A significant difference was found between the distribution of athletes of the first relative age quarter and the expected normal distribution ( $\chi^2 (2, n = 86) = 17.69; p < 0.001; \omega = 0.46$ ) because a comparable high percentage of late maturing athletes (27%) was present. Additionally, the observed distribution of early, normal and late maturing athletes of the last relative age quarter significantly differed from the expected normal distribution ( $\chi^2 (2, n = 39) = 12.08; p = 0.002; \omega = 0.58$ ) because a high percentage of early maturing athletes (31%) and a small percentage of late maturing athletes (8%) was present. No significant difference was found among athletes of the third relative age quarter ( $p = 0.668$ ); a tendency was present among athletes of the second relative age quarter ( $p = 0.054$ ) with a similar distribution as in relative age quarter 4 (early: 23%; late: 9%).

## Discussion

The present study was the first study that investigated the influence of the biological maturity status on the RAE in international under-9 soccer players. Participants of the U9 Eurochampionship Soccer Tournament in 2016 in Vienna were investigated and a RAE was found. Furthermore, only athletes of the first eligible birth year participated, whereas the younger athletes did not get the chance. Soccer players of the first relative age quarter were significantly less mature compared to the other quarters. Additionally, a significant difference was found between the observed distribution of early, normal and late maturing athletes of the last relative age quarter and the expected normal distribution; nearly one third of the athletes of Q4 were early maturing. Thus, the biological maturity status is strongly associated with the RAE in international under-9 soccer.

The RAE is a well-documented phenomenon at national and international levels of elite and adolescent soccer and at national levels of youth soccer (Sierra-Díaz et al., 2017). However, to date, several studies did not consider diverse age-cohorts (e.g., two years-cohort), and no study assessed the RAE at an international level among athletes younger than 9 years. As a consequence, the present study was the first study to investigate soccer players who were selected for the U9 Eurochampionship in 2016 in Vienna. Not surprisingly, a RAE was found, particularly since the observations of previous studies supported these findings at national levels or older age groups (Sierra-Díaz et al., 2017). More importantly, only athletes of the oldest eligible birth year participated in the tournament, younger athletes were not considered in the selection for the tournament. However, it has to be considered, that only half of the teams wanted to participate in the present study; thus, the results have to be interpreted with caution. Nevertheless, in the future, a fixed quota of athletes of the diverse eligible birth years might be considered in order to equalize the possibilities of the young talents.

Soccer players who were born in the first three months of the first eligible birth year (Q1) had a 2.7 to 4.9 times higher likelihood of selection compared to athletes of

Q2 (OR = 2.7; CI: 1.7-4.5), Q3 (OR = 3.7; CI: 2.2-6.1) and Q4 (OR = 4.9; CI: 2.9-8.3). Significant differences in the selection likelihood were found between Q1 and all other quarters, whereas in comparable studies at national youth levels, differences were mostly found only between Q1 and Q4. Müller et al. (2017) revealed a significant 5.7 times (CI: 3.7-8.9) higher likelihood of selection for Youth Development Centers in Austria for soccer players of Q1 compared to athletes of Q4. Among U11 and U12 Scottish youth soccer players the magnitude of the selection bias was smaller with OR of 2.7 (CI: 1.7-4.3) and 2.1 (CI: 1.4-3.2), respectively (McCunn et al., 2017). Among international adolescent soccer players participating at the UEFA Youth League in 2014/2015, OR of 3.4 (CI: 2.8-4.0) were found between athletes of Q1 and Q4 (Takacs and Romann, 2016). The significant higher likelihood of Q1 compared to all three other quarters, and not only Q4, might be explained by the very high selection pressure prior to the national nomination process for the championship in the participating teams from 18 differing countries. The present findings revealed that the selection system in international under-9 soccer is biased and discriminates against relatively younger athletes. Thus, in the future, strategies have to be considered in order to contribute to more fairness and to not exclude relatively younger athletes. Gutierrez Diaz Del Campo et al. (2010) showed that the main cause of RAE seems to be the talent identification process. They argue that clubs or soccer academies must raise the awareness of this problem and train the coaches, trainer, scouts and directors with this in mind. More importantly, they should be kept informed that the real potential of a soccer player might not become apparent until they are fully mature (Gutierrez Diaz Del Campo et al., 2010). Another possibility with respect to the competition system at national levels might be a rotating cut-off date for grouping athletes into competition categories because in case, all athletes would benefit from relative age advantages throughout their talent development phases (Hurley et al., 2001). To better understand the underlying factors of the selection bias, the role of the biological maturity status on the selection of international soccer players younger than 9 years was evaluated in the present study.

