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Relative age effects are (mostly) absent among Canadian Olympic athletes

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The relative age effect (RAE; when one's birthdate leads to participation or performance advantages over their peers) has been studied among many groups, but one that is largely understudied is elite amateur athletes. The purpose of this study was to investigate the prevalence of RAEs among Canadian Olympians to better understand the pervasiveness of RAEs and long-term selection advantages. Participants included 1461 Canadian Olympic athletes across 54 sports who competed between 2004 and 2018. Birthdates were converted into quartiles based on the selection year for each sport. Chi-square was used to compare the observed distribution of birthdates with the expected distribution. Analyses indicated that the RAE was mostly absent within the sample. A lone outlier was female ice hockey players, where the RAE was present with an overrepresentation of athletes born in the second quartile of the selection year. Our discussion draws connections to existing explanations of RAEs.

KEY WORDS: Canada, Elite Sport, Birth Distribution, Birth Quartiles.

Each year around the globe, millions of children participate in organized sport (Merkel, 2013). This is beneficial, as researchers have demonstrated that sport fosters positive youth development (i.e., competence, confidence, connection, and character; Vierimaa et al., 2012). Benefits of youth sport participation extend to other contexts as well, with youth athletes experiencing physical (e.g., cardiovascular fitness; Cvetković et al., 2018), psychosocial (e.g., mental health and well-being; Eime et al., 2013), and academic (e.g., course grades; Ibis & Aktug, 2018) gains. Since youth sport offers such broad and salient benefits, it is imperative that researchers continue exploring elements in the sport environment that might indicate unequal access to sport. Unfortunately, athletes' birthdates are one element that often leads to different sport experiences.

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In an effort to minimize physical, cognitive, and skill differences between young athletes, youth sport organizations often group participants into one- or two-year age bands (e.g., grouping all youth who were born between January 1st and December 31st of the same year). Though well intended, observable differences between athletes in the same age band are evident (Stracciolini et al., 2016). Compared to their later-born peers, youth athletes who are born earlier in their sport's calendar year appear to have participation (e.g., more likely to join sport; less likely to drop out of sport), physical (e.g., typically taller, heavier, and more cognitively advanced), and performance (e.g., more likely to be selected to elite teams) advantages (Hancock, Adler, & Côté, 2013; Hancock, 2020). When these advantages exist, it is termed the relative age effect (RAE; Barnsley et al., 1985).

Following Barnsley et al.'s (1985) original study that identified RAEs in ice hockey players, several researchers investigated the prevalence of the RAE in sport. From these studies, we know that RAEs exist in ice hockey (Geithner et al., 2018), soccer (Delorme et al., 2010), basketball (Delorme & Raspaud, 2009), volleyball (Campos et al., 2020), rugby (Till et al., 2010), swimming (Costa et al., 2013), judo (Albuquerque et al., 2015), athletics (Hollings et al., 2014), and badminton (Bilgiç & Devrilmez, 2021), to name a few.

Hancock (2020) provided a narrative explaining how RAEs manifest. At youth ages, relatively older athletes are more likely to be bigger in stature (height and weight) when compared to relatively younger athletes. Such physical size differences are often combined with the unfounded perception from coaches and parents that taller/stronger youth are better athletes. This results in selection benefits where relatively older youth have a greater likelihood of being selected to competitive teams, thereby acquiring more coaching, practice, and competitive opportunities. Furthermore, as a function of being alive longer, relatively older children have more opportunities for self-initiated practice, training, and free play than their younger peers, leading to higher rates of sport participation among older peers.

Nevertheless, researchers identified that the strength of RAEs varies based on athletes' ages (Cobley et al., 2009; Smith et al., 2018). For instance, Smith et al. (2018) showed that RAEs were strongest at the youngest youth sport divisions, but then tapered off as athletes reached adulthood as pubertal differences become less noticeable. Additionally, as athletes progress to professional sport, RAEs have been shown to continually diminish (Brustio et al., 2021). Further highlighting the reduced RAE as athletes age, some researchers have noted that relatively younger professional athletes receive more awards, earn higher salaries, and achieve greater performance outcomes (Fumarco et al., 2017), which is known as the "underdog hypothesis" (Smith & Weir, 2020).

