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# The Role of Relative Age, Community Size, and Positive Youth Development on Female Youth Soccer Participation

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By

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## DECLARATION OF CO-AUTHORSHIP / PREVIOUS PUBLICATION

I. Co-Authorship

I hereby declare that this thesis incorporates material that is result of joint research, as follows:

Appendix A is a co-authored publication. I led the study, performed the literature search, led data screening and data extraction, quality assessment, data interpretation, oversaw meta-analysis and result interpretation, and completed writing and editing of all paper sections. Dr. Stephen Cobley supervised the study providing guidance related to the literature search, screening, and data extraction. Steve contributed to all methodological steps and completed all meta-analyses and results write-up. He contributed and edited all paper sections. Dr. Patricia Weir provided recommendations for study design, modified the STROBE checklist, and contributed to discussion write-up and editing of all paper sections. Dr. Kevin Till and Dr. Michael Romann completed study quality assessments, contributed to writing and edited manuscript development.

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| Thesis Chapter | Publication title/full citation | Publication status |
|---|---|---|
| Appendix A | Smith, K.L., Weir, P.L., Till, K., Romann, M., & Cobley, S. (2018). Relative age effects across and within female sport contexts: A systematic review and meta-analysis. *Sports Medicine, 48*(6), 1451-1478. | Published |

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# ABSTRACT

**Objective:** The overarching purpose of this dissertation was to use relative age as a basis to examine the developmental sport experience of youth and explore factors related to sport engagement and positive youth development in organized, female soccer in Ontario, Canada. Female dropout trends were documented for the first time in a longitudinal manner (i.e., covering the pre-adolescent to post-adolescent transition years) in a popular youth sport context. Analyses were informed by multiple points of reference (i.e., date of birth, participation records, competition level, community size and density, and self-report of the participants). New research avenues were explored to generate hypotheses for future research; which included neighbourhood level variables and developmental assets.

**Methods:** An anonymized dataset of all female registrants in a one-year cohort was provided by *Ontario Soccer*. This dataset included all registration entries across a seven-year period (age 10 to 16 years). A total of 38,248 registration entries for 9,915 participants were available for examination. Several quantitative approaches were used across three studies, including Kaplan Meier and Cox regression survival analyses, odds ratio analyses, discriminant analysis, binary logistic regression, and chi-square analysis.

**Results:** The key finding of the current research suggests that relative age continues to be an important variable with respect to youth sport participation and continued engagement; with the relatively oldest being more likely to participate and remain engaged between the ages of 10 to 16 years. Competition level was observed to be an important variable, with 'competitive' and 'recreational' trajectories varying in terms of relative age distribution and retention rates (55.9% vs. 20.7% continued to participate at age 16 years, respectively). In general, mid-sized and less densely populated communities appeared to provide the greatest likelihood of participation in youth soccer; although considerable within-category variation was observed. Built environment emerged as a potential avenue for future research. Overall developmental asset scores did not appear to be protective against sport dropout; but relatively younger female soccer players scored higher in two internal asset categories, *commitment to learning* and *positive values*, suggesting sport-related challenges may further individual development in these areas.

**Conclusions:** Relative age effects continue to contribute to participation and development inequities in sport. Detailed research into the underlying mechanisms and potential intervention strategies is still required. Future studies should be guided by an appropriate theoretical framework; the selection of which depends on the primary goal(s) of the research.

# DEDICATION

For Tristan and his little sister.

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To Patti, I am not sure that I can adequately convey how thankful I am for your influence in my life and guidance through this process. I appreciate your support both within and outside of academics. You always seem to know when I need some encouragement, and I know that I would not have survived this process without you.

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## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

**LIST OF APPENDICES**

## LIST OF ABBREVIATIONS / SYMBOLS

| | |
|---|---|
| RAE | Relative age effect |
| Q1/2/3/4 | Birth quartile 1, 2, 3, or 4 |
| BPE | Birthplace effect |
| GIS | Geographic information systems |
| CS | Community size (overall number of inhabitants) |
| CD | Community density (number of people/$km^2$) |
| PYD | Positive youth development |
| VIF | Variance inflation factors |

# CHAPTER 1

# INTRODUCTION

## *1.1 General Introduction and Rationale*

Participation in organized sport during childhood and adolescence has been associated with a variety of desirable outcomes including improved physical health, psychosocial development (e.g., life skills such as cooperation and leadership), and the learning of fundamental motor skills for continued sport participation (Côté & Fraser-Thomas, 2011; Eime, Young, Harvey, Charity, & Payne, 2013; Fraser-Thomas, Côté, & Deakin, 2005). The benefits appear to extend beyond those attributable to physical activity alone, some of which are reinforced by the social nature of sport competition (Vella, Cliff, & Okely, 2014). For instance, Bloom, Grant, and Watt's 2005 report highlighted sport as a source of fun and relaxation, an enhanced sense of personal accomplishment and satisfaction, socialization and connections with others, and an opportunity to improve social, analytical, and life skills.

Organized sport also appears to be an attractive option for parents. The current perception of heightened neighbourhood danger is believed to be contributing to reduced time spent by children in outdoor play and other unstructured physical activity (Lee et al., 2015). However, 75% of 5- to 19-year old Canadians are reportedly participating in organized sport (CFLRI, 2014), suggesting it may be viewed as a 'safer' option and a potential strategy to counteract the current levels of inactivity (ParticipACTION, 2015). Unfortunately, high rates of sport dropout are also being reported (e.g., Balish, McLaren, Rainham, & Blanchard, 2014; Petlichkoff, 1996) with lack of enjoyment, low perceived competence, an increase in family and intrapersonal pressure, and physical factors (maturation and injury) being cited as primary contributors (Crane & Temple, 2015).

Within the context of organized sport, children are often grouped by chronological age. These divisions are intended to promote a developmentally appropriate environment to practice sport by providing equal access to training, competition, and opportunities to achieve success (Barnsley, Thompson, & Legault, 1992). However, individual variability within these same-age cohorts is often resulting in achievement inequities among members due to relative age (Baker, Schorer, & Cobley, 2010; Cobley, Baker, Wattie, & McKenna, 2009). To illustrate, *Ontario Soccer* uses a December 31st cut-off to group players across the province. Therefore, a child born in January will have up to a 12-month relative age advantage over a child born in December of the same year, leading to physical, psychological, and experiential differences in maturity among peers (Barnsley et al., 1992; Dixon, Horton, & Weir, 2011). In addition, there is also considerable variability in biological maturity present through to adolescence (Malina, Bouchard, & Bar-Or, 2004; Musch & Grondin, 2001). These differences can lead to selection advantages and playing opportunities for the older players; and may ultimately result in differences in the average attainment levels of otherwise similar individuals (Barnsley et al., 1992). Conversely, being relatively younger may pose a disadvantage, potentially contributing to negative sport experiences or dropout from sport (Lemez, Baker, Horton, Wattie, & Weir, 2014). The relatively younger players may not have the same opportunity to develop and are more likely to struggle with issues of competence and self-worth (Barnsley & Thompson, 1988; Delorme, Boiché, & Raspaud, 2010; Helsen, Starkes, & Van Winckel, 1998).

The Relative Age Effect (RAE) is the term used to describe these potential advantages or disadvantages that result from differences in age among children in the same cohort (Barnsley, Thompson, & Barnsley, 1985). With respect to sport, the advantage conveyed to those who are relatively older is assumed to be present when an over-representation of relatively older players is observed among sport participants (e.g., athletes born in the earlier months of the year in a system that uses December 31$^{st}$ as a cut-off to group participants), particularly at elite levels of competition. Its presence has been established across a variety of sport and cultural contexts (refer to Cobley et al., 2009 for a review), and predominantly investigated among male participants in team sports such as soccer (e.g., Helsen, Van Winckel, & Williams, 2005), ice hockey (e.g., Wattie, Baker, Cobley, & Montelpare, 2007), and handball (e.g., Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009).

Individual, but still physically demanding activities, may also be affected with RAE patterns documented in sports such as tennis (e.g., Edgar & O'Donoghue, 2005), skiing (e.g., Baker, Janning, Wong, Cobley, & Schorer, 2014), and sprinting (e.g., Romann & Cobley, 2015). In contrast, sports that are more reliant on skill than physical prowess tend not to exhibit a RAE (e.g., golf; Côté, MacDonald, Baker, & Abernethy, 2006; shooting sports; Delorme & Raspaud, 2009a). The RAE has also been documented within the education system including attainment in physical education classes and sport team participation (Cobley, Abraham, & Baker, 2008), high school leadership activities (Dhuey & Lipscomb, 2008), standardized test scores (math and science) and university attendance (Bedard & Dhuey, 2006). Relative age has also been reported to affect emotional regulation (i.e., reduced levels of self-esteem for the relatively younger; Thompson, Barnsley, & Battle, 2004).

In light of the potential benefits of sport participation (Côté & Fraser-Thomas, 2011; Vella et al., 2014), effective strategies to encourage engagement in organized sport are needed for developing youth. Relative age has the potential to be counterproductive to this objective. Therefore, the continued study of the RAE is necessary to gain a thorough understanding of the contributing factors and to identify meaningful ways to reduce the adverse effects associated with it. The completed studies outlined in this document used relative age as a basis to examine the developmental[1] sport experience of youth and explore factors related to sport engagement and positive development in organized, female youth soccer in Ontario, Canada. Multiple points of reference were included to provide insight into participation trends. The first study established the pattern of over-representation in a female pre-adolescent cohort and evaluated the longitudinal pattern of dropout for a period of seven years retrospectively. The impact of community size and level of play / competition level was considered as part of this analysis; as recommended in previous research (e.g., Smith & Weir, 2013). The second study expanded on these findings using geospatial mapping to evaluate the influence of community size and community density on participation rates; and subsequently explored neighbourhood-level variables to generate hypotheses for future research. Finally, the third study explored a potential connection between relative age and the possession of developmental assets (Benson, 1997). Preliminary work in the form of a systematic

[1] The term 'developmental' refers to an individual who is in the process of growth or progress in his/her athletic skill development at non-professional levels (Smith & Weir, 2013).

review and meta-analysis of RAEs in female sport contexts is also included (refer to section 1.2 and Appendix A).

The data were drawn from Ontario Soccer's player population, which is comprised of more than 400,000 players, coaches, referees, and administrators. The selected cohort for this research was comprised of a one-year (i.e., all participants were born in the same year), provincially representative sample of female registrants ($n$ = 9,915). The information obtained enhances current understanding of the influence of relative age on dropout and engagement among female soccer players, highlights avenues for future research, and can be used to inform strategic planning to promote increased participation and positive sport experiences.

### *1.2 A Systematic Review and Meta-Analysis of Existing Literature – Relative Age Effects Among Female Sport Participants*

Sex is believed to be a significant moderator of the effect (Baker, Schorer, et al., 2010). However, the majority of studies have traditionally focused on male athletes (Cobley et al., 2009) and continued examination of female samples is needed. In general, the effect has been anticipated to be smaller in magnitude for females when compared to male samples (Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009; Baker, Schorer, et al., 2010; Wattie, Schorer, & Baker, 2015). To determine whether RAEs were prevalent in female sport contexts and quantify the effect, a systematic review and meta-analysis of female sport samples was conducted (Smith, Weir, Till, Romann, & Cobley, 2018). Following PROSPERO (Reg. no. 42016053497) and PRISMA systematic search guidelines, 57 studies spanning 1984–2016 were identified and contained 308 independent samples across 25 sports. The overall prevalence and strength of RAEs across and within female sport contexts was determined (including moderating factors of age, competition level, and sport type) using odds ratio (OR; events vs. non-events) meta-analyses, applying an invariance random-effects model. Based on identified studies, pooled data comparing the relatively oldest (Quartile 1) vs. relatively youngest (Quartile 4) suggested the relatively oldest were 25% more likely to be represented across a range of female sport contexts (OR 1.25, 95% CI 1.21,1.30).

When pooled findings from this meta-analysis were compared to estimates for the RAE in males, a smaller overall RAE magnitude was observed for females[2] (male Quartile 1 vs. Quartile 4 OR 1.65, 95% CI 1.54, 1.77; see Cobley et al. [2009] for the most comprehensive meta-analysis of RAEs conducted on male athletes). For females, greater RAE magnitude was associated with pre-adolescent (11 years old or younger) and adolescent (12-14 years old) age categories; and decreased in magnitude following the completion of maturation (Smith et al., 2018). In contrast, an increasing risk was observed for male samples from the child (under 10 years old) to adolescent category (15 to 18 years old); decreasing thereafter but still remaining significant at the senior, adult level (Cobley et al., 2009).

Additional sub-group analyses suggested the factors of competition level, sport type, and context significantly moderated estimates of overall RAEs. Greater RAEs were associated with higher levels of sport competition, where selection processes for the purpose of talent identification were likely to be present. Relative age effect risk did decrease in the 'elite' category with increasing age but remained significant. Reduced

[2] Sex appeared to have minimal impact in the estimates generated by Cobley et al. (2009); however, the researchers noted that the overall female estimate was based on only 24 samples available at the time of data collection (i.e., representing only 2% of all participants included in the analysis).

RAE-risk was observed at the recreational level across age groups. Greater RAEs were evident in both team-based (e.g., ice hockey, handball, basketball) and individual sports associated with high physiological demands (e.g., alpine skiing, swimming, track and field; Smith et al., 2018).

Interestingly, a marginal over-representation of athletes born in the second quartile was observed; a pattern reported in previous work and often associated with female samples from Canadian ice-hockey (e.g., Hancock, Seal, Young, Weir, & Ste-Marie, 2013; Smith & Weir, 2013; Weir, Smith, Paterson, & Horton, 2010) and adult-aged soccer in Europe (e.g., Baker et al., 2009; Delorme et al., 2010). The classic RAE trend is typically linear, with the first quartile over-represented (i.e., January to March birthdates in a system that uses December 31st as a cut-off date; Quartile 1 [Q1]) and a gradual decrease in representation for each sequential quartile (i.e., Quartile two [Q2], three [Q3], and four [Q4]; Addona & Yates, 2010; Baker, Cobley, Montelpare, Wattie, & Faught, 2010). This pattern would be expected according to the argument that being relatively older is likely to be a benefit in athletics (Hancock, Seal, et al., 2013). A detailed examination of available samples did reveal the classic Q1 over-representation in the pre-adolescent age group (i.e., less than 11 years of age) at competitive levels, while Q2 over-representation was observed at recreational levels. However, a Q2 over-representation was evident in both competitive and recreational trajectories by adolescence (i.e., 12-14 years of age); possibly suggesting an interaction between growth and maturational processes and intensified sport involvement at pre-adolescent ages (Smith et al., 2018). The validity of this hypothesis and the association of this Q2-trend with female samples requires further investigation.

*Please note: The systematic review and meta-analysis of RAEs in female sport contexts can be found in Appendix A.*

### *1.3 Proposed Mechanisms of the Relative Age Effect*

Musch and Grondin (2001) suggested that the underlying cause of RAEs is multi-factorial in nature, with a combination of factors working together to produce the effect (e.g., physical, cognitive, emotional, motivation, social). The most commonly cited explanation consists of two complementary, interacting mechanisms that have been termed the 'maturation-selection' hypothesis (Baker, Cobley, et al., 2010; Cobley et al., 2009; Lovell et al., 2015). This hypothesis suggests that greater chronological age is likely to be accompanied by enhanced physical characteristics (e.g., height, mass, muscular strength). This provides a performance advantage in sport, particularly those that are physical in nature such as ice hockey and soccer. While recognizing that maturational timing may deviate considerably between individuals, the relatively older theoretically enter puberty earlier (i.e., generally, at 12-14 years of age in girls and 13-15 years of age in boys), further exacerbating the variation in physical characteristics between peers until the process is complete for the entire cohort. The relatively older and early maturing may appear to be more talented because of their advanced physical status and consequently, are selected by coaches for the more elite teams. By being selected, they will likely have access to higher levels of competition, training, and coaching expertise (Helsen et al., 1998), thereby generating an experience advantage that may accumulate over the years and lead to an increased chance of being selected again in the future (Cobley et al., 2009). Thus, the original advantage of enhanced physical characteristics among the relatively older is perpetuated while simultaneously making it more difficult for the younger peers to stay in the system (MacDonald & Baker, 2013).

Socio-cultural factors (e.g., population growth, increased popularity of a sport[3]) have also been discussed in the literature and are theorized to impact the ‘depth of competition’ by increasing the potential pool of athletes competing for a designated number of playing positions; thereby inflating the influence of the RAE within a cohort (Baker et al., 2009; Musch & Grondin, 2001; Schorer et al., 2009). To illustrate, if 20 spots are available and only 20 players are interested in filling those positions, a RAE will not be expected because every player will have an opportunity to play. However, if 200 individuals are interested in those 20 playing positions, there will be strong competition to be selected for membership on the team and a RAE is likely to be observed. This suggests that the sport has to be popular enough that a competitive pool of potential players is available, or a RAE is unlikely (Cobley et al., 2009; Musch & Grondin, 2001). Yet, the RAE has been observed at young ages in less competitive environments. Delorme and Raspaud (2009b) reported an unequal birthdate distribution in the ‘7-8’ and ‘9-10’ year old age categories among female, French basketball players even though there were no official games or competition in these age divisions and therefore, no associated selection processes to gain a position on the team and consequently promote RAEs. Other studies have reported similar findings in various sport contexts at the developmental level (e.g., Hancock, Ste-Marie, & Young, 2013; Lemez, MacMahon, & Weir, 2016; Smith & Weir, 2013). Parental awareness of the

[3] See Wattie, Baker, Cobley, and Montelpare (2007) for an example in Canadian ice hockey.

RAE may be influencing these trends; as evidenced by a lack of registration by relatively younger participants in the youngest chronological age groups (Delorme et al., 2010; Smith & Weir, 2013) where athlete selection on the basis of perceived talent would not yet play a role in membership.

The depth of competition hypothesis was also weakened to some extent by a study of Swedish female hockey. Stenling and Holmström (2014) examined a sample of youth ($n$ = 2811, age 5-20 years) for the 2011/2012 season, in addition to junior elite players who participated in the women's under-18 regional tournament over a ten-year period ($n$ = 399), and elite level players from the national championships and 'Rikserrien' (highest women's elite league) over ten years ($n$ = 688). A significant over-representation of players in Quartile 1/Quartile 2 and under-representation in Quartile 4 with small effect sizes were consistently found throughout various levels of the sample. The popularity and participant numbers present in this context are lacking compared to Canadian ice hockey, yet the pattern observed was comparable to previous findings (Smith & Weir, 2013; Weir et al., 2010). This suggests that the RAE persists despite reduced depth in competition and therefore, this element may not be as important of an antecedent as originally thought (Stenling & Holmström, 2014).

### *1.4 Theoretical Models*

The study of the RAE has been predominantly 'atheoretical' to date (Cobley et al., 2009); which has limited our understanding of how RAEs influence both the developmental aspects of youth participation and the achievement of sport expertise (Wattie et al., 2015). A theoretical framework is needed to guide the interpretation of RAE data and develop testable hypotheses; and this model must account for all potential direct and indirect influences (Schorer et al., 2009). A few attempts have been made to develop an appropriate conceptual framework to investigate the RAE. For instance, Hancock, Adler, and Côté, (2013) used the *Matthew Effect* (i.e., initial advantages are maintained), the *Pygmalion Effect* (i.e., perceptions of others shape behaviour), and the *Galatea Effect* (i.e., self-expectations match outcomes) to explain how the behaviour of athletes, parents, and coaches are connected to RAEs. However, this model has been criticized for being too general (i.e., not sport specific) and too simplistic to capture the inherent complexity of the RAE (Wattie et al., 2015). Pierson, Addona, and Yates (2014) formulated a dynamic, mathematical model to evaluate the RAE as a positive feedback loop, and the effects of three proposed intervention strategies. While this model provided a good fit with Canadian youth ice hockey data, it was also general in nature and lacked consideration of details specific to different sports, settings, and sex (Pierson et al., 2014).

Wattie et al. (2015) used *Newell's Model of Interacting Constraints* (i.e., individual, task, and environmental) and *Developmental Systems* Theory (Araujo et al., 2010; Lerner 2006; Newell, 1986), along with supporting evidence from the existing RAE literature, to outline how interactions occur between constraints to produce this phenomenon. This model accounts for the fact that RAEs 'occur within the actual ecology of youth development' (Wattie et al., 2015; pp. 84); and thus, considers a variety of influencing factors. For instance, date of birth, size, and sex are all recognized as individual constraints that may influence RAEs. Additional individual, task, and environmental constraints are identified in Table 1. Noted interactions exist between these constraints and it is acknowledged that once a particular outcome is created, it can alter the developmental system. For example, knowledge of the RAE has influenced family planning among couples of higher socioeconomic status (SES), with targeted birthdates at the start of the sport and/or academic year (Bedard & Dhuey, 2006). Likewise, 'red-shirting' is the name given to children who are held back a year in order to position them as the relatively oldest among their peers (McLaren, 2015). Families of lower SES may not have opportunity to adopt these strategies, adding to their already disadvantaged position (Bedard & Dhuey, 2006).

***Table 1.1***

Relative age effects: Examples of individual, task, and environmental constraints

| Type of Constraints | Examples |
|---|---|
| Individual | Birth date, variability between chronological and biological age (i.e., related to timing and tempo of maturation), size, sex, handedness, relative age* |
| Task | Sport type (e.g., team vs. individual, physical vs. tactical vs. artistic), laterality advantage, participation level, playing position |
| Environment | Age- and other grouping policies, family influence, popularity of sport, sport's maturity, coach influence, social and cultural norms, relative age* |

*Source: Adapted from Wattie et al. (2015)*

**Note: Relative age depends on the age-grouping policy employed by the respective sport organization; thus, there must be a simultaneous interaction between an individual and environmental constraint for 'relative age' to exist.*

The principles of diversity and plasticity are represented in the model. *Diversity* acknowledges that individual differences are inherent in development. Not all first-quartile born athletes will be successful in sport; nor are all later-born participants disadvantaged. *Plasticity* reflects the possibility for change throughout the lifespan. Therefore, RAEs are probabilistic not deterministic (Wattie et al., 2015, p. 89).

To date, Wattie and colleagues have provided the most comprehensive model with a sport-specific foundation from which to test future hypotheses within a sport expertise perspective. The use of a 'causal pie' allows for the development of predictive models of RAE-likelihood in specific sport contexts and the authors suggest this model can be used to test the impact of interventions on the identified constraints (Wattie et al., 2015). It is noted that research guided by this model will require triangulation of findings from multiple sources and research methods (e.g., qualitative and quantitative), and a multi-disciplinary approach. Additional frameworks may be beneficial depending on the goal of the research (e.g., health related, positive youth development) and will be considered in the remaining chapters when appropriate.

### *1.5 Additional Background and Rationale*

#### *1.5.1 Relative Age Effects and Sport Dropout*

Dropout from organized sport with respect to relative age has not been adequately studied among females and preliminary evidence suggests that patterns may differ between the sexes. Previous examinations of male samples have shown that the relatively youngest are at greatest risk of sport dropout (e.g., Delorme, Chalabaev, & Raspaud, 2011; Lemez et al., 2014). However, Wattie et al. (2014) found that relatively older females showed higher rates of decline from German youth sport clubs; a sample that was noted to be primarily composed of athletes from artistic sport contexts (e.g., gymnastics) and recreational in nature. Vincent and Glamser (2006) suggested the pattern may depend on the sport context and the degree to which it is acceptable for females to participate in that particular culture. Thus, female sport dropout patterns are important to define in order to unravel the underlying mechanisms involved and understand the role of relative age in sport participation. If relatively older females are dropping out of sport earlier for an identifiable reason (e.g., increased social pressure associated with undergoing maturation prior to one's peers), this information is necessary to develop effective intervention strategies. Please refer to Chapter 2 (i.e., Study #1 – *An Examination of Relative Age and Athlete Dropout in Female Developmental Soccer*) of this document for further discussion.

#### ***1.5.2 Community Sport Context***

An athlete's developmental environment has the potential to impact continued participation in sport and ultimate level of achievement. Researchers have suggested that the size of the community where their sport development occurs (Côté et al., 2006), and more recently, the population density of the community (Rossing, Stentoft, Flattum, Côté, & Karbing, 2018) may be important. It has been suggested that the psychosocial environments of smaller communities (e.g., opportunities to develop supportive relationships, a greater sense of belonging) encourage young athletes to stay involved in sport (e.g., Fraser-Thomas, Côté, & MacDonald, 2010). Additional explanations put forth are related to the opportunities for quantity and quality of play and practice that communities of a particular size can provide (refer to Côté, Baker, & Abernethy, 2007 for a review of *deliberate play* and *deliberate practice*). Examinations of sport dropout with respect to community context are needed to highlight where intervention is required and could also lead to further discovery of the characteristics of successful sport contexts that can be applied to other programs. Please refer to Chapter 3 (i.e., Study #2 – *Geospatial Mapping of Female Youth Soccer Participation and Continued Engagement: Associations with Community Size and Community Density*) for further discussion.

### *1.5.3 Positive Youth Development*

Current research is moving away from documenting the RAE and exploring the underlying mechanisms of the phenomenon. Consideration of how youth develop within multilevel systems (i.e., macro-level approach) and detailed research into specific constraints has been recommended (Wattie et al., 2015). Given that the RAE has the potential to influence sport program delivery for each participant, the relationship between psychosocial development and athlete performance is one area for future investigation. For example, while the relatively younger are believed to suffer from disadvantages at a young age, there is evidence that the challenges they encounter may provide useful or 'structured trauma' (Collins & MacNamara, 2012), facilitating the development of important qualities such as mental toughness and resilience (Andronikos, Elumaro, Westbury, & Martindale, 2016; Collins & MacNamara, 2012) which may lead to a later career advantage (Baker & Logan, 2007; Fumarco, Gibbs, Jarvis, & Rossi, 2017). This idea could provide an explanation for the observed decrease in the RAE at professional levels in some sport contexts (Cobley et al., 2009). Please refer to Chapter 4 (i.e., Study #3 – *Relative Age and Positive Youth Development: Do Developmental Assets Play a Role in Creating Advantage Reversals?*) for further exploration of this hypothesis.

## *1.6 Summary*

The overarching objective of this work was to examine the developmental sport experience of female athletes to inform strategies aimed at promoting organized sport participation and associated benefits (e.g., physical health, psychosocial development, learning of fundamental motor skills; Côté & Fraser-Thomas, 2011; Fraser-Thomas et al., 2005; Eime et al., 2013). Manuscripts for three complementary studies have been provided in the remaining chapters, which use relative age as a basis to examine the sport experience of young female soccer participants in a longitudinal manner (i.e., covering the pre-adolescent to post-adolescent transition years). A general discussion of the main findings and directions for future research has also been provided.

## *1.7 References*


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# CHAPTER 2

# AN EXAMINATION OF RELATIVE AGE AND ATHLETE DROPOUT IN FEMALE DEVELOPMENTAL SOCCER

## *2.1 Introduction*

### *2.1.1 Relative Age and Sport Dropout*

Sport dropout rates among children and youth present a growing concern for researchers and policy makers alike. From a healthy development perspective, organized sport participation is associated with a variety of physical, psychological, and social benefits (Eime, Young, Harvey, Charity, & Payne, 2013; Janssen & LeBlanc, 2010; Lagestad, 2019). For example, youth who engage in organized sport may experience greater social competence (Howie, Lukacs, Pastor, Reuben, & Mendola, 2010) and fewer depressive symptoms (Boone & Leadbeater, 2006; Sanders, Field, Diego, & Kaplan, 2000); and may be more likely to develop fundamental movement skills that promote physical activity engagement in alternative sport contexts and healthy leisure pursuits across the lifespan (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Stodden et al., 2008). From a talent development perspective, sport dropout causes a reduction in potential talent for future advancement in sport, as the development of expertise is theoretically predicated by ongoing participation. While high rates of organized sport participation have been reported[4], high levels of dropout have also been observed and are estimated to be between 30-35% per year (Balish, McLaren, Rainham, & Blanchard, 2014;

[4] Seventy-seven percent of Canadian children and youth aged five to 19-years-old participate in organized physical activity or sport, as reported by their parents (CFLRI, 2016).

