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Research article

The Role of a Relative Age Effect in the 7th International Children's Winter Games 2016 and the Influence of Biological Maturity Status on Selection

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Abstract

The aim of this study was to analyse the role of a relative age effect (RAE) and to investigate the influence of biological maturity status on the RAE at the 7th International Children`s Winter Games. The birth dates of all 572 participants (365 males, 207 females) were analysed, and the biological maturity status of 384 athletes (243 males, 141 females) was assessed by the age at peak height velocity (APHV) method. A RAE was present in the total sample (χ^2 = 67.81; $p < 0.001$), and among both male (χ^2 = 49.02; $p < 0.001$) and female athletes (χ^2 = 37.00; $p < 0.001$) as well as for strength- (χ^2 = 56.46; $p < 0.001$), endurance- (χ^2 = 20.48; p = 0.039) and technique-related types of sports (χ^2 = 20.48; p = 0.041). No significant differences in biological maturity status were present between the male athletes of single relative age quarters. Among the female athletes a significant difference was present (F = 5.94, $p < 0.001$); relatively younger female athletes had significantly lower values in the APHV, which indicated that they were maturing earlier. However, when dividing the athletes into normal, early and late maturing athletes, it could be seen that among the relatively younger athletes, hardly any late maturing athletes were present. These findings revealed that relatively younger athletes seemed to only have a chance for selection if they were early maturing, whereas relatively older athletes had an increased likelihood for selection independent of their biological maturity status. In the future, the relative age and the biological maturity status should be considered in the talent development system for various types of winter sport, to contribute to more fairness and to not discriminate against relatively younger and less mature athletes.

Key words: Birth quarter distribution, maturation, major single junior winter event, talent development

Introduction

The first International Children's Summer Games was held in Slovenia in 1968, and the first International Children's Winter Games (ICG) was held in Canada in 1994. Since then, 49 summer and 6 Winter Children's Games have been organized (www.innsbruck2016.com/ueber-uns/icg-geschichte/). The main goal of the Games is to bring together young athletes from all over the world to compete against each other in friendship. Apart from the European Youth Olympic Festival (EYOF) and the Youth Olympic Games (YOG), the International Children's Games are an important venue for young athletes to present their talent on an international platform. The 7th ICG were held in Innsbruck, Austria in 2016 for 12- to 15-year-old athletes. Overall, 572 young athletes from 22 different countries participated in eight sports.

Only a limited number of athletes in each discipline and for both sexes within in each nation were allowed to participate. Thus, it can be assumed that these restrictions could have led to high selection pressure within each nomination process, which could have caused a so-called *relative age effect* (RAE) (Barnsley and Thompson, 1985). This well-documented phenomenon exists when the relative age quarter distribution of a selected sports group shows a biased distribution with over-representation of relatively older athletes (i.e., athletes whose birth months are close after the cut-off date for the classification of the selection year) (Musch and Grondin, 2001). The existence of a RAE indicates a severe loss of talent; because talent in a sport does not depend on birth month (Lames et al., 2008). Thus, the biased distribution of the relative age quarters shows that various talent development systems are biased against relatively younger athletes. They have fewer opportunities in reaching the elite level despite their talents and efforts (Musch and Grondin, 2001).

This RAE was first documented in Canadian ice hockey (Barnsley and Thompson, 1985), and since then, its presence has been assessed in many other sports, as well. It has mostly been investigated separately in diverse types of sports, but data on a single major junior winter event are lacking. Only two studies have investigated the role of a RAE in such junior winter events: one study assessed the occurrence of the RAE at the first Winter YOG in 2012 in Innsbruck (Raschner et al., 2012), and another study examined the 12th winter EYOF in Vorarlberg (Austria) and Liechtenstein (Müller et al., 2016a). At both events, two birth years were allowed to participate in each discipline, which led to possible age differences of up to two years between athletes participating in the same competition. Therefore, not surprisingly, at both events a highly significant RAE was found. Additionally, a significant RAE was found for strength- and endurance-related winter sport disciplines; at the YOG, a significant effect was present among athletes participating in technique-related sports, which was not the case at the EYOF. In technique-related winter sports, technical components predict performance. Thus, a maturation-related developmental lead is not considered to be an advantage. Additionally, in technique-related sports such as figure skating, it is even advantageous to be less mature, since peak performance age in these sports is often reached during the adolescent years (Baker et al., 2014). Another important finding was that relative age influenced not only the participation rate of the junior events, but also performance because highly significantly more relatively older athletes

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were able to win a medal at both events. Considering the high importance of these single major junior events where youth athletes can showcase their talents, each athlete should have the same opportunity to participate and to be able to win medals. However, both studies have clearly demonstrated the discrimination against relatively younger athletes in winter sport disciplines, and therefore, the underlying factors should be assessed. (Müller et al., 2016a)

