Relative age effects and the second-quartile phenomenon in young female ice hockey players

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Abstract

Relative age effects exist across sports and cultures (Cobley, Baker, Wattie, & McKenna, 2009), though a recent, unusual trend is females born in the second quartile of the selection year are most over-represented on elite teams. The purpose of this study was to test the hypothesis that the second-quartile phenomenon was the result of first-quartile female athletes registering to play male sport. Players included 29,924 female ice hockey players (ages 7-17 years). Relative age effects (the second quartile most over-represented) existed for the entire sample (χ^2 [3, 29923] = 401.95, $p < .001$), those registered for female ice hockey (χ^2 [3, 24984] = 369.90, $p < .001$) and those registered for male ice hockey (χ^2 [3, 4938] = 37.88, $p < .001$). It appears the second-quartile phenomenon cannot be explained by athletes' choice to play male sport. The discussion includes integration of results with previous literature, along with plausible explanations.

Keywords: *birthdate*, *participation*, *birth rate distribution*, *female sport*

In sport, relative age effects (RAEs) exist when athletes' birthdates lead to participation or performance (dis)advantages (Wattie, Cobley, & Baker, 2008). Participation advantages manifest as earlier and more frequent enrollment (Musch, 2002), whereas disadvantages include increased dropout (Delorme, Boiché, & Raspaud, 2010a). For performance, advantages and disadvantages relate to chances of being selected or deselected to elite sport teams (Helsen, Van Winckel, & Williams, 2005). With few exceptions (e.g., female gymnasts; Hancock, Ste-Marie, & Starkes, 2015), advantages are afforded to relatively older athletes. This pervasive trend exists in several team sports including ice hockey (e.g., Daniel & Janssen, 1987), soccer (e.g., Schorer et al., 2015), baseball (e.g., Thompson, Barnsley, & Stebelsky, 1991), basketball (e.g., Delorme & Raspaud, 2009), and rugby (e.g., Till et al., 2011), as well as across countries such as Canada (e.g., Côté, MacDonald, Baker, & Abernethy, 2006), United States (e.g., Giacomini, 1999), United Kingdom (e.g., Till et al., 2011), Germany (e.g., Cobley, Schorer, & Baker, 2008), and France (e.g., Delorme & Raspaud, 2009). Notwithstanding, one understudied population in RAEs is female athletes, who represent fewer than 2% of all participants in RAE studies (Cobley, Baker, Wattie, & McKenna, 2009).

Addressing sport inequities caused by RAEs is important for several reasons, framed herein using the 3Ps (participation, performance, and personal development; Côté, Strachan, & Fraser-Thomas, 2007) approach to sport. First, sport participation offers positive health benefits, which ought to be available to all youth, regardless of birthdate. As noted, however, relatively younger athletes are more likely to drop out of sport (Delorme et al., 2010a), thereby missing participatory experiences. Second, increased dropout of youth athletes prematurely shrinks the talent pool, causing systemic reductions in performance (Côté et al., 2007). Finally, sport offers several beneficial psychosocial outcomes (e.g., Côté et al., 2007), but benefits are only available to athletes who remain engaged in sport. Therefore, for several reasons, it is important to minimize RAE inequities that negatively influence the 3Ps.

One impediment to reducing RAE inequities is a poor understanding of the effects. Musch and Grondin (2001), for instance, offered four mechanisms that contribute to RAEs: (1) depth of competition (i.e., RAEs are stronger when many athletes compete for few roster positions); (2) maturational differences (i.e., RAEs are exacerbated in sports where physical prowess is desired); (3) cognitive differences (i.e., RAEs result from psychological maturity advantages among relatively older athletes); (4) experience (i.e., RAEs exist because relatively older children have been alive longer than relatively younger children). A lack of direct hypothesis testing around these mechanisms, however, limits their explanatory power.