Explanations of RAE patterns could be strengthened with continued research in the field, particularly if researchers target understudied sports or populations. One such group is amateur adult athletes, as the majority of RAE literature focuses on youth or professional athletes (Hancock, 2017; Thompson et al., 1991). Though some research exists on adult athletes at the elite amateur levels (e.g., athletes representing national teams), researchers have noted equivocal results across these studies. As an example, Albuquerque et al. (2012, 2015) found no RAEs among Olympic taekwondo athletes, yet RAEs existed for Olympic judo athletes. Given that both sports share similar characteristics (i.e., combat sports and widely known for fostering discipline and respect in athletes), it is surprising that RAE patterns were dissimilar. Meanwhile, Joyner et al. (2020) observed RAEs among Olympians, though their research combined all athletes from all sports over a 30-year period. Though studying elite amateur athletes is important, analyzing athletes from all countries represented in one or several Olympic sports does not capture the nuances of RAEs that are possible when examining RAEs in one country across several sports.

It is also imperative to continue studying female athletes, who remain an understudied population in RAEs research (Hancock, 2017). Recent studies indicate increased efforts to studying female athletes (e.g., Hancock, 2017, Smith et al., 2018). Similar to Olympic athletes, equivocal results are also found across the studies targeting female athletes. Specifically, some studies have observed traditional RAEs (i.e., advantages for the relatively oldest athletes and disadvantages for the relatively youngest athletes), whereas other studies have found no RAEs whatsoever (see Smith et al., 2018 for a review). There is also a recent trend whereby RAEs exist that benefit the second-oldest group of athletes in a cohort (i.e., the second-quartile phenomenon; Hancock, 2017). Prioritizing studies on female athletes RAEs is important to better understand these effects.

Clearly, further exploration of RAEs among elite amateur adult athletes (and including female athletes) is warranted. Consequently, the purpose of this study was to investigate the prevalence of RAEs among Canadian national team athletes who were competing in the Olympics. This study is necessary to gain a better understanding of how the advantages associated with being relatively older might impact long-term selection among adult athletes, as well as contribute to a dearth of literature focused on elite amateur adult athletes (of both sexes) who compete in several sports for one country. Ultimately, this study will provide a better understanding of the RAE.

Methods

Since the research implemented archival data collection, the research board at the authors' institution indicated that ethics were not required for this project.

Participants

Participants included 1,461 Canadian athletes (female = 702, male = 759) who competed in the Summer or Winter Olympic Games between 2004 and 2018. Fifty-four sports were represented in the sample. The most prevalent sports (in terms of number of participants) were ice hockey (n = 122), athletics (n = 121), rowing (n = 85), and swimming (n = 81).

Data Collection

The official Canadian Olympic Team website (https://olympic.ca/) has a database of all Canadian athletes who have ever competed at an Olympic Games or other international multisport event since the year 1900. The database includes athletes' profiles across 74 sports[1] recognized by the Canadian Olympic Committee. Each profile listed the athletes' birthdate, sport, sex, and Olympics attended, which we extracted and organized into a Microsoft Excel file.

Data Analysis

After data extraction, participants were organized into four quartiles (Q) based on their birthdates. These quartiles aligned with each sport's selection year, with the oldest athletes placed in Q1 and the youngest in Q4. With the exception of curling, sport selection years were based off the calendar year (i.e., oldest athletes born January 1 and youngest athletes born December 31) where Q1 was January to March with the remaining quartiles following chronological order (Q2 = April to June; Q3 = July to September; Q4 = October to December). Curling follows a calendar where the oldest athletes are born in July (Q1 = July to September). Data were imported to SPSS 26.0 for analysis. We implemented chi-square goodness of fit tests to compare the observed birthdate distributions in our sample to the live birth rates of the general Canadian population. Live birth rate data from 1991 to 2000 were collected from Statistics Canada. From this, we set our expected distribution as the average percentage of births in each quartile over the 10-year period: Q1 = 24.5%, Q2 = 26.3%, Q3 = 25.8%, and Q4 = 23.4%. Effect sizes (w) helped determine the strength of the findings, with 0.1, 0.3, and 0.5 representing small, medium, and large effects, respectively (Cohen, 1988). Finally, standardized residuals (SR) were added as post-hoc tests for any significant chi-square result. An SR greater than 1.96 indicated an overrepresentation of athletes, while an SR less than -1.96 indicated an underrepresentation of athletes, when compared to the expected distribution.