Baker et al. (2014) showed that talent identification systems often promoted selection biases that confuse maturation for talent (so-called `maturation hypothesis`), which contributes to the fact that the relative age of an athlete is often related to his/her physical and cognitive maturation. The selection of athletes is often influenced by maturational differences between athletes born early and late in the selection year (Baker et al., 2014). Considering the short-term talent development process, relatively older and early maturing athletes are favourably selected as potentially more talented, and less mature. As a consequence, relatively younger athletes are often overlooked and are not provided the same opportunities (Malina et al., 2004; Romann and Cobley, 2015). Based on this result, the combination of a relatively older age and advanced physical maturation leads to a selection advantage, and consequently, to the RAE (Baker et al., 2014; Bjerke et al., 2016; Cobley et al., 2009; Romann and Cobley, 2015). Additionally, Till et al. (2014) showed that the selection of relatively older and early maturing athletes may be counterproductive in the long term because it probably excludes equally skilled relatively younger athletes from reaching an elite level due to their delayed physical characteristics. Therefore, it seems important to assess the influence of biological maturity status on the RAE and on the selection process prior to a major single junior winter event. It can be assumed that biological maturity status could probably be an important factor in the selection process for events such as it was in alpine ski racing (Müller et al., 2016b).

The RAE was seen at two single major junior winter events at the international and European level. However, the role of the RAE within a major single junior winter event with younger participants than at the YOG (15- to 19-year-old athletes) and at the EYOF (15- to 18-year-old athletes) has not been investigated. Additionally, in the ICG, three birth years were allowed to participate, which could have led to age differences of up to three years between individuals competing in the same competition. It can be assumed that the selection bias could be even greater. However, the role of the RAE in the 7th ICG in 2016 has yet to be assessed. The influence of biological maturity status on the selection of the athletes for such single major junior winter events has not been investigated, as well.

Therefore, the aim of the present study was to investigate the role of the RAE and additionally, to investigate the influence of biological maturity status on the RAE at the 7th ICG held in Innsbruck in 2016.

Methods

Participants

In total, data from all 572 participants (365 males, 207 females) of the 7th ICG 2016 from 22 different countries were evaluated in the present study. The mean age of the participants was 13.8 ± 0.84 years and ranged from 12.1 to 15.0 years. Some nations did not want to participate in the analyses concerning the biological maturity status of their athletes, so the biological maturity status analysis was limited to 384 athletes (243 males, 141 females), which corresponded to a compliance of 67%. Table 1 presents the anthropometric data (means and standard deviations) for male and female athletes separated by type of sport and eligible age groups.

Procedures

The organizing committee of the ICG provided a list with the birthdates of all participants. The cut-off date used for the competition categories was January 1 in general in the single disciplines of the ICG. In all disciplines, athletes who were born in 2001-2003 were eligible to participate. Since three birth years were allowed to participate in all sports, the birth months and the birth years (2001-2003) were used to establish twelve groups of relative age quartiles, not the four groups that are typical in RAE research. The months of the first eligible birth year (2001; 1) were split into relative age quartiles (Q1(1)-Q4(1)) as follows (the number in parenthesis after the quartile corresponds to the eligible birth year): Q1(1) includes the months January, February and March; Q2(1) the months April, May, and June; Q3(1) the months July, August, and September; Q4(1) the months October, November, and December of the first eligible birth year (2001). Similarly, the months of the second (2002; 2) and third eligible birth years (2003; 3) were split into the relative age quarters Q1(2) – Q4(2) and Q1(3) – Q4(3), as well.

Similar to the study of the 1st YOG in 2012 (Raschner et al., 2012) and the 12th winter EYOF in 2015 (Müller et al., 2016a), the different sports were divided into three groups (strength-, endurance- and technique-

Table 1. Anthropometric data and age at peak height velocity of participants according to sport and age group. Data are means (±SD).

		Male			Female		
		Height [m]	**Weight [kg]**	**APHV [yrs]**	**Height [m]**	**Weight [kg]**	**APHV [yrs]**
Type of sport	Strength-related	1.65 (.09)	56.7 (11.4)	13.9 (.6)	1.61 (.07)	53.6 (8.5)	12.3 (.5)
	Endurance-related	1.63 (1.00)	51.4 (9.0)	14.0 (.6)	1.60 (.05)	52.0 (7.0)	12.4 (.4)
	Technique-related	161 (.08)	52.6 (11.8)	14.0 (.6)	1.65 (.07)	50.0 (8.1)	12.5 (.4)
Age group	First year	1.70 (.07)	60.7 (10.2)	13.9 (.6)	1.62 (.06)	54.3 (7.3)	12.6 (.4)
	Second year	1.62 (.08)	51.8 (8.5)	14.0 (.6)	1.59 (.06)	51.7 (7.4)	12.3 (.4)
	Third year	1.55 (.06)	45.0 (7.7)	14.0 (.5)	1.57 (.06)	48.1 (8.1)	12.0 (.4)
Total		1.64 (.09)	54.4 (11.0)	14.0 (.6)	1.60 (.06)	52.2 (7.9)	12.4 (.5)

APHV = age at peak height velocity

related sports) to establish a RAE in various types of sports. Strength- and endurance-related sports were categorized based on the performance-predictive roles of power and endurance; whereas, technique-related sports were identified by the criteria of judging points (Müller et al., 2016a; Raschner et al., 2012). Alpine skiing and ice hockey were categorized as strength-related sports. Biathlon, cross-country skiing and speed skating were categorized as endurance-related sports, and figure skating, snowboarding and freestyle skiing were designated technique-related sports.