Petlichkoff, 1996); although current estimates are unavailable and likely vary by sex, sport context, and chronological age (Butcher, Lindner, & Johns, 2002).

A recent systematic review examining organized sport dropout identified that intrapersonal (e.g., lack of enjoyment) and interpersonal (e.g., parental pressure) constraints are commonly associated with disengagement among children and youth (Crane & Temple, 2015). This review also highlighted a potential connection between frequently cited dropout factors and relative age: that being, physical factors (e.g., maturation) and perceptions of competence. Commonly known as *Relative Age Effects* (RAEs), this term refers to the (dis)advantages resulting from subtle variations in chronological age and thus, lived experience and physical / psychological development in age-grouped peers (Wattie, Cobley, & Baker, 2008). Within sport, RAEs are believed to advantage those who are relatively older (i.e., born earlier and closer to an organization-imposed cut-off date for grouping similar-age athletes) by providing increased access to higher levels of competition, training, and coaching (Helsen, Starkes, & Van Winckel, 1998; Musch & Grondin, 2001).

The underlying mechanisms contributing to RAEs are likely multi-factorial in nature and include a variety of individual, task, and environmental contributors (Musch & Grondin, 2001; Wattie, Schorer, & Baker, 2015); the 'maturation-selection' hypothesis is most commonly cited by researchers (Baker, Cobley, Montelpare, Wattie, & Faught, 2010; Cobley, Baker, Wattie, & McKenna, 2009; Lovell et al., 2015). Briefly, this hypothesis suggests that advanced chronological age is accompanied by greater anthropometric (e.g., stature) and physical attributes (e.g., muscular strength and endurance) which provide performance advantages in many sport contexts. These differences are further exacerbated during adolescence. Consequently, relatively older children who are likely to be further along in terms of maturational development, receive more attention from coaches and may experience a higher likelihood of selection for elite levels of sport competition; which ultimately furthers their athletic development. Conversely, relatively younger participants may not have the same opportunity to develop and are more likely to struggle with perceptions of competence and self-worth (Barnsley & Thompson, 1988; Delorme, Boiché, & Raspaud, 2010a; Helsen et al., 1998). In the Crane and Temple review (2015), five of the six studies identifying maturation as a contributing factor to dropout suggested that RAEs were a factor; although the reviewers also noted that more research was needed to understand the connection between competing with chronologically older peers and experiences leading to dropout.

### *2.1.2 Review of Relevant Literature*

Relative age effects are well-documented in the realm of sport among male and female competitors across numerous sport contexts (e.g., ice hockey, soccer, tennis) and developmental levels (i.e., from sport initiation years to pre-elite; Cobley et al., 2009; Smith, Weir, Till, Romann, & Cobley, 2018). Advantages for the relatively older are inferred in sport when an over-representation of athletes born earlier in the selection year are observed to have membership at elite levels of competition. While there is some evidence that a small percentage of relatively younger athletes may ultimately benefit from challenges encountered from their disadvantaged birthdate position[5], many are subject to negative sport experiences (Cobley, Miller, Till, & McKenna, 2013) and these experiences could theoretically lead to an increased risk of sport dropout. Yet, the impact

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[5] See Gibbs, Jarvis, and Dufur (2012) and Collins and MacNamara (2012) for a discussion of the *Underdog Hypothesis* and the role of structured trauma in development, respectively.

of RAEs on sport dropout has not been adequately examined or explained in the literature to date.

Initial observations of an association between relative age and sport dropout were made several decades ago by Barnsley and colleagues (Barnsley, Thompson, & Barnsley, 1985; Barnsley & Thompson, 1988), who suggested that relatively older Canadian ice hockey players were more likely to remain engaged in the sport when compared to the relatively youngest participants. Similarly, an examination of male youth soccer in Belgium indicated that a higher rate of dropout was present among later-born players at 12 years of age (Helsen et al., 1998). Large scale, cross-sectional studies of French soccer and basketball provided further evidence of increased rates of dropout amongst the relatively youngest over a one-year period (Delorme et al., 2010a; Delorme, Boiché, & Raspaud, 2010b; Delorme, Chalabaev, & Raspaud, 2011). These trends were consistent across a variety of pre- to post-adolescent age groups in both male and female samples; leading the researchers to suggest that the over-representation of relatively older participants often observed in sport samples may be in part due to a greater number of relatively younger among the ‘dropouts’ (Delorme et al., 2011).

Recent studies have continued to examine sport engagement with respect to relative age; albeit with a different approach to earlier dropout work. A cross-sectional study was completed by Cobley and Till (2017), who examined participation trends for one season in UK Rugby League (both male and female participants, age 7-21 years) from an ecological systems perspective (Bronfenbrenner, 1977; 1995; 1999). Participation numbers were observed to steadily increase in pre-adolescent age groups (‘Under-8 to Under-12’), without any suspected influence of RAEs. However, marked declines in participation trends for third- and fourth-quartile born athletes (i.e., the relatively youngest) were evident by ‘Under-13,’ aligning with peak maturational periods and the introduction of competitive tiers and associated selection processes. In contrast, observations of first- and second-quartile (i.e., the relatively oldest) did not show this decline until ‘Under-15;’ leading the researchers to suggest that the combined effect of being relatively younger during the adolescent years along with the introduction of talent identification tiers, could produce significant disparities in birthdate representation. These findings highlight the need for continued investigation of *transient* participation trends across age groups (Cobley & Till, 2017).

Two longitudinal examinations of relative age and dropout have also been conducted. Figueiredo, Coelho-e-Silva, Cumming, and Malina (2018) reported inconsistent tracking of participation by birth quartile for male soccer players at two- and ten-year timepoints after baseline analyses (i.e., 11- and 13-years of age); playing status could not be predicted by birth quartile. However, this study was limited by a small sample size ($n$ = 112). Lemez and colleagues provided a more substantial analysis of male athletes by examining 14,325 registrants in Canadian ice hockey over a five-year period (age 10 to 15 years). Relatively younger participants born in the fourth quartile were found to be 17% more likely to drop out than their first-quartile counterparts (OR 1.175, 95% CI 1.054, 1.309; Lemez, Baker, Horton, Wattie, & Weir, 2014). Subsequent analyses attempted to unravel the impact of player movement between competition levels on the observed patterns of dropout. Observations suggested that dropout players were more likely to remain at the same level of competition prior to disengagement from the sport.

While the weight of the evidence in published literature points to a higher risk of sport dropout for the relatively youngest, one exception to this pattern has been noted. Wattie et al. (2014) observed increased odds of reported dropout among relatively older female participants at the recreational level in German youth sport clubs, with no comparable effect in the male sample. This finding may have been driven by a high proportion of athletes participating in artistic or individual sport contexts (e.g., gymnastics) within the sample, with smaller physical size providing a competitive advantage. However, these findings also raise questions about the possibility of sex differences in dropout trends. Vincent and Glamser (2006) suggested the 'maturation-selection' hypothesis may exemplify the male sporting experience to a greater extent than that of females due to the associated disadvantages that maturation brings for female athletes (e.g., shorter legs and wider hips; Malina 1996) compared to the physical advantages afforded to early maturing males (e.g., increased speed, power, and endurance in motor skills; Malina, Bouchard, & Bar-Or, 2004). The findings of Wattie and colleagues may also implicate a role played by talent identification and development processes, as the athletes examined participated in recreational contexts (Wattie et al., 2014). Indeed, entry into competitive contexts at young ages – known as *early specialization* – has been associated with negative sport experiences (e.g., sport withdrawal, burnout; Côté & Abernethy, 2012; Fraser-Thomas, Côté, & Deakin, 2008; Wall & Côté, 2007).

### *2.1.3 Purpose of the Study*

Given the consistent presence of RAEs at introductory levels and related evidence with respect to dropout, it is necessary to continue to evaluate participation trends across various age, sport, and competitive levels in a longitudinal manner. Sport participation likely varies across the lifespan and many factors may contribute to an athlete's decision to participate in a certain sport context. Consequently, the primary objective of this study is to examine dropout in a female cohort retrospectively across a seven-year period (i.e., covering the pre-adolescent to post-adolescent transition years) with respect to relative age. Additional factors that have been found to influence participation are also evaluated; including community size (e.g., Fraser-Thomas, Côté, & MacDonald, 2010; Turnnidge, Hancock, & Côté, 2014) and competition level (e.g., Lemez et al., 2014; Smith & Weir, 2013).

## *2.2 Methods*

Following institutional ethics approval, an anonymized dataset of all female members in a one-year cohort registered with *Ontario Soccer* from the age of ten years was obtained from the provincial organization. This dataset included all subsequent registrations across a six-year period for the initial cohort of members (i.e., up to and including any existing registration entries at 16 years of age). A total of 38,248 registration entries for 9,915 participants were available. Prior to analysis, the participant data were screened for inconsistent and / or missing information with respect to birth month. Twenty-three registration entries were corrected based on confirmation of birth month with a minimum of two other entries for the participant (0.0006% of original sample). One participant was removed because month of birth could not be confirmed (total of seven registration entries); one participant was removed because the entries were believed to be a duplicate set (total of five registration entries); and five additional participants were removed because they had an 'inactive' status in 2010 and no subsequent registrations beyond that year. Therefore, 99.9% of registration entries were retained (*n* = 9,908 participants).

The remaining participants' birthdates were coded for *birth quartile* (i.e., Quartile One [Q1]: January to March; Quartile Two [Q2]: April to June; Quartile Three [Q3]: July to September; Quartile Four [Q4]: October to December) in consideration of the December 31st cut-off date employed in Ontario youth soccer. The data were also coded for two other potential determinants of participation. *Community size* was coded according to *census subdivision*[6] using categories employed in previous research (1: >1,000,000 people; 2: 500,000 – 999,999; 3: 100,000 – 499,999; 4: 30,000 – 99,999; 5: 10,000 – 29,999; 6: 5,000 – 9,999; 7: 2,500 – 4,999; 8: 1,000 – 2,499; 9: <1,000; e.g., Côté et al., 2006; Curtis & Birch, 1987). Level of play at time of last registration (i.e., representing competition level prior to disengaging from the sport or at age 16 years) was coded according to the *Ontario Soccer* organization structure (1: Mini outdoor; 2: Recreational; 3: Competitive)[7].

A preliminary Chi-square analysis and visual inspection of the birth distribution were conducted to ascertain whether a RAE might be present in the initial year of registration entries at age ten years. The observed number of participants born in each

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[6] Census subdivision corresponds with the municipality structure that would determine funding for local sport facilities in Canada (G. Morin, personal communication, September 25, 2017).
[7] Mini Outdoor is a small sided game, typically for players 12 years and under. Beyond age 12, players are typically categorized as recreational level (e.g., house league where selection processes are absent) or competitive (e.g., representative or more elite-players). This structure is recommended by Ontario Soccer, and may or may not be followed at the local level.

quartile was compared to the number expected based on the number of days in each quartile[8]. A statistically significant chi-square value ($p < .05$) was used to calculate the *w* effect size statistic to determine the strength of the relationship[9]. Cohen (1992) proposed that *w* values of 0.1, 0.3, and 0.5 represent small, medium, and large effect sizes, respectively. The calculation of standardized residuals was planned for a chi-square analysis producing *w* values ≥ 0.1, with a value of ≥ 1.96 indicating an over-representation and a value of ≤ -1.96 indicating an under-representation in terms of relative age distribution.

Survival analyses were then carried out to assess the impact of relative age on dropout from developmental soccer between the ages of ten and 16 years. *Dropout* was identified using the last registration entry present in the longitudinal dataset provided by *Ontario Soccer*. Thus, a participant who last registered at an age of ten through 15 years would be coded as a 'dropout' and a participant who had a registration entry at age 16 years would be coded as 'engaged.' A *Kaplan Meier* analysis was used to investigate dropout with respect to relative age by birth quartile. The log-rank test assessed the null hypothesis of a common survival curve. This was followed by a *Cox Regression* to further evaluate the impact of birth quartile with consideration of community size and

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[8] Traditionally, an equal distribution of 25% has been utilized as the expected proportion of participants for each birth quartile in RAE research. Delorme and Champely (2015) argue this method inflates the risk of Type I error. Thus, the actual distribution of the population from which the sample was taken should be utilized and in absence of this information, the expected distribution should be adjusted for the number of days present in each birth quartile. For this study, the birth distribution for the overall population of Ontario female soccer players was not available and therefore, the expected distribution was calculated by dividing the number of days in each quartile by 365.

[9] The *w* effect size statistic is calculated by taking the value of chi-square divided by the number of subjects [$w = \sqrt{(\chi 2 / n)}$]; Cohen (1992).

competition level. The proportional hazards assumption[10] was tested using the goodness-of-fit approach (see Kleinbaum & Klein, 2012).

## *2.3 Results*

### *2.3.1 General Findings – Relative Age*

Results from the preliminary chi-square analysis are presented in Table 2.1. An over-representation of relatively older participants was observed in the initial sample ($\chi^2$ (3) = 182.972, $p < .001$) with a small effect size ($w = .14$). Quartile 2 had the highest number of participants at ten years of age, followed by Q1, Q3, and Q4. The Kaplan Meier analysis revealed that 23.3% of the initial cohort remained at the end of the seven-year period. The survival curve for each birth quartile is available in Figure 2.1. The log-rank test indicated that the null hypothesis should be rejected ($\chi^2$ (3) = 26.321, $p <$ .001). A median survival rate of four years was observed for players born in the first quartile over the subsequent six years of registration; this differed from a median survival of three years for players born in the remaining quartiles (outlined further in Table 2.2).

### *2.3.2 Additional Factors – Competition Level and Community Size*

Prior to conducting the Cox Regression, it was recognized that players who dropped out during 'mini outdoor' would bias the survival analysis as any player who was classified in this category (i.e., coded according to last registration entry) would theoretically drop out by age 12 years according to *Ontario Soccer*'s organizational structure. Thus, only players coded as 'competitive' ($n$ = 2,327) and 'recreational' ($n$ = 4,836) at the time of last registration were included in the Cox Regression (overall $n$ =

[10] The proportional hazards assumption states that the hazard (i.e., risk of dropping out) for one individual must be proportional to the hazard for any other individual, and the hazard ratio must be constant over time (Kleinbaum & Klein, 2012).

7,163). The findings are presented in Table 2.3a and 2.3b. The analysis indicated that birth quartile was not statistically significant ($p > .05$) when the impact of community size and competition level were considered. Community size did not predict dropout in this analysis; but competition level was observed to be a significant predictor of continued sport involvement ($p < .001$).

The survival and hazard function[11] using the mean for competition level can be found in Figures 2.2 and 2.3, respectively. By percentage, 55.9% of competitive players were still registered with Ontario Soccer at age 16 years while only 20.7% of recreational-level players remained (see Table 2.3b and Figure 2.2). Descriptively, this corresponds to a yearly dropout rate of more than 30% of recreational players each year. Competitive players were more than twice as likely to remain engaged in soccer until age 16 years when compared to recreational level participants (Hazard ratio[12] 2.593, 95% CI 2.419, 2.779; see Figure 2.3). In consideration of the significance of competition level, a graphical representation of the quartile distributions for each year were generated for both the competitive and recreational streams to inspect the transient relative age distribution. The competitive trajectory (see Figure 2.4) showed a classic RAE with Quartile 1 consistently over-represented and Quartile 4 consistently under-represented across the seven-year period; while the recreational stream (see Figure 2.5) shows an over-representation in Quartile 2 and under-representation in Quartile 4.

[11] The survival function gives the probability of surviving (or not experiencing dropout) at each timepoint, up to that time. The hazard function gives the likelihood that the event will occur (per unit of time), given that the individual has survived up to that time (Kleinbaum & Klein, 2012).

[12] The hazard ratio is the measure of effect that is typically used in survival analysis. The interpretation of this estimate is similar to an odds ratio: A hazard ratio of '1.0' would indicate that there is no effect; while a hazard ratio of '3.0' would indicate the exposed group has three times the hazard of the unexposed group (Kleinbaum & Klein, 2012).

## *2.4 Discussion*

### *2.4.1 Overall Findings*

The primary objective of this study was to examine dropout with respect to birth quartile in a female cohort retrospectively for a total of seven years: beginning at age ten years and subsequently followed across a six-year period. Thus, this study provides a longitudinal snapshot of the pre-adolescent to post-adolescent transition years within female soccer in Ontario. A significant RAE was observed in the initial cohort with the relatively oldest participants (i.e., those born earlier in the same-age cohort) having the highest rates of participation at age ten years. Participants born in the first quartile were found to have a greater likelihood of continued engagement in youth soccer during the examination period; as inferred by a median survival rate of one additional year when compared to their peers. However, birth quartile was not found to be a significant factor when competition level and community size were considered as part of the analysis.

The outcome of this study suggests that female dropout patterns in Ontario soccer are comparable to previous findings in team sport contexts with the relatively youngest exhibiting higher rates of disengagement. The one noted exception in the literature (Wattie et al., 2014) may be differentiated by the artistic / individual sport contexts in which the participants engaged. Physical contact is inherent in the sport of soccer, providing an advantage to those with advanced growth and / or maturational status. Additionally, the team context might also emphasize physical differences as comparisons between players occur on the field of play and are generally based on more subjective evaluations of participants by coaches, as opposed to objective measures that are more commonly associated with individual sports (e.g., 100-metre swim time; Baker, Janning, Wong, Cobley, & Schorer, 2014). The aforementioned sample (Wattie et al., 2014) was also considered to be 'recreational' in nature. Interestingly, competitive level was observed to be an important variable in the current analysis, negating the impact of birth quartile when included in the analysis.

### *2.4.2 Practical Implications*

If considered to be an accurate estimate, the findings of this study suggest that approximately 7,200 participants (or 73%) of this one-year, provincial cohort (*n* = 9,908) are at risk of dropping out one year earlier because of their birthdate position with respect to an arbitrary, age-group cut-off. This statistic is alarming from both a healthy development (i.e., continued participation is associated with positive outcomes; refer to examples in *Section 2.1 Introduction*) and a systems perspective (i.e., continued growth of the sport). For example, a significant reduction in participation contributes to an economic / market loss (Cobley & Till, 2017); that is, a high rate of dropout contributes to a reduction in game interest, loss of membership fees, and a reduced talent pool for future advancement in sport. Further, youth sport is predominantly run by volunteers. Individuals who disengage from a sport during childhood or adolescence may be less likely to transition to a contributive role in their adult years.

### *2.4.3 Additional Factors – Competition Level and Community Size*

These findings also highlight the potential impact of competitive streaming on sport dropout. While a greater proportion of competitive level players were engaged at age 16 years (55.9% vs. 20.7% of recreational), a more biased birthdate distribution favouring the relatively older was also evident in the competitive context when evaluated by each year of registration (see Figure 2.4). This may suggest that RAEs resulting from initial growth differences are being perpetuated by talent selection processes (Smith et al., 2018). At no point during the seven-year period were the relatively youngest observed to 'catch-up,' despite culmination of maturational processes within the examined timeframe. While the recreational stream had a more evenly distributed birth representation (see Figure 2.5), the high disengagement of athletes over the seven-year period may highlight a concerning trend for recreation-level athletes. This is somewhat surprising given the reduced demands of playing at a recreational level compared to higher levels of competition, where the increased demands of additional training and performance might conflict with other priorities for this age demographic (e.g., school work, part time employment, social activities). However, it may also be indicative of athletes choosing to prioritize alternative forms of sport participation.

Community size did not appear to be a significant factor with respect to sport dropout in this sample. This finding differs from previous research studies (e.g., Balish, Rainham, & Blanchard, 2015; Curtis & Birch, 1987; Fraser-Thomas et al., 2010; Imtiaz, Hancock, Vierimaa, & Côté, 2014) that have found increased rates of participation in small to medium-sized communities that are large enough to support youth sport leagues but not so densely populated that the competition for sport facilities, team membership, etc. is detrimental to participation. The survival analyses utilized in this study may not have detected subtle trends related to sport dropout in this sample due to the large range of community sizes in Ontario (i.e., census subdivisions range from five to 2,615,060 inhabitants). The impact of community size in this sample will be evaluated further in future analyses using geospatial mapping and odds ratio analyses.

### *2.4.4 Second Quartile Over-Representation*

Although not a primary goal of this work, this study documented a second quartile over-representation in the initial cohort at ten years of age (followed by Q1, Q3, and Q4, respectively); the first RAE observed in a Canadian soccer sample. This pattern differs from the classic, linear RAE pattern (Q1 > Q2 > Q3 > Q4) that would be expected based purely on chronological age differences. Female samples have been associated with a Q2 over-representation in previous studies, particularly in Canadian ice hockey at developmental and national levels (Smith & Weir, 2013; Weir, Smith, Paterson, & Horton, 2010); but also observed in adult female soccer samples (Baker, Schorer, Cobley, Braütigam, & Büsch, 2009; Delorme et al., 2010a).

The cause of this Q2-trend has largely been undetermined to date. Previous hypotheses have suggested that the 'best' Q1-born, female athletes may be playing in male sport to gain a competitive advantage, or perhaps engaged in a more popular sport leaving those born in the second quartile to experience success in the context under examination. This study adds evidence against the latter hypothesis in consideration of the Canadian Heritage *Sport Participation 2010* report (Canadian Heritage, 2013), which identified soccer as the mostly highly played sport by Canadian children. However, it was noted that the Q2 over-representation in this study was primarily driven by registration numbers in the recreational context when the sample was evaluated by competitive stream (cf. Figure 2.4 vs. Figure 2.5); suggesting the relatively oldest are experiencing greater success within the context of soccer at both competitive and recreational levels.

Underlying patterns observed in a sample compiled for a recent meta-analysis of female athletes provide evidence that the effect might possibly be associated with early specialization opportunities for Q1-born athletes and consequent burnout, injury, and / or sport withdrawal (see Smith et al., 2018 for further discussion). This hypothesis might partially explain the observed trends in this sample. However, the birth quartile distribution showed essentially the same pattern of representation across all years examined at both competitive (i.e., Q1 over-representation) and recreational (i.e., Q2 over-representation) levels; no transitional RAEs were observed. Thus, the underlying mechanisms of these trends requires further examination; and the exact contributor in this sample and others remains unknown.

#### *2.4.5 Future Directions*

The dropout rates observed in this longitudinal analysis are reflective of the high rates of dropout that have been observed in other samples (e.g., Balish et al., 2014; Bélanger, Gray-Donald, O'Loughlin, Paradis, & Hanley, 2009; Petlichkoff, 1996; Telama & Yang, 2000). Sport administrators should seek to organize sport in a way that promotes the personal development of all its members, with varying levels of ability and motivation (Jakobsson, 2014; Lagestad, 2019). Strategies to support recreational level athletes appear to be of particular need. Future applied research should evaluate whether the provision of opportunities for skill development and other experiences that competitive players have (e.g., tournaments, inter-city play, skill development initiatives, team building events) would encourage engagement in recreational streams with increasing chronological age; while still maintaining the reduced time demands (vs. competitive levels) that are likely desirable for high-school age athletes. The recent trend towards sport specific academies (i.e., academic institutions offering combined athletic and academic curricula) may be a promising avenue for continued sport engagement into the adolescent / post-adolescent years, as they offer access to facilities / coaching and a flexible academic schedule. However, continued alignment between these academies and existing sport governing bodies is needed (Balderson, 2015; Way, Repp, & Brennan, 2010).

### *2.4.6 Strengths and Limitations*

This study adds to the limited pool of longitudinal research examining relative age and dropout in youth sport samples. To date, dropout from organized sport with respect to relative age has not been adequately studied and continued evaluation of the patterns that exist in different sport contexts (i.e., team vs. individual, competitive vs. recreational), across age groups, and between the sexes are required. Following a one-year cohort through the pre-adolescent to post-adolescent transition was an important element in this analysis, as adolescence has been identified as a critical timepoint for overall declines in physical activity levels (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). However, information is still lacking with respect to participants who declined participation prior to age ten years and beyond 16 years of age. An evaluation of a broader age range and a comparative male sample from Ontario youth soccer would be beneficial.

Future studies also need to consider the longitudinal nature of sport participation along with the dynamic nature of athletic development. For instance, Cobley et al. (2018) identified *transient* relative age advantages among national level Australian swimmers, with the relatively oldest and youngest over-represented at different time points (i.e., age 12 and 18 years, respectively); suggesting detailed examinations are justified to increase knowledge and understanding of relative age mechanisms. A multi-level systems perspective should be maintained (Bronfenbrenner, 1977; 1995; 1999) in these future investigations, as athlete development does not occur within a vacuum.

The use of survival analysis provided an alternative way of assessing dropout; that being, time to event. Traditional statistical methods of assessing the birth date distributions of athlete samples, such as chi-square analysis and linear regression, cannot handle the censoring of events (i.e., when survival time is unknown). Yet (as discussed above), survival analysis may not be sensitive enough to pick up community size-related variations and this variable will require a deeper level of examination in future studies. A consistent approach was taken to coding each participant's registration entry by census subdivision due to the correlation of this variable with municipal funding for sport facilities; this consistency has been lacking in previous community size research. However, this approach still has limitations as the census subdivision may not be the true size of the community and does not account for proximity of neighbouring communities which might provide additional options for sport club membership, opportunities for training, an enhanced pool of competition, etc. Finally, this analysis is limited in the same manner as many relative age studies; the evaluation of quantitative trends cannot answer the question 'why' and 'how' relative age influences dropout. Mixed method approaches are needed in future research.

### *2.5 Conclusions*

Relative age effects are present in developmental level, female soccer in Ontario. A higher risk of dropout is incurred by the relatively youngest and recreational level players. Future research is needed to confirm the exact mechanism(s) contributing to these trends and to determine effective methods of supporting at-risk athletes.