In accordance with a previous study in national soccer (Müller et al., 2017), a significant difference was found in APHV between the four relative age quarters. Athletes of Q1 were significantly less mature compared to the other quarters; they will reach their individual peak growth spurt in mean 3.6 months later than athletes of Q4. Sherar and colleagues (2007) assessed that with every 1-month increase in APHV, adolescent male ice hockey players became 17% less likely to be selected for competitive squads. Nevertheless, these findings show that relatively older soccer players have an increased likelihood of selection independent of their biological maturity status, whereas relatively younger athletes have to be more mature to be selected. As a consequence, these results demonstrate that talent identification systems are biased; it seems that relatively younger and less mature athletes are excluded during the selection process. However, it has to be considered that all other factors contributing to talent

development (e.g., training processes, training age, training quality etc.) were not controlled in the present study.

As performed in the study by Deprez et al. (2013) and as suggested by Sherar et al. (2007), the athletes were divided into three groups of maturity status: early, normal and late maturing soccer players. The distribution did not significantly differ from the expected normal distribution, however a tendency can be observed ( $p=0.077$ ). A more detailed analysis of the distribution of the three maturity groups separated by relative age quarter revealed that the percentage of early maturing soccer players increased from Q1 to Q4, whereas the percentage of late maturing athletes decreased. A significant difference between the observed distribution of the maturity groups and the expected normal distribution was found for Q1 and Q4, a trend was shown for Q2. Among the athletes of Q1 a biased distribution was found compared to an expected normal distribution with a relatively high percentage of late maturing athletes (27%). In contrast, among the relatively younger athletes (Q4) a high percentage of early maturing (31%) and only a small percentage of late maturing soccer players (8%) was present. These results underline the prior mentioned assumption that talent identification processes in youth soccer discriminate against relatively younger and less mature athletes; thus, it can be presumed that a lot of talented young soccer players who are delayed in their development and who additionally might be born late in the year, are denied access to highly qualified and professional training facilities. These findings are in line with the results of the study performed by Deprez et al. (2013); they demonstrated that early maturing soccer players were overrepresented in the last relative age quarter, whereas late maturing athletes were overrepresented in the first relative age quarter. They concluded that athletes of the last relative age quarter may have an increased chance of selection (despite their relatively younger age) if they reach their individual peak growth spurt (PHV) at an earlier age, whereas athletes of the first relative age quarter have an increased chance of selection independent of their biological maturity status. Similar results were found also at national levels of youth soccer; 43% of the athletes of the last relative age quarter who were selected for Elite Youth Development Centers in Austria were early maturing (Müller et al., 2017). In this context, one possibility to contribute to more fairness in the talent development in soccer could be bio-banding, a concept of grouping children on the basis of physical rather than chronological age (Cumming et al., 2017). However, within this concept the psychological and tactical development of young soccer players is not considered. Therefore, a more effective talent development program might include both age group and bio-banded activities, which offer the athletes a multifaceted learning stimulus (Cumming et al., 2017). Considering this, young athletes are challenged to deal with regularly changing training partners, coaches and requirements. Additionally, Tucker et al. (2016) argued that a "hybrid" approach, which might include monthly or bimonthly bio-banded competitions in addition to the normal game program, would expose athletes to a broader range of learning contexts and challenges.

The results of the present study show that already at the ages of about 9 years, the biological maturity status has

a strong association with the relative age effect and thus, with the selection in international elite under-9 soccer. It can be hypothesized that a lot of talents get lost because relatively younger and less mature athletes may be denied access to elite training, and consequently, they do not have the same opportunities for reaching their full potential (Torres-Unda et al., 2016).

### Limitation

The results showed that it would be possible to be young by relative age and average by maturation, and nevertheless be selected for the tournament. Therefore, it has to be considered as limitation of the present study, that the measurements could only be performed once during the tournament; thus, growth processes and the association with training sequences could not be considered. As a consequence, future studies should focus on follow-up investigations including the examination of the impact of training and puberty on selection in youth soccer.