The non-invasive method of calculating the age at peak height velocity (APHV) proposed by Mirwald et al. (2002) was used to assess biological maturity status. For these sex-specific prediction equations, the following anthropometric parameters were recorded according to previously described procedures (Malina and Koziel, 2014): body mass (0.1 kg, Seca, Hamburg, Germany), body height (0.1 cm, Seca Portable Stadiometer, Hamburg, Germany) and sitting height (0.1 cm, Seca Portable Stadiometer, Hamburg, Germany; sitting height table). All measurements were performed without shoes. The anthropometric data were measured by two experienced members of the study team. Every participant was measured by each member of the study team. If different values were measured (cut-off 0.1 cm), the measurements were repeated by both members. Additionally, leg length was defined as the difference between body height and sitting height, and actual chronological age at the time of measurement was calculated. Using these parameters in the prediction equations, the maturity offset, as the time before or after peak height velocity, could be predicted. The predicted APHV could then be calculated as the difference between chronological age and maturity offset. As suggested by Sherar et al. (2007), the participants were divided into three maturity groups: late, normal and early maturing. The categorization was based on the mean (M) ± standard deviation (SD) of the APHV of the total sample and separated by sex. An athlete was classified as normal maturing if his or her APHV was within M ± SD, early maturing if his or her APHV was less than M – SD, and late maturing if his or her APHV was higher than M + SD. This study was approved by the institutional review board of the Department of Sport Science of the University of Innsbruck. The responsible National City delegations provided written informed consent for their athletes.

Statistical analysis

To assess the differences between the expected and the observed relative age quarter distributions, a chi-square (χ^2) test was used for the total sample and for samples separated by sex and sports group. Similar to previous research studies, an equal distribution among the quarters was assumed (Helsen et al., 2005; Sherar et al., 2007). The relative age quarter distribution of the general populations of Austria, Germany and Switzerland for the same birth years as the participants of the ICG (2001-2003) showed an equal distribution among the relative age quarters. The effect size ω was calculated for the χ^2- tests, as proposed by Wattie et al. (2008). Odds ratios (*OR*) and 95% confidence intervals (95% *CI*) were calculated for the relative age quarter distribution of the total sample and according to sex and sports group, as proposed by Cobley et al. (2009).

The normal distribution of APHV was tested using the Kolmogorov-Smirnov test (separated by sex, sports group and single relative age quarters). To evaluate differences in the APHV between the three sports groups, univariate analyses of variance were used (dependent variable: biological maturity status; independent variable: sports group). Analyses of variance were also used to assess differences in the biological maturity status between athletes of the single relative age quarters (dependent variable: biological maturity status; independent variable: relative age quarter). The variance homogeneity was assessed with the Levene test, the contrasts were examined with the Helmert test, and for post-hoc-tests, Scheffé tests were used. To evaluate the difference between the expected (normal) distribution of early, normal and late maturing athletes in the total samples and among each relative age quarter as well as the observed distribution (separated by sex), χ^2- tests were used. The level of significance was set at $p < 0.05$, and high significance was set at $p < 0.01$. All of the calculations were performed using IBM Statistics 21.0, and the effect size was assessed using G*Power 3.1.9.2.

Results

Alpine skiing had the highest participation rates among the total sample (28.7% of all athletes) and the female athletes (24.7%). Among male athletes, ice hockey had the highest participation rate (36.2%; no female ice hockey). The majority of both male (46.8%) and female athletes (47.8%) were born in the first eligible birth year (2001). The distribution of the participants according to sex, eligible age group and sport discipline is presented in Table 2.

A significant difference between the expected equal distribution and the relative age quarter distribution of the total sample was shown ($\chi^2(11, n = 572) = 67.81$, $p < 0.001$, $\omega = 0.34$) with an over-representation of athletes born at the beginning of the first eligible age group and an under-representation of athletes born in the last relative age quarters (Table 3). Among both male ($\chi^2(11, n = 365) = 49.02$, $p < 0.001$, $\omega = 0.37$) and female athletes ($\chi^2(11, n = 207) = 37.00$, $p < 0.001$, $\omega = 0.42$) a highly significant difference in the relative age quarter distribution was present compared to an equal distribution (Table 3). The descriptive odds ratio and the corresponding χ^2 for each quarter for the overall sample and separated by sex are presented in Table 4. The effect size increased with the quarter from Q2(1) to Q4(3) for the total sample and for both sexes. In the total sample, the likelihood of selection for the ICG of a relatively older athlete was 3.5 times higher than for an athlete from the last relative age quarter. Among the male athletes, the likelihood was 3.1 times higher and among the female athletes, it was 4.2 times higher.