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***Table 2.1***

Results from the preliminary chi-square analysis

| | Observed (*n*) | Expected | Standardized Residual |
|---|---|---|---|
| Quartile 1 | 2,674 | 2443.1 | **4.56** |
| Quartile 2 | 2,803 | 2470.2 | **6.74** |
| Quartile 3 | 2,472 | 2497.4 | -0.476 |
| Quartile 4 | 1,959 | 2497.4 | **-10.745** |

*Notes:*
*Bolded values indicate an over-representation (i.e., ≥ 1.96) or under-representation (i.e., ≤ -1.96) with respect to relative age distribution by quartile.*

***Table 2.2***

Results from the Kaplan-Meier survival analysis: Means and medians for survival time

| | Mean | | | | Median | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 95% Confidence Interval | | | | 95% Confidence Interval | |
| Birth Quartile | Estimate | Std. Error | Lower | Upper | Estimate | Std. Error | Lower | Upper |
| Q1 | 3.840 | .046 | 3.750 | 3.929 | 4.000 | .097 | 3.809 | 4.191 |
| Q2 | 3.748 | .045 | 3.660 | 3.835 | 3.000 | .097 | 2.811 | 3.189 |
| Q3 | 3.688 | .048 | 3.595 | 3.782 | 3.000 | .119 | 2.767 | 3.233 |
| Q4 | 3.483 | .052 | 3.381 | 3.586 | 3.000 | .086 | 2.831 | 3.169 |
| Overall | 3.705 | .024 | 3.659 | 3.752 | 3.000 | .054 | 2.894 | 3.106 |

*Notes:*
*Estimation is limited to the largest survival time if it is censored.*

***Table 2.3a***

Results from the Cox regression survival analysis (overall)

| | Regression Coefficient | Std. Error | *p* > \|z\| | Hazard Ratio | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Q1 | .015 | .043 | .717 | 1.016 | .934 | 1.104 |
| Q2 | .005 | .042 | .901 | 1.005 | .926 | 1.092 |
| Q3 | .025 | .043 | .565 | 1.025 | .942 | 1.116 |
| CS | .003 | .002 | .080 | 1.003 | 1.000 | 1.007 |
| Comp. Level | .953 | .035 | .000 | 2.593 | 2.419 | 2.779 |

*Notes:*
*Quartile 4 used as reference category. Community size (CS) divided by 100,000 for analysis purposes. Confidence intervals that include a value of 1.0 indicate equivalence in the hazard rate (i.e., not statistically significant).*

***Table 2.3b***

Results from the Cox regression survival analysis (competition level)

| Competitive Level | Dropout Before Age 16 Years (*n*) | Engaged At Age 16 Years (*n*) | % | Overall *n* |
|---|---|---|---|---|
| Competitive | 1,027 | 1,300 | 55.9% | 2,327 |
| Recreational | 3,835 | 1,001 | 20.7% | 4,836 |

*Figure 2.1*

Survival curve for each birth quartile: Indicating the highest cumulative survival over the seven-year period

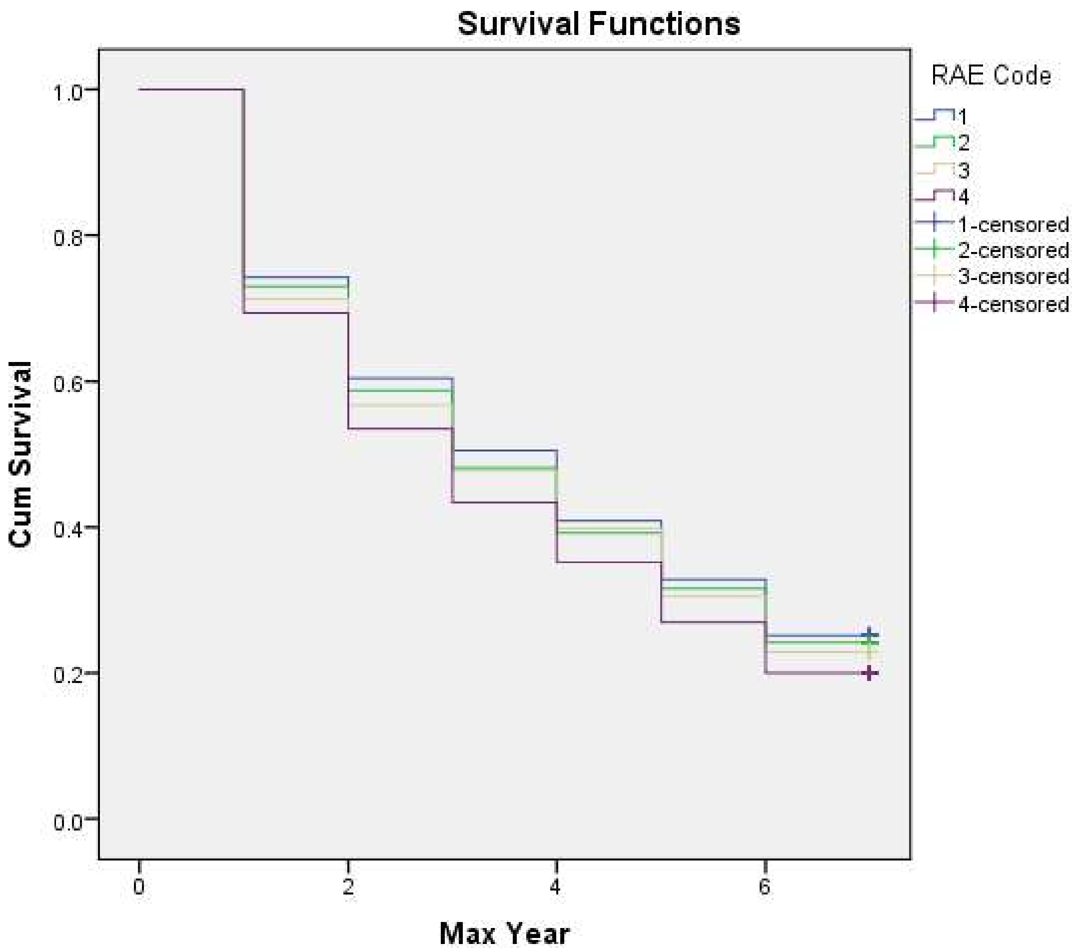
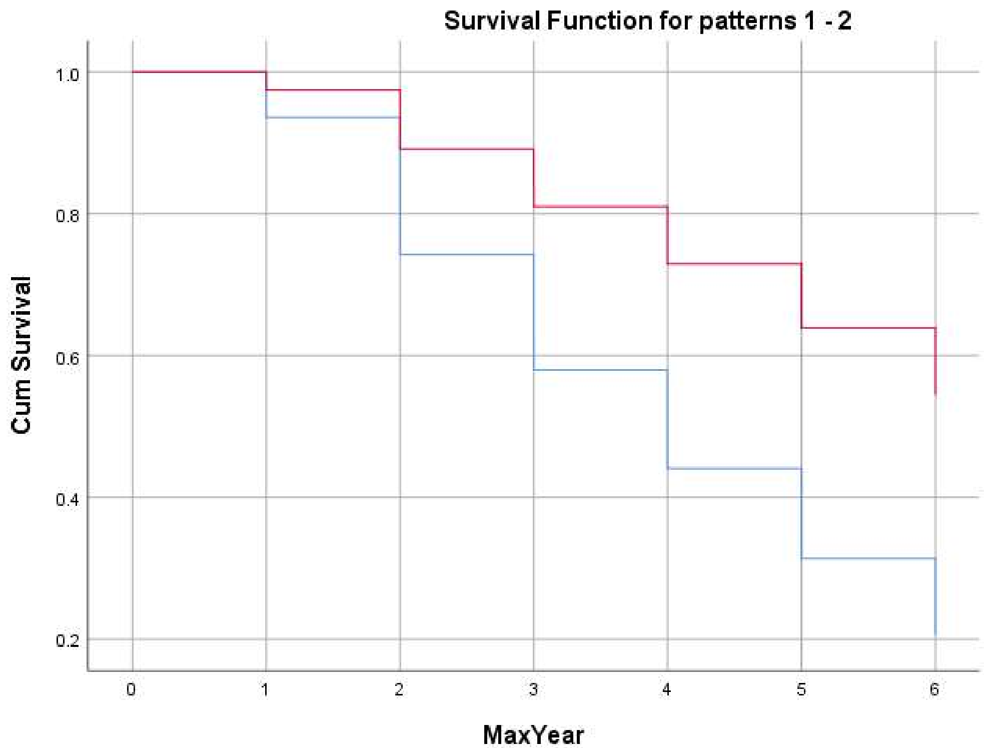


***Figure 2.2***

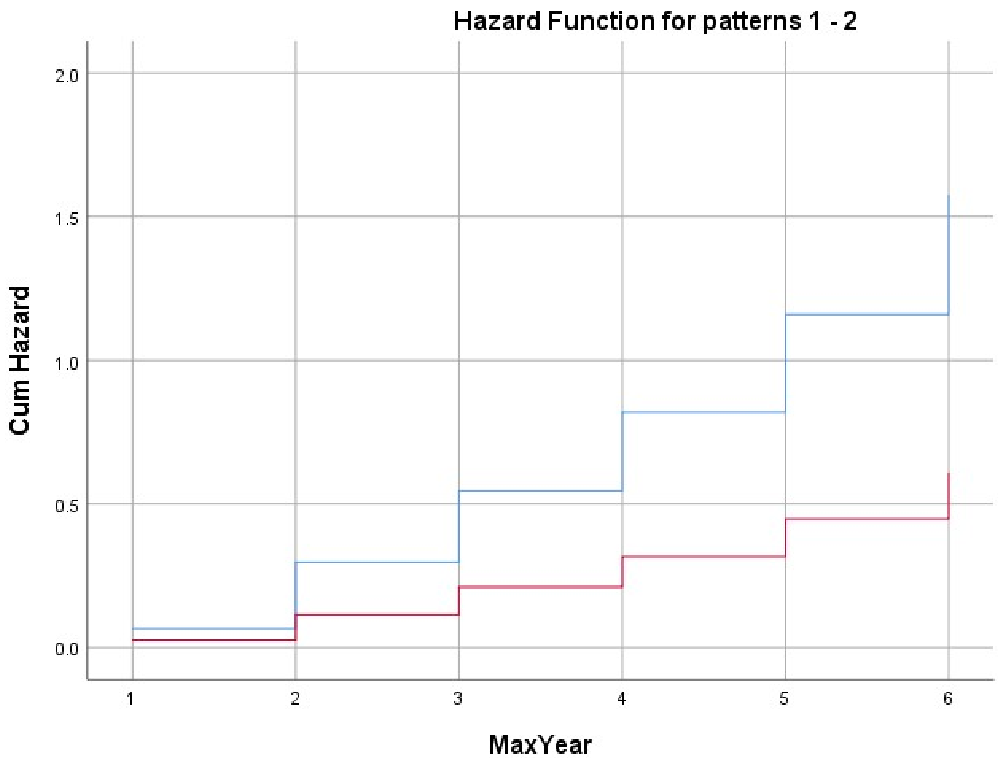
Survival function at the mean for competition level: Competitive (red) and recreational (blue)




*Notes:*
*The vertical axis shows the probability of survival. The horizontal axis shows time to event.*

***Figure 2.3***

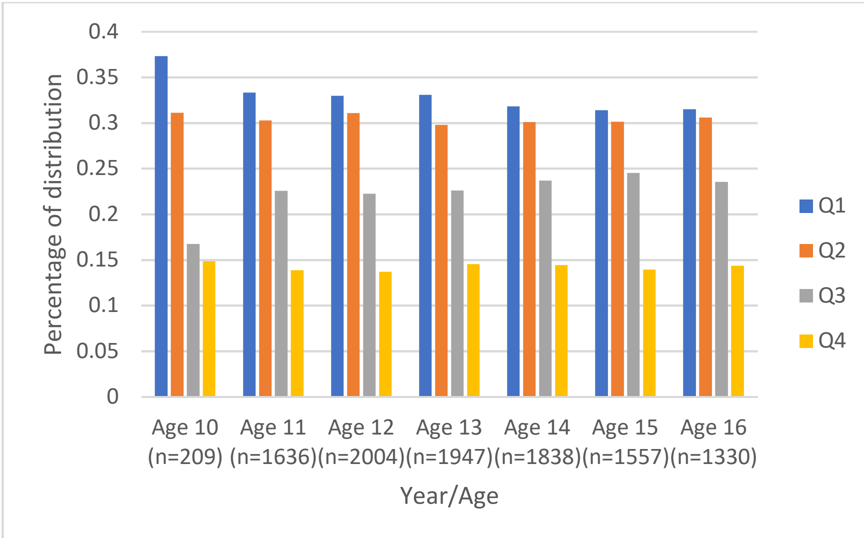
Hazard function at the mean for competition level: Competitive (red) and recreational (blue)




*Notes:*
*The vertical axis shows the cumulative hazard, equal to the negative log of the survival probability. The horizontal axis shows the time to event.*

***Figure 2.4***

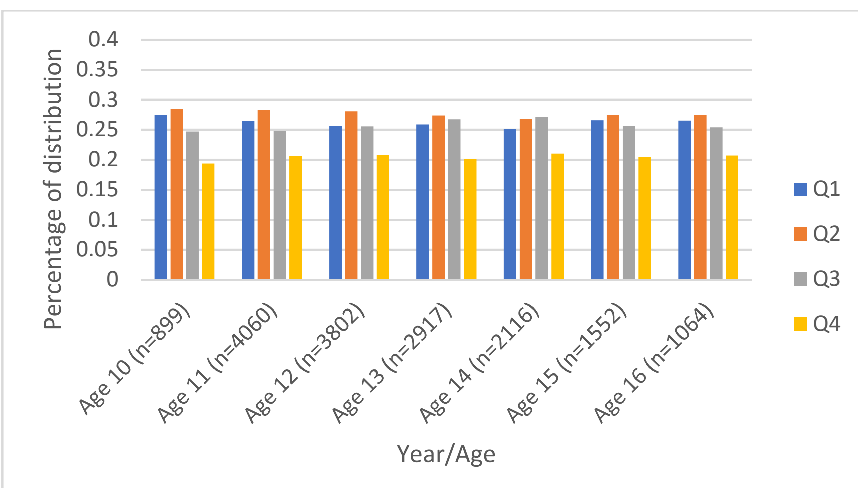
Birth quartile distribution for competitive players: Age 10-16 years




*Notes:*
*Ages 10-12 years may be biased because the majority of participants in this age group would be classified as 'mini outdoor' according to Ontario Soccer's organizational structure and are therefore, not included in this portion of the analysis.*

***Figure 2.5***

Birth quartile distribution for recreational players: Age 10-16 years




*Notes:*
*Ages 10-12 years may be biased because the majority of participants in this age group would be classified as 'mini outdoor' according to Ontario Soccer's organizational structure and are therefore, not included in this portion of the analysis.*

# CHAPTER 3

# GEOSPATIAL MAPPING OF FEMALE YOUTH SOCCER PARTICIPATION AND CONTINUED ENGAGEMENT: ASSOCIATIONS WITH COMMUNITY SIZE AND COMMUNITY DENSITY

## *3.1 Introduction*

### *3.1.1 Relative Age and Community Size Effects*

Athletic development pathways are multifaceted and successful achievement of elite status is difficult to predict. A variety of direct (e.g., genetics, personality characteristics) and indirect factors (e.g., opportunities for skilled instruction and competition) can interact to enhance or constrain athletic potential (see Baker & Horton, 2004 for a review). For instance, the relative age effect (RAE), has received considerable attention for its impact on sport participation and athletic achievement (e.g., Helsen et al., 2012). This commonly recognized (dis)advantage results from subtle age differences among peers grouped within the same cohort (Barnsley, Thompson, & Barnsley, 1985; Musch & Grondin, 2001; Wattie, Cobley, & Baker, 2008), and is considered to be present in sport when an over-representation of relatively older athletes is observed among the participant population of a particular sport, especially at elite levels.

In the past two decades, the RAE has been routinely examined in combination with the 'birthplace effect.' This variable is thought to represent the environment or location in which a young athlete spent his or her developmental years (Côté, MacDonald, Baker, & Abernethy 2006), and may be more accurately known as a population or community size effect. Both relative age and community size have been recognized as indirect influences on athlete development (Baker & Logan, 2007; Mann, Dehghansai, & Baker, 2017). These two contextual variables do not appear to be related; previous studies have reported no evidence of an interaction between them (e.g., Bruner, MacDonald, Pickett, & Côté, 2011; Côté et al., 2006; Turnnidge, Hancock, & Côté, 2014). When effect sizes for these variables were compared within the same study, the community size effect was found to be greater in magnitude (Côté et al., 2006); yet variability has been observed in the patterning of community size effects across different sport and cultural contexts (e.g., Baker, Schorer, Cobley, Schimmer, & Wattie, 2009; Wattie, Schorer, & Baker, 2018).

Relative age and community size can potentially bias the athlete experience throughout the developmental years of sport and ultimately, influence attainment at the professional level (Bruner et al., 2011; Côté et al., 2006; Rossing, Nielsen, Elbe, & Karbing, 2016). For example, the RAE can impact an athlete's exposure to sport in early childhood. Relative age studies have suggested that parents may be hesitant to register later-born, potentially smaller children in physical sports, such as soccer (Delorme, Boiché, & Raspaud, 2010) and ice hockey (Smith & Weir, 2013), as inferred by lower registration numbers for the relatively youngest at the introductory levels of sport. The RAE is also believed to increase the likelihood that the relatively older – individuals who are more physically and psychologically mature due to greater accumulated life experience – will be selected to elite levels of sport at stages involving selection processes, where they will have access to higher quality training, coaching, and competition (Helsen, Starkes, & Van Winckel, 1998; Musch & Grondin, 2001). This increased access to development opportunities can theoretically enhance the likelihood of reaching elite status in athletics for the relatively oldest (Cobley, Baker, Wattie, & McKenna, 2009); conversely, the relatively youngest may be at greater risk for negative sport experiences, leading to decreased competence and a decline in sport participation altogether (Barnsley & Thompson, 1988; Delorme et al., 2010; Helsen et al., 1998; Lemez, Baker, Horton, Wattie, & Weir, 2014).

Likewise, community size can impact the availability of early sport experiences. Very small, rural communities may lack facilities (e.g., ice rinks, soccer fields) and associated resources, as well as the human capital (e.g., coaches, participants, volunteers) to sustain organized leagues. Conversely, very large cities may suffer from insufficient availability of facilities and resources, leading to competition for access among community members. Indeed, several studies have shown that small to medium-sized communities (i.e., cities or towns that provide a balance between resources and demand), provide superior opportunities for young athletes in terms of participation at developmental levels (e.g., Turnnidge et al., 2014) and the likelihood of becoming an elite / professional athlete (e.g., Curtis & Birch, 1987). However, the identification of exact estimates for the ideal community size in various sport contexts has been somewhat elusive (Farah, Schorer, Baker, & Wattie, 2019; Wattie et al., 2018).

### *3.1.2 Review of Relevant Literature*

Traditionally, community size research has focused on the birthplace size of professional athletes, using the location of birth as a proxy for early athlete development. For instance, both Curtis and Birch (1987) and Côté et al. (2006) reported that large cities (>500,000) and rural communities (<1,000) were under-represented as birthplaces of elite ice hockey players in North America. Similar findings have been observed for professional basketball (Côté et al., 2006), baseball (Côté et al., 2006), football (MacDonald, Cheung, Côté, & Abernethy, 2009) and golf (Côté et al., 2006; MacDonald, King, Côté, & Abernethy, 2009). Results in other parts of the world have not been as consistent; even when cultural context is controlled. For example, Baker, Schorer, Cobley, Schimmer et al. (2009) examined the German first leagues of four sports: soccer, basketball, handball, and volleyball. While there was some evidence that communities with very small or very large populations were less likely to produce elite athletes, exceptions also occurred across the sport contexts examined. Similarly, Lidor and colleagues found variable 'birthplace effects' among male (Lidor, Côté, Arnon, Zeev, & Cohen-Maoz, 2010) and female athletes (Lidor, Arnon, Maayan, Gershon, & Côté; 2014) from several 'Division I' sports in Israel. No consistent trends were identified between the two samples in any sport or population category, with the exception of elite volleyball players originating from very small communities (<2,000). Wattie et al. (2018) suggest that the inconsistencies may be attributable to broader social, political, and cultural factors both between and within countries.

A small number of studies have also examined the impact of community size on youth participation rates and continued engagement in sport, prior to reaching an elite or professional level. Turnnidge et al., (2014) found higher rates of youth ice hockey participation in smaller cities within Ontario, Canada (male, age 8-16 years). An increased likelihood of participation (i.e., odds ratios greater than one) was found in population categories less than 100,000 and a decreased likelihood (i.e., odds ratios less than one) was found in categories with greater than 100,000 people. Imtiaz, Hancock, Vierimaa, and Côté (2014) found community size was also related to longer-term participation in the same sport context in the only existing longitudinal study to date. Engagement rates of youth ice hockey players over a seven-year period (male, age 7-14 years) revealed a negative correlation with city size, with athletes from large cities (>500,000 inhabitants) being almost three times more likely to drop out of the sport during the examined timeframe.

To date, the aforementioned participation trends in youth sport do not explain the production of elite athletes with respect to community size. Rossing et al. (2016) found that elite football and handball athletes were generally more likely to come from communities with greater than 30,000 inhabitants, despite a higher likelihood of participation among youth football and handball players in smaller communities (<30,000). However, additional examinations of both variables (i.e., youth participation and associated likelihood of becoming an elite athlete) within the same sport and cultural context, are required before reliable conclusions can be made.

Recent studies have also considered community density as an important variable; use of this measure to evaluate athletic development contexts was first suggested in Baker, Schorer, Cobley, Schimmer et al. (2009). Community density considers the number of people living within a specific unit of area, typically by square kilometre and may be a better indicator of the number of people drawing on available sport resources within a community. Hancock, Coutinho, Côté, and Mesquita (2018) examined the location of development by population size and density for 4,062 elite, Portuguese volleyball players. Medium-sized cities (200,000-399,999 inhabitants) provided the best odds of reaching elite status in volleyball for both male and female athletes. Notably, the most elite 'first-league' male players were found to come from less-densely populated areas; possibly facilitated by the availability and safe use of sport resources during development, and / or provision of a social structure that promoted athletic expertise (Hancock et al., 2018). No comparable findings were reported for females.

Rossing, Stentoft, Flattum, Côté, and Karbing (2018) examined the developmental locations of elite and national football and handball players in Denmark, along with community-level youth as a comparison group. Odds ratio analyses suggested inconsistencies in the optimal community size and density for athlete development based on the sport. However, a trend towards larger, more densely populated cities was found for elite (>30,000 inhabitants; >250 people/km$^2$) and national (>50,000 inhabitants; ≥1000 people/km$^2$) football players, while mid-sized communities appeared best for elite (between 30,000-100,000 inhabitants; 250-1000 people/km$^2$) and national (between 30,000-50,000 inhabitants; no optimal population density identified) handball athletes. It has yet to be determined whether inclusion of the population density variable helps to explain the inconsistencies in community size research; however, it is evident that both overall size and community density should be included in future studies.

### *3.1.3 Theory and Related Frameworks*

Several theoretical frameworks may assist research in this area and have been utilized in previous studies; yet, no particular theory has emerged as a forerunner for this domain of research. Bronfenbrenner’s (1977; 1995; 1999) *bioecological systems* perspective proposes that human development is the result of person-context interactions, and that the study of development must occur with consideration of environmental context and include the interrelated systems in which the individual is situated. This theory places the study of community size within the ‘macrosystem’ (i.e., cultural and social forces related to sport). However, the microsystem(s) (e.g., coach – athlete relationship), mesosystem(s) (e.g., coach – parent relationship), exosystem(s) (e.g., broader sport policies) and chronosystem(s) (e.g., change over time to personal characteristics or the environment) can all play a role in the developmental process. The RAE also has the potential to cause interactions within the sport context to be dysfunctional, thereby compromising development.

Hancock, Adler, and Côté's (2013) theoretical model incorporates mechanisms that may assist with conceptualization of observed trends (discussed further in Hancock & Côté, 2014). For instance, the *Big Fish Little Pond Effect* (Marsh, 1984; 1987) links community size outcomes to the *Galatea Effect* (Merton, 1957): that is, expectations influence an individual's behaviour. The self-concept of athletes in less populated areas may be greater due to a smaller, less talented reference group. Further, smaller communities may provide more support and recognition to their athletes, thereby increasing the individual's expectations of success (Hancock et al., 2013; Hancock & Côté, 2014). The *Matthew Effect* suggests initial advantages persist over time (Merton, 1968). Smaller cities may be better suited for providing early development opportunities, such as increased free play, greater and more diverse sport involvement (i.e., sampling; Côté, 1999), etc. Likewise, coaches in smaller communities might promote participation through the *Pygmalion Effect* (initial expectations inform subsequent outcomes; Rosenthal & Jacobson, 1968) by encouraging long-term involvement, skill development, and enjoyment; as opposed to an emphasis on immediate performance and winning that might be more common in larger cities where a greater number of participants must be accommodated (Hancock & Côté, 2014; Imtiaz et al., 2014).

### *3.1.4 Purpose of this Study*

In consideration of previous research, this study evaluated three separate, but related research objectives concerning female youth soccer participation in the province of Ontario, Canada.  First, female participation rates in developmental soccer were compared to the actual population distribution within the province using community size (CS) and community density (CD).  Consideration of both variables has been recommended in previous research (Hancock et al., 2018; Rossing et al., 2016) and by doing so, this analysis further evaluated each measure as a proxy for the developmental environment in a longitudinal manner.

Second, this study examined whether relative age has any association with CD. While no relationship between the RAE and the 'birthplace effect' (or CS) has been reported in previous research, the null findings may be attributed to the use of an ambiguous variable (i.e., overall population size).  Competition for a position on a team has been identified as an important factor for the RAE to emerge (Baker, Schorer, Cobley, Bräutigam , & Büsch, 2009; Musch & Grondin, 2001).  Thus, theoretically a hypothesis can be made that communities with greater competition for resources and playing positions (i.e., due to a high CD) could experience a greater risk of RAEs in youth sport; while consideration of the overall number of inhabitants (i.e., CS) may not reveal this underlying contributor if the allocation of resources is sufficient for the number of people living in the community.  Some evidence for the impact of CD on RAEs was found by Finnegan, Richardson, Littlewood, and McArdle (2017), who reported that the strongest effect size for RAEs was present in the most densely populated Irish province.

Third, this study explored other potential associations between demographic variables and sustained participation at the most detailed census level in order to generate hypotheses for future research. Community size and community density are only proxies for the underlying mechanisms that influence sport participation and continued exploration of constraints has been recommended (Wattie et al., 2018).

### *3.2 Methods*

A one-year cohort of female soccer participants was identified by the provincial-level governing body for developmental[13] soccer, *Ontario Soccer* ($n$ = 9,915). Registration entries were tracked over a seven-year period (i.e., age 10 to 16 years). Prior to analysis, the anonymized dataset was screened for inconsistent and / or missing information with respect to birth month. Each participant was coded by birth quartile based on the December 31st cut-off employed by Ontario Soccer for age groupings (i.e., Quartile 1 [Q1]: January through March; Quartile 2 [Q2]: April through June; Quartile 3 [Q3]: July through September; Quartile 4 [Q4]: October through December); consistent with previous research (e.g., Smith & Weir, 2013; Weir, Smith, Paterson, & Horton 2010).

Longitude and latitude for each participant's home address were obtained using the *Google Maps Geocoding* platform. Missing or problematic postal codes were confirmed using alternate entries for the participant when available, or the entry was removed. Postal codes from outside of the province of Ontario were excluded (i.e., Michigan and Quebec). A selection of demographic variables was obtained at the

[13] The term 'developmental' refers to an individual who is in the process of growth or progress in his / her athletic skill development at non-professional levels (Smith & Weir, 2013).

neighbourhood level (i.e., dissemination area[14]) for each participant from the *2011 Census Profile / National Household Survey* (e.g., number of people living in the neighbourhood, median income per household; additional variables listed below). Community size (CS; overall number of inhabitants) and community density (CD; number of people per km$^2$) were also obtained at the census subdivision level[15]. Registration entries at age 10 years ($n$ = 9,826) and 16 years ($n$ = 2,305) of age were isolated for analysis, representing the pre- to post-adolescence transition years for this female cohort.

To compare participation rates in Ontario by CS and CD, the expected distribution (based on the population distribution within the province of Ontario) was compared to the observed distribution of female soccer players at age 10 years. Nine CS categories were applied; consistent with previous research (e.g., Baker & Logan, 2007; Baker, Schorer, Cobley, Schimmer et al., 2009; Wattie et al., 2018). These categories are as follows: 1) <2,500; 2) 2,500-4,999; 3) 5,000-9,999; 4) 10,000-29,999; 5) 30,000-99,999; 6) 100,000-249,999; 7) 250,000-499,999; 8) 500,000-999,999; 9) >1,000,000.