In an effort to synthesize the various speculated mechanisms of RAEs, researchers have recently proposed theoretical models to understand and explain RAEs. Hancock, Adler, and Côté (2013), for instance, posited that social agents (i.e., parents, coaches, and athletes) are primarily responsible for RAEs. Here, the authors suggested that parents and coaches perceive maturational/psychological advantages as talent, leading to earlier sport opportunities (i.e., Matthew Effects; Merton, 1968) for relatively older athletes. Early experiences, then, facilitate athletic proficiency, confirming parents' and coaches' initial perceptions of talent (i.e., Pygmalion Effects; Rosenthal & Jacobson, 1968). Similarly, Pierson, Addona, and Yates (2014), proposed that RAEs resulted from positive feedback loops rooted in earlier and more frequent practice opportunities. Finally, using a developmental system model, Wattie, Schorer, and Baker (2015) suggested that RAEs result from the combination of individual, task, and environmental constraints. Individual constraints include physical and cognitive maturity. Task constraints reflect the respective goals and rules of a given sport (e.g., permitted physical contact).

Environmental constraints include social (e.g., coaches) and physical environment (e.g., available green space) influences. Collectively, the models are excellent frameworks that offer testable explanations of advantages for the relatively oldest athletes and disadvantages for the relatively youngest athletes. One trend not explicitly described in these theories, however, is the second-quartile phenomenon in female sport.

In sport, youth are often grouped in annual age cohorts. Researchers typically examine RAEs by dividing an annual cohort into equal quartiles, with relatively older athletes described as first-quartile athletes. Using such methods, researchers have identified the second-quartile phenomenon as a recent trend in regionally-popular female sports (i.e., European soccer and Canadian ice hockey), where athletes born in the second quartile of the selection year are most over-represented on elite sport teams[1]. Baker and colleagues (Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009) identified this trend in American adult female soccer players, which was supported by Delorme, Boiché, and Raspaud (2010b), who examined French youth soccer players. In Canadian ice hockey, Weir, Smith, Paterson, and Horton (2010) noted the second-quartile phenomenon in adult players, while Hancock, Seal, Young, Weir, and Ste-Marie (2013) observed the same trend in youth players.

The underpinnings of the second-quartile phenomenon are perplexing and have yet to be empirically investigated. It is expected that first-quartile athletes are more physically and emotionally mature, affording them advantages during team selections (Hancock, Adler, & Côté, 2013). Further, recent RAE models suggest that the mere perception of advanced maturation enhances first-quartile athletes' chances of being selected to elite teams (Hancock, Adler, & Côté, 2013; Wattie et al., 2015). Finally, Musch and Grondin (2001) stated that traditional RAEs

[1] While studies have noted unusual trends for third- (Lemez, MacMahon, & Weir, 2016) and fourth-quartile athletes (Hancock et al., 2015), the focus here is on the second quartile, as it has been replicated across sports and ages.

exist in sports with significant depth of competition. In other words, to find RAEs, there must be a sufficient number of athletes vying for a limited number of roster positions. Considering the regional popularity of the above sports, it stands to reason that the sampled participants came from sports with a strong depth of competition. Collectively, these rationales indicate favoritism for athletes born in the first quartile—a result that has been traditionally found in female sport—not the second quartile. Thus, it is unclear why the recent second-quartile phenomenon exists in certain regionally-popular female sports.

One proposed explanation is that female athletes born in the second quartile are over-represented in female sports as first-quartile athletes seek more elite sport opportunities (i.e., male sports; Hancock, Seal, et al., 2013). This might be particularly true in Canadian ice hockey and European soccer, where female players join male teams that offer stronger competition, more practice time, and therefore greater chances for skill development. This hypothesis aligns with Hancock, Adler, and Côté's (2013) model, which describes initial enrollment advantages for the relatively oldest athletes. Consider, for a moment, female ice hockey players. If female players born in the first quartile choose to play male ice hockey, then the initial enrollment advantages (i.e., Matthew Effects; Merton, 1968) in female ice hockey would defer to female athletes born in the second quartile. Because of their initial enrollment advantages, second-quartile female athletes would receive more experience, practice, and coaching—resulting in more talented athletes—thereby confirming parents' and coaches' initial expectations (i.e., Pygmalion Effects; Rosenthal & Jacobson, 1968).