The χ^2-calculations based on the type of sport revealed that a highly significant difference was present between the expected and observed relative age quarter

Table 2. Eligibility of participants according to sex and sport discipline.

Sport	Male							Female							Total (n)
	2001		2002		2003			2001		2002		2003			
	n	%	n	%	n	%	Total (n)	n	%	n	%	n	%	Total (n)	
Alpine Skiing	44	48.9	29	32.2	17	18.9	90	36	48.6	16	21.6	22	29.7	74	164
Biathlon	10	45.5	6	27.3	6	27.3	22	10	45.5	6	27.3	6	27.3	22	44
Cross-Country Skiing	12	28.6	19	45.2	11	26.2	42	22	55.0	7	17.5	11	27.5	40	82
Figure Skating	6	54.4	2	18.2	3	27.3	11	17	51.1	9	27.3	7	21.2	33	44
Freestyle Skiing	13	56.5	6	26.1	4	17.4	23	2	25.0	1	12.5	5	62.5	8	31
Ice Hockey	60	45.5	49	37.1	23	17.4	132	None	None	None	None	None	None	None	132
Snowboard	10	55.6	6	33.3	2	11.1	18	5	55.6	1	11.1	3	33.3	9	27
Speed Skating	16	59.3	5	18.5	6	22.2	27	7	33.3	11	52.4	3	14.3	21	48
Total (n)	171		122		72		365	99		51		57		207	572

Table 3. Relative age quarter distribution of total sample and separated for sex, type of sport and biological maturity status.

Category		Relative age quarter distribution												Total (n)
		First eligible year (1)				Second eligible year (2)				Third eligible year (3)				
		Q1(1)	Q2(1)	Q3(1)	Q4(1)	Q1(2)	Q2(2)	Q3(2)	Q4(2)	Q1(3)	Q2(3)	Q3(3)	Q4(3)	
		[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	
Total sample	**Total**	13.8	11.9	11.0	10.5	9.8	6.6	7.7	6.1	6.5	7.0	4.7	4.4	572
	Male	11.8	11.8	13.2	10.1	10.7	7.1	9.3	6.3	5.2	6.3	4.1	4.1	365
	Female	17.4	12.1	7.2	11.1	8.2	5.8	4.8	5.8	8.7	8.2	5.8	4.8	207
Type of sport	**Str-Rel**	14.5	14.9	10.5	7.4	12.2	6.4	7.4	5.7	6.1	7.1	4.4	3.4	296
	End-Rel	13.2	6.9	9.8	14.4	8.0	8.6	8.6	5.7	5.2	8.6	5.7	5.2	174
	Tech-Rel	12.7	11.8	14.7	12.7	5.9	3.9	6.9	7.8	9.8	3.9	3.9	5.9	102
Biological Maturity Status	**Early**	4.9	8.2	13.1	13.1	8.2	9.8	8.3	3.3	8.2	8.2	8.2	6.6	61
	Normal	12.4	11.2	10.9	11.6	12.0	6.6	8.5	5.4	5.4	6.6	5.4	3.9	258
	Late	21.5	16.9	9.2	10.8	6.2	7.7	7.7	9.2	6.2	4.6	None	None	65
	NM	16.0	12.2	11.2	8.0	8.5	5.3	6.4	6.9	7.4	8.0	4.3	5.9	188

Str-Rel = Strength-related; End-Rel = Endurance-related; Tech-Rel = Technique-related; NM = Not measured

Table 4. Descriptive odds ratio across all relative age quarters according to sex.