No known breakdown could be obtained from research conducted within North America for CD; although one such breakdown was available for a European country (see Rossing et al., 2016). Thus, a categorization system was developed based on the actual densities found within Ontario and the overarching objective of providing a

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[14] A dissemination area is the smallest standard geographic unit for which all census data are disseminated. It is composed of one or more, relatively stable, adjacent dissemination blocks with an average population of 400-700 people. Dissemination areas cover the entire territory of Canada (Statistics Canada, 2016a).

[15] Census subdivision (CSD) refers to a municipality (as determined by provincial / territorial legislation) or areas treated as municipal equivalents for statistical purposes (e.g., Indian reserves, Indian settlements and unorganized territories; Statistics Canada, 2016b). The CSD level is also associated with funding and maintenance of recreational facilities by local municipalities out of the property tax base (personal communication with G. Morin, 2017).

detailed analysis of CD within the province. The eight CD categories are as follows: 1) <50 people/$km^2$; 2) 50-<200; 3) 200-<400[16]; 4) 400-<1,000; 5) 1,000-<1,500; 6) 1,500-<2,000; 7) 2,000-2,500; 8) =4149.5 (i.e., Toronto). Odds ratio analyses were conducted within each category for all 10-year old, female registrants across the province; 95% confidence intervals were obtained and used to indicate statistical significance. This procedure was repeated for all registrants at 16 years of age using the expected distribution at age 10 years (to avoid bias) to examine continued engagement into the post-adolescent years. Finally, the procedure was applied for each individual community by community size to ascertain the presence or absence of within-category variation and identify 'hot spots' for maintaining engagement in developmental soccer.

To examine the association between relative age and CD, a four (birth quartiles) by eight (CD categories) chi-square analysis was conducted using IBM SPSS Statistics 25. This procedure is consistent with Turnnidge et al., (2014).

To explore potential factors associated with sustained involvement in youth soccer until age 16 years at the neighbourhood level (i.e., dissemination area), a binary logistic regression was selected using engagement status at age 16 years as the dependent variable (active registration at age 16 years = coded as 1; dropout at age 15 years or younger = coded as 0). Due to a lack of pre-existing research on which to base hypotheses, a backwards stepwise procedure (likelihood ratio method) was selected (Field, 2012; Menard, 1995). The model included relative age as a consistent predictor of sport dropout in this sample and others (e.g., Lemez et al., 2014). Neighbourhood size

[16] A density of 400 or more people/$km^2$ is used as a threshold to distinguish between rural areas and population centres (Statistics Canada, 2017).

and neighbourhood density were selected as both CS and CD have been previously associated with sport participation at a broader community level; but, these predictors were measured at the more detailed census level of *dissemination area* to provide an examination within the smallest possible regional unit. Additional demographic variables were selected from the *2011 Census Profile / National Household Survey* to assess hypotheses related to the underlying mechanisms of previously observed community effects. The percentage of children between 6-14 years of age and median household income were selected as measures of neighbourhood household characteristics (e.g., presence or absence of a family-oriented neighbourhood, indicator of socioeconomic status; Clark, 2008; Farah et al., 2019). The percentage of females who self-identified as recent immigrants within the neighbourhood was selected as an indicator of ethnic diversity (Clark, 2008; Farah et al., 2019)[17]. The use of active transportation[18] (Grow et al., 2008; Mitra & Buliung, 2012) and median commute time (Cervero & Murakami, 2010; Guo & Chen, 2007) were selected as indicators of built environment. Residuals were examined to evaluate how well the model fit the data.

## *3.3 Results*

### *3.3.1 General Findings*

The overarching purpose of this study was to examine the likelihood of participation in female developmental soccer with respect to community size (CS) and

[17] Ethnic diversity has been suggested as an explanatory factor in previous research involving ice hockey (Farah et al., 2019). In consideration of the international popularity of soccer (compared to ice hockey), the number of recent immigrants was selected as a more representative variable (vs. number of visible minorities) as recent immigration to a new country may be more likely to affect organized sport participation (Clark, 2008).
[18] This variable was formulated by adding the percentage of females who reported both walking or bicycling as their usual mode of transportation.

community density (CD) within Ontario. The odds ratios (ORs) and 95% confidence intervals (CIs) by CS category are presented in Table 3.1 (i.e., 2010 participation compared to the general population) and Table 3.2 (i.e., 2016 participation compared to the expected population from 2010). At the 10-year age mark within this female cohort, mid-sized communities within population size categories ranging from 10,000-249,999 were found to have a greater likelihood of participation based on the overall number of inhabitants (ORs ranging from 1.31-1.56); while very small (<4,999; ORs ranging from 0.47-0.63) and very large (>1 million; OR 0.44) were observed to have a decreased likelihood of participation. Communities ranging from 250,000-499,999 deviated from the general trend with low observed ORs for participation (OR 0.63). However, communities within this category maintained the highest likelihood of continued engagement at the 16-year age mark within this cohort (OR 1.29). Other community size categories were unremarkable in terms of keeping participants engaged at 16 years of age (i.e., ORs ~1), with the exception of very large communities greater than one million people (OR 0.77).

Community density revealed a slightly different pattern of association with participation and engagement into post-adolescence. The odds ratios (ORs) and 95% confidence intervals (CIs) by CD category are presented in Table 3.3 and Table 3.4. Communities with a CD of 50 to <400 population/km$^2$ (i.e., two of the less densely populated categories in the analysis) appeared to be optimal for enhancing participation (ORs ~1.5), while participation in larger communities (i.e., 2000 to <2,500 population/km$^2$) and the largest community (i.e., Toronto) appeared to suffer (ORs of 0.85 and 0.44, respectively). With respect to the association of CD with continued engagement at 16 years of age, communities with populations of 200 to <1500 population/km$^2$ appeared to be optimal (ORs ranging from 1.12-1.15); while very small (<50 population/km$^2$; OR 0.84) and very large (4149.5 population/km$^2$; OR 0.77) had an increased risk of dropout.

### *3.3.2 Within-Category Variation by Community Size*

To further investigate the impact of CS, ORs were calculated for all individual census subdivisions (i.e., 'communities') greater than 10,000 inhabitants[19]. Within the three categories that had greater than expected participation rates (i.e., significant ORs in communities of 10,000-249,999 people), community-level ORs varied considerably with greater-, neutral, and lower-than expected participation rates in each of the three categories. Odds ratios ranged from 0.08-4.03 in the 10,000-29,999 category; from 0.10-2.89 in the 30,000-99,999 category; and from 0.29-2.25 in the 100,000-249,999 category. Community density did not explain the variable ORs within CS categories. As CS increased, CD became more variable within the CS category.

The deviation from the general trend was explored in the 250-000-499,999 category; ORs were variable as observed in other categories (ORs ranging from 0.33-1.10). Yet, the community[20] with the lowest odds of participation at the 10-year age mark (OR 0.33, 95% CIs 0.11, 0.55), also maintained the highest level of player engagement at age 16 years within this category (OR 1.97, 95% CIs 1.52, 2.42). It should also be noted that this particular category considered a lower number of

[19] Sample sizes for participants in communities of less than 10,000 inhabitants were considered to be too small within this one-year cohort and therefore, community level ORs were not calculated.
[20] The overall population size will not be provided to maintain the confidentiality of this community.

communities due to the overall population distribution within Ontario, resulting in a smaller sample size vs. other community categories.

### *3.3.3 Relative Age and Community Density*

There did not appear to be any association between birth quartile (representing relative age) and CD. Results of the four by eight chi-square analysis were not statistically significant, $\chi^2$ (21, $n$ = 9,826) = 14.876, $p > .05$. Thus, there was a failure to reject the null hypothesis.

### *3.3.4 Exploration of Demographic Variables*

The third purpose of this study was to explore demographic variables at the neighbourhood level for association with a high or low likelihood of participation. Prior to conducting the binary logistic regression, the assumption of a linear relationship between continuous predictors and the logit of the outcome variable was assessed using the procedure outlined by Field (2012, pp. 792-797; based on recommendations from Hosmer & Lemeshow, 1989). Interactions between the predictors and each respective log transformation were not significant ($p > .05$) and thus, deemed to be suitable for analysis. The presence of multicollinearity was evaluated by inspecting tolerance values, variance inflation factors, and variance proportions; all values were within acceptable limits. Relative age was the only categorical predictor and each cell had an ample number of participants (i.e., 392 or more).

The overall model $\chi^2(6) = 34.401$, $p < .01$, did predict continued engagement in female youth soccer at age 16 years. Coefficients for each predictor included in the final model are available in Table 3.5. Relative age ($p < .01$) was observed to be a statistically significant predictor with the relatively oldest born in the first birth quartile found to be more likely to be engaged when compared to the fourth quartile (OR 1.34, 95% CIs 1.16, 1.54), as were those born in the second (OR 1.26, 95% CIs 1.10, 1.46) and third quartile (OR 1.18, 95% CIs 1.02, 1.36). Additional demographic variables included as statistically significant predictors in the final model were the number of children between 6-14 years of age ($p < .05$), active transportation ($p < .05$), and median commute time ($p < .01$). The number of children between 6-14 years of age had a positive association with engagement; while active transportation and median commute time had a negative association. An inspection of standardized residuals did not reveal any issues (i.e., all scores $< \pm 3$). However, examination of leverage values revealed several cases that were possible outliers on the predictor variables; approximately 1.4% of the sample had a score more than three times higher than the expected leverage value. Upon inspection, the common characteristic among these cases was membership in a community with an atypically high active transportation score compared to other neighbourhoods represented in the sample.

## *3.4 Discussion*

### *3.4.1 Overall Findings*

The primary objective of this study was to examine female participation in developmental soccer between the ages of 10 and 16 years, with consideration of community size (CS) and community density (CD) measures within Ontario, Canada. Thus, this study provides a longitudinal analysis of both demographic variables and their association with participation (at age 10 years) and continued engagement (at age 16 years). Mid-sized CS categories ranging from 10-000-249,999 people were observed to have the greatest likelihood of participation when compared to the population distribution in Ontario, while very small (<4,999) and very large (>1 million) had significantly lower participation than expected. However, significant within-category variation was observed upon detailed examination of each respective community. The greatest likelihood of participation was associated with CD categories of 50-<400 people per square km (notably, defined as 'rural' by Statistics Canada, 2017). However, there were no differences in birth quartile distribution with respect to CD; disconfirming hypotheses. The exploratory binary logistic regression highlighted several demographic variables for future analysis at the neighbourhood level (i.e., number of children between 6-14 years of age, active transportation, median commute time) and reconfirmed the impact of relative age on sport engagement.

#### *3.4.2 Detailed Findings – Community Size*

The favourable likelihood of participation observed in medium-sized community categories are somewhat consistent with previous findings for youth sport participation in Canada. However, the ideal CS for *female soccer* players appears to be slightly larger (i.e., between 10,000-249,999 inhabitants) than the favourable estimates for *male ice hockey* players (i.e., categories of <99,999 people; Turnnidge et al., 2014). Medium-sized communities may experience higher participation rates for a variety of reasons. For instance, there may be greater access to club membership and facilities compared to larger communities, which may suffer from a population to resource imbalance (Curtis & Birch, 1987). Yet, medium-sized communities are still large enough to sustain organized leagues, which may be difficult in a rural community with a small population, especially if it is in a geographically remote location. The sport environment of larger cities might also be more competitive because there are more participants to accommodate; this could lead to an emphasis on performance and winning over enjoyment and personal development, which may have a negative impact on long-term sport participation (Cervelló, Escartí, & Guzmán, 2007; Hancock & Côté, 2014; Weiss & Williams, 2004). These findings are also likely to be consistent with the observed advantages of residing in medium-sized communities with respect to becoming an elite athlete. Although this variable was not assessed in this analysis, the availability of a larger pool of athletes can theoretically enhance the level of competition experienced during youth and consequently, facilitate athlete development in the long-run.

The likelihood of maintaining engagement at 16 years of age was not as closely tied to medium-sized communities as the participation rates originally observed at the age of 10 years. The ideal category based on OR analysis was 250,000-499,999 (OR 1.29, 95% CIs 1.10, 1.48); notably, a category that also had a lower likelihood of participation at 10 years of age (OR 0.63, 95% CIs 0.54, 0.72). This trend could possibly suggest that membership is not particularly inclusive, or that other options exist for organized sport in the community; but those who do maintain engagement with local soccer clubs have positive experiences. The 30,000-99,999 category also appeared to be advantageous (OR 1.12, 95% CIs 1.01, 1.22) in terms of maintaining engagement; while all other mid-sized categories hovered near an OR of 1.0, indicating engagement rates were aligned with the observed participation numbers at 10 years of age. Very small (<2,500 inhabitants[21]) and very large (>1 million inhabitants) had a low likelihood of maintaining engagement at 16 years of age. This finding of a low likelihood for continued engagement in the largest

[21] Note: The sample size may be too small to produce an accurate estimate for this category; as evidenced by the large confidence interval (see Table 3.2). The OR should be interpreted with caution.

category differs from a previous longitudinal study in Ontario, Canada. Specifically, Imtiaz et al. (2014) found an OR of 2.88 (95% CIs 2.52, 3.29) for the largest category included in the study (i.e., >500,000 inhabitants). Notably, this category is not directly comparable to this study which employed a high endpoint of greater than one million people, which solely represented the city of Toronto, Ontario. Further, Imtiaz and colleagues examined male ice hockey players who likely develop under different organizational sport structures and cultural attitudes about participation in their respective sport in Canada.

The different categories employed in this line of research also highlight a recent criticism of community size research. The use of wide population categories can potentially hide meaningful variation within the categories themselves (Wattie et al., 2018). Indeed, this was the case when engagement rates for individual communities were examined and has also been observed for National Hockey League draftees across Canada (Farah et al., 2019). Underlying reasons for these findings are likely multifactorial and variable between regions. For instance, geographic location may impact participation in communities of comparable size (e.g., adverse climates in northern regions, proximity of neighbouring communities for competition purposes and associated travel time); the characteristics of the clubs themselves may influence participation and continued engagement (e.g., an emphasis on inclusion, participation, and development vs. performance and winning); and decision-making at the municipal level determines allocation of funding and consequently, the number and type of facilities and programming that are available to residents. Farah et al. (2019) also suggested that socioeconomic contributors (e.g., affecting the affordability of organized sport) and ethnic diversity (e.g., affecting cultural importance of the sport within the community) may impact athletic pursuits and achievement.

### *3.4.3 Detailed Findings – Community Density*

A high likelihood of participation was associated with less densely populated communities in Ontario, with the best odds of participation found within the categories of 50-<200 people/km$^2$ (OR 1.54, 95% CIs 1.47, 1.60) and 200-<400 people/km$^2$ (OR 1.53, 95% CIs 1.48, 1.58). Conversely, densely populated cities appeared to have a detrimental impact on participation as observed in the ORs for the 2,000-<2,500 people/km$^2$ category (OR 0.85, 95% CIs 0.76, 0.94) and 4,194.5 people/km$^2$ (OR 0.44, 95% CIs 0.38, 0.51). Comparisons to previous research are not available with respect to the impact of CD on participation, as studies incorporating this measure have focused on the development of elite athletes as opposed to overall participation at developmental levels. Advantages in less densely populated cities have been reported for Portuguese, male volleyball players (but not for females; Hancock et al., 2018). However, findings in the opposite direction were found for elite, male football players from Denmark (Rossing et al., 2018).

Mid-range categories appeared to be best for maintaining engagement at age 16 years and thus, might be hypothesized to be the best environment for producing elite female soccer players as the development of expertise requires ongoing participation. However, further research is needed to support this hypothesis. These findings also support suggested mechanisms for the 'birthplace effect.' Less densely populated communities may offer greater opportunities for free play and organized participation, provided that they are populated enough to provide the necessary resources for participation (e.g., sport facilities, coaches and competitors; Côté et al., 2006; Curtis & Birch, 1987).

Consistent with previous attempts to find an association between CS and the RAE (Bruner et al., 2011; Côté et al., 2006; Turnnidge et al., 2014), there did not appear to be a relationship between CD and birth quartile distribution. While both CD and the RAE appear to be related to sport participation and ongoing engagement (or dropout), the relationship between the place of early development and the RAE is likely complicated and not easily isolated by the statistical methods used to date. Many variables can potentially influence athlete development (Baker & Horton, 2004) and this development does not occur in a vacuum; interactions between multiple systems of the developing individual are ongoing throughout the years of sport participation (Bronfenbrenner, 1977; 1995; 1999).

#### *3.4.4 Future Directions*

An exploratory analysis of demographic variables reconfirmed the impact of relative age on continued engagement in organized sport; consistent with previous research (Delorme et al., 2010; Lemez et al., 2014). Neighbourhood size and density measured at the level of dissemination area by Statistics Canada, were not observed to be predictors of sport dropout; perhaps suggesting that the broader community within which the neighbourhood is situated is more important or that the influence of these variables becomes irrelevant when other measures are considered (e.g., neighbourhood characteristics such as built environment, socioeconomic status, etc.). Both indicators of built environment (i.e., active transportation, median commute time) showed an association with sport engagement at 16 years of age. Each variable may provide an indication of urban density for a particular community. For instance, active transportation in the form of walking or cycling may be the preferred mode of transportation in densely populated communities where high traffic volume discourages car ownership. Similarly, median commute time may be indicative of high population densities and thus associated with increased competition for sport resources, access to facilities, and so on. Due to the exploratory nature of this analysis and the lack of evidence upon which to build the model, these findings currently suggest that built environment may simply be a promising research avenue for unraveling community size / density mechanisms and additional work is needed before definitive conclusions can be made.

In general, mechanisms of CS and CD are largely unknown and represent promising avenues of investigation (Hancock et al., 2018; Wattie et al., 2018). Future research in this sample population and others should investigate the contributions to both high and low participation and ongoing engagement, such as the number of soccer facilities and open spaces for unorganized play; distances travelled both within (i.e., between home and club locations) and between neighbouring communities (i.e., for competition between elite teams); the organizational structures and philosophies of local clubs (as recommended in Fraser-Thomas, Côté, & MacDonald, 2010), and proximity to elite teams (Rossing et al., 2018). This type of research can inform strategies to increase participation at the local level. For instance, community officials and sport administrators can utilize current and future research to promote a sporting structure that enhances the self-concept of individual athletes. Consideration of more inclusive sport systems (e.g., reducing team selections, smaller teams to increase playing time) and a focus on creating a sense of team identity (e.g., establishing community support and recognition) would likely be beneficial (Hancock & Côté, 2014). The proxies of CS and CD should be considered simultaneously in future analyses as both variables have shown an association with participation rates, ongoing engagement, and the likelihood of becoming an elite athlete. Further, observations from this study show that CS and CD are truly unique and separate variables; one does not inform the other.

#### *3.4.5 Strengths and Limitations*

This study adds to current literature by providing a longitudinal analysis of female developmental soccer participation with consideration of both CS and CD. Community density has been observed to be an important variable in recent studies with respect to elite athlete development, and this study is one of the first to consider a relationship with sport participation at developmental levels. Soccer is currently the most popular sport among Canadian youth (Canadian Heritage, 2013; Clark, 2008) and thus, provided an ideal sport context for examination due to the high number of participants it attracts (sport selections made by Cobley, Hanratty, O'Connor, & Cotton, 2014 and Rossing et al., 2016 with a similar rationale) and its accessibility to the local community. This analysis also explored community variables at a more detailed (i.e., neighbourhood) level, as recommended in previous literature (e.g., Wattie et al., 2018); however, the selection of variables was limited to information available through the *Canadian Census Profile / National Household Survey*.

The use of postal codes, geocoding, and census subdivisions provided an objective, consistent method of coding for community location and characteristics; a limitation present, but rarely discussed in previous literature. Census subdivision is consistent with municipal funding structures that may impact sport programming and facility funding. However, it should be noted that it is still subject to limitations with respect to accounting for the proximity of neighbouring communities (e.g., for competition purposes, options for club membership). The use of home location (as opposed to club location) might be criticized for not providing an exact indicator of the community in which sport participation took place. However, participation rates at age 10 years were compared to the overall population distribution within the province, which are based on location of residence; thus, the use of club location could have introduced bias and home location was the best choice for this particular analysis. Future work will expand on trends for club location. Hometown was also used by Wattie et al. (2018); and either measure is preferable to using an athlete's birthplace, which may suffer to a greater degree from geographic movement / migration and conceal effects for small communities that lack medical facilities for childbirth (Rossing et al., 2016).

The choice of CS and CD categories may affect the direction of findings in this line of research and important variation can be lost when large ranges are used (see discussion in Wattie et al., 2018). Community size categories for this study were selected to allow for comparisons with previous research; the majority of existing studies have employed a similar breakdown (e.g., Baker & Logan, 2007; Baker, Schorer, Cobley, Schimmer, et al., 2009; Wattie et al., 2018). The limitations of using these groupings in this particular study included unbalanced sample sizes at age 10 years (i.e., only three communities were included in the '250,000-499,999' category due to the population distribution in Ontario) and a very small sample size for rural communities at age 16 years. Community density categories were selected using guidelines from Statistics

Canada and the actual population distributions in Ontario. However, there are no existing studies available for comparison within North America and European categories are not appropriate to use due to significant geographical differences between countries (Baker, Schorer, Cobley, Schimmer, et al., 2009; Wattie et al., 2018). Furthermore, generalization of the findings to other regions in Canada cannot be made as the population of Ontario disproportionately contributes to the national population distribution and significant variation is present between provinces (Wattie et al., 2018).

The cohort information examined in this study was collected retrospectively. Ideally, an examination of participant engagement would be conducted during the actual development process and include both male and female athletes of various ages; however, this was not logistically feasible when seeking to obtain a provincially-representative sample from the provincial organization. Initial participation was measured at age 10 years and again at age 16 years, which provided a valuable analysis of the pre- to post-adolescent transition years; but it does not tell us about participants who started playing soccer in early childhood and dropped out prior to 10 years of age.

### *3.5 Conclusions*

Community size and community density are both associated with female soccer participation in the province of Ontario, Canada. In general, mid-sized communities appear to provide the best odds of participation and continued engagement during the pre- to post-adolescent transition years; less densely populated communities also appear to be ideal. However, future studies should be mindful of within-category variation and region-to-region differences between communities of comparable size. Additional longitudinal examinations of youth sport participation are needed to confirm these findings and unravel the underlying mechanisms contributing to these effects. Built environment may be a promise avenue for future research in this area.

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***Table 3.1***

Odds ratios and 95% confidence intervals: Participation in 2010 compared to the general population in Ontario by community size (CS)

| | Province of Ontario | | Ontario Soccer 2010 | | Odds Ratio | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|---|
| CS Category | Total Population | % | Total Participants | % | | Lower | Upper |
| <2,500 | 180,952 | 1.41% | 66 | 0.67% | **0.47** | 0.23 | 0.72 |
| 2,500-4,999 | 219,575 | 1.71% | 106 | 1.08% | **0.63** | 0.44 | 0.82 |
| 5,000-9,999 | 617,113 | 4.80% | 434 | 4.42% | 0.92 | 0.82 | 1.01 |
| 10,000-29,999 | 1,424,976 | 11.09% | 1,412 | 14.37% | **1.35** | 1.29 | 1.40 |
| 30,000-99,999 | 1,830,277 | 14.24% | 2,019 | 20.55% | **1.56** | 1.51 | 1.61 |
| 100,000-249,999 | 2,366,327 | 18.41% | 2,241 | 22.81% | **1.31** | 1.26 | 1.36 |
| 250,000-499,999 | 956,161 | 7.44% | 472 | 4.80% | **0.63** | 0.54 | 0.72 |
| 500,000-999,999 | 2,640,694 | 20.55% | 2,082 | 21.19% | 1.04 | 0.99 | 1.09 |
| >1,000,000 | 2,615,060 | 20.35% | 994 | 10.12% | **0.44** | 0.38 | 0.51 |
| Total | 12,851,135 | | 9,826 | | | | |

*Notes:*
*Bolded text indicates a significant odds ratio.*

***Table 3.2***

Odds ratios and 95% confidence intervals: Participation in 2016 compared to 2010 by community size (CS)

| | Ontario Soccer 2010 | | Ontario Soccer 2016 | | Odds Ratio | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|---|
| CS Category | Total Participants | % | Total Participants | % | | Lower | Upper |
| <2,500 | 66 | 0.67% | 8 | 0.35% | 0.52 | 0 | 1.25 |
| 2,500-4,999 | 106 | 1.08% | 23 | 1.00% | 0.92 | 0.47 | 1.38 |
| 5,000-9,999 | 434 | 4.42% | 92 | 3.99% | 0.90 | 0.67 | 1.13 |
| 10,000-29,999 | 1,412 | 14.37% | 319 | 13.84% | 0.96 | 0.83 | 1.09 |
| 30,000-99,999 | 2,019 | 20.55% | 516 | 22.39% | **1.12** | 1.01 | 1.22 |
| 100,000-249,999 | 2,241 | 22.81% | 521 | 22.60% | 0.99 | 0.88 | 1.09 |
| 250,000-499,999 | 472 | 4.80% | 141 | 6.12% | **1.29** | 1.10 | 1.48 |
| 500,000-999,999 | 2,082 | 21.19% | 502 | 21.78% | 1.04 | 0.93 | 1.14 |
| >1,000,000 | 994 | 10.12% | 183 | 7.94% | **0.77** | 0.60 | 0.93 |
| Total | 9,826 | | 2,305 | | | | |

*Notes:*
*Bolded text indicates a significant odds ratio.*

***Table 3.3***

Odds ratios and 95% confidence intervals: Participation in 2010 compared to the general population in Ontario by community density (CD)

| | Province of Ontario | | Ontario Soccer 2010 | | Odds Ratio | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|---|
| CD Category (Population/km$^2$) | Total Population | % | Total Participants | % | | Lower | Upper |
| <50 | 1,989,273 | 15.48% | 1,498 | 15.25% | 0.98 | 0.93 | 1.04 |
| 50-<200 | 971,559 | 7.56% | 1,097 | 11.16% | **1.54** | 1.47 | 1.60 |
| 200-<400 | 1,661,603 | 12.93% | 1,822 | 18.54% | **1.53** | 1.48 | 1.58 |
| 400-<1000 | 1,618,015 | 12.59% | 1,267 | 12.89% | 1.03 | 0.97 | 1.09 |
| 1000-<1500 | 1,901,533 | 14.80% | 1,674 | 17.04% | **1.18** | 1.13 | 1.23 |
| 1500-<2000 | 1,300,671 | 10.12% | 954 | 9.71% | 0.95 | 0.89 | 1.02 |
| 2000-<2500 | 793,421 | 6.17% | 520 | 5.29% | **0.85** | 0.76 | 0.94 |
| 4149.5 | 2,615,060 | 20.35% | 994 | 10.12% | **0.44** | 0.38 | 0.51 |
| Total | 12,851,135 | | 9,826 | | | | |

*Notes:*
*Bolded text indicates a significant odds ratio.*

***Table 3.4***

Odds ratios and 95% confidence intervals: Participation in 2016 compared to 2010 by community density (CD)

| | Ontario Soccer 2010 | | Ontario Soccer 2016 | | Odds Ratio | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|---|
| CD Category (Population/km$^2$) | Total Population | % | Total Participants | % | | Lower | Upper |
| <50 | 1,498 | 15.25% | 304 | 13.19% | **0.84** | 0.71 | 0.98 |
| 50-<200 | 1,097 | 11.16% | 240 | 10.41% | 0.92 | 0.78 | 1.07 |
| 200-<400 | 1,822 | 18.54% | 477 | 20.69% | **1.15** | 1.04 | 1.26 |
| 400-<1000 | 1,267 | 12.89% | 331 | 14.36% | **1.13** | 1.00 | 1.26 |
| 1000-<1500 | 1,674 | 17.04% | 432 | 18.74% | **1.12** | 1.01 | 1.24 |
| 1500-<2000 | 954 | 9.71% | 204 | 8.85% | 0.90 | 0.75 | 1.06 |
| 2000-<2500 | 520 | 5.29% | 134 | 5.81% | 1.10 | 0.91 | 1.30 |
| 4149.5 | 994 | 10.12% | 183 | 7.94% | **0.77** | 0.60 | 0.93 |
| Total | 9,826 | | 2,305 | | | | |

*Notes:*
*Bolded text indicates a significant odds ratio.*

***Table 3.5***

Coefficients of the final model predicting sport engagement

| | B | SE (B) | *p* | Odds | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Included | | | | | | |
| Constant | -1.428 | .158 | .000 | | | |
| Relative age (Q1 vs. Q4) | .291 | .072 | .000 | **1.34** | 1.16 | 1.54 |
| Relative age (Q2 vs. Q4) | .235 | .072 | .001 | **1.26** | 1.10 | 1.46 |
| Relative age (Q3 vs. Q4) | .162 | .074 | .003 | **1.18** | 1.02 | 1.36 |
| Number of children between 6-14 years | .008 | .004 | .048 | **1.01** | 1.00 | 1.02 |
| Active transportation | -.019 | .010 | .047 | **.981** | .963 | 1.00 |
| Median commute time | -.009 | .003 | .003 | **.991** | .986 | .997 |

*Notes:*
*Bolded test indicates a significant odds ratio.*
*Model* $\chi^2(6) = 34.401, p < .01$
*Hosmer & Lemeshow = .853; Cox & Snell = .004; Nagelkerke = .005*

# CHAPTER 4

# RELATIVE AGE AND POSITIVE YOUTH DEVELOPMENT: DO DEVELOPMENTAL ASSETS PLAY A ROLE IN CREATING ADVANTAGE REVERSALS

## *4.1 Introduction*

### *4.1.1 Relative Age and Advantage Reversals*

Relative age inequities are well documented among youth sport participants (Cobley, Baker, Wattie, & McKenna, 2009; Smith, Weir, Till, Romann, & Cobley, 2018), and commonly associated with disadvantages for those who are relatively younger in a same-age cohort (see Musch & Grondin 2001 for a review of negative outcomes). Whilst acknowledging that this is often the case, *Relative Age Effects* (RAEs) are probabilistic as opposed to deterministic (Wattie, Schorer, & Baker, 2015). Individuals born closer to, but following an organizational cut-off date are not always advantaged; nor are the later-born always disadvantaged. Examples of success and / or protective factors among the relatively youngest can be found in the literature. For instance, Wattie and colleagues (2007) reported lower rates of injury among relatively younger, male ice hockey players (age 10-15 years). At entry levels to professional ranks, Baker and Logan (2007) observed that relatively younger players were chosen earlier in the National Hockey League (NHL) entry draft between 2000-2005; while McCarthy, Collins, and Court (2016) observed relatively younger (male) players were more likely to make a successful transition from the junior levels to senior national teams in professional rugby union and cricket.