The purpose of this study was to test the hypothesis that the second-quartile phenomenon is a result of female athletes' registration decisions (i.e., playing male or female sport). This objective was achieved by examining RAEs for females playing female sport, compared to females playing male sport. Such an investigation is warranted to better understand the complexities and nuances of RAEs, which could have implications for RAE models that explain the effect. Canadian ice hockey was chosen for this study to ensure a strong depth of competition, minimizing confounding explanations of the results. Based on the statements above, the first hypothesis was that female athletes who played on female ice hockey teams would show a RAE with an over-representation of athletes born in the second quartile. The second hypothesis was that female athletes who played on male ice hockey teams would show a traditional RAE (i.e., athletes born in the first quartile being most over-represented). As noted in the introduction, female athletes are understudied in RAE research (Cobley et al., 2009). A secondary purpose of the study, therefore, was to examine RAE trends across female ice hockey age divisions. Aligned with Hancock, Adler, and Côté’s (2013) explanation of early advantages, the third hypothesis was that RAEs would be strongest at younger ages, weakening at older ages, as experience and physical differences decrease with time.

Methods

Participants

Participants were 29,924 female ice hockey players between the ages of 7 and 17 years. Youth ice hockey players were chosen, as female players often play on male teams at this time. Participants were registered in the Ontario Hockey Federation during the 2012 season, and were categorized based on teams’ dominant sex (female or male) and age division (see Table 1).

Data Collection

The Ontario Hockey Federation provided access to a registration database, which contained participants’ sex, team (i.e., female or male), birthdate, season of play, and age division. Female players registered in 2012 were imported into a Microsoft® Excel document.

Entries with missing data were removed from the analysis. Birthdates were transformed into quartiles following the Hockey Canada selection year: Q1 (January-March), Q2 (April-June), Q3 (July-September), and Q4 (October-December). As all participant information contained non-identifying information that could be collated through publicly accessed websites, the study was deemed exempt from institutional ethics review.

Data Analysis

Data were analyzed using SPSS® version 22. A series of chi-square goodness of fit tests were employed to determine if RAEs existed in the sample. Chi-square tests identify if observed distributions differ from expected distributions. Some researchers argue that the expected distribution should be derived from population birth rates (e.g., Addona & Yates, 2010); thus, if 24.7% of Canadians were born between January and March, then the expected distribution in Q1 should be 24.7%. Others argue that since population birth rates only marginally differ across quartiles, interpretation of the data is simplified when expected distributions are set at 25% (e.g., Baker & Logan, 2007). To answer the first research question, chi-square tests were conducted on athletes playing female or male ice hockey, and across five age divisions; therefore, setting the expected distribution at 25% provided clearer results. For the second research question, chi-square tests provided insights into changes in RAEs across female ice hockey age divisions. To best achieve this, expected distributions were based on the distribution found in the previous age division (Delorme, Boiché. & Raspaud, 2010c). Thus, if 30% of 9- and 10-year-old athletes were born in the first quartile, then the expected distribution of first-quartile 11- and 12-year-old athletes was 30%. For the youngest age division, expectations remained at 25% per quartile.

Critical *p*-values for each test were set at $p < .05$. Effect sizes (w) were provided to highlight the strength and meaningfulness of each test. Values of 0.1 were considered small effects, while 0.3 and 0.5 indicated medium and large effects, respectively (Cohen, 1988). When significant RAEs existed, standardized residuals (*SR*; Hancock, Seal, et al., 2013) were employed to ascertain which quartiles were most over- and under-represented. Similar to *z*-scores (M = 0.00, SD = +/- 1.00), *SR* are effective in identifying significant deviations from an expected distribution. Positive *SR* (> 1.96) denoted significant over-representations of birth quartiles compared to the expected distribution. Negative *SR* (< -1.96) indicated significant under-representations of birth quartiles compared to the expected distribution. The values of +/- 1.96 equated to a p-value of < .05.