Quarter	Total			Male			Female		
	χ^2	p	OR [95% CI]	χ^2	p	OR [95% CI]	χ^2	p	OR [95% CI]
Q1(1):Q2(1)	0.82	.364	1.18 [0.84, 1.68]	0.00	1.00	1.00 [0.64, 1.57]	1.98	.159	1.53 [0.88, 2.67]
Q1(1):Q3(1)	1.80	.179	1.29 [0.91, 1.84]	0.28	.600	0.88 [0.57, 1.37]	8.65	.003	2.69 **[1.43, 5.10]**
Q1(1):Q4(1)	2.60	.107	1.37 [0.96, 1.96]	0.45	.502	1.18 [0.74, 1.89]	2.86	.091	1.68 [0.96, 2.96]
Q1(1):Q1(2)	3.92	.048	1.48 **[1.03, 2.12]**	0.20	.659	1.12 [0.70, 1.77]	6.81	.009	2.35 **[1.28, 4.34]**
Q1(1):Q2(2)	14.37	<.001	2.25 **[1.50, 3.38]**	4.19	.041	1.74 **[1.05, 2.90]**	12.00	.001	3.42 **[1.72, 6.79]**
Q1(1):Q3(2)	9.96	.002	1.92 **[1.30, 2.84]**	1.05	.305	1.30 [0.81, 2.09]	14.70	<.001	4.15 **[2.00, 8.61]**
Q1(1):Q4(2)	16.98	<.001	2.46 **[1.62, 3.73]**	6.06	.014	1.99 **[1.17, 3.27]**	12.00	.001	3.42 **[1.72, 6.79]**
Q1(1):Q1(3)	15.21	<.001	2.32 **[1.54, 3.49]**	9.29	.002	2.43 **[1.39, 4.26]**	6.00	.014	2.21 **[1.21, 4.04]**
Q1(1):Q2(3)	12.78	<.001	2.13 **[1.43, 3.18]**	6.06	.014	1.99 **[1.17, 3.37]**	6.81	.009	2.35 **[1.28, 4.34]**
Q1(1):Q3(3)	25.51	<.001	3.23 **[2.06, 5.09]**	13.52	<.001	3.12 **[1.70, 5.72]**	12.0	.001	3.42 **[1.72, 6.79]**
Q1(1):Q4(3)	28.04	<.001	3.51 **[2.20, 5.59]**	13.52	<.001	3.12 **[1.70, 5.72]**	14.7	<.001	4.15 **[2.00, 8.61]**

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

distribution in the strength-related types of sport (χ^2(11, n = 296) = 56.46, p < 0.001, *ω* = 0.44). A significant difference was also present in the endurance-related (χ^2(11, n = 174) = 20.48, p = 0.039, *ω* = 0.34) and the technique-related types of sport (χ^2(11, n = 102) = 20.35, p = 0.041, *ω* = 0.45). Thus, a strong RAE was shown (Table 3). A closer examination of the different disciplines revealed RAEs in alpine skiing (χ^2(11, n = 164) = 38.6, p < 0.001, *ω* = 0.49) and ice hockey (χ^2(11, n = 132) = 30.91, p = 0.001, *ω* = 0.48). The descriptive odds ratio and the corresponding χ^2 for each quarter for the three groups of sports are presented in Table 5. In strength-related sports, the relatively older athletes had a 4.9 times higher likelihood of selection for the ICG than athletes from the last relative age quarter. In endurance-related sports, the likelihood was 2.8 times higher for an athlete from Q1(1) compared to an athlete from Q4(3). In technique-related sports, the likelihood was 3.6 times higher for an athlete of the first relative age quarter compared to an athlete of Q3(3).

The anthropometric parameters and the calculated APHV of the athletes participating in the study concerning the biological maturity status (n = 384) separated by sex, type of sport and eligible age group are presented in Table 1. These parameters are separated by relative age quarter in Table 6. As shown in Table 6, male athletes of the twelve relative age quarters significantly differed in height (*F*(11, 243) = 15.26, p < 0.001) and weight (*F*(11, 243) = 10.97, p < 0.001). Post-hoc tests revealed that athletes of the first four relative age quarters (Q1(1)-Q4(1)) were significantly taller (p < 0.001) and heavier (p < 0.001) than the relatively younger athletes of the other relative age quarters. The female athletes of the single

Table 5. **Descriptive odds ratio across all relative age quarters according to type of sport.**

	Strength			Endurance			Technique		
Quarter	χ^2	**p**	**OR [95% CI]**	χ^2	**p**	**OR [95% CI]**	χ^2	**p**	**OR [95% CI]**
Q1(1):Q2(1)	0.01	.915	0.97 [0.62, 1.53]	3.46	.063	2.06 [0.99, 4.23]	0.04	.841	1.10 [0.47, 2.53]
Q1(1):Q3(1)	1.95	.163	1.45 [0.89, 2.38]	0.90	.343	1.41 [0.72, 2.74]	0.14	.705	0.8 [0.38, 1.88]
Q1(1):Q4(1)	6.79	.009	2.12 **[1.23, 3.64]**	0.08	.773	0.91 [0.49, 1.67]	0.00	1.00	1.00 [0.44, 2.28]
Q1(1):Q1(2)	0.62	.431	1.23 [0.76, 1.97]	2.19	.139	1.74 [0.86, 3.51]	2.58	.110	2.34 [0.85, 6.41]
Q1(1):Q2(2)	9.29	.002	2.48 **[1.41, 4.36]**	1.68	.194	1.61 [0.81, 3.21]	4.77	.029	3.58 **[1.13, 11.38]**
Q1(1):Q3(2)	6.79	.009	2.12 **[1.23, 3.64]**	1.68	.194	1.61 [0.81, 3.21]	1.80	.180	1.98 [0.76, 5.19]
Q1(1):Q4(2)	11.27	.001	2.79 **[1.55, 5.02]**	5.12	.024	2.50 **[1.15, 5.42]**	1.19	.275	1.72 [0.68, 4.34]
Q1(1):Q1(3)	10.25	.001	2.62 **[1.48, 4.67]**	6.13	.013	2.79 **[1.25, 6.22]**	0.39	.532	1.34 [0.56, 3.22]
Q1(1):Q2(3)	7.56	.006	2.23 **[1.29, 3.85]**	1.68	.194	1.61 [0.81, 3.21]	4.77	.029	3.58 **[1.13, 11.38]**
Q1(1):Q3(3)	16.07	<.001	3.70 **[1.94, 7.04]**	5.12	.024	2.50 **[1.15, 5.42]**	4.77	.029	3.58 **[1.13, 11.38]**
Q1(1):Q4(3)	20.55	<.001	4.86 **[2.39, 9.87]**	6.13	.013	2.79 **[1.25, 6.22]**	2.58	.108	2.34 [0.85, 6.41]