Likewise, a variety of benefits have been reported for the relatively youngest professional athletes such as, being more likely to reach career benchmarks (e.g., 400 games played in the NHL; Deaner, Lowen, & Cobley, 2013); receive higher wages (German professional soccer – Ashworth & Heyndels, 2007); experience longer career duration and selection to the most elite teams (e.g., Olympic ice hockey – Gibbs, Jarvis, & Dufur, 2012); and representation in later career stages of professional sport (German handball – Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009). Thus, the sport-related social and organizational structures that contribute to RAEs may not disadvantage all relatively younger athletes to the extent that is often implied (MacDonald & Baker, 2013).

McCarthy et al. (2016) proposed the term 'advantage reversal' to describe the advantage that is conveyed to a small number of relatively younger participants. Similar terms include the 'Underdog Hypothesis' (Gibbs et al., 2012) and 'inverse RAEs'. The underlying mechanisms contributing to this reversal are currently speculative. Baker and Logan (2007) and Schorer et al. (2009) have suggested that younger players may develop superior performance skills to compete with relatively older teammates, allowing these previously disadvantaged players to excel once size differences equalize following maturation. Collins and MacNamara (2012) proposed that the challenges relatively younger youth encounter may provide useful or 'structured trauma', facilitating the development of important qualities such as mental toughness and resilience (Andronikos, Elumaro, Westbury, & Martindale, 2016; Collins & MacNamara, 2012; McCarthy & Collins, 2014), which could ultimately lead to a later career advantage.

On the opposite end of the spectrum, the perceived advantages of being relatively older may actually be detrimental to the athlete's overall well-being in the long run. Relatively older youth theoretically have greater opportunities for *early specialization* in sport (Côté, 1999; Côté & Hay, 2002), a trajectory associated with reduced levels of physical health and an increased risk of emotional and / or physical 'burnout' (Strachan, Côté, & Deakin, 2009). Consequently, this path that may also contribute to a premature end to an athlete's career. While the association between sport withdrawal and 'advantage reversals' has only preliminary evidence at best, the hypotheses discussed above (e.g., Collins & MacNamara, 2012) could lead to a deeper understanding of relative age trends at elite levels in some sport contexts (Cobley et al., 2009) and the associated advantages for relatively younger, professional athletes.

#### *4.1.2 Positive Youth Development*

The concept of useful challenge has surfaced in the positive youth development (PYD) literature (Fraser-Thomas & Strachan, 2015). Briefly, 'PYD' is a strength-based perspective that views children and youth as 'resources to be developed' (Lerner et al., 2005; p. 20). Optimal development occurs through appropriately structured activities and leads to a range of competencies that are beneficial or protective for young people in their current circumstances and in the future (Gould & Carson, 2008; Holt et al., 2017; Roth, Brooks-Gunn, Murray, & Foster, 1998). Several frameworks of measuring PYD have been put forward in the literature. For example, Lerner's '*Five Cs*' (Lerner, Fisher, & Weinberg, 2000) is commonly cited, recognizing *character, caring, competence, confidence,* and *connection* as desirable outcomes. Sport-specific approaches are also available, such as Petitpas' *Framework for Planning Youth Sport Programs* (Petitpas, Cornelius, Van Raalte, & Jones, 2005), the *Personal Assets Framework* (Côté, Turnnidge, & Evans, 2014; Côté, Turnnidge, & Vierimaa, 2016), and the *Applied Sport-Programming Model of Positive Youth Development* (Fraser-Thomas, Côté, & Deakin, 2005). The frameworks share common elements, including a focus on relationships between the individual and others (e.g., with teammates, coaches, parents), and on the context in which the sport takes place (e.g., organizational structure of the sport club, characteristics of the broader community wherein participation occurs).

Benson's 40 developmental assets (Benson, 1997) are believed to facilitate PYD when delivered through youth programming (Fraser-Thomas et al., 2005; Holt et al., 2017).

These assets have been described as the 'building blocks' of human development, and asset possession is believed to provide a protective, enhancement, and resiliency role for youth (Benson, 1997). In the realm of sport, developmental asset possession has been proposed to impact personal development, performance factors, and lifelong participation (Côté et al., 2014; Côté et al., 2016; Fraser-Thomas et al., 2005). Specific links have been reported between developmental assets and sport outcomes by Strachan et al. (2009), who identified an association between three developmental asset categories (*positive identity, empowerment,* and *support* as measured by the Developmental Assets Profile; Search Institute, 2004) and two important sport outcomes (reduced burnout and enhanced enjoyment) in a sample of competitive, adolescent athletes ($n$ = 123). Developmental assets have also been differentiated at the environmental level, supporting the importance of context. Fraser-Thomas, Côté, and MacDonald (2010) demonstrated that competitive swimmers (overall $n$ = 181) from smaller communities (i.e., less than 500,000 inhabitants) scored higher on the *commitment to learning, positive identity, empowerment,* and *support* categories (Search Institute, 2004) compared to individuals from larger cities.

There has been debate as to whether positive developmental outcomes are automatically incurred as a result of sport participation (cf., Coakley, 2011 v. Holt et al., 2017). Holt et al. (2017) synthesized the qualitative findings generated for more than 2,400 individuals and concluded that sport participation can routinely lead to identifiable positive outcomes within a PYD climate; although negative findings were excluded from the meta-analysis. However, Fraser-Thomas and colleagues (2005) outline in the *Applied Sport-Programming Model of Positive Youth Development*, that if sport program delivery is not suitable for all participants (e.g., developmental assets are not being promoted, challenges are not developmentally appropriate and result in negative sport experiences, etc.), PYD may be limited and an increased risk of dropout may ensue. Therefore, the presence or absence of development assets could promote sport engagement and facilitate PYD or alternatively, lead to dropout and reduced PYD.

### *4.1.3 Purpose of the Study*

To date, a direct connection between PYD and RAEs is not evident in the literature. However, relative age can alter the impact of sport program delivery for each respective participant (i.e., the relatively oldest are provided with development opportunities while the relatively youngest are overlooked; see discussion on the ‘maturation-selection’ hypothesis in *Section 1.3*). Thus, it seems necessary to explore the relationship between developmental assets and youth sport participation to attempt to unravel the ‘reversal of advantage’ for the relatively younger participants, with the over-arching objective of improving the sport experience for all athletes. Therefore, the primary aim of this study is to explore the possibility of a relationship between developmental assets and RAEs within the realm of sport. It is hypothesized that relatively younger participants who remain in the sport system until post-adolescence (i.e., beyond 15 years of age) may ultimately benefit from enhanced developmental asset possession as a result of the challenges encountered from being less physically and / or psychologically developed compared to peers. A secondary purpose of this study is to ascertain whether overall developmental asset levels are protective against dropout during post-adolescence (i.e., between 17-18 years of age), in line with implications of the *Applied Sport-Programming Model of Sport Participation* (Fraser-Thomas et al., 2005). In doing so, this study will extend the findings of Fraser-Thomas et al. (2010) to the context of female soccer in Ontario.

## *4.2 Methods*

A one-year cohort (i.e., same birth year) of female soccer participants was identified by *Ontario Soccer*. The email addresses associated with registrants from the 2015 and 2016 seasons ($n$ = 4192) were selected and an invitation to the online survey was distributed directly by the provincial organization, in order to maintain the anonymity of members. Instructions for survey completion were directed to the player, and also to the parent (i.e., to be completed by daughter(s) currently or previously registered in youth soccer) to account for instances where the provided email address did not belong to the youth participant. The first portion of the survey included nine demographic questions, followed by the 58-item Developmental Assets Profile (DAP; Search Institute, 2004).

Prior to data cleaning, 177 individuals provided consent and started the survey[22]. Fifty-one of these respondents were removed due to insufficient data[23]. The average DAP completion time has been found to lie between five and seven minutes (Search Institute, 2005); thus, the remaining responses were reviewed with respect to completion time. One was removed due to questionable reliability (i.e., completed in under three minutes); while several others completed in less than five minutes were carefully reviewed and retained for further analysis. An additional four participants[24] were removed resulting in 68% of initial respondents being retained. The remaining sample of female participants ($n$ = 121) were between the ages of 15 and 19 years ($M$ = 17.1; SD = 0.37).

All responses were coded for relative age based on the December 31st cut-off employed by *Ontario Soccer* for age groupings. Sample size requirements for reporting purposes (i.e., minimum of 30 responses per group; Search Institute, 2005) and a desire to maintain the maximal amount of statistical power dictated that half-year comparisons would be possible. Thus, all participants born in January through the end of June were coded as *relatively older* (H1), and those born in July through December were coded as *relatively*

[22] An exact response rate could not be determined due to lack of information about email contacts.
[23] The DAP requires no more than six questions left unanswered, which corresponds to 10% missing data. Many of these respondents exited the browser prior to completion: twelve appeared to be female participants within the targeted age group; 16 appeared to be parents (nine males, seven females); one was a younger child; and 19 are unknown. Three respondents clicked through the survey (i.e., technically finished) but did not provide any responses.
[24] One identified as 'male;' two were outside of the DAP target age range (age nine and 21 years); and, one was suspected to be a duplicate response.

*younger* (H2). Further coding of data was completed with respect to: 1) Participant status in the most recent year (i.e., no longer playing soccer or 'dropout,' not playing with intentions to return, playing soccer or 'engaged,' or other); 2) Competition level in the most recent year of participation (i.e., recreational, competitive, or other); 3) Age of initiation in organized soccer by actual age and according to the *Ontario Soccer Long Term Player Development Plan*[25]; and 4) Community size of the individual's current hometown, as estimated by the participant (i.e., rural / small town of less than 5,000 people; medium-sized town or city of 5,000-500,000 people, large city of more than 500,000 people, or 'unsure'). Participants were also asked to list any other sports that they participated in outside of soccer which were coded based on the total number listed. This information is summarized in *Table 4.1*.

Respondents rated the relevance of 58 items from the DAP questionnaire on a four-point scale (i.e., 'Not at all or rarely' = 0 to 'Extremely or almost always' = 3). Sample questions include: 'I tell the truth even when it is not easy,' 'I take responsibility for what I do,' and 'I deal with frustration in positive ways.' This questionnaire was designed to capture the developmental experiences of young people in grades six through twelve, and has been found to be a valid and reliable measure through field tests ($n$ = 1300; Search Institute, 2005, 2016). Quantitative scores were calculated for eight developmental asset scales; four *external* (support, empowerment, boundaries and expectation, constructive use of time) and four *internal* (commitment to learning, positive values, social competencies, and positive identity). An outline of the eight scales is available in Appendix B. Participants could score a maximum of 30 points on each respective asset scale. The overall external and internal asset scores were then calculated (representing the average of the four respective scales for each category and thus, ranging from 0-30) and combined to calculate the overall

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[25]The *Ontario Soccer Long Term Player Development Plan* includes: Active Start (U4-U5, inclusive of age five years); FUNdamentals (U6-U8); Learn to Train (U9-U12); Soccer for Life (13+; including recreational, competitive, and talented trajectories).

developmental assets score (ranging from 0-60) in accordance with instructions provided in the DAP User Manual (Search Institute, 2005). The overall developmental asset scores for the sample are summarized in Table 4.1 according to the interpretative ranges provided in the DAP User Manual (Search Institute, 2005) and outlined further in Appendix C.

A one-factor, between-subjects multivariate analysis of variance (MANOVA) was planned to test for group differences between relatively older (H1; $n = 64$) and relatively younger (H2; $n = 57$) respondents on the eight development asset categories (outlined above). Reliability estimates were calculated using Cronbach's alpha. Data were examined for the presence of outliers and assessed for suitability based on the assumptions of MANOVA (i.e., multivariate normality and homogeneity of the covariance matrices) prior to conducting the analysis. The analysis was conducted using IBM SPSS Statistics 25. A statistically significant result ($p < .05$) was followed by a discriminant analysis to evaluate group membership for descriptive purposes. Structure coefficients greater than .33 (10% of overlapping variance) were considered eligible for interpretation (Tabachnick & Fidell, 2007). Cross-validation was conducted using a random selection (i.e., 80%) to assess how well the discriminant function equation predicted the outcome.

To assess whether overall developmental asset levels are protective against sport dropout in female youth soccer, a binary logistic regression was planned to compare 'dropout' vs. 'engaged' participants (note: participants who reported 'not playing but planning to play in the future' were excluded from this portion of the study) and the overall developmental asset scores (continuous scores ranging from 0-60). Participants who were 16 years of age or younger were excluded ($n = 2$) from this portion of the analyses to maintain consistency with respect to the chronological age of the targeted one-year cohort. The analysis was first conducted with all members belonging to the targeted one-year cohort ($\geq 17$ years of age; $n = 102$) and then re-analysed with respondents who had missing data with respect to chronological age (*n* = 107) to assure no influence of these additional respondents on the model. This was followed by a second binary logistic regression analysis to extend previous findings (Fraser-Thomas et al., 2010) with respect to community size to female youth soccer participants in Ontario. This analysis was conducted with additional predictors in the model that may influence engagement, including chronological age (e.g., Fraser-Thomas et al., 2010), relative age (e.g., Delorme, Chalabaev, & Raspaud, 2011; Lemez, Baker, Horton, Wattie, & Weir, 2014; Smith & Weir, 2017), competition level (e.g., Smith & Weir, 2017), and age of initiation in soccer. Bootstrapped confidence intervals (95%) and standard errors were obtained. Residuals were examined to evaluate how well the model fit the data.

### *4.3 Results*

#### *4.3.1 Primary Findings – Relative Age and Developmental Assets*

Reliability estimates (Cronbach alpha values) are presented in Table 4.2. In accordance with previous research and recommendations, values of .70 and above were considered to be reliable (Field, 2012; Kline, 1999). The scale '*constructive use of time*' did not meet this criterion ($\alpha$ = .288). This asset category has been observed to have the lowest reliability estimate in field testing (overall $\alpha$ = .59; Search Institute, 2005), and has also been suggested to be unreliable for sport participants due to the definition and nature of this scale (Strachan et al., 2009). Specifically, it seeks to determine the presence or absence of involvement in any one of several possible enriching activities, rather than the quantity of such involvement (Search Institute, 2005). It also has the fewest number of items of all scales measured in the DAP. Thus, the decision was made to remove this scale prior to conducting the MANOVA to prevent any detriment to statistical power. Strachan et al. (2009) similarly removed this construct due to a low reliability value ($\alpha$ = 0.34) among their athlete sample (*n* = 123).

Five participants had missing information for chronological age (4.1%). Little MCAR's test indicated that this information was missing completely at random ($p$ = .242). Four participants (3.3%) had a permissible amount of missing information (range of one to two questions left unanswered per person) and this was accounted for when scale scores were calculated (see the Developmental Assets Profile User Manual [Search Institute, 2005] for more information). The missing data occurred on five separate DAP items with a maximum occurrence of one for each individual question and were thus considered to be missing at random.

Standardized residuals were assessed to identify univariate outliers on the scale scores, with any score > ±3 requiring further examination (Stevens, 2009). Extreme scores on two scales were identified for one participant: *Support* (ZRE = -3.77, score of 0/30) and *empowerment* (ZRE = -4.18; score of 3/30). The model was statistically significant with or without this case ($p < .05$). In order to retain this participant in the sample but prevent undue influence, transformations of the raw scores were conducted by assigning each score to be one unit smaller than the next most extreme occurrence in the distribution (Tabachnick & Fidell, 2007). Leverage values were examined to identify outliers on the predictors with scores $>3p/n$ indicative of extreme values (Stevens, 2009); no such cases were identified.

Examinations of normality and homogeneity of the covariance matrices underlying MANOVA did not reveal any substantial anomalies. Bivariate scatterplots of the dependent variables produced approximate elliptical scatterplots. *Shapiro-Wilks'* test was significant in several instances. However, skewness and kurtosis values were within an acceptable range (within -/+ 2 and -/+3, respectively), and there was no evidence of platykurtosis; suggesting minimal effect on power. No concerns were identified during visual inspection of the distribution. *Box's Test of Equality of Covariance Matrices* was not significant ($p$ = .158) suggesting the covariance matrices were approximately equal, as required. The MANOVA was conducted with birth half as the independent variable (i.e., relatively older [H1] vs. relatively younger [H2]), and the seven remaining development asset scales as the dependent variables. Results from the MANOVA were statistically significant according to Wilks' Λ (.850), $F$ (7, 113) = 2.850, $p < .01$. Therefore, the null hypothesis was rejected. Descriptive statistics are presented in Table 4.3.

The MANOVA was followed by a discriminant analysis to explore differences between the two groups. Preliminary analysis of the covariance matrices revealed all developmental asset categories were positively related in both the relatively older and relatively younger groups. Wilks' Lambda for the single discriminant function (DF) was .850, $\chi^2(7) = 18.778$, $p < .01$ and the canonical $R^2$ was .15. The DF coefficients and structure coefficients for the seven developmental asset scales can be found in Table 4.3. The correlations revealed that the internal asset categories *commitment to learning* (.402) and *positive values* (.366) contributed to group separation. The standardized DF coefficients suggested that *positive identity* was the most important predictor to participant scores; however, it did not contribute highly to group separation. Thus, *positive identity* was evaluated further as a potential suppressor variable; this scale appeared to exhibit a suppressor effect on the *social competencies* scale when it was included in the model. The mean variate scores (group centroids) for each group are presented in Table 4.4.

#### *4.3.2 Secondary Findings – Developmental Assets and Sport Dropout*

Prior to conducting the binary logistic regression, the assumption of a linear relationship between continuous predictors (i.e., overall developmental asset score[26], chronological age, age of initiation in soccer) and the logit of the outcome variable was assessed using the procedure outlined by Field (2012, pp. 792-797; based on

[26] This overall score included all eight developmental asset categories (as recommended by the Search Institute [J. Roskopf, personal communication, June 8, 2018]) because the developmental assets framework and the research to support its validity relies on it being present.

recommendations from Hosmer & Lemeshow, 1989). The estimation failed when chronological age was included, which was not surprising in light of the small number of participants outside of the 17-year-old category ($n$ = 18). Thus, chronological age was removed. Interactions between the remaining predictors and each respective log transformation were not significant ($p > .05$) and thus, deemed to be suitable for analysis. The presence of multicollinearity was evaluated by inspection of tolerance values, VIF, and variance proportions; no issues were noted. Finally, contingency tables were reviewed to ensure a sufficient number of participants in each cell for each categorical predictor (i.e., relative age categorized into birth halves [H1 and H2], dichotomous breakdown of community size at a criterion of 500,000 inhabitants, and competition level separated into recreational and competitive categories).

The preliminary binary logistic regression was run with and without participants with missing data for chronological age. There were no meaningful differences in the outcome and therefore, all participants classified as 'dropout' or 'engaged' were included ($n$ = 107). The overall model $\chi^2(5) = 9.863$, $p > .05$, did not predict engagement in female youth soccer. Coefficients for each predictor included in the model are available in Table 4.5. Relative age was the only statistically significant predictor ($p < .05$) with the relatively youngest (H2) observed to be 4.6 times[27] more likely to be 'engaged' in youth soccer compared to the relatively oldest (H1) members of this sample. Inspection of standardized residuals revealed four participants (3.7% of cases) with scores > ± 3. Upon closer inspection, the common characteristic of these four individuals was a 'low' score on the *constructive use of time* scale (range: 8-10/30), with 'fair to good' overall developmental asset scores. An examination of leverage values identified two participants who were outliers on the predictor variables: one

[27] The original odds were reversed to facilitate interpretation. The new value was calculated by dividing one by the odds value obtained during the analysis, which compared the relatively oldest to the relatively younger (i.e., odds of 0.217/1). Refer to Table 4.5.

was the only 19-year-old in the sample and the other had listed her playing status as ‘occasional’ but was grouped with the ‘dropout’ players for classification purposes.

### *4.4 Discussion*

#### *4.4.1 General Findings*

The present study is an exploratory examination of positive youth development (PYD) in female youth soccer players. The primary objective was to determine if an association exists between developmental asset scales (i.e., a facilitator of PYD) and relative age by birth halves. The secondary objective was to evaluate whether overall developmental asset scores were protective against ‘dropout’ in a post-adolescent age group with consideration of other potential predictors. Based on the data available, the findings suggest that relatively younger, female soccer players possess higher levels of developmental assets in two internal categories, *commitment to learning* and *positive values*; although the structure coefficients were ‘*poor'* in nature (Comrey & Lee, 1992). These findings provide preliminary, albeit extremely cautious, support for the hypothesis that ‘advantage reversals’ (McCarthy et al., 2016) may be in part associated with enhanced PYD resulting from developmental challenges or experiences (as suggested by Collins & MacNamara, 2012). Overall developmental asset scores did not appear to be protective against sport-specific dropout in this context. However, relative age was observed to be an important factor with relatively younger participants being greater than four times more likely to be engaged in soccer in this sample.

#### *4.4.2 Detailed Findings – Relative Age and Developmental Assets*

The *commitment to learning* scale best differentiated relatively older and younger participants in this post-adolescent, female sample. The items contained in this category reflect both the motivation to learn and active engagement in the learning process (Search

Institute, 2005). If a relatively younger athlete is presented with RAE-related challenges during the developmental levels of participation, a commitment to learn the technical aspects of their chosen sport could theoretically enable the individual to surpass the skill level of his or her relatively older counterparts who may rely more on advanced physical size. This finding could explain observations of superior motor performance in relatively younger athletes (Votteler & Honer, 2014) and associated hypotheses (Baker & Logan, 2007; Schorer et al., 2009); but could also support a commitment to learn psychological skills such as coping and persistence in the face of failure or adversity. Detailed research into the mechanism(s) by which *commitment to learning* assists relatively younger athletes is required to make conclusions. It should also be noted that sampling occurred with female soccer participants with active registration until at least 15 years of age[28]. Thus, measures of this scale in relatively older and younger athletes who dropped out prior to age 15 and younger would be important to examine.

The *positive values* scale reflects personal virtues of the individual; honesty, integrity, responsibility, and restraint are included, as well as caring about others and working for equality / social justice (Search Institute, 2005). These qualities are highly reflective of both the 'character' and 'caring' outcomes outlined by Lerner and colleagues in their model for the integration of families, children, and civil society (Lerner et al., 2000). The finding of higher scores on this scale among the relatively younger may suggest enhanced PYD outcomes for the relatively younger, which has been theorized to be an outcome of useful or 'structured trauma' (Collins & MacNamara, 2012) resulting from the deferred position within a peer cohort. The virtues of the *positive values* scale may also reflect a proposed '6$^{th}$ C' (Lerner et al., 2005); that being, *contribution*, the eventual outcome of the other five. Indeed, the one participant who provided evidence of *contribution* in her survey responses (i.e., coaching

[28] The invitation to participate was sent to those with active registration within the past two years and the age of the cohort at the time of data collection was approximately 17 years old.

youth soccer) scored in the top tertile for the *positive values* scale in this sample. Case studies of participants who transition to a contributive position in sport (e.g., coach, volunteer, referee) with consideration of RAE-related challenges may illuminate whether positive outcomes exist, over and beyond the advantages observed at professional levels of sport.

#### *4.4.3 Detailed Findings – Developmental Assets and Sport Dropout*

An increased risk of dropout was observed among relatively older participants at age 17 years in this sample (OR 4.6, 95% CI 1.39, 15.18); although it was noted that the number of 'dropout' players was small in comparison to 'engaged.' A similar finding has been reported among recreation level, female soccer players in Germany (Wattie et al., 2014). This increased risk for the relatively older deviates from earlier longitudinal findings in this cohort. Specifically, players born in first quartile (i.e., January through March) were observed to have a median survival of four years between the ages of 10-16 years; while all other quartiles had a median survival of three years (Smith & Weir, 2017; see *Chapter 2* for further discussion). This may suggest underlying, transient patterns of relative age advantage that require further investigation. Relatively older athletes theoretically have greater opportunities for *early specialization* in sport (i.e., selected to elite teams where they experience higher levels training and competition; Côté, 1999; Côté & Hay, 2002); a trajectory associated with additional negative aspects of sport such as burnout and injury (e.g., Strachan et al., 2009). If relatively older athletes are leaving sport at earlier ages than their relatively younger peers, it could lend support to reducing specialized sport involvement at younger ages.