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[1] Twenty sports did not compete between 2004 and 2018, hence they are not included in our analysis.

Results

The full results are in Tables I and II. RAEs did not exist for the entire sample ($X^2_{[3, 1460]} = 0.422, p > 0.05, w = 0.017$), male athletes ($X^2_{[3, 758]} = 0.587, p > 0.05, w = 0.028$), female athletes ($X^2_{[3, 701]} = 1.495, p > 0.05, w = 0.031$), Summer Games athletes ($X^2_{[3, 884]} = 2.102, p > 0.05, w = 0.049$), or Winter Games athletes ($X^2_{[3, 575]} = 1.241, p > 0.05, w = 0.046$). To further examine sex differences, chi-square tests were conducted for each sex at each type of games (i.e., Summer and Winter). No RAEs were present (all $p > 0.05$) for any of these analyses. Next, three chi-square tests were performed for each of the four most prevalent sports: (1) all participants in the sport, (2) male participants in the sport, and (3) female participants in the sport (see Table 2). No RAEs were present in ice hockey ($X^2_{[3, 121]} = 3.061, p > 0.05, w = 0.158$), athletics ($X^2_{[3, 120]} = 1.902, p > 0.05, w = 0.125$), rowing ($X^2_{[3, 84]} = 4.349, p > 0.05, w = 0.226$), or swimming ($X^2_{[3, 80]} = 1.439, p > 0.05, w = 0.133$). For all but one sport, no RAEs existed for the male-only or female-only samples (all $p > 0.05$). The lone exception was female ice hockey ($X^2_{[3, 46]} = 7.929, p < 0.05, w = 0.412$), which had a significant overrepresentation of athletes born in Q2 (*SR* = 2.158).

TABLE I
Relative Age Statistics for Canadian Olympians

Analyzed Sample	**n**	**X²**	**p**	**w**	**Q1%**	**Q2%**	**Q3%**	**Q4%**
Entire Sample	1461	0.422	0.936	0.017	24.6	27.0	25.3	23.1
Male	759	0.587	0.899	0.028	25.3	26.1	26.2	22.4
Female	702	1.495	0.683	0.031	23.8	27.9	24.4	23.9
Summer	885	2.102	0.511	0.049	23.8	28.4	25.5	22.3
Winter	576	1.241	0.743	0.046	25.7	24.8	25.0	24.5
Male Summer	425	0.981	0.806	0.048	25.1	27.8	24.0	23.1
Male Winter	334	2.668	0.466	0.089	25.4	24.0	29.0	21.6
Female Summer	460	2.798	0.424	0.078	22.6	28.9	27.0	21.5
Female Winter	242	6.758	0.080	0.167	26.0	26.0	19.5	28.5

Note: Expected quartile distributions were Q1 = 24.5%, Q2 = 26.3%, Q3 = 25.8%, Q4 = 23.4%.

Table II
Relative Age Statistics for Canadian Olympians by Sport

Analyzed Sample	n	X^2	p	w	Q1%	Q2%	Q3%	Q4%
Ice Hockey	122	3.061	0.382	0.158	24.6	32.8	23.0	19.6
Ice Hockey (M)	75	1.106	0.776	0.121	25.3	26.7	29.3	18.7
Ice Hockey (F)	47	7.929	0.047*	0.412	23.4	42.6	12.8	21.2
Athletics	121	1.902	0.593	0.125	29.7	24.8	24.8	20.7
Athletics (M)	63	6.681	0.083	0.326	36.5	19.0	28.6	15.9
Athletics (F)	58	1.335	0.721	0.152	22.4	31.0	20.7	25.9
Rowing	85	4.349	0.226	0.226	18.8	24.7	35.3	21.2
Rowing (M)	48	2.091	0.554	0.208	18.7	31.3	31.2	18.8
Rowing (F)	37	5.031	0.170	0.369	19.0	16.2	40.5	24.3
Swimming	81	1.439	0.696	0.133	27.2	29.6	24.7	18.5
Swimming (M)	37	1.159	0.763	0.177	19.0	27.0	32.4	21.6
Swimming (F)	44	4.206	0.240	0.309	34.1	31.8	18.2	15.9

Note: M = Male, F = Female; * = $p < 0.05$. Expected quartile distributions were Q1 = 24.5%, Q2 = 26.3%, Q3 = 25.8%, Q4 = 23.4%.