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

Table 6. **Anthropometric characteristics and age at peak height velocity according to relative age quarter. Data are means (±SD).**

		Relative age quarter											
		First eligible year (1)				Second eligible year (2)				Third eligible year (3)			
		Q1(1)	**Q2(1)**	**Q3(1)**	**Q4(1)**	**Q1(2)**	**Q2(2)**	**Q3(2)**	**Q4(2)**	**Q1(3)**	**Q2(3)**	**Q3(3)**	**Q4(3)**
BW	♂	61.0 (9.0)	62.2 (9.8)	61.4 (10.9)	58.3 (10.8)	53.5 (6.8)	54.4 (10.4)	50.6 (7.6)	46.7 (8.1)	43.5 (9.1)	44.9 (9.5)	46.1 (4.7)	45.5 (7.0)
[kg]	♀	55.2 (6.2)	54.3 (6.4)	52.2 (8.9)	54.6 (9.1)	51.5 (6.6)	54.0 (6.7)	53.3 (8.0)	47.8 (8.6)	47.8 (8.4)	47.9 (8.8)	48.8 (8.9)	48.1 (6.8)
BH	♂	1.71 (.06)	1.71 (.06)	1.71 (.08)	1.67 (.08)	1.65 (.07)	1.64 (.09)	1.61 (.07)	1.58 (0.10)	1.54 (.09)	1.55 (.07)	1.55 (.05)	1.55 (.04)
[m]	♀	1.63 (.06)	1.60 (.05)	1.63 (0.06)	1.62 (.06)	1.59 (.06)	1.63 (.05)	1.60 (.07)	1.55 (.02)	1.59 (.06)	1.58 (.08)	1.56 (.05)	1.55 (.05)
APHV	♂	14.0 (.5)	13.9 (0.6)	13.8 (.6)	13.9 (.7)	14.0 (.5)	14.0 (.6)	14.1 (.7)	14.1 (.7)	14.2 (.5)	14.0 (.5)	13.8 (.3)	13.7 (.4)
[yrs]	♀	12.7 (.4)	12.7 (.3)	12.5 (.4)	12.3 (.4)	12.4 (.3)	12.1 (.4)	12.1 (.4)	12.4 (.3)	12.1 (.4)	12.0 (.5)	11.9 (.4)	11.9 (.3)

BW = Body weight; BH = Body height.

relative age quarters also significantly differed in height (*F*(11, 141) = 2.69, p = 0.004). Although no significant difference was shown in body weight, there was a trend (p = 0.062), and the Helmert test revealed a significant difference in body weight between athletes of the first relative age quarter compared to the other athletes (p = 0.012). The male athletes of the single relative age quarters did not significantly differ from each other in calculated APHV. The female athletes significantly differed in APHV (*F*(11, 141) = 5.94, p < 0.001). However, post-hoc tests revealed a significant difference only between athletes of the first and last three relative age quarters. As shown in Table 6, the female athletes of the last relative age quarters (Q1(3)-Q4(3)) had lower values in calculated APHV, which meant that they will reach their individual peak growth spurt at a younger age.

The athletes were categorized as normal, early or late maturing based on the mean and standard deviation of the calculated APHV of the total sample separated by sex. The distribution of normal, early and late maturing male and female athletes (Table 3) did not significantly differ from the expected normal distribution, for the total sample of male and female athletes or the sample separated by the type of sport. Additionally, the distribution of normal, early and late maturing athletes did not significantly differ from the expected normal distribution when looking at the distribution separated by relative age quarter. However, the descriptive analyses showed that among the male athletes of the last two relative age quarters, no late maturing athletes were present. Additionally, among the female athletes of the first two relative age quarters, no early maturing athletes were present, whereas among the female athletes of the last four relative age quarters (Q1(3)-Q4(3)), no late maturing athletes were present.