Sport engagement was not predicted by other variables in this sample, including overall developmental asset scores, community size, competition level, and age of initiation in soccer. While acknowledging that this study was exploratory in nature, it is surprising that community size did not emerge as a significant determinant. Fraser-Thomas et al. (2010) found that practicing sport in a large city with a population greater than 500,000 significantly increased the risk of dropout among adolescent, competitive swimmers (OR 4.74, 95% CI 2.29-9.09). This did not appear to be the case in this sample and could possibly be attributed to undetermined, qualitative differences in the two sport contexts (e.g., individual vs. team sport, season length, training hours). However, this finding is preliminary and future longitudinal studies of this cohort will attempt to unravel the impact of community size in a more objective manner using alternative statistical techniques. Overall developmental asset levels were not protective against dropout for the adolescent, competitive swimmers (Fraser-Thomas et al., 2010), mirroring the findings in the present study.

#### *4.4.4 Future Directions*

A future consideration would be to compare sport engagement / dropout to the eight developmental asset scales individually, rather than the overall score. This study has shown potential differences in *internal asset* categories when analysed by relative age; while Fraser-Thomas and colleagues (2010) showed significant differences in two *external* and one *internal* category with respect to community size. The protective nature of developmental assets against sport-specific dropout is likely much more complex than can be observed using an overall score, and future studies should seek more detailed analyses with larger samples of participants. These studies should include relative age, community size, chronological age, and sex, along with other potential determinants when available (e.g., competition level). Individuals of varying chronological age and sex could not be recruited in sufficient numbers for this analysis due to logistical constraints; while this provides a purer sample in terms of temporal influences (e.g., similar sport structures being employed at the provincial level during development), it does not permit evaluation of these relevant variables or detailed comparison between groups.

The findings of this study are aligned with the *Applied Sport-Programming Model of Positive Youth Development* (Fraser-Thomas et al., 2005), to the extent that can be tested. The participants in this sample were engaged in soccer until at least 15 years of age (i.e., potentially avoiding the decline in physical activity participation that is often associated with adolescence; e.g., van Mechelen, Twisk, Post, Snel, & Kemper, 2000); and more than half of the sample scored in the ‘good’ range or higher on overall developmental asset levels. However, much more detailed analysis of sport context is required at the club / organization and individual athlete levels to understand how developmental assets contribute to sport engagement. Although a framework that bridges the gap between these two lines of research (i.e., RAEs and PYD) is not currently available, a theoretical model should be incorporated whenever possible. For instance, Bronfenbrenner’s *bioecological theory* (1977; 1995; 1999) suggests several interacting systems play a role in development over time. Thus, recognizing individual differences, relationships between sport stakeholders (e.g., between athletes and coaches, coaches and parents), and community / environmental level contributions will be essential in future research. Qualitative analyses in the form of case studies, interviews with athletes, coaches and parents, and document analysis of organizational philosophies, would be beneficial.

With respect to relative age research in sport, it is important to remember that being required to overcome challenges as a relatively younger participant only benefits a small number of later-born athletes. Largely, birth date inequities have been tied to sport dropout among relatively younger participants (Delorme et al., 2011; Lemez et al., 2014), or to a lack of registration altogether at the youngest ages (Delorme, Boiché, & Raspaud, 2010; Smith & Weir, 2013). Researchers need to determine what differences exist between those who overcome relative age disadvantages and those who decline sport participation. Consideration of how youth develop within multilevel systems, as well as individual-level analyses to examine inter-quartile and intra-quartile variation in relative age outcomes, have been recommended to better understand the probabilistic advantages / disadvantages that result from RAEs (Wattie et al., 2015).

According to Holt et al.'s (2017) m*odel of PYD through sport*, PYD outcomes can be obtained through both implicit (e.g., everyday interactions between athletes and coaches) and explicit processes (e.g., intentional teaching of life skills and implementation of transfer activities). The implicit pathway is important as many coaches are volunteers and may prefer not to be tasked with the additional responsibilities of a life skill building program. This implicit pathway may provide an explanation for enhanced PYD outcomes in the relatively younger, should future studies continue to provide evidence of this trend. The provision of an appropriate sport climate and supportive relationships may assist these relatively younger athletes in overcoming the sport-related challenges that they encounter as a result of their birthdate position within an age-grouped cohort. Yet, knowledge of RAE-related mechanisms can still be applied in an explicit manner to further the development of all athletes – whether they be relatively older or younger within their peer group. For instance, all athletes could be given the opportunity to experience being both relatively (e.g., to develop leadership skills) and relatively younger (e.g., to enhance technical and / or psychological skill development) during their athlete development years. Ultimately, the 'structured trauma' that leads to enhanced PYD should not be a coincidental outcome of RAEs, but rather intentionally and thoughtfully incorporated into sport programming for the benefit of all participants (Collins & MacNamara, 2012).

### *4.4.5 Strengths and Limitations*

Strengths of this study include a provincially representative sample distribution. Although the exact distribution by region and overall response rate is unknown[29], it is believed that the invitation to participate was distributed to all participants of the same age and sex in Ontario, Canada who had registered with *Ontario Soccer* within the designated two-year period. The limitations of this study include concerns inherent with any type of self-report questionnaires (e.g., social desirability bias, response bias), a small sample size, and unequal group sizes (engaged > dropout). A detailed breakdown of participants beyond first and second halves of the year, dichotomous community sizes, etc. was not possible and may have resulted in a loss of information. Future studies of this nature should seek a larger number of respondents along with a more representative sample across chronological age groups, sex, and geographical regions. Further, the overall developmental asset scores could not be used in the binary logistic regression without inclusion of the *constructive use of time* scale; a subcategory with relatively low internal consistency and some questionability among athlete populations. Future research would also benefit from knowing whether dropout in one sport is related to engagement in another sport context. This information was available for this sample of participants, but limited sample size prevented analysis related to the magnitude of sport involvement.

## *4.5 Conclusions*

Relative age research is transitioning from documenting the effect to more detailed exploration of the underlying mechanisms of this phenomenon. The relationship between psychosocial factors (e.g., resiliency) and athlete performance is a promising area for future investigation.

[29] *Ontario Soccer* noted that email addresses provided by members could belong to participants or parents / guardians. Duplicate contact information (i.e., multiple contacts for the same player) may also have been present in the distribution list.

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***Table 4.1***

Selected demographic information

| | Number of Participants | % of Sample |
|---|---|---|
| Status as a Soccer Participant in the Most Recent Year | | |
| No longer playing soccer: 'dropout' | 22 | 18.2 |
| Not playing but planning to play in the future | 11 | 9.1 |
| Playing soccer: 'engaged' | 87 | 71.9 |
| Other: Coaching | 1 | 0.8 |
| Competition Level in Most Recent Year of Participation | | |
| Recreational (e.g., house league, 'just for fun') | 52 | 43 |
| Competitive (e.g., travel, representative) | 69 | 57 |
| Initiation Age for Soccer (Based on Ontario Soccer LTPD) | | |
| Active Start (U4-U5, inclusive of age 5) | 83 | 68.6 |
| FUNdamentals (U6-U8) | 31 | 25.6 |
| Learn to Train (U9-U12) | 7 | 5.8 |
| Soccer for Life (13+) | 0 | 0 |
| *Includes recreational, competitive, and talented streams* | | |
| Current Community Size (Estimated by Participant) | | |
| Not sure | 3 | 2.5 |
| Rural / small town (e.g., less than 5,000 people) | 12 | 9.9 |
| Medium-sized town or city (e.g., 5,000-500,000 people) | 74 | 61.2 |
| Large city (e.g., more than 500,000 people) | 32 | 26.4 |
| | Mean (Median) | Range |
| Engagement in Additional Sports (i.e., Other than soccer) | 1.81 (1) | 0 – 8 |
| Overall Developmental Asset Scores: Interpretative Ranges | Number of Participants | % of Sample |
| Excellent (51-60) | 12 | 9.9 |
| Good (41-50) | 53 | 43.8 |
| Fair (30-40) | 50 | 41.3 |
| Low (0-29) | 6 | 5.0 |

***Table 4.2***

Internal consistency reliabilities for the Developmental Assets Profile (DAP) scales

| | Cronbach Alpha Value (α) *Present study* | Cronbach Alpha Value (α) *Field testing (Females) -Search Institute* |
|---|---|---|
| DAP External Assets | | |
| Support | .802 | .85 |
| Empowerment | .752 | .78 |
| Boundaries and expectations | .813 | .85 |
| Constructive use of time | .288* | .55 |
| | | |
| DAP Internal Assets | | |
| Commitment to learning | .720 | .83 |
| Positive values | .795 | .85 |
| Social competencies | .704 | .81 |
| Positive identity | .840 | .84 |

*Notes:*
**Indicates low internal consistency/reliability of scale; A similar finding among athletes has been reported for 'constructive use of time' (Strachan, Côté, & Deakin, 2009).*

***Table 4.3***

Means (M), standard deviations (SD), discriminant function (DF) coefficients [DF without suppressor variable] and structure coefficients for relatively older (H1) and relatively younger (H2) on developmental asset categories

| | Group | M | SD | Standardized DF Coefficient | Canonical Variate Structure Coefficients |
|---|---|---|---|---|---|
| DAP External Assets | | | | | |
| Support | H1 | 21.63 | 5.722 | -.275 | -.097 |
| | H2 | 21.18 | 5.349 | [-.753] | |
| | Total | 21.41 | 5.531 | | |
| Empowerment | H1 | 23.02 | 4.282 | -.611 | -.093 |
| | H2 | 22.67 | 4.730 | [-.959] | |
| | Total | 22.85 | 4.483 | | |
| Boundaries and expectations | H1 | 20.77 | 5.209 | .709 | .226 |
| | H2 | 21.70 | 4.675 | [.995] | |
| | Total | 21.21 | 4.966 | | |
| DAP Internal Assets | | | | | |
| Commitment to learning | H1 | 21.56 | 4.642 | .653 | .402* |
| | H2 | 23.07 | 4.309 | [.513] | |
| | Total | 22.27 | 4.533 | | |
| Positive values | H1 | 19.91 | 4.389 | .618 | .366* |
| | H2 | 21.21 | 4.135 | [.526] | |
| | Total | 20.52 | 4.303 | | |
| Social competencies | H1 | 21.53 | 4.071 | .282 | .301 |
| | H2 | 22.51 | 3.680 | [.054] | |
| | Total | 21.99 | 3.906 | | |
| Positive identity | H1 | 18.72 | 5.789 | -1.067 | -.171 |
| | H2 | 17.91 | 5.485 | [N/A] | |
| | Total | 18.34 | 5.638 | | |

*Notes:*
*Maximum score for each scale is 30.*
**Indicates eligibility for interpretation (Tabachnick & Fidell, 2007).*

***Table 4.4***

Group Centroids: Mean variate scores for each group

| | Function 1 |
|---|---|
| Group | |
| H1 (Relatively older) | -.393 |
| H2 (Relatively younger) | .442 |

***Table 4.5***

Coefficients of the model predicting sport engagement [95% BCa bootstrap confidence intervals based on 1000 samples]

| | B [95% CI] | SE (B) | *P* | Odds | 95% CI for Odds Ratio Lower | 95% CI for Odds Ratio Upper |
|---|---|---|---|---|---|---|
| Included | | | | | | |
| Constant | 1.117 [-3.893, 22.187] | 3.765 | .598 | | | |
| Overall developmental assets score | .038 [-.046, .126] | .039 | .286 | 1.038 | .969 | 1.113 |
| Community size [Sm.:Lg.] | .044 [-1.780, 1.429] | 1.692 | .943 | 1.045 | .313 | 3.496 |
| Relative age [H1:H2] | -1.526 [-2.734, -.857] | 2.402 | .012* | .217 | .066 | .717 |
| Competition level [Rec.:Comp.] | -.467 [-1.605, .525] | .608 | .385 | .627 | .218 | 1.798 |
| Age of initiation in soccer | -.015 [-.379, .336] | .188 | .931 | .985 | .696 | 1.393 |

*Notes:*
*Model* $\chi^2(5) = 9.863$, $p = .079$; * $p < .05$
*Hosmer & Lemeshow = .103; Cox & Snell = .090; Nagelkerke = .145*

# CHAPTER 5

# GENERAL DISCUSSION

## *5.1 Overall Purpose*

The overarching purpose of this work was to use relative age as a basis to examine the developmental sport experience of female athletes and explore factors related to sport engagement and positive development through sport. The completed studies were designed in consideration of a direction for relative age research to move beyond the traditional methods of describing the effect and focus on understanding the relevant contributors (Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009). Analyses were informed by multiple points of reference (i.e., date of birth, participation records, competition level, community size and density, and self-report of the participants). Female dropout trends were documented for the first time in a longitudinal manner (i.e., covering the pre-adolescent to post-adolescent transition years) in the most popular youth sport context in Canada (i.e., soccer) within the most populated province of Ontario. The findings will direct future research and inform strategies aimed at promoting organized participation and positive experiences, for the purpose of mitigating sport dropout. Thus, the remainder of this chapter will highlight key findings and contributions of each study, summarize considerations for future research, discuss existing theoretical frameworks in this area, provide practical applications for sport administrators, and document the overall strengths and limitations of the completed work.

## *5.2 Key Findings and Contributions*

Relative age persisted as an important variable for youth sport and the study of dropout in all three of the completed studies. This is consistent with previous assertions that despite knowledge of the existence of relative age effects (RAEs), participation and developmental inequities persist (Helsen et al., 2012; Hill & Sotiriadou, 2016) and likely impact all stages of sport from the initiation years through post-adolescence to the professional levels (see Cobley, Baker, Wattie, & McKenna [2009] and Smith, Weir, Till, Romann, & Cobley [2018] for a review of male and female RAEs, respectively). The consistency of the Quartile 1 over-representation at the competitive level and Quartile 2 over-representation at the recreational level across each year examined in the current studies (see *Chapter 2*) demonstrated that efforts to remove this inequity are still required. Further, the findings of this study suggest that approximately 7,200 participants (or 73%) of this one-year, provincial cohort (*n* = 9,908) are at risk of dropping out one year earlier because of their birthdate position with respect to an arbitrary, age-group cut-off; as inferred by a median survival rate of one additional year for participants born in the first quartile as compared to their peers born in Quartiles 2, 3, and 4. The importance of competition level with respect to dropout rates was reaffirmed and highlighted two needs: 1) Relative age intervention is required with respect to selection processes occurring at young ages (i.e., initial growth differences are being perpetuated within this cohort despite the completion of maturation during the examined timeframe); 2) Additional support is needed for recreation-level players (i.e., extremely low rate of continued engagement over the seven-year period).

Analysis of participation trends within *census subdivisions* in Ontario using geospatial mapping provided an objective method of assessing youth sport within community size (CS) and community density (CD) categories (refer to *Chapter 3*). In general, mid-sized (10,000-249,999 inhabitants) and less densely populated (50-<400 people/km$^2$) communities appeared to provide the best likelihood of participation in female youth soccer. However, the extreme variation observed within categories is an important consideration for future studies of this nature and detailed analyses are required to fully comprehend the use of CS / CD as proxies for athlete development.

The completed work explored new research avenues for athlete development. The use of neighbourhood-level variables was incorporated to assess community / environmental context at the most detailed census level available (i.e., *dissemination area*). Built environment emerged as a potential area for future consideration. The examination of developmental assets (see *Chapter* 4) as an indicator of positive youth development employed the use of a reliable measure (i.e., the *Developmental Assets Profile* [DAP]; Search Institute, 2004) within the context of sport. While overall developmental asset scores were not found to be protective against sport dropout, relatively younger, female soccer players scored higher in two internal asset categories, *commitment to learning* and *positive values*. This suggests sport-related challenges may further individual development in these areas (e.g., commitment to learn technical and / or psychological skills, such as resiliency; caring about others and making positive contributions to sport). Athlete populations have been identified as an understudied but promising avenue for future studies involving developmental assets (Strachan, Côté, & Deakin, 2009). Further research is required to evaluate hypotheses related to the resiliency of a small number of relatively younger athletes (i.e., relative age 'advantage reversals').

### *5.3 Implications for Future Research*

#### *5.3.1 Researchers are getting closer to explaining the 'Q2' over-representation in female sport, but additional work is needed.*

The over-representation of the second quartile (Q2) has been observed in select studies in past decades (e.g., Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009; Delorme, Boiché, & Raspaud, 2010), but was not explicitly addressed until it was found in a sample of Canadian women's ice hockey players (Weir, Smith, Paterson, & Horton, 2010). Since that time, researchers have speculated that this deviation from the classic relative age distribution (i.e., Q1 > Q2 > Q3 > Q4; Hancock, Seal, Young, Weir, & Ste-Marie, 2013) might be specifically associated with female samples (Wattie, Schorer, & Baker, 2015). Suggested mechanisms have included females playing in a more popular sport or competing in male leagues to gain a competitive advantage. However, soccer has the highest rates of participation among Canadian youth (Canadian Heritage, 2013), dispelling the first contention in this region; and Hancock (2017) found that the second-quartile trend was present along females playing in both male and female ice hockey leagues within Ontario, Canada.

Smith et al. (2018) highlighted that the Q2 trend was primarily driven by two female sport contexts in a recent meta-analysis of published literature: 1) Ice hockey at the developmental (province of Ontario) and elite (national) levels; 2) Adult soccer in Europe. This may suggest that the cultural importance of a sport may play a role. Ice hockey is arguably the most loved sport of Canadians and a source of national pride (Brunt, 2017); while soccer participation is widespread across Europe and events such as F.I.F.A. World Cup have a tremendous amount of cultural importance (Mohammed, 2018). Thus, the Q2 trend may be (in part) a reflection of the cultural value placed on these sports and current trends toward intensive involvement, year-round training, etc. for the purpose of talent development. Relatively older athletes theoretically have a greater likelihood of being selected to enter talent development programs / participate on elite teams due to advanced physical and psychological development and lived experience (Barnsley, Thompson, & Legault, 1992). However, the path of *early specialization* is also associated with negative sport experiences such as physical / emotional burnout and may lead to premature dropout from sport (Côté & Abernethy, 2012; Fraser-Thomas, Côté, & Deakin, 2008; Wall & Côté, 2007). Analyses of dropout trends among female athletes in these two contexts (i.e., Canadian ice hockey and European soccer) would be required to confirm these ideas and qualitative investigations would also be beneficial to learn from the players themselves.

The aforementioned hypothesis does not appear to be operational in the present sample. Second quartile trends were largely driven by registration at the recreational levels and remained stable across each year examined. However, the analysis is limited to a one-year cohort across a seven-year period. It remains unknown if transient RAE-related changes are present beyond 16 years of age. The Canadian women's soccer team has achieved success on the world stage in recent years (e.g., two-time Olympic bronze medalists in 2012 and 2016, seven consecutive appearances in the F.I.F.A. World Cup between 1995 and 2019). However, Canadian women's soccer has not yet shown a level of dominance in international competition that is comparable to the Canadian women's ice hockey team. This may change as soccer currently has the highest participation rates among Canadian youth (Canadian Heritage, 2013) and these players will supply the future pool of elite talent. It will be informative to see if relative age patterns change as Canada becomes increasingly more competitive at the international level.

#### *5.3.2 Community / environmental context research needs to go beyond the pooling of effects and examine individual community characteristics at a deeper level.*

Similar to relative age research, community / environmental context studies need to go beyond documentation of the effect and start to unravel the underlying mechanisms. The variable odds ratios found for individual communities within community size (CS) categories (refer to *Chapter 3*) suggest researchers should stop pooling participation rates into arbitrary classifications and start looking at community characteristics in a more detailed manner. Participation rates are intricate and likely depend on a complex range of factors (e.g., characteristics of the individual, local sport club, and broader community). Thus, this area of study would benefit from more in-depth analyses such as qualitative interviews with sport stakeholders; content analysis of club philosophies and community policies on sport leagues; case studies; etc. to inform quantitative findings. The continued use of geospatial mapping (also known as geographic information systems or 'GIS') would also be beneficial to evaluate built environment features such as land use mix (Davison & Lawson, 2006; Wattie, Schorer, & Baker, 2018), access and proximity to sport facilities (Davison & Lawson, 2006; Norman et al., 2006; Wattie et al., 2018), and distances travelled for competition purposes. This will likely require the development of complex, customized data files to answer questions relevant to sport (C. Luo, personal communication, November 24, 2017).

The extreme variation within CS categories with respect to community density (CD) suggests that CS and CD are separate and unique variables. For example, within the '30,000-99,999 inhabitants' category, community density ranged from 14.5 people/km$^2$ – 2,086.3 people/km$^2$ (see Table 5.1 for a detailed breakdown). While unique, they are also equally relevant variables based on current knowledge. The previously mentioned recommendations for more in-depth analyses will determine what level of consideration is required – but for now, both remain equal / unique aspects of research concerning youth sport participation and elite athlete development.

***Table 5.1***

Example – Detailed breakdown of community density categories within one community size category (30,000-99,999 inhabitants)

| Community Density Category (Number of people/km$^2$) | Percentage of Communities (%) |
|---|---|
| <50 | 15.6% |
| 50 - < 200 | 28.1% |
| 200 - < 400 | 18.8% |
| 400 - < 1,000 | 12.5% |
| 1,000 - < 1,500 | 18.8% |
| 1,500 - < 2,000 | 3.1% |
| 2,000 – < 2,500 | 3.1% |
| Equal to 4,149.5 | 0% |

Elite athlete research should not be conducted in isolation from developmental athlete / youth participation research as the developmental pool directly feeds talent development programs and elite teams. Bronfenbrenner's *bioecological theory* (Bronfenbrenner 1977; 1995; 1999) suggests that multiple systems interact to influence development, ranging from the *microsystem* (e.g., athlete – parent relationship) to the broader *chronosystem* where athletes might be influenced by elite athletes from their own community, accessibility to high-level development facilities / programs, etc. One example that these types of interactions are starting to be recognized is found in a research study involving youth (< 12 years of age), elite (Under 17-years-old to Under 19-years old), and national youth players that evaluated CS, CD, and proximity to elite clubs (see Rossing, Stentoft, Flattum, Côté, & Karbing, 2018). Geospatial analyses demonstrated that most national and elite level athletes developed in communities located near a talent club, indicating proximity to elite teams is an important factor in athlete development.

#### *5.3.3 'Advantage reversals' remain largely unexplained*

The manuscript contained in *Chapter 4* ('Relative Age and Positive Youth Development: Do Developmental Assets Play a Role in Creating Advantage Reversals?') explored a novel hypothesis related to a phenomenon highlighted in research known as a relative age 'advantage reversal' (McCarthy, Collins, & Court, 2016) or 'underdog hypothesis' (Gibbs, Jarvis, & Dufur, 2012). Briefly, it has been noted that a small number of relatively younger players who successfully transition to professional levels experience superior athletic careers vs. their relatively older counterparts; often measured through performance variables such as games played, points scored, or length of career (e.g., Fumarco, Gibbs, Jarvis, & Rossi, 2017; Schorer et al., 2009). This trend may be responsible for the decline in RAEs in certain sports contexts at professional levels (see Cobley et al., 2009 for further discussion). Suggested hypotheses include development of superior technical skills by the relatively youngest to compete with relatively older / physically larger peers (Baker & Logan, 2007; Schorer et al., 2009), as well as superior psychological skills (such as resiliency and mental toughness) resulting from being required to overcome RAE-related challenges during development (Collins & MacNamara, 2012).

The finding of higher internal asset scores in the *commitment to learning* and *positive values* categories for the relatively younger participants provides preliminary evidence that sport-related challenges (i.e., as a result of being relatively younger) may further individual development in these areas. While this evidence is weak at best – it is a start towards unravelling the underlying mechanisms at work in a small, but interesting subset of athletes. The ultimate goal is that relative age-related challenges would no longer be a coincidental outcome of RAEs, but rather thoughtfully and intentionally incorporated into sport programming to benefit all participants (Collins & MacNamara, 2012). Thus, future plans to expand this work will include collection of data from a larger, more representative sample. To date, evidence for advantage reversals has only been observed in male samples but few studies of this nature have included female samples (e.g., Bjerke, Pedersen, Aune, & Lorås, 2017). Thus, it is important to administer the DAP to representative samples of both male and female athletes in order to facilitate comparisons between the sexes. It would also be beneficial to evaluate this potential mechanism with chronological age included in the analysis to better understand the progression in developmental asset possession. To accomplish this goal, additional soccer organizations from across Canada will be approached for permission to recruit participants. Local clubs within Ontario have also indicated a willingness to assist with data collection through *Ontario Soccer*. A qualitative study is also underway which will seek to expand on this hypothesis and potentially generate new theories for examination.

#### *5.3.4 Future RAE research in female samples should be qualitatively different than male investigations*

Across various forms of sport dropout research, consistent findings related to high rates of disengagement persist (see Crane & Temple [2015] for a review) and females are often observed to be at higher risk of dropout than males (e.g., Bélanger, Gray-Donald, O'Loughlin, Paradis, & Hanley, 2009). Relative age is one of many factors associated with these dropout trends, with consistent observations of unequal birth distributions in sport samples. The 'maturation-selection' hypothesis (e.g., Baker, Cobley, Montelpare, Wattie, & Faught 2010; Cobley et al., 2009; Lovell et al., 2015) and related ideas of 'accumulated advantage' (e.g., Cobley et al., 2009; Murray, 2003) are highly relied upon as explanatory mechanisms and certainly, there is some truth to these ideas. However, maturation begins earlier and is less variable among females (Baxter-Jones, 1995). Further, maturational processes bring about sport disadvantages for females (e.g., wider hips, increased body mass to height ratio) as opposed to advantages for males (Malina 1996; Malina, Bouchard, & Bar-Or, 2004). Vincent and Glamser (2006) also suggested that sport participation choices for females depend on sport and cultural considerations and the degree to which it is acceptable for females to participate. Thus, the 'maturation-selection' hypothesis may mirror the male sporting experience to a greater degree than that of a female athlete.

Evidence to support this idea is found in a comparison of trends by age group in the two most comprehensive meta-analyses of RAE research completed to date. Cobley et al. (2009) found an increased risk progressing from the 'child' (<10 years old) to 'adolescent' (15-18 years of age) categories in male samples, which decreased thereafter but remained significant at the 'senior' (>19 years old) level. This suggests a 'ramping up' of relative age inequities as athletes move into adolescence when variation in physical characteristics would be at peak levels. Females in contrast, had the greatest RAE risk in the youngest age group

(<11 years old), which decreased with increasing age and disappeared altogether in the 'adult' (>19 years old) category. Within the most competitive 'elite' category, RAE risk persisted to the adult level but still followed the same trend of decreasing magnitude with increasing age (Smith et al., 2018). Thus, initial differences between female participants create a relative age inequity which likely persists to some extent, but there is no accumulated advantage rolling into adolescence. These differences between the sexes must inform future work and female investigations should be qualitatively different if researchers are going to be able to uncover meaningful and effective ways to prevent participation inequities, and subsequently encourage female participation. Physical / maturational differences and social processes at play in the female sport experience must be considered.

The relatively younger in the current sample did not appear to 'catch up' at any point (i.e., the proportion of Quartile 3- and Quartile 4-born players did not increase appreciably over the years examined; see Figures 2.4 and 2.5 in *Chapter 2*). This is somewhat unexpected if a decreasing RAE-magnitude is anticipated for female samples and contrasts with observations in Australian national level swimmers reported by Cobley et al., (2018) which documented a *transient* RAE across age groups, resulting in a Quartile 4 over-representation by 18 years of age. Differences may be attributable to sport context; gaining membership on an elite soccer team would be based more on subjective performance evaluations (i.e., coaches' perceptions and preconceived expectations of athletes), while swimming relies more on objective measures (i.e., race time). Additional differences between these two contexts may exist (e.g., opportunities for independent practice and continued development, etc.). This reinforces the importance of considering sport-specific task constraints in future studies (Wattie et al., 2015).