Results

Full results for purpose one are presented in Table 1, though a synopsis is provided herein. It was evident that a significant RAE existed for the entire sample (χ^2 [3, 29923] = 401.95, p < .001, w = 0.12), females who played female ice hockey (χ^2 [3, 24984] = 369.90, p < .001, w = 0.12), and females who played male ice hockey (χ^2 [3, 4938] = 37.88, p < .001, w = 0.09). In every instance, athletes born in Q2 were most over-represented (*SR* = 10.68, 10.09, 3.95, respectively) and Q4 athletes were most under-represented (*SR* = -16.41, -15.82, -4.80, respectively).

Further examining purpose one and the second-quartile phenomenon, a series of chi-square tests assessing RAEs was performed for each age division, separating athletes who played female versus male ice hockey (see Table 1). Novice (ages 7-8) players, regardless of whether they played female or male ice hockey, showed identical RAE patterns (*p*s < .001; Q2 most over-represented; Q4 most under-represented). This same trend was noted among Atom (ages 9-10) players in male ice hockey, but for those in female ice hockey, Q3 was most over-represented, while Q4 remained most under-represented. Minor variations existed at the Peewee age division (ages 11-12), where athletes in female ice hockey showed a significant RAE (p < .001), though Q1 was marginally over-represented compared to Q2. For those playing male ice hockey, there was no significant RAE (p > .05). Moving into the Bantam age division (ages 13-14), there was a significant RAE for female and male ice hockey players (ps < .05), though those in female ice hockey had an over-representation of Q2 athletes, while those in male ice hockey had an over-representation of Q1 athletes. Finally, at the Midget age division (ages 15-17), participants in female ice hockey showed a significant RAE (p < .001), with an over-representation of Q2 athletes, but players in male ice hockey had no significant effects (p > .05).

Focusing on purpose two (see Table 2), a significant RAE existed for all age divisions (ps < .05) with the exception of the Bantam age division, which approached significance (p = .07). Of particular relevance to purpose two was the strength of RAEs across age divisions, which was strongest at the youngest ages (w = 0.16 and 0.12 for Novice [ages 7-8] and Atom [ages 9-10], respectively) and weakest at the oldest ages (w = 0.03 and 0.04 for Bantam [ages 13-14] and Midget [ages 15-17], respectively). Examining *SR* within age divisions provided additional findings. Novice (ages 7-8) players had significant over-representations of Q2 athletes (*SR* = 6.02) and under-representations of Q4 athletes (*SR* = -6.05). This rebalanced for Atom (ages 9-10) players, with fewer than expected Q2 athletes (*SR* = -5.23), while Q3 (*SR* = 3.40) and Q4 athletes (*SR* = 3.91) increased more than expected. For Peewee (ages 11-12) players, there were significantly more Q1 athletes (*SR* = 3.04) than expected, with significantly fewer Q3 athletes (*SR* = -2.66) than expected. The Bantam (ages 13-14) age division had more Q2 athletes (*SR* = 2.00) than expected, though this should be interpreted cautiously as the chi-square test was non-significant. Finally, for Midget (ages 15-17) players, there were fewer Q1 athletes (*SR* = -2.35) than expected.