Discussion

The results of the present study showed that relative age had a strong influence on the participation rate at the ICG in 2016 held in Innsbruck. Based on the fact that three birth years were allowed to participate, the selection pressure was very high in the national nomination processes, although it could have been assumed that the importance of these events was not as high compared to the YOG or the EYOF, and thus, the selection pressure may not have been high. This was not the case, as the findings of the present study revealed. The percentage of participants born in each quarter steadily declined from Q1(1) to Q4(3). Furthermore, the odds ratio calculation revealed that the likelihood for participation of an athlete from Q1(1) was 3.5 times higher than for an athlete from Q4(3). These results were in line with the results obtained in the studies investigating the EYOF in 2015 (Müller et al., 2016a) and the YOG in 2012 (Raschner et al., 2012). The findings revealed that the nomination processes for a single major junior event with younger participants (12- to 15-year-old athletes) than at the YOG and the EYOF were also biased by favourably selecting relatively older athletes. Based on the results of these three studies, it can be assumed that many young athletes did not have the chance to participate in such events and present their talents.

In literature, conflicting results were found for the RAE and sex in various types of sport but also at single major junior winter events. Often a RAE did not occur in the female context (Delorme et al., 2009; Müller et al., 2016a). However, in several winter sport disciplines, a RAE was not only found for male athletes but also for female athletes (Baker et al., 2014; Müller et al., 2016c).

In the present study, a highly significant RAE was present also among the female participants with a larger effect size for females (ω = 0.42) compared to the males (ω = 0.37). This outcome did not agree with the results of other studies, such as in alpine ski racing (Müller et al., 2016c) or for the YOG in 2012 (Raschner et al., 2012), in which larger effect sizes were found for male athletes. One possible explanation could be the general participation rate in sport related to sex. It can be assumed that there is a relatively high involvement in sport for females younger than 16 years. However, with increasing age, girls are less interested in high-performance sport and therefore, the participation rate and selection pressure is smaller compared to their male counterparts.

Conflicting results were also found with regard to the RAE and the type of sport. In the present study, a significant RAE with a large effect size (ω = 0.45) was found also in technique-related sports, not only in strength- and endurance-related types of sport. These findings are in line with the study at the YOG in 2012 (Raschner et al., 2012). However, at the EYOF, no significant RAE was shown among athletes participating in technique-related sports (Müller et al., 2016a). The authors argued that in technique-related sports, technical components predict performance, which leads to the assumption that a maturation-related developmental lead is not very decisive, and consequently, these athletes do not have the same advantages seen in strength-related sports. (Müller et al., 2016a) However, in the present study figure skating, snowboarding and freestyle skiing were designated technique-related sports; it might be assumed that especially in snowboarding and freestyle skiing a maturation-related development lead is indeed advantageous and as a consequence, a RAE was found also in these sports. At the EYOF, figure skating, snowboarding and ski jumping were categorized as technique-related sports (Müller et al., 2016a). In line with previous studies (Raschner et al., 2012; Müller et al., 2016a), the largest effect sizes were found for alpine ski racing (ω = 0.49) and ice hockey (ω = 0.48).

In many sports, such as ice hockey (Sherar et al., 2007), basketball (Torres-Unda et al., 2013) and alpine ski racing (Raschner et al., 1995), taller and heavier athletes have advantages and are favourably selected. At the YOG (Raschner et al., 2012) and the EYOF (Müller et al., 2016a), male athletes born at the beginning of the first eligible year were significantly taller and heavier than those born at the end of the second year; among female athletes no significant differences were found. In line with these studies, a significant difference was found among the male athletes also in the present study. However, among female athletes significant differences were present in body height and there was a tendency for a difference in body weight (p = 0.062). The Helmert test also revealed that female athletes from the first relative age quarter had a significantly higher body weight compared to athletes of the other relative age quarters. These results showed that the anthropometric characteristics significantly influenced the RAE. Relatively older athletes had an additionally higher likelihood for selection if they were taller and heavier. Thus, these findings were in line with the results of other studies conducted on ice hockey (Sherar et al., 2007), basketball (Torres-Unda et al., 2013) and alpine ski racing (Müller et al., 2015).

Similar to previous studies of alpine ski racing (Müller et al., 2015, 2016b) and soccer (Deprez et al., 2013; Gil et al., 2014), the findings of the present study revealed that there was no significant difference in the calculated APHV (as indicator of the biological maturity status) between the male participants of single relative age quarters. Consequently, the athletes will reach their individual peak growth spurt at nearly the same age. Additionally, it can be assumed that relatively younger male athletes can counteract their relative age disadvantages if they are at the same biological maturity status as the relatively older athletes (Müller et al., 2016b). However, among the female participants, significant differences were present. Female athletes of the last relative age quarters (Q1(3)-Q4(3)) had significantly lower values in the calculated APHV compared to the other athletes, which indicated that they were more mature because they will reach their individual peak growth spurt at a younger age. Sherar et al. (2007) assessed that with every 1-month increase in APHV, adolescent male ice hockey players became 17% less likely to be selected for elite squads. Müller et al. (2016b) showed that youth ski racers selected for national final races reached their individual peak growth spurt earlier than athletes not selected for the national races, who participated only at regional levels (males: 2 months; females: 3.5 months). Among the female participants in the present study, it can be assumed that relatively younger athletes of the last four relative age quarters were probably only selected for the ICG because they were more mature compared to athletes of the other quarters and therefore, they could counteract their relative age disadvantages.