Discussion

The literature on RAEs in youth sport is quite consistent across countries, sports, and sexes; that is, if there is sufficient depth of competition (Musch & Grondin, 2001), RAEs likely exist, but dissipate over time. At the elite amateur adult ranks, however, results are far more inconsistent. Thus, the purpose herein was to investigate the prevalence of RAEs among Canadian Olympic athletes, with the goal of better understanding how the advantages associated with being relatively older might influence long-term selection among adult athletes. To summarize, we found no RAEs in our overall, male, female, Summer, or Winter samples. Further, the effect did not exist in athletics, rowing, or swimming, regardless of sex. Male ice hockey followed suit, but a lone outlier was female ice hockey, where a significant RAE was discovered with an overrepresentation of Q2 athletes. Our findings contribute to an evolving, yet equivocal literature base. Herein, we explain these findings by highlighting the four most prevalent sports in our results, as the explanations therein apply to the larger samples (e.g., male athletes and female athletes) that were analyzed as well.

Starting with athletics, no RAEs were present for any of the analyzed samples (i.e., entire sample of athletics, male athletes, and female athletes). The explanation for this finding might relate to depth of competition. Sports vary in popularity between countries. An example of this is ice hockey in Canada and handball in Germany – both are very popular sports in their respective countries, but not as popular in the other country. With higher sport popularity there is more frequent athlete participation; to accommodate the influx of interested athletes, sport organizations typically provide more opportunity for various levels of competition (e.g., AAA, AA, and A teams in ice hockey). While this makes sense for sport organizations, grouping athletes based on competitive level increases the likelihood for RAEs to be present (Hancock & Côté, 2014). When there are more participants competing to be selected onto teams, there are also more individuals being deselected (Hancock, 2020). RAEs, therefore, are more likely when there are 200 athletes trying out for a team as compared to 20 athletes trying out for that same team. As athletics in Canada is not a particularly popular sport-especially at younger ages-this lack in depth of competition could explain why there were no RAEs for these athletes.

Moving into rowing, it is important to reiterate that RAEs typically begin in youth sports (Delorme & Raspaud, 2009) due to possible physical and cognitive differences that exist between athletes. Such mechanisms of RAEs (e.g., maturation, growth, and annual age bands), however, become less prevalent at older ages. Rowing in Canada is a sport many individuals join later in life, after reaching full adult stature and physiology (Rowing Canada Aviron, 2015). Thus, during their initial entry to sport, physiological and cognitive differences based on differences in relative age are minimal or non-existent. This likely means success in the sport is more a function of skill and ability, rather than misguided perceptions of youth talent and inferred potential at adult ages. Such an explanation is useful for considering why RAEs are absent among this sample of rowers.

As made evident by rowing, the date of entry into sport contributes to the presence of RAEs. However, the date of sport competition might also play a contributing role. In swimming, for example, age groups for competition are determined by the first day of the meet (USA Swimming INC, 2020). In this scenario, a swimmer could be 11 years and 364 days old on day one of a meet and compete in the 10- to 11-year-old age group. The next weekend, at 12 years and 6 days old, they would compete in the 12- to 13-year-old age group. This fluid age grouping differs from most sports that use fixed age bands for an entire competitive season. In the context of swimming, it means that no youth athlete is always the relatively oldest/youngest. Grouping athletes in this manner ensures that every athlete will have the chance at being among the oldest and youngest athletes competing. By virtue of this, RAEs are much less likely to be prevalent among swimmers, as all share the benefits of being relatively older. This provides a rationale for why RAEs did not exist among swimmers in our sample.