#### *5.3.5 Future relative age research should involve testing, modification, and continued development of theoretical frameworks*

A theoretical framework (e.g., *Developmental Systems* Model; Wattie et al., 2015) is needed to guide the design of future research studies and interpretation of RAE data; and any model used must consider a variety of direct and indirect influences (Schorer et al., 2009). While testing of a theoretical framework was not a goal of this research, it is hoped that the findings will inform future analyses (e.g., qualitative study underway). Wattie and colleagues (2015) suggest that progression in this area will require triangulation of findings from multiple sources and research methods (e.g., both qualitative and quantitative), and a multi-disciplinary approach. Further discussion of relevant theoretical models with consideration of the current studies is contained in *Section 5.4*.

### *5.4 Theoretical Considerations*

Data collected in future studies should be used to test the tenets of proposed theoretical framework(s). The *'Developmental Systems Model'* outlined by Wattie et al. (2015) currently provides the best model for relative age research because it considers the complexity and changing nature of RAEs; and the unique context of sport, an essential element to any RAE-model. Bronfenbrenner's well-established *bioecological theory* (Bronfenbrenner, 1977; 1995; 1999) concerning the impact of interacting systems on developmental processes is incorporated into Wattie et al.'s model through the general principles of a *developmental systems theory* approach (Lerner, 2006); thus, providing a solid foundation for the framework. Community size and community density considerations should also be incorporated under *environmental* constraints (see *Chapter 1, Section 1.4* for a more comprehensive outline of this model).

Additional frameworks might also be beneficial for relative age research that extends into other domains (e.g., positive youth development, health, etc.). The *'Applied Sport-*

*Programming Model of Positive Youth Development'* proposed by Fraser-Thomas, Côté, and Deakin (2005) is particularly relevant to studies of relative age and dropout because it recognizes the impact of sport delivery and participation trajectories (i.e., sampling, specializing, and investment; Côté, 1999; Côté & Hay, 2002; Côté & Fraser-Thomas, 2011), which are closely tied to the selection processes and development opportunities that perpetuate RAEs. It acknowledges that sport programs can be designed and implemented in a positive or negative manner. This model would also be useful for guiding analyses of the organization structures of local sport clubs and continued work in the area of positive youth development. One limitation of Fraser-Thomas et al.'s (2005) model in terms of relative age research is that it does not directly recognize some types of *task* constraints (e.g., handedness; Loffing, Schorer, & Cobley, 2010) which have been well established as moderators of RAEs (e.g., Wattie et al., 2015). Eime, Young, Harvey, Charity, and Payne's (2013) *'Health through Sport'* conceptual model could also be useful for guiding studies that examine positive outcomes of sport participation (i.e., physical, psychological, and / or social) and associations with sport context (e.g., team vs. individual).

### *5.5 Practical Applications for Sport Administrators*

As stated in *Section 5.2*, the current studies have identified target areas for intervention in Ontario female soccer at the developmental level. Relative age effects (RAEs) are consistently present in the one-year, female cohort from ages 10-16 years. A consistent RAE was observed at the competitive level, indicating that selection processes for the purpose of talent identification are perpetuating the effect. While a more evenly distributed birth quartile representation was observed for recreational level players, it was also accompanied by high rates of disengagement during the examined period (i.e., more than 30% of participants dropped out each year and only 20.7% of the original cohort remained registered in the final year), suggesting that additional support is needed. Additionally, significant variation was observed between communities in Ontario, Canada in terms of the likelihood of participation; indicating that community and / or club-related variables are affecting participation in some manner.

Previous recommendations for reducing RAE-related disparities have included rotating cut-off dates on a regular basis (Barnsley, Thompson, & Barnsley, 1985) and employing smaller age bands (e.g., six-month age groupings vs. one- to two-year cohorts; Boucher & Halliwell, 1991). Minimal evidence that these types of interventions have been successfully implemented is available, perhaps due to associated administrative challenges for local clubs that are often run by volunteers. Cobley (2016) suggested that sport organizations should delay structured competition and competitive streaming of athletes until later ages to promote inclusive participation. Indeed, several sport organizations including *Ontario Soccer* have made these types of recommendations, but they may not be adhered to at the local level where trends toward intensive sport involvement and the professionalization of youth sport (Weinberg & Gould, 2011) are rampant and likely influenced by well-meaning, but uninformed parents. Recent intervention attempts such as corrective performance adjustments for individual sport contexts (e.g., track and field; Romann & Cobley, 2015), age-ordered shirt numbering (Mann & van Ginneken, 2017), and bio-banding initiatives (Malina et al., 2019) have shown promise, but have yet to be implemented in a widespread manner.

Hancock & Côté (2014) have suggested that the three main theoretical principles active in creating birth advantages (i.e., *Matthew, Pygmalion, and Galatea Effects*; Hancock, Adler, & Côté, 2013) can be leveraged to promote participation and continued engagement in youth sport. To increase opportunities for young children to participate in sport and counteract enrollment bias, parents should provide unstructured sporting opportunities within their local neighbourhoods. For example, this could be achieved by supervising regular opportunities for groups of children to play at a local park. Likewise, sport policy makers should promote a sporting structure that facilitates early participation in organized sport programs in an unstructured manner. Structuring the sport environment to enhance the self-concept of individual athletes would also be beneficial and might be accomplished by creating a sense of team identity and / or establishing community support; these recommendations might be particularly relevant for increasing the commitment level of recreation-level athletes. Consideration of more inclusive sport systems (e.g., reducing team selections, smaller teams to increasing playing time) and implementation of appropriate developmental trajectories (e.g., the *developmental model of sport participation*; Côté, 1999; Côté & Hay, 2002; Côté & Fraser-Thomas, 2011) might also be beneficial.

General recommendations for minimizing sport dropout are also available. Weiss and Williams (2004) suggest strategies should focus on maintaining and enhancing physical competence, which promotes intrinsic motivation for continued skill development. Variation and choice in sport-related activities should be provided to enhance enjoyment. Success should be defined in self-referent terms as opposed to performance outcomes (i.e., known as a *mastery motivational climate*). Social support from parents, coaches, and peers should be maximized through appropriate reinforcement and feedback, responding to errors with encouragement and instruction, and avoiding punitive behaviours. Finally, children and youth should be empowered to help themselves by being taught self-regulation strategies; this will allow athletes to self-monitor skill progression and goal achievement (Weiss & Williams, 2004).

### *5.6 Strengths and Limitations*

The current studies add to the very limited pool of research on dropout from organized sport with respect to relative age in female athletes. A provincially representative sample was provided by the provincial sport governing body from official registration records and analysed in a longitudinal manner with consideration of several sources of data. Ideally, a broader age range and simultaneous comparison of a male sample would have been included, but a targeted cohort was required to make a provincially representative sample feasible (i.e., compilation and anonymization of the dataset required a substantial time commitment incurred by Ontario Soccer). Thus, the pre- to post-adolescent transition years were selected as a critical timepoint for decline in organized sport and physical activity participation (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008; Statistics Canada, 2015).

A variety of quantitative techniques were utilized to analyse the data (i.e., survival analysis, odds ratio analysis, discriminant analysis). Most of the relative age research has relied on chi-square analysis, which has been contested by some researchers to be an inappropriate method (see Delorme & Champely [2015] for further discussion). The practical limitation of these quantitative methods is that the question 'why?' cannot be answered. For example, we still do not know the exact reason(s) that participants choose to disengage from youth soccer (known as 'lapsed users'), which is a concern to both local and provincial sport organizations. Questions with respect to whether these 'dropouts' are engaging in other sports or types of extracurricular activities; devoting more time to schoolwork, part-time jobs, or family demands; and what can be done to keep these athletes engaged, still need to be answered. These questions and others will be explored through a qualitative study (i.e., semi-structured interviews with participants from the same cohort) that has been prepared in parallel with the current analyses. The identified trends will inform the interview protocol with the goal that the qualitative data will further inform / (dis)confirm current findings.

Community size (CS) and community density (CD) were evaluated simultaneously with respect to youth sport. The majority of research in this area has focused on elite athletes. However, developmental-level participation is equally important as these athletes directly impact the talent pool available for future advancement in sport; whether it be a decrease due to dropout, or an increase through inclusive participation and continued engagement. The use of census subdivision (CSD) provided an objective method of categorizing participants into CS / CD categories; avoiding a reliance on the self-report of participants and inconsistent categorization of community location (i.e., use of CSD vs. population centre). However, analyses are still limited in that the actual characteristics of the community and associated club(s) are not being examined; but rather, general trends within groups of a similar size or density.

Hypotheses were generated for future research. Built environment was identified as a potential research avenue; although it is acknowledged that the variables available through the *Canadian Census Profile / National Household Survey* were not ideal for the purpose of this analysis at the neighbourhood level. The explored connection between relative age and positive youth development provides preliminary evidence (albeit weak due to a small sample size) for future studies. Potential differences between all developmental asset categories should be investigated in joint studies of relative age and community context. In theory, internal assets are more likely to be related to relative age-related considerations (as demonstrated in this study); while external assets may be more relevant to broader community characteristics and the sport environment that is provided (along with a potential impact on some internal assets; as observed in Fraser-Thomas, Côté, & MacDonald , 2010). The evaluation of developmental assets among athletes is also beneficial for the general purpose of assessing the effectiveness of sport programming (Strachan et al., 2009). In the current sample, more than half of the participants scored in the 'good' range on the DAP.

Ideally, analyses of the relative age effect (RAE) would avoid collapsing participants into birth quartiles or halves to prevent a loss of information. Wattie et al. (2015) has recommended that detailed research be conducted at the individual level (i.e., 'person-oriented' analyses as opposed to 'variable-oriented'). More specifically, researchers should seek to examine inter-quartile and intra-quartile variation in RAE outcomes to better understand the probabilistic advantages and disadvantages that result from relative age. Additional options include structuring analyses by birth month or by day using decimal age if linear regression is utilized (see Romann & Cobley, 2015 for an example).

### *5.7 Conclusions*

Relative age effects are present among female athletes enrolled in developmental-level soccer in Ontario, Canada; which contribute to participation and development inequities in sport. The current studies established longitudinal trends in a one-year, provincially representative cohort with consideration of competition level, community size and density, and exploration of developmental assets. Detailed research into the underlying mechanisms and potential intervention strategies is still required, and the findings presented can be used to develop testable hypotheses. Future studies should be guided by an appropriate theoretical framework; the selection of which depends on the primary goal(s) of the research.

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## APPENDIX A

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**Relative Age Effects Across and Within Female Sport Contexts: A Systematic Review and Meta-Analysis**

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**Relative Age Effects Across and Within Female Sport Contexts: A Systematic Review and Meta-Analysis**


**Abstract**

*Background*: Subtle differences in chronological age within sport (bi-) annual-age groupings can contribute to immediate participation and long-term attainment discrepancies; known as the Relative Age Effect (RAE). Voluminous studies have examined RAEs in male sport; however, their prevalence and context-specific magnitude in female sport remain undetermined. *Study Objective*: To determine the prevalence and magnitude of RAEs in female sport via examination of published data spanning 1984-2016. *Methods*: Registered with PROSPERO (No: 42016053497) and using PRISMA systematic search guidelines, 57 studies were identified, containing 308 independent samples across 25 sports. Distribution data was synthesised using odds ratio meta-analyses, applying an invariance random-effects model. Follow-up subgroup category analyses examined whether RAE magnitudes were moderated by age-group, competition level, sport type, sport context and study quality. *Results*: When comparing the relatively oldest (Q1) v youngest (Q4) across all female sport contexts, the overall pooled estimate identified a significant but small RAE (OR 1.25; 95% CI = 1.21-1.30; $p$ = 0.01; OR adjusted = 1.21). Subgroup analyses revealed RAE magnitude was higher in pre-adolescent (≤ 11 years) and adolescent (12-14 years) age groups and at higher competition levels. RAE magnitudes were higher in team-based and individual sport contexts associated with high physiological demands. *Conclusion*: Findings highlight RAEs are prevalent across the female sport contexts examined. RAE magnitude is moderated by interactions between developmental stages, competition level and sport context demands. Modifications to sport policy, organisational and athlete development system structure and practitioner intervention are recommended to prevent RAE-related participation and longer-term attainment inequalities.


**Key points:**

- Relative age effects (RAEs) have a small, but consistent influence on female sport.
- RAE magnitudes are moderated (i.e., increased or reduced) by the factors of participant age, competition level, sport type and sport context under examination.
- Modifications to the organisational structure of sport and athlete development systems are recommended to prevent RAE-related inequalities.

**Relative Age Effects Across and Within Female Sport Contexts: A Systematic Review and Meta-Analysis**

## 1 Introduction

Whether considered from an athlete development or public health perspective, the dynamic factors that influence sport participation and achievement are of key interest to researchers, policy-makers, sport organisations and their practitioners. In terms of athlete development, Baker and Horton [1] highlight how the path to expertise is a complex process, reflecting an interplay of direct (e.g., genetic makeup; quantity and quality of training) and indirect factors (e.g., coaching knowledge and expertise; social-cultural milieu [2]). In this process, one indirect factor - relative age - has emerged as a consistent influence on both immediate sport participation and longer-term attainment [3-5].

With the goal of grouping children and adolescents according to similar developmental stages, one or two-year chronological age groupings are common in youth sport. However, variations in age remain, leading to participation and attainment (dis)advantages. Relative age effects (RAEs) [6-8] refer to those (dis)advantages and outcomes that fundamentally result from an interaction between one's birthdate and the dates used to logistically organise participants [9]. Sporting RAE's in junior and youth athlete participants are commonly reflected by an over-representation of the relatively older. The relatively older are advantaged in terms of athletic selection and achievement [10], but may also be at greater risk of injury due to the increased sport exposure associated with higher competitive levels, such as an increased number of games/matches and training time [11]. While RAEs and selection biases can lag into adult sports, recent evidence suggests that in the long-term the relatively older are less likely, in proportion to those selected in athlete development programs, to go on to attain elite sporting echelons [4, 12, 13]. Thus, both perceived advantages and disadvantages of RAEs are undesirable for athlete development [14].

### 1.1 Brief background on RAEs

RAEs were initially recognized in the education system [15-17] and only identified in sport some several decades later. Grondin, Deschaies and Nault [18] first reported an unequal distribution of birthdates among Canadian ice hockey players. Across various skill levels, those born in the first quartile[30] of a same-age group were over-represented relative to those born in the last quartile. At a similar time, Barnsley and colleagues observed comparable relative age inequalities in 'top tier' minor hockey teams (i.e., 11 years and older) [19],

[30] The first quartile corresponds to the first three months following the sport-designated cut-off date used to group participants by age. For instance, the first quartile in a system using August 1st as a cut-off would correspond to August, September and October.

Canadian elite developmental and National Hockey League [6] players. Since these early studies, RAEs have been identified across a variety of team sport and cultural contexts including North American and European ice hockey [20-22] as well as soccer [23, 24] and rugby worldwide [10, 25, 26]. RAEs are also documented in individual sports such as swimming [27, 28], tennis [27, 29, 30] and Alpine skiing [31, 32]. That said, RAEs are not ubiquitous as the effect has not been consistently observed in adult senior professional sport [33, 34] and is absent in sports dependent on technique or skill rather than physical attributes *per se* (e.g., golf [35]; shooting sports [36]).

In a prior meta-analysis of research evidence (spanning studies published from 1984-2008), the relative age distribution of 130,108 (predominantly male) sport participants from 253 independent samples contained within 38 studies from 16 countries and 14 sports were examined [37]. Consistent overall RAEs were identified with a small-moderate effect size (Quartile 1 (Q1) vs Q4 odds ratio (OR)[31] = 1.65, 95%CI 1.54-1.77). Further, subgroup analyses revealed that age, competition level and sport context moderated RAE magnitude. Specifically, RAE risk increased with age from child (> 11 years; OR estimate = 1.22) to adolescent (15-18 years; OR = 2.36) age categories, before declining at senior levels (≥ 19 years OR = 1.44). RAEs increased from recreational (OR = 1.12) to pre-elite (OR = 2.77) competition levels; though with a lower risk in adult elite contexts (OR = 1.42). Five team sports exhibited consistent Q1 v Q4 over-representations with the highest magnitudes associated with basketball (OR = 2.66), soccer (OR = 2.01) and ice-hockey (OR = 1.62). Findings from this review subsequently contributed to the focus and emphasis of onward RAE studies, including recommendations for examining female sport contexts.

### 1.2 Explanations for RAEs

In their narrative review, Musch and Grondin [7] proposed that the underlying causes of RAEs were potentially multi-factorial, referring to a combination of physical, cognitive, emotional, motivational and social factors. Whilst acknowledging this possibility, the most common data-driven explanations have been associated with two interacting processes, notably maturation and selection (i.e., the ‘maturation-selection’ hypothesis) [9, 24, 37, 38]. The hypothesis suggests that greater chronological age is accompanied by favourable anthropometric (e.g., stature) and physical (e.g., muscular strength) characteristics, which may provide sporting performance advantages (e.g., soccer) [24]. While recognizing that maturational processes can deviate

[31] An odds ratio (OR) represents the odds, or likelihood, that an event will occur in one group compared to another. In this instance, the OR represents the odds that an athlete will be born in the first quartile (i.e., following a sport cut-off date) compared to the fourth quartile. An OR of one (1.00) would indicate that the outcome under investigation is equal in both groups, while an OR of two (2.00) would indicate the event is twice as likely to be observed in one compared to the other.

substantially between individuals, it is conceivable that a relatively older individual may experience puberty-associated transformations (e.g., generally 12-14 years in girls and 13-15 years in boys [37, 39-42]) prior to relatively younger peers. From this point and until maturation termination, the anthropometric and physical variations between similar age-peers may be exacerbated further. During this time, the relatively older and/or early maturing individual may appear more talented as a result of anthropometric/physical advances rather than skill level, and be selected for representative levels of sport. With selection, additional benefits may occur such as access to higher quality training and coaching expertise [38]; which translate into further advantages in terms of sport-specific skills and experience. For the relatively younger and later maturing, overcoming the physical and performance advantages may be extremely challenging in sports system structure incorporate stable and fixed (bia-)annual age grouping policies and accompanying selection and competition calendars [43, 44].

Due to maturation-selection processes, RAEs are highlighted as discriminating against the relatively younger and later maturing [45], and are implicated in eliminating athletic potential before having the (equitable) opportunity to develop sport expertise [37, 39]. In fact, it has been proposed that the relatively younger are more likely to encounter negative sport experiences and terminate sport participation earlier [46]; particularly at stages when selection and representative tiers of participation are introduced in athlete development systems [14]. Such discrepancies are not surprising when social-cultural values emphasise elitism, which may continue to drive selection and talent identification processes despite negative outcomes (e.g., injury and burnout [47, 48]) and the low predictability of success even at the pre-elite level [49, 50].

Though with a lesser volume of supporting evidence, psychological [51] and socio-cultural explanations [7] have also been highlighted [22, 52, 53]. For instance, the ‘depth of competition’ hypothesis describes how the ratio of players available for playing rosters and positions could influence an individual’s likelihood of participating or being selected for team membership. If a significant imbalance is present (i.e., a high number of athletes are competing for a small number of playing opportunities), the level of competition experienced by players striving to obtain a position is inflated, potentially magnifying the influence of relative age within a cohort. Therefore, the interest (or popularity) and availability (resource) imbalance in a sport system could account for RAE magnification [7, 52, 54, 55]. Parental influence may also attenuate trends at the time of initial sport involvement [9]. Some evidence suggests parents may be hesitant to register a later-born (potentially physically smaller) child in the early years of participation, as reflected in lower registration numbers of relatively younger participants [20, 56]. Selection processes are also notably absent at these early levels, and emphasis is placed on participation and beginner skill development. Thus, the contributing mechanisms outlined in the 'maturation-selection' hypothesis should be negligible.

**1.3 Rationale for a meta-analysis**

It has frequently been reported that RAE magnitudes are greater in male than female samples [39], even when participation numbers are equal [52]. This may be a reasonable conclusion when the breadth of sport differences between the sexes is considered (e.g., media attention, sport-specific funding, cultural acceptance of athletes, level of physicality etc.), in addition to the proposed influences from maturation. Yet in Cobley et al.'s meta-analysis [37], findings suggested little evidence of overall sex difference in pooled odds ratio estimates; though only 2% of participants (24 samples) had been tested for RAEs in female sport in 2008. What therefore remains unknown is whether RAEs are prevalent across and within female sport contexts; their effect magnitude; contexts associated with higher and lower RAE risk; and akin to male sport contexts, whether developmental time points are associated with higher RAE effect sizes. There has been a surge in female samples in published literature and a review of female RAE studies is therefore timely and necessary to answer these questions.

**1.4 Study objective**

The purpose of this systematic review and meta-analysis was to determine RAE prevalence and magnitudes across and within female sport participation. To achieve the objective, published literature (1984-2016) examining relative age (quartile) distributions in female sports were synthesised using odds ratio analyses. To identify moderators of RAE magnitude, identified samples were analysed in subgroups according to age, competition level, sport type and sport context categories. Based on existing literature, it was hypothesised that RAEs were prevalent across female sport; and, that the highest RAE risks in female sport contexts would be observed immediately prior to and during adolescence (i.e., 12-14 years of age) in comparison to early childhood and post-maturation/adult samples. RAEs were also expected to increase with selection across representative (competitive) tiers of sport participation. RAE magnitudes were expected to then progressively minimise following maturation (i.e., beyond 15 years of age) and remain low in recreational sport. At higher competition levels, it was expected that RAEs would persist through pre-elite levels though reducing with age and entry into professional contexts.

## 2 Methods

Procedural steps employed in completing the systematic and meta-analytical review adhered to both the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines [57] and PROSPERO guidelines (Registration No: 42016053497).

### 2.1 Inclusion & exclusion criteria

Inclusion criteria stipulated that only peer-reviewed studies examining RAEs in female sport contexts would be included. Studies could be in any language and assess any age range, level or form of participation (e.g., elite or recreational). Studies examining associated topics (e.g., maturation or sport dropout) were included if they explicitly reported relative age distributions or reported RAE trends. Studies were excluded if they: (1) exclusively examined male athletes or sex was not identified; (2) failed to report relative age distribution on their participants; (3) examined RAEs in school sport or physical education; (4) examined other outcomes (e.g., fitness, fundamental movement skills, physical activity); (5) examined RAE interventions or solutions; (6) included older (Master) athletes where participation distributions were confounded by ageing processes; (7) examined other developmental or behavioural outcomes (e.g., leadership, anxiety); (8) examined cognitive performance (e.g., chess).

### 2.2 Systematic search

Published RAE studies were identified via systematic searching of electronic databases, scanning the reference lists of identified papers and existing meta-analyses [37, 58], and reviewing email alerts from research databases. Six electronic databases were searched: CINAHL, Medline via OVID, Scopus, Sports Discus, Web of Science, and PsycINFO (APAPsycNET) with no restriction on publication date. Search terms were categorised into three groups: (i) Relative age (relative age OR relative age effect* OR age effect* OR birthdate/birth date effect* OR season of birth OR RAE OR age position); AND (ii) Female (e.g., female* OR girl* OR wom?n;); AND (iii) Sport (sports/sport* OR game* OR league*). Results were then limited to (i) humans, and (ii) female. The search process was completed between January-March 2017. Following the search, the first author (KS) removed duplicates and screened titles/abstracts. If there was uncertainty as to whether inclusion criteria were met, study eligibility was determined by KS and SC. The majority of these studies were published in English; though two were found in Spanish; and one each in Chinese and French respectively. The Spanish papers were translated using Google Translate©. The Chinese study was reviewed by a native speaker, while the French was reviewed by a bilingual Canadian. Refer to Figure 1 for a summary of study screening and selection.

*(Insert Figure 1 about here)*

## 2.3 Data extraction

The systematic search yielded 57 studies spanning 1984-2016 and specific information was then extracted, including: Author(s), year of publication, location, sample characteristics (e.g., age, nationality, number of participants), sport setting (e.g., type of sport, level of competition), competition year, method of grouping athletes, relative age distributions (e.g., quartiles) and the distributions used for comparison purposes (e.g., 25% per quartile, population birth rates etc.). Corresponding authors were contacted when any information was not provided or where further clarity was needed (e.g., age or competition level)[32]. In total, 22 authors were contacted. Nine provided requested information; seven were unable to provide required information (e.g., data no longer accessible); four failed to respond, and two could not be located. Data from 44 of the 57 studies were used where possible in overall meta and subgroup analyses. In cases where participant numbers were not reported, but presented in tables or figures, estimates were extracted[33]. Samples that could not be utilized due to missing information were still assessed for methodological quality and reported in review summary tables.

## 2.4 Study quality assessment

An adapted version of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist [59] determined the quality of study reporting. The checklist included 14 items grouped into five categories: Abstract, Introduction, Methods, Results, and Discussion. A score of '0' for "absent or insufficient information provided" or '1' "item is explicitly described" was assigned to items. An overall score of 5-9 was considered 'lower quality;' 10-11 'medium quality;' and 12-14 'high quality' [60]. Two independent reviewers (KT and MR) completed study quality assessment. Rating disagreements were resolved by KS and inter-rater reliability calculated.

## 2.5 Meta-analyses: Data inclusion & exclusion

Data identified from the systematic search was included in meta-analyses. Inclusion criteria specified that with the exception of elite national levels, samples had to have examined ≥ 50 participants in a given age category or competition level, to help avoid artificially inflating RAE estimates. Where samples of < 50 participants were apparent, but multiple independent samples in the sport context were reported (e.g., age categories - Under 14, 15 and 16), these were collapsed in alignment with sport-designated age categories. Data

[32] Identification of sample age and/or an age-group breakdown were the most common sources of missing information.

[33] Participant numbers were estimated from tables (i.e., overall sample numbers and percentage of participants per quartile were provided, but raw numbers per quartile were not available) by calculating an estimation of the number per quartile using the available values and rounding to the nearest whole number if required. Participant numbers were estimated from figures (i.e., presented in a graph but raw numbers per quartile not provided) by extrapolating from the graph using a ruler and rounding to the nearest whole number if required. Estimated samples within studies are coded and highlighted in Table 3.

from two studies were modified this way [25, 61]. Sport contexts where a participant may have been present in several samples, due to multiple event entries (e.g., Breaststroke and Freestyle in swimming) were included as this was reflective of the organisational structures employed in the respective sport. However, studies that examined RAEs in multi-sport samples and a broader overall athlete population (e.g., Youth Olympic Games) were excluded due to inherent variability and small sample size. Further, to keep the analysis relevant to modern participant trends, samples derived from archival data prior to 1981 were excluded. This competition year coincided with the first documented evidence of RAEs in sport [18], and corresponded to birthdates from the early 1960s onward. When applied, criteria yielded 308 independent samples from 44 studies. Retained samples examined 25 different sport contexts in at least 17 countries[34]. A range of junior-adult ages and a variety of competition levels (i.e., local community recreational - adult elite professional) were included.

**2.6 Meta-analyses**

All data extracted were analysed using Comprehensive Meta-Analysis software (Biostat, Inc. 2005). An Odds Ratio (OR) estimate, along with log odds ratio and standard error were calculated for each independent sample. For each sample, the relative age distributions observed (i.e., *n* Quartile 1 v *n* Quartile 4 participants) were compared relative to an expected frequency assuming equal distributions (e.g., $N = 100$, expected quartile count = 100/4 = 25). When comparing relative age quartiles in analyses, Quartile 4 (i.e. relatively youngest) acted as the reference. Overall summary estimates were calculated using an invariance random-effects model [62], with the assumption that samples across studies were drawn from divergent populations across different sport contexts. Thus, an exact effect size was not expected to exist across samples.