As performed in the study by Sherar et al. (2007), the athletes in the present study were divided into three groups based on maturity status: early, normal and late maturing athletes. It was seen that most of the measured athletes (n = 384) were normal maturing (n = 258; 67.2%). The distribution of early (n = 61; 15.9%) and late maturing athletes (n = 65; 16.9%) was nearly the same. In contrast to the study of Müller et al. (2016b), the distribution of normal, early and late maturing athletes did not significantly differ from the expected normal distribution in the present study, as it did in a previous study investigating youth ski racers selected for national final races, where a higher percentage of early maturing athletes was present. It might be hypothesized that in alpine ski racing a maturation-related development lead is much more decisive than in other winter sport disciplines. Additionally, the study in ski racing was performed in a country in which the selection pressure in alpine ski racing is very high; consequently, a maturation-related selection bias is pronounced. Maybe this selection pressure and consequently the maturation-related selection bias is not that pronounced in the other winter sport disciplines and in other countries. Additionally, in the present study, the distribution did not significantly differ from the expected normal distribution when considering the three types of sport or when looking at the data separated by single relative age quarters. However, the descriptive analyses revealed that among the male athletes of the last two relative age quarters no late maturing athletes were present. Among the female athletes of the first two relative age quarters, no early maturing athletes were present, whereas among the female athletes of the last four relative age quarters, no late maturing athletes were present. These results emphasize the findings of Müller et al. (2016b) in alpine ski racing in that the biological maturity status indeed played a role in the talent selection process of youth athletes of winter sport disciplines because late maturing athletes seem to be rarely selected for the ICG. Additionally, the descriptive analyses showed that among both male and female athletes of the last relative age quarters hardly any late maturing athletes were present. This result indicated that relatively younger athletes only have a chance of selection for the ICG if they were maturing early. In contrast, relatively older athletes had an additionally higher likelihood of selection independent of their biological maturity status. These results agreed with the results of Deprez et al. (2013) from soccer, in which early maturing athletes were overrepresented in the last relative age quarters and late maturing athletes were overrepresented in the first relative age quarter. Additionally, in alpine ski racing (Müller et al., 2016b), early maturing athletes were over-represented in the last relative age quarter, and in general, there were hardly any late maturing athletes present among the participants selected for national final races.

Conclusion

The classification of the single disciplines as strength-, endurance-, and technique-related types of sport was performed according to the approach used by Raschner et al. (2012) and Müller et al. (2016b). However, this classification may lack specificity, even though it was established by the authors according to the predictive performance factors determined by previous research. The authors of the present study recognize this as a limitation of the study. Another limitation of the present study was that the measurements required for calculating the APHV as an indicator of the biological maturity status could be performed only among 384 athletes, not among the total sample of participants (n = 572). Some nations did not want to participate in a study concerning the biological maturity status. Therefore, only a smaller sample was included in the analyses concerning biological maturity status.

The method used to assess biological maturity status may not be the most accurate approach; a more precise assessment of biological age is X-rays of the left wrist. However, the method of calculating the APHV proposed by Mirwald et al. (2002) was used in several recently published studies including youth athletes (Deprez et al., 2013; Gil et al., 2014). Additionally, the validity of this method was previously proven for youth alpine ski racers and individuals of the same age (10-13 years) by comparing the mentioned method with the X-rays of the left wrist to calculate skeletal age. Good validity for the method was demonstrated (Müller et al., 2015), although it still may be a limitation of the current study. However, the assessment of biological age by X-rays would have not been possible within such a big cohort of youth athletes at a single major junior event.

The results of the present study and the results of the YOG in 2012 (Raschner et al., 2012) and the EYOF in 2015 (Müller et al., 2016a) revealed that the nomination processes for such major single junior winter events are biased by favourably selecting relatively older athletes. Additionally, the present study revealed that relatively younger athletes seem to only have a chance for selection if they are maturing early. Based on these findings, in the future, the relative age and the biological maturity status should be considered in the talent development system for various types of winter sport, to contribute to more fairness and to not discriminate against relatively younger and less mature athletes.

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Key points

- The relative age strongly influenced the participation rate at the 7th ICG in 2016.
- A highly significant RAE was present among male and female participants and among athletes of all three groups of sport disciplines: strength-, endurance- and technique-related types of sport.
- A significant influence of the biological maturity status on the selection was present among female participants – relatively younger female athletes were more mature than relatively older athletes.
- Relatively younger male and female athletes seem to only have a chance for selection for the Games if they are early maturing, whereas relatively older athletes have an increased likelihood for selection independent of their biological maturity status.
- In the future, the biological maturity status and the relative age should be considered in the talent development system for various types of winter sport, to contribute to more fairness and to not discriminate against relatively younger and less mature athletes.

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