RAEs have been well documented in ice hockey (Barnsley et al., 1985; Geithner et al., 2018; Hancock, Seal et al., 2013). Despite this, we found mixed results. First, no RAE was discovered in male ice hockey, contradicting past research (e.g., Barnsley et al., 1985). It is noteworthy that with exception of the athletes who represented Canada in men's ice hockey at the 2018 Winter Olympics, all the male ice hockey players in our sample were in the National Hockey League at the time of their respective Olympics. Based on this, one would expect to see a RAE in male ice hockey for this study. Our findings, then, might be explained by the "underdog hypothesis" (Smith & Weir, 2020). The underdog hypothesis is the concept that relatively younger athletes overcome RAEs and eventually benefit from their late birthdays due to the adversity they face during their years in youth sport (Smith & Weir, 2020). While the underlying mechanisms are likely a combination of many factors, Smith and Weir (2020) outline three main tenets of the underdog hypothesis. The first is that relatively younger players might possess superior physical skills. To remain competitive with their older peers, relatively younger athletes must develop greater performance skills such as technical or tactical skills. Once these relatively younger athletes catch up in physical development, they now have the advantage due to the refinement of these performance skills, ultimately helping them overcome RAEs. Second is that relatively younger players develop superior psychological skills. The struggles that relatively younger athletes must face and overcome might prove useful for developing mental skills, which are critical tools for elite athletes. An example of this is developing resilience. This refers to an athlete's ability to adapt to and overcome difficult situations. Athletes who are relatively younger than their peers are negatively impacted by selection biases and must adapt to overcome this. By developing these mental skills, when relatively younger youth athletes reach elite levels of sport, they might be better prepared to face the stressors associated with it. The third tenet is that the perceived advantages of being relatively older could be detrimental to athletes' overall well-being. Relatively older athletes are commonly selected for more elite teams than their younger peers, potentially leading to increased likelihood of early sport specialization. Consequently, athletes are at a higher chance of overuse injuries, burnout, and dropout (Gould, 2010). If relatively older athletes are dropping out before they reach the elite levels of sport, relatively younger athletes might be given a chance to succeed at this level.

Female ice hockey players in our study demonstrated a RAE with athletes born in the second quartile of the selection year most overrepresented. This pattern has previously appeared in numerous studies (e.g., Geithner et al., 2018; Hancock, 2017; Hancock, Seal et al., 2013). There is little clarity explaining this phenomenon, but some possible explanations exist. One consideration was that female ice hockey players born in the first quartile of the selection year might choose to participate in male ice hockey for better training and competition. Hancock (2017) studied this, but still found an overrepresentation of second-quartile females participating in male hockey, albeit in only one region of Canada. Another hypothesis is that females born in the first quartile might opt to register for more stereotypical female sports such as gymnastics or figure skating (Hancock, Seal et al., 2013), though extensive studies on this possibility do not yet exist. Thus, while the underlying cause for the second-quartile phenomenon remains a mystery, the findings of this study follow the findings of previous research.

A limitation of this study was that the sample consisted only of Canadian Olympians who competed at the Olympic Games between 2004 and 2018, which does not capture the entire landscape of elite international competitions for Canadian athletes. Specifically, national team athletes that competed exclusively at other major games (e.g., Pan American Games, Commonwealth Games, Paralympic Games) were not included in the study. Furthermore, there are numerous sports in these other multi-sport international games that Canada did not qualify for at the Olympics or are not included in the Olympics at all (e.g., karate, handball, or surfing). To extend our understanding of the pervasiveness of RAEs among elite amateur adult athletes – and in turn, the nature of the long-term selection advantages – we suggest researchers continue this line of work with other international athletes.

Since results of this study have revealed that there is no RAE present for most Canadian Olympians, it appears that relatively younger youth athletes are able to overcome their initial disadvantages by the time they reach elite amateur adult levels. While explanations such as the underdog hypothesis are useful to understand how this might happen, more research is needed to truly understand the process through which relatively younger athletes progress that enables them to be as successful in elite amateur adult sports as their relatively older counterparts. Furthermore, the second-quartile phenomenon is a prevailing trend in female sport, but an explanation for the phenomenon remains absent. More investigations need done to explore the underlying mechanisms that cause this phenomenon. It is hoped that further research within these areas will help advance the knowledge of RAEs, ultimately pushing towards practical and meaningful solutions ensuring nondiscriminatory sport participation.

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