Another limitation of this study is the assessment of the biological maturity status. As performed in several studies including youth athletes (e.g., Gil et al., 2014), the biological maturity was assessed using the APHV-method. This method is often criticized because it seems that predictions of PHV are dependent on age and body size at prediction and that a large standard deviation was found (Cumming et al., 2017; Malina & Koziel, 2014). Additionally, the validity of this method was only assessed on Caucasian boys aged 10-15 years (Malina & Koziel, 2014), and on Austrian youth ski racers and pupils of the same age aged 10-13 years (Müller et al., 2015). The more accurate method would be the x-rays of the left wrist, which, however, are limited in its practicability (radiation, medical expertise, costs) (Lloyd et al., 2004).

### Conclusion

Up to now, studies have focused on within-one-year RAE in national and international youth soccer. The present study showed that the selection of young soccer players for an international tournament was biased because only athletes of the oldest eligible birth year were selected, whereas it has to be considered that only half of the teams participating at the tournament could be examined. Nevertheless, a clear RAE was present with more than 40% of the athletes being born in the first three months of the year.

To the author's knowledge, the influence of the biological maturity status on the RAE in national youth soccer was examined among athletes older than 10 years, yet. Therefore, the present study was the first to assess this influence in international soccer among athletes younger than 10 years of age. In accordance with previous studies at national levels (Johnson et al., 2017; Towlson et al., 2017; Müller et al., 2017), the present study revealed that the selection of international elite soccer players younger than 9 years is strongly associated with the biological maturity status and the relative age. Relatively younger soccer players seem to have a better chance for selection for international tournaments, if they enter puberty at an earlier age, whereas relatively older athletes seem to have an increased likelihood for selection independent of their biological

maturity status. However, it has to be considered that the athletes who were not selected for the tournament could not be examined; therefore, the interpretation of these results should be taken with caution. As a consequence, in the future, the biological maturity status and the relative age have to be considered in the talent selection process in national and international youth soccer in order to not exclude relatively younger and less mature athletes (Torres-Unda et al., 2016). In this context, a more effective talent development program might include both age group and bio-banded activities, which offer the athletes a multifaceted learning stimulus (Cumming et al., 2017). Additionally, a “hybrid” approach of including monthly or bimonthly bio-banded competitions in addition to the normal game program, would expose athletes to a broader range of learning contexts and challenges. However, the assessment of the biological maturation still remains a challenge in the youth sport context, upon which the classification of the athletes with respect to bio-banding would be possible.