Table 1

Relative Age Statistics for Females Playing Female and Male Ice Hockey

Division	**Age**	**Team**	**n**	**χ^2**	***p***	***w***	**Q1%**	**Q2%**	**Q3%**	**Q4%**	**Q1 SR**	**Q2 SR**	**Q3 SR**	**Q4 SR**
All	7-17	All	29924	401.95	.001	0.12	26.14	28.09	25.52	20.26	3.93	10.68	1.79	-16.41
All	7-17	F	24985	369.90	.001	0.12	26.17	28.19	25.64	20.00	3.69	10.09	2.03	-15.82
All	7-17	M	4939	37.88	.001	0.09	25.98	27.56	24.88	21.58	1.37	3.59	-0.17	-4.80
Novice	7-8	F	2972	73.49	.001	0.16	25.54	30.52	24.50	19.45	0.59	6.02	-0.55	-6.05
Novice	7-8	M	1444	16.66	.001	0.11	25.35	27.91	26.11	20.64	0.26	2.21	0.84	-3.32
Atom	9-10	F	4074	25.73	.001	0.08	25.28	26.44	26.61	21.67	0.36	1.83	2.05	-4.25
Atom	9-10	M	1393	15.72	.001	0.11	24.69	28.64	25.48	21.18	-0.23	2.72	0.36	-2.86
Peewee	11-12	F	5511	76.56	.001	0.12	27.31	27.22	25.40	20.07	3.43	3.29	0.60	-7.32
Peewee	11-12	M	1025	4.00	.262	0.06	26.34	26.73	23.80	23.12	0.86	1.11	-0.77	-1.21
Bantam	13-14	F	6063	119.38	.001	0.14	26.77	28.62	25.35	19.26	2.75	5.63	0.54	-8.93
Bantam	13-14	M	665	7.92	.048	0.11	28.27	26.02	24.96	20.75	1.68	0.52	-0.02	-2.19
Midget	15-17	F	6365	106.23	.001	0.13	25.47	28.67	26.05	19.81	0.74	5.86	1.67	-8.28
Midget	15-17	M	412	4.91	.178	0.11	27.91	27.18	21.12	23.79	1.18	0.89	-1.58	-0.49

Note: ‘Team’ refers to whether participants played on female or male ice hockey teams.

Table 2

Age Division Comparisons for Females Playing Female Ice Hockey

Division	**Age**	**n**	**χ^2**	***p***	***w***	**Q1%**	**Q2%**	**Q3%**	**Q4%**	**Q1 SR**	**Q2 SR**	**Q3 SR**	**Q4 SR**
Novice	7-8	2972	73.49	.001	0.16	25.54	30.52	24.50	19.45	0.59	6.02	-0.55	-6.05
Atom	9-10	4074	55.06	.001	0.12	25.28	26.44	26.61	21.67	-0.90	-5.23	3.40	3.91
Peewee	11-12	5511	21.60	.001	0.06	27.31	27.22	25.40	20.07	3.04	1.39	-2.66	-1.84
Bantam	13-14	6063	7.24	.065	0.03	26.77	28.62	25.35	19.26	-0.75	2.00	0.15	-1.62
Midget	15-17	6365	10.78	.013	0.04	25.47	28.67	26.05	19.81	-2.35	-0.49	1.67	1.48

Discussion

The main purpose herein was test the hypothesis that first-quartile females registering to play male sport could explain the second-quartile phenomenon in female ice hockey. Hancock, Adler, and Côté's (2013) model provided the basis for this hypothesis, particularly the concepts of initial enrollment advantages (i.e., Matthew Effects; Merton, 1968) and self-fulfilling prophecies (i.e., Pygmalion Effects; Rosenthal & Jacobson, 1968). A secondary purpose was describing RAE patterns across female ice hockey age divisions, addressing the under-representation of female athletes RAE literature (Cobley et al., 2009).

For the first purpose, combining all participants revealed a statistically significant RAE, with athletes born in the second quartile being most over-represented, while athletes born in the fourth quartile were most under-represented. There was support for the first hypothesis that athletes playing female ice hockey would replicate the second-quartile phenomenon. There was limited support for the second hypothesis that athletes playing male ice hockey would possess a traditional RAE (i.e., Q1 most over-represented). For athletes playing female ice hockey, the second-quartile phenomenon was evident throughout with two minor exceptions. First, in Atom ice hockey, 26.4% and 26.6% of players were born in the second and third quartiles, respectively. Second, in Peewee ice hockey, 27.3% and 27.2% of the registrants were born in the first and second quartiles, respectively. For females playing male ice hockey, however, there were deviations at the two oldest age divisions. At the Bantam division, 28.3% and 26.0% of the registrants were born in the first and second quartiles, respectively, which supports the second hypothesis. Additionally, though to a lesser extent, the same trend existed in the Midget division (Q1: 27.9%; Q2 27.2%), but this result should be interpreted with caution as the chi-square test was non-significant.

The second purpose centered on differences in birth rate distributions across the age divisions, specifically for females playing female ice hockey. Using effect sizes, there was support for the third hypothesis that RAEs would be strongest at younger ages, while becoming weaker at older ages. For *SR*, there were numerous inter-quartile variations at younger ages, but variations were less frequent at older ages.

The findings herein complement previous literature showcasing the existence of the second-quartile phenomenon in female sports (Baker et al., 2009; Delorme et al., 2010b; Hancock, Seal, et al., 2013; Weir et al., 2010), yet none of the aforementioned studies, nor this one, have a clear explanation of the effect, which is imperative to our understanding of the mechanisms that facilitate RAEs. The theory underpinning this research was that some elite female ice hockey players would register for male teams, as typically there is stronger competition, more frequent practice time, and an increase in scheduled games, leading to enhanced developmental opportunities. Since RAEs generally favor those born in the first quartile (Cobley et al., 2009), possibly due to initial enrollment advantages (Hancock, Adler, & Côté, 2013), it was anticipated that participants born in the first quartile would have a propensity to register for male teams, compared to their relatively younger peers. In female ice hockey, this would then defer initial enrollment advantages to second-quartile athletes. The results, however, clearly indicated an over-representation of second-quartile female players in male ice hockey. Importantly, the decision to play on male teams was frequent, with 16.5% of the participants registering for male teams; thus, the results cannot be attributed to lack of participation on male ice hockey teams. Instead, it remains unclear why the second-quartile phenomenon exists for certain female athletes.

An unexplored suggestion from Hancock, Seal, and colleagues (2013) was to examine RAEs in stereotypical female sports such as softball, gymnastics, and swimming. The logic is that females born in the first quartile might have high participation rates in these sports, leaving other sports with a deficit of females born in the first quartile. Integrating this with Hancock, Adler, and Côté's (2013) model, initial enrollment advantages in non-stereotypical female sports would then be afforded to second-quartile athletes, as fewer first-quartile athletes would register. Another explanation of the second-quartile phenomenon is derived from the work by Wattie and colleagues (2014). Here, the authors intimated that early onset of puberty for female athletes might initiate symptoms of depression, weight concerns, and decreases in self-worth, all of which could lead to sport dropout. Though not a direct link, the onset of puberty is likely earlier among relatively older athletes, increasing their odds of negative emotions that could lead to dropout. This would not explain the second-quartile phenomenon at the youngest female age divisions; nevertheless, it is an important consideration for understanding the second-quartile phenomenon. A final possibility involves the value coaches place on physical maturity versus talent (Hancock, Adler, & Côté, 2013). In female ice hockey, rules prohibit body checking. Perhaps then, there is less consideration for physical size, more of an emphasis on talent, and the result is fewer players being selected simply based on maturity (i.e., Q1 athletes). Whether this is due to rule differences in female and male sports, or stereotypical perceptions of how female athletes should perform (i.e., less physical, more finesse) is unclear; yet, this idea surely warrants further consideration.

A noted limitation in interpreting the study findings relates to practical significance. Throughout the analyses, effect sizes were low, implying minimal practical significance. This was especially true for the second study purpose, where effect sizes signified the strength of RAEs over time. Such results are typical in RAEs research, where significant results are often driven by large sample sizes. While it is not prudent to arbitrarily reduce sample sizes, the practical significance herein should be interpreted cautiously.

In conclusion, it is important that researchers seek theoretically-grounded explanations for the second-quartile phenomenon in female sport. A suggestion for future researchers is a systematic analysis of RAEs for female athletes in one region or country, but across several sports and age divisions. In doing so, a more complete understanding of the RAE—along with any perturbations or deviations—can be discovered. For instance, this could identify if certain sports have an over-representation of females born in the first quartile, while others might show a second-quartile phenomenon. Additionally, changes across the lifespan, particularly around pubertal ages, can be illuminated. Such an approach benefits RAE research. Lastly, it might be helpful to interview coaches of female athletes to inquire about their perceptions of the role of physical maturity for athletic success. With a better understanding of the factors that contribute to selection decisions, researchers might then formulate hypotheses to explain the effect. It is hoped that such an understanding would facilitate revised RAE models that better articulate the effect, while generating practical solutions to ensure equitable sport participation.

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