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### References

- Baker, J., Janning, C., Wong, H., Cobley, S. and Schorer, J. (2014) Variations in relative age effects in individual sports: Skiing, figure skating and gymnastics. *European Journal of Sport Science* **14**, 183-190.
- Cobley, S., Baker, J., Wattie, N. and McKenna, J. (2009) Annual age-grouping and athlete development. A meta-analytical review of relative age effects in sports. *Sports Medicine* **39**, 235-256.
- Cumming, S. P., Lloyd, R. S., Oliver, J. L., Eisenmann, J. C. and Malina, R. M. (2017) Bio-banding in sport: applications to competition, talent identification, and strength and conditioning of youth athletes. *Strength and Conditioning Journal* **39**, 34-47.
- Deprez, D., Coutts, A. J., Deconinck, F., Lenoir, M., Vaeyens, R. and Philippaerts, R. (2013) Relative age, biological maturation and anaerobic characteristics in elite youth soccer players. *International Journal of Sports Medicine* **24**, 897-903.
- Gil, S., Badiola, A., Bidaurreaga-Letona, I., Zabala-Lili, J., Gravina, L., Santos-Concejero, J., Lekue, J.A. and Granados, C. (2014) Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *Journal of Sports Sciences* **32**, 479-486.
- Gutierrez Diaz Del Campo, D., Pastor Vicedo, J. C., Gonzalez Villora, S. and Contreras Jordan, R. C. (2010) The relative age effect in youth soccer players from Spain. *Journal of Sports Science and Medicine* **9**, 190-198.
- Hancock, D. J., Seal, K., Young, B. W., Weir, P. L. and Ste-Marie, D. M. (2013) Examining mechanisms that contribute to relative age effects in pre-pubescent female ice hockey players. *Talent Development and Excellence* **5**, 59-66.
- Helsen, W. F., van Winckel, J. and Williams, A. M. (2005) The relative age effect in youth soccer across Europe. *Journal of Sports Sciences* **23**, 629-636.
- Hurley, W., Lior, D. and Tracze, S. (2001) A proposal to reduce the age discrimination in Canadian minor hockey. *Canadian Public Policy* **27**, 65-75.
- Johnson, A., Farooq, A. and Whiteley, R. (2017) Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Science and Medicine in Football* **1**, 157-163.
- Lames, M., Augste, C., Dreckmann, C., Görsdorf, K. and Schimanski, M. (2008) Der „Relative Age Effect“ (RAE): neue Hausaufgaben für den Sport [„Relative Age Effect“ (RAE): new homework for the sport]. *Leistungssport* **37**, 4-9.
- Lloyd, R. S., Oliver, J. L., Faigenbaum, A. D., Myer, G. D. and De Ste Croix, M. B. A. (2004) Chronological age vs. biological maturation: implications for exercise programming in youth. *Journal of Strength and Conditioning Research* **28**, 1454-1464.
- Malina, R. M., Eisenmann, J. C., Cumming, S. P., Ribeiro, B. and Aroso, J. (2004) Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. *European Journal of Applied Physiology* **91**, 555-562.
- Malina, R. M. and Koziel, S. M. (2014) Validation of maturity offset in a longitudinal sample of Polish boys. *Journal of Sports Sciences* **32**, 424-437.
- McCunn, R., Weston, M., Hill, J. K. A., Johnston, R. D. and Gibson, N. V. (2017) Influence of physical maturity status on sprinting speed among youth soccer players. *Journal of Strength and Conditioning Research* **31**, 1795-1801.
- Mirwald, R. L., Baxter-Jones, A. D. G., Bailey, D. A. and Beunen, G. P. (2002) An assessment of maturity from anthropometric measurements. *Medicine and Science in Sports and Exercise* **34**, 689-694.
- Müller, L., Müller, E., Hildebrandt, C., Kapelari, K. and Raschner, C. (2015) Die Erhebung des biologischen Entwicklungsstandes für die Talentselektion – welche Methode eignet sich? [The assessment of biological maturation for talent selection – which method can be used?] *Sportverletzung Sportschaden* **29**, 56-63. (In German: English abstract).
- Müller, L., Gonaus, C., Perner, C., Müller, E. and Raschner, C. (2017) Maturity status influences the relative age effect in national top level youth alpine ski racing and soccer. *PLoS ONE* **12**, e0181810.
- Musch, J. and Grondin, S. (2001) Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review* **21**, 147-167.
- Romann, M. and Cobley, S. (2015) Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS One* **10**, e0122988.
- Schorer, J., Wattie, N. and Baker, J. (2013) A new dimension to relative age effects: constant year effects in German youth handball. *PLoS One* **8**, e60336.
- Sherar, L. B., Baxter-Jones, A. D. G., Faulkner, R. A. and Russell, K. W. (2007) Do physical maturity and birth date predict talent in male youth ice hockey players? *Journal of Sports Sciences* **25**, 879-886.
- Sierra-Diaz, M. J., González-Villora, S., Pastor-Vicedo, J. C. and Serrano-Olivares, J. (2017) Soccer and relative age effect: a walk among elite players and young players – a review. *Sports* **5**, 5.
- Steingröver, C., Wattie, N., Baker, J., Helsen, W. F. and Schorer, J. (2017) The interaction between constituent year and within-1-year effects in elite German youth basketball. *Scandinavian Journal of Medicine and Science in Sports* **27**, 627-633.
- Takacs, S. and Romann, M. (2016) Selection of the oldest: relative age effects in the UEFA youth league. *Talent Development and Excellence* **8**, 41-51.
- Torres-Unda, J., Zarrasquin, I., Gravina, L., Zubero, J., Seco, J., Gil, S. M., Gil, J. and Irazusta, J. (2016) Basketball performance is related to maturity and relative age in elite adolescent players. *Journal of Strength and Conditioning Research* **30**, 1325-1332.
- Towson, C., Cobley, S., Midgley, A. W., Garrett, A., Parin, G. and Lovell, R. (2017) Relative age, maturation and physical biases on position allocation in elite-youth soccer. *International Journal of Sports Medicine* **38**, 201-209.
- Tucker, R., Raftery, M. and Verhagen E. (2016) Injury risk and tackle ban in youth rugby union: reviewing the evidence and searching for targeted, effective interventions: a critical review. *British Journal of Sports Medicine* **50**, 921-925.

### Key points

- The relative age strongly influenced the selection in international elite under-9 soccer.
- A significant association of the biological maturity status with the selection was present among soccer players younger than 9 years – relatively older athletes were significantly less mature compared to relatively younger players.
- The biological maturity status is strongly associated with the relative age effect among international soccer players younger than 9 years – relatively younger athletes seem to have a better chance for selection for an international tournament if they are early maturing, whereas relatively older athletes have an increased chance independent of their biological maturity status.

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