Pooled OR estimates along with accompanying 95% confidence intervals indicated whether overall effects existed in a given analysis. Accompanying $Z$ and $p$ values tested the null hypothesis that OR estimates between relatively older and younger distributions (i.e., Q1-Q3 v Q4 comparisons) were not statistically different. The Cochran $Q$ statistic[35] [63] (with $df$ and $p$) tested whether all studies shared a common effect size. $I^2$ identified the proportion of observed variance reflecting differences in true effect sizes as opposed to sampling error. Moderate (> 50%) to high values (> 75%) were used to indicate value in subgroup analyses and to account for potential heterogeneity sources. $T^2$ provided the estimate of between-study variance in true

[34] Seventeen different countries were named in the literature. However, the total number represented may be larger as some studies reported "international" samples or participants from "across Europe."

[35] The Cochran $Q$ test [63] assesses true heterogeneity in a meta-analysis. In essence, $Q$ is a measure of dispersion of all effect sizes (individual studies) about the mean effect size (overall pooled effect) on a standardised scale.

effects, and *T* estimated the between-study standard deviation in true effects. When heterogeneity was detected, sources were explored using sub-stratification analysis with specific application to Q1 v Q4 data.

To determine the presence of publication bias, funnel plot asymmetry[36] was assessed with Log OR estimates plotted against corresponding standard error. The Egger test [64] confirmed asymmetry; as a result, Duval & Tweedie's 'trim and fill' procedure[37] [65] was applied to determine whether estimates required adjustment based on missing studies. Asymmetry assessments and adjustments for all comparisons (i.e., Q1-Q3 v Q4) are reported.

**2.7 Sub-stratification (subgroup) analyses**

To determine whether age moderated Q1 v Q4 pooled OR estimates, samples were categorised as pre-adolescent (≤ 11 years), adolescent (12-14 years [37, 39-42]), post-adolescent (15-19 years) and adult (> 19 years of age[38]). Samples where ages spanned across categories were excluded from the analysis. To determine whether competition level moderated OR estimates, all samples were categorised based on an adaptation from Cobley et al. [37]: recreational (i.e., typified by an absence of selection or official competition), competitive (i.e., local community level with structured competition), representative (i.e., regional or provincial representative levels based on selection) and elite (i.e., competition at an international level or a career athlete). Elite was further subdivided into adolescent, post-adolescent, adult and combination categories; following age divisions outlined above. If competition level was unclear, data was added to a 'not codable' subgroup for analysis. To determine if the type of sport context moderated OR estimates, samples were categorised into team and individual types. Consistent with prior work [67], team sports were those often played with multiple team members (i.e., more than one participant per team), and individual sports were those involving a single participant in a given event or in direct competition against another. Individual sports were further subdivided into those deemed physically demanding (i.e., predominantly determined by strength or endurance for example [68, 69]); technique or skill-based sports, typically identified by judging of movement criteria [68, 69]; and contexts utilising weight-classifications or categories [70]. To determine whether particular sport contexts

[36] A funnel plot is a scatter plot of treatment effect (e.g., odds ratio) set against a measure of study size (e.g., standard error). It provides an initial visual aid to detect bias or systematic heterogeneity. In the absence of heterogeneity, 95% of the studies should lie within the funnel defined by the two diagonal lines. Publication bias is suggested when there is asymmetry in the plot.

[37] 'Trim and fill' uses an iterative procedure to remove the most extreme (small) studies from the positive side of the funnel plot, re-computing the effect size at each iteration until the funnel plot is symmetric about the (new) effect size. In theory, this yields an unbiased estimate of the effect size. While trimming yields the adjusted effect size, it also reduces the variance of the effects, yielding a (too) narrow confidence interval. Therefore, the algorithm then adds the original studies back into the analysis and imputes a mirror image for each [65].

[38] The 90$^{th}$ percentile female attains adult stature at 20 years old when a criterion of four successive six-month increments < 0.5 cm is utilized [66].

moderated RAEs, data related to each sport context (e.g., volleyball, swimming etc.) were combined and pooled estimates generated. Finally, to determine if study quality moderated pooled estimates, samples were categorised into three groups (i.e., lower quality, scores 5-9 = 13 studies; medium, scores 10-11 = 23 studies; and, higher, scores 12-14 = 21 studies) based on a tertile division of the overall scores obtained on the study quality assessment criteria, as outlined in sub-section 2.4.

## 3 Results

### 3.1 Studies systematically identified

Figure 1 summarises the systematic search and study selection process. Initial database searches identified 1,806 studies with 12 studies identified through other sources. Following title and abstract screening, 89 full-text articles were selected for further review. Twenty-one of these were removed as they examined male sport contexts (not reported in abstracts); while 11 were removed as they did not report relative age (quartile) comparisons (see Figure 1). Overall, 57 studies met inclusion and reporting criteria[39].

*(Insert Figure 1 about here)*

### 3.2 Study quality

Table 1 summarises study quality ratings assessments. Twenty-one of 57 (36.8%) were considered ‘higher quality’ according to the RAE-modified STROBE checklist [59]. Twenty-three (40.4%) were deemed ‘medium quality.’ Thirteen studies (22.8%) were considered ‘lower quality;’ due to limited reporting of methodological and analysis details. Criteria commonly absent in reporting were related to the handling of missing data and/or duplicate entries for an individual athlete (i.e., when multiple competition years are assessed from the same sport context and an athlete may be represented on multiple rosters); an absence of post-hoc comparisons between quartiles; reporting of effect size; and, not identifying study limitations/biases. The inter-rater correlation between KS and independent reviewers was 0.92 and 0.88 respectively.

*(Insert Table 1 about here)*

### 3.3 Summary of sample distributions

With consideration of the annual cut-off dates employed in each respective sport context (e.g., August 1st, January 1st etc.), the descriptive relative age distributions for the total sample of 646,383 female sport participants (former or present) in 308 independent samples identified an uneven distribution (i.e., Q1 =

[39] Fifty-seven studies met inclusion criteria for the systematic review; 44 had useable data that could be included in the overall meta and subgroup analyses.

25.97%; Q2 = 26.32%; Q3 = 25.13%; Q4 = 22.58%). Table 2 provides a summary of unadjusted odds ratio estimates for each independent sample within each study.

*(Insert Table 2 about here)*

Table 3 summarises the distribution of total sample numbers according to subgroup categories. Samples were fairly evenly distributed across age categories, with adult (> 19 years; 5.58%) and post-adolescence (15-19 years; 30.53%) containing the lowest and highest numbers respectively; with 13% approx. not readily age-categorised (i.e., sample age crossed the designated age groupings for subgroup analyses). In terms of competition level, 57.12% contained recreational level participants, with considerably smaller competitive (7.32%), representative (1.87%), elite adolescent (12-14 years; 0.08%), elite post-adolescent (15-19 years; 0.83%), elite adult (> 19 years; 0.34%) and elite combination (i.e., not codable by age; 2.43%) involvement. Thirty percent of sample numbers could not be clearly coded into a competition level category, mainly due to limited contextual information provided in study reporting. For sport type, samples were evenly distributed (154) between team and individual sport contexts. Within the individual subcategories, more samples (28.57%) and participant numbers (51.42%) were engaged in physically demanding contexts. Meanwhile, technique/skill-based and weight-categorised contexts contained 3.93% and 0.37% of total participants respectively. The sport contexts with the largest sample sizes represented (in order) were: Alpine skiing (31.2% of athletes), basketball (16.9%), ice hockey (12.4%), soccer (11.5%), tennis (9.63%) and track and field (9.56%).

*(Insert Table 3 about here)*

**3.4 Meta-analyses**

Based on 44 studies containing 308 independent samples, overall pooled data comparing participation distributions of the relatively oldest (Q1) v relatively youngest (Q4) identified a significant, but small, OR estimate = 1.25 (95%CI = 1.21-1.30; $Z$ = 13.74, $p$ = 0.0001), suggesting the relatively older were 25% more likely to be represented. The $Q$ statistic of 2135.50 ($df$ = 307, $p$ = 001) highlighted the true effect size was not similar across samples. $I^2$ = 85.62 indicating approximately 85% of variance in the observed effects were due to true effects, while $T^2$ and $T$ were 0.04 and 0.21 (in log units) respectively. A similar RAE magnitude was identified for Q2 v Q4 (i.e., OR = 1.24; 95%CI = 1.21-1.27, $Z$ = 15.75, $p < 0.01$) before reducing for Q3 v Q4 (OR = 1.13; 95%CI = 1.11-1.15, $Z$ = 14.18, $p < 0.01$) respectively. Akin to the Q1 v Q4 findings, heterogeneity was apparent (Q2 v Q4 $Q$ = 1335.29, $df$ = 307, $p < 0.01$, $I^2$ = 77.02; Q3 v Q4 $Q$ = 513.2, $df$ = 307, $p < 0.01$, $I^2$ = 40.24). Descriptive Q2 total participation numbers were marginally higher than Q1; thus, a Q1 v Q2 comparison was also conducted. No overall pooled OR differences were identified 0.99 (95%CI = 0.97-1.01; $Z = -1.21$, $p = 0.23$). As evidence for heterogeneity was consistent, follow-up subgroup stratification analyses examined their potential sources using Q1 v Q4 data.

The asymmetry of funnel plots suggested publication bias was apparent. Inspection of Figure 2 revealed that estimates with larger samples and more precise comparative estimates between Q1 and Q4 frequencies were distributed about the overall estimate. Further, there was a comparative absence to the 'left' of the pooled estimate in terms of less precise studies with more conservative estimates for Q1 v Q4 proportions. Asymmetry potentially may also have occurred as smaller powered published samples may have inflated pooled effect size estimates, resulting in a slight overestimation of the actual trend. Studies containing the largest samples were clustered symmetrically around overall effect size estimates. The Egger test for Q1 v Q4 confirmed asymmetry (intercept = 0.91, SE = 0.20, $p < 0.01$). Duval and Tweedie's ''trim and fill'' procedure provided an adjusted pooled estimate = 1.21 (95%CI 1.15-1.25; $n = 39$ imputed samples). Nonetheless, the adjusted estimate remained significant and close to the original. Similar results were evident for Q2 v Q4 (adjusted OR = 1.19, 95%CI = 1.16-1.22; $n = 34$) and Q3 v Q4 (adjusted OR = 1.11, 95%CI = 1.09-1.13; $n = 38$). The follow-up Q1 v Q2 comparison did not suggest asymmetry was apparent ($p < 0.10$).

**3.5 Sub-stratification (subgroup) analyses**

For a summary of Q1 v Q4 subgroup analyses according to moderating factors, refer to Table 4.

*(Insert Table 4 about here)*

**3.5.1 Age**

When stratified according to defined age categories (i.e., pre-adolescent to adult), significant pooled OR estimates were apparent in all categories, except adults (> 19 years). Q1 v Q4 OR estimates were similar in pre-adolescent (≤ 11 years) and adolescent (12-14 years) categories (OR = 1.33 and 1.28), before reducing by 14% in post-adolescence (15-19 years) and becoming insignificant in adulthood. The between groups $Q$ statistic and $p$-value suggested changes were significant. Total within-age subgroup variance and heterogeneity estimates identified subgroups did not share a common effect size and substantial dispersion was apparent within pre-adolescent, adolescent and post-adolescent categories. When studies containing samples that traversed the designated age groupings were independently assessed, a similar estimate ($n = 79$, OR = 1.37, 95%CI = 1.29-1.46) to the overall pooled estimate was evident, and a common effect size was not apparent.

### 3.5.2 Competition level

When stratified according to competition level (i.e., recreational to elite combined), significant OR estimates were consistently apparent with OR's ranging from 1.08 (recreational level; $n$ = 76 samples) – 2.70 (elite adolescent; $n$ = 5). OR estimates increased with competition level, prior to an OR reduction at the elite adult stage. In samples traversing competition categories ($n$ = 56), the OR = 1.19 was similar to the recreational level. Changes identified across subgroup categories were regarded as systematic ($Q$ = 77.09; $p$ = 0.0001). Total within subgroup variance and heterogeneity estimates identified high dispersion was apparent (or a high proportion of variance remained unexplained) in the recreational and 'not-codable' categories ($I^2$ = 92.71 and 84.62). Moderate-high heterogeneity was apparent in competitive, representative, elite post-adolescent and 'elite combined' subgroup categories. Whilst acknowledging fewer samples in elite adolescent and elite adult categories, a more common effect size was estimated as lower/no evidence of estimate dispersion was apparent.

### 3.5.3 Sport type

When samples were stratified according to individual v team sports, subgroup differences were apparent ($p$ = 0.001), as team sports were associated with higher RAE estimates (OR = 1.33 v 1.18). A large proportion of variance within the subgroups was unexplained ($I^2$ = 88.70 and 77.79), and when individual sports were further analysed, significant estimates remained for physically demanding sports (OR = 1.23). Meanwhile, technique/skill-based (OR = 1.06) and weight-categorised (OR = 1.18) sport types were generally not associated with RAEs. The proportion of variance still unexplained was reduced for technique/skill and weight-categorised ($I^2$ = 51.77 and 19.81, respectively), but remained high for physically demanding sports ($I^2$ = 92.82).

### 3.5.4 Sport context

Table 5 summarises Q1 v Q4 subgroup analyses according to more specific sport contexts. Of the 25 sports examined to date, 15 had ≥ 6 independent samples available for analysis. Nine of these had pooled OR estimates exceeding the overall pooled OR estimate (1.25). Those most notable with higher Q1 representations were volleyball (OR = 1.81), swimming (OR = 1.67), handball (OR = 1.41) and ice-hockey (OR = 1.39). In contrast, contexts associated with no RAEs included table tennis (OR = 0.85), gymnastics (OR = 1.06), rugby (OR = 1.07), shooting (OR = 1.07) and snowboarding (OR = 1.16).

*(Insert Table 5 about here)*

### 3.5.5 Study quality

When stratified according to study quality, effect sizes again differed ($p$ = 0.001). Lower quality rated studies ($n$ = 38 samples from 13 studies, OR = 1.63) had significantly higher OR estimates than medium ($n$

samples = 92 from 23 studies, OR = 1.29) and higher quality rated studies (*n* samples = 178 from 21 studies; OR = 1.19). The finding suggests that studies with lower rated methodological and reporting qualities were more likely to be associated with higher RAE Q1 v Q4 OR estimates. Again, across studies categorised as medium and higher quality, a large proportion of variance remained unexplained (refer to Table 4).

## 4 Discussion

### 4.1 Overview of main findings

The present study represents the most comprehensive systematic review and meta-analysis of RAEs amongst female sport participants and athletes to date. The primary objective was to determine RAE prevalence and magnitude across and within female sport. The secondary objective was to determine whether moderator variables affected RAE magnitude. Based on data available, findings identified RAEs are consistently prevalent in female sport contexts, with 25% (21% adjusted) more relatively older (Q1) participants than relatively younger (Q4). Compared to males, and generally speaking, findings identified a smaller overall RAE magnitude. Nonetheless, the factors of age, competition level, sport type and context significantly moderated overall RAE magnitude estimates; generally confirming original hypotheses, with some novel additions. Unlike males, greater RAE (Q1 v Q4) magnitude was associated with both the pre-adolescent (≤ 11 years old) and adolescent (12-14 years old) age categories. RAEs then reduced afterwards coinciding with completion of biological maturation. As expected, RAEs were lower at the recreational level and increased with higher competition, particularly in the elite adolescent (12-14 years) to post-adolescent years (15-19 years) where anthropometric and physical variability may have affected performance and selection processes. RAE risk did reduce in the adult elite category; remaining significant but with smaller effect sizes in adult/professional athletes. Collectively, findings now provide female-specific estimates that have only previously been speculated upon.

### 4.2 Summary of subgroup analyses

Related to the age subgroup analyses, the highest level of RAE risk was associated with the youngest age category (≤ 11 years; OR = 1.33); a finding partially contradicting the prior meta-analysis [37] where the highest risk was associated with adolescence. This may be explained by the large proportion of male samples in previous work (i.e., females comprised only 2% of participants in Cobley et al. [37]), and genuinely different RAE patterns could be evident in females. If accurate, the earlier emergence of RAEs pre-maturation implicates the influences of both normative biological growth disparities (pre-maturation) within age-grouped peers and other psycho-social processes. For instance, growth charts tracking stature and body mass across chronological age highlight the potential for important relative (within age-group) differences in a given year [71, 72]. These may also relate to motor coordination, control and physical (e.g., muscular force) characteristic development advantages that assist sport-related performance (e.g., soccer). Interacting with age-related biological differences, parental and young participants' choices may also account for increased RAE magnitude. As part of initial recreation and participation experiences, the identification of an appropriate 'sporting fit' relative to physical characteristics of similarly aged girls (and possibly boys - in early age mixed sport contexts; e.g., soccer) may occur.

Age findings also partially resonate with the general findings of prior literature. After the adolescent age category (12-14 years; OR = 1.28), RAE magnitudes reduced with age; possibly suggestive of a declining influence of growth and maturational processes on sporting involvement. To acknowledge however, the overall adolescent age estimates could have been confounded by competition level as approximately two-thirds of adolescents were recreational level participants. This may explain why RAE magnitude estimates in adolescence were potentially smaller than expected when compared to prior reviews and given existing explanatory mechanisms. Finally, there were many samples (79) that could not be coded into subgroup categories; likely for several reasons including the analyses of samples in original studies that were collapsed across multiple age groups. Future studies will need to be mindful of such collapsing, as they may be potentially missing important changes in RAE estimates.

Competition level also moderated RAE risk, with increasing magnitude at higher competition levels. The interaction of elite competition level with ages coinciding with adolescence (12-14 years) and post-adolescence (15-19 years) was associated with the greatest RAE risk (i.e., OR = 2.70 & 1.65). These findings corroborate previous studies examining representative athletes in talent identification and development systems, and the maturation-selection hypothesis [9, 24, 37, 38]. As higher tiers of representation necessitate the requirement for higher performance levels at a given age or developmental stage, selection is likely to favour those with more favourable anthropometric and physical characteristics; and thereby relatively older in a given junior/youth grouping process [38]. Distinct trends within epidemiological (national) data samples support the hypothesis in accounting for RAE perpetuation. For instance, Romann and Fuchslocher [61] provided data at recreational levels and sport organisation-imposed age categories in Alpine skiing, tennis and track/field. At recreational levels, significant RAEs existed in these contexts until approximately 15 years of age (i.e., post-*peak height velocity* for females [42]). RAEs then continued in competitive tiers where selection processes were present, perpetuating early growth and physical advantages. Furthermore, a slow reversal of recreational-level RAE trends at post-15 years was observed, possibly indicating the relatively older were either participating at higher levels of competition or had ceased participation.

At elite representative levels, significant pooled RAEs remained, although they did decrease with age (e.g., elite adult; OR = 1.27). Prior study findings have also been inconsistent at the elite adult (i.e., professional athlete) level, suggesting potential variability in RAE risk which may be associated with context-specific conditions and performance demands. The definitive explanations for why RAEs reduce and even reverse at the elite adult stage remain somewhat speculative and deserving of further attention. Initial explanations from male contexts suggest later ages benefit from anthropometric and physical development [4, 13] 'equalisation' and delayed, less intensive sporting involvement with training specialisation occurring later in development [73-75]. One alternative, referred to as the 'underdog' hypothesis [76], suggests that challenges (e.g., non-selection; physical dominance by relatively older players) encountered at younger ages may ultimately facilitate longer-term athlete development [77] through a combination of needing to develop greater resiliency and coping skills in such psycho-social conditions, along with enhanced or alternative skill development to circumvent the performance hurdles. Such successful transitions may partially account for the greater presence of the relatively younger in adult professional sport [12, 55, 76].

Related to sport type, the highest RAE risk was associated with team-based sports (OR = 1.33) whereby the nature of the field of play and performance emphasizes the requirement for anthropometric and physical capabilities to outcompete opponents [78]. Accordingly, and coinciding with individual study samples, higher RAEs were apparent in elite level basketball [79, 80] and representative volleyball [18, 81]. The examination of other team sports with ≥ 6 samples available highlighted notably higher RAE magnitudes than the overall estimate in handball, swimming, ice-hockey and soccer (see Table 4). Overall, these findings adhere to those found in the predominantly male meta-analytical review [37]. Perhaps most surprising, given game physicality requirements, was that rugby [10, 25] did not show significant RAEs (OR = 1.06, 95%CI 0.95-1.18) despite estimates being based on 27 samples from three countries (Canada, New Zealand, UK). However, it should be noted that both rugby union and rugby league samples were combined, and independent RAE estimates were significant at pre-adolescent (≤ 11 years) levels in rugby union when sample size was more robust [25]. There were no pre-adolescent rugby league samples available for comparison.

Individual sport types were initially examined holistically, identifying an RAE below the pooled estimate (i.e., Q1 v Q4 OR = 1.18 v 1.25) with a high level of within-group heterogeneity. To follow-up, individual sports were re-categorised with consideration of predominant sport demands (i.e., physical/endurance, technique/skill) as well as those implementing weight-categorisation instead of age-based cohort grouping. Findings identified variable RAE risk. Individual sports associated with strength and/or endurance requirements illustrated some of the highest RAEs at particular age and competition levels. For instance, Alpine skiing OR's ranged between 2.00-2.51 between 11-14 years at competitive/representative levels [61, 82]. In track and field, Romann and Fuchslocher [61] reported OR's of 2.30-2.6 in competitive 15-16-year-olds; while Costa et al. [28] identified OR's exceeding 4.00 in a sample of junior representative swimmers. Overall, these findings are novel for individual sport contexts, and efficacy for these estimates can be derived from the multiple large samples spanning age groups and competition settings.

Based on the 59 samples containing varying age and competition levels, skill/technique-based sports (e.g., table tennis, OR = 0.85; gymnastics, OR = 1.06) were not associated with any RAE risk (OR = 1.06, 95% CI=0.97-1.16); a finding consistent with suggestions in previous studies [35]. Such a contrast between pooled estimates of individual skill/technique-based sports and those with physical/endurance requirements again points toward the importance of physical and maturation disparities driving RAEs, and to a lesser extent selection processes. Likewise, when weight-categorised sports were examined, RAE magnitude was lower. However, this finding should be interpreted with caution due to limited samples available and the absence of samples at lower competition levels. Further assessment in weight-categorised sport (e.g., martial arts) is warranted as such processes attempt to mitigate and neutralise the effect of anthropometric and physical discrepancies from impacting competition.

With reference to study quality, findings highlighted that higher study quality was associated with a lower RAE estimate and vice versa. Though no prior RAE reviews have identified such a trend; the finding is aligned with meta-analytical reviews in other sport science [83] areas. This finding highlights the importance of detailed reporting on the sport context (e.g., characteristics of competition and selection across age groups), sufficient sampling of participants and reporting of participant characteristics (e.g., quartile distributions, ages, one-year age groupings, levels of competition etc.) and implementation of appropriate data analysis steps (i.e., techniques for comparison; effect size) [84] to enable valid estimates of true RAE sizes. The adapted reporting checklist used in this review may be useful to help enable appropriate sampling and reporting in future RAE studies.

### 4.3 Unexpected findings

One unexpected finding, even though OR comparisons showed no differences, was that Q2 representation was either similar or descriptively higher than Q1. Marginal Q2 over-representation has previously been reported, primarily in Canadian ice-hockey [20, 84, 85] but also in adult female soccer [52, 56]. Canadian ice-hockey samples provided 12.63% of relative weight to present analyses, and so their influence may be apparent. Further examination in this context also identifies subtle but pervasive shifts in Q1+Q2 over-representation according to age and competition categories. Specifically, Q1 over-representations are apparent at pre-adolescent (≤ 11 years) competitive levels, while Q2 over-representation is evident at age equivalent recreational levels. By adolescence (12-14 years) however, Q2's were over-represented at both recreational and competitive levels in the same sport system. These transitions potentially suggest adverse effects from intensified involvement at a younger age (where RAE OR's are highest), and possible interactions with growth and maturational processes. Rather than an accumulated advantage as suggested by the 'maturation-selection' hypothesis, intensified involvement in pre-adolescence and during adolescence (maturation) in Canadian ice-hockey may be associated with greater risks of injury, burnout and sport withdrawal [11, 86, 87]. By contrast, a lower intensity-level involvement until adolescence (or post-peak growth) may be more protective and conducive to long-term participation. Nonetheless, caution is necessary for recognising the specificity of Q2 trends and in attempting to account for them accurately.

### 4.4 Limitations

Several limitations can be acknowledged in the present study. First, it is plausible that despite comprehensive searches, some published literature may not have been identified even though systematic steps were taken (as reported) to avoid such possibilities. Second, the sporting landscape has changed in past decades and it was not possible to assess whether the intensification of competitive youth sport was associated with increased RAE magnitude. Third, within identified studies, inconsistency and variability in data reporting were apparent, and therefore multiple authors had to be contacted for data verification and further extraction to enable present analyses. In conducting subgroup meta-analyses, pooled estimates may have been affected by 'non-codable' data that traversed categories (e.g., age). Such data was still examined to determine if data dispersions were apparent. Further, and as was often the case, multiple data samples still remained generating likely valid pooled subgroup estimates. Finally, in subgroup analyses, a large amount of heterogeneity often remained unaccounted for, suggesting other variables (not examinable) may still moderate RAEs. It also highlights the potential for multi-factorial explanations of RAEs across and within sport contexts.

### 4.5 Implications: RAE intervention and removal

Relative age research is fundamentally concerned with participation and development inequalities. Present findings are therefore concerning with respect to the relatively younger, who are more likely to refrain from engagement in the early years (e.g., 6-11 years) of recreational sport and/or withdraw, possibly due to less favourable participation experiences and conditions. With the inequality continuing into the (post-) adolescent years, and being exacerbated by forms of selection and representation, the need for organisational policy, athlete development system structure and practitioner intervention can be recommended. Previous recommendations have suggested changes to age-grouping policies, such as rotating cut-off dates [6]; creating smaller age bands (e.g., 9-month rotating bands) [88] and increasing RAE awareness via education for sport-system practitioners (e.g., coaches, scouts) [37, 46]. However, despite increasing RAE awareness, few prior recommendations have been implemented organisation wide and in the long-term. Meanwhile, a cultural performance emphasis in many junior/youth sports systems has grown with the development of RAEs [5, 89].

Considerate of emerging literature and sport organisation trends, Cobley [90] recently summarised a range of feasible organisational and practitioner strategies for national sporting organisations. At an organisation level, these included a general recommendation to delay age time-points for structured competition and to delay tiers of selective representation (e.g., post-maturation). These strategies would help enable inclusive participation and dissociate with an early-age performance emphasis (and RAE bias [39, 91]). Potentially more relevant for individual sport contexts (e.g., sprinting, track and field), the application of corrective performance adjustments could potentially remove performance differences related to growth and development [9]. For team sports (e.g., soccer, ice-hockey), body mass or biological maturity banding at particular development time-points (e.g., maturation years) could help dissipate performance inequalities and improve participation experiences [7, 92, 93]. With organisational alignment and support, recommended practitioner strategies included the development of psycho-social climates that emphasised ‘personal learning and development’ in junior/youth sport as opposed to inter-individual/team competition *per se*; explicit cueing of relative age or biological maturity differences (e.g., ordered shirt number) in player evaluation/selection [89]); and, the benefit of longer-term athlete tracking on various indicators (i.e., physiological and skill-based) [94, 95]. Notwithstanding these strategies, there is still further developmental work required in identifying effective and feasible interventions for female sport.

### 4.6 Future research

Based on current evidence and findings, future research should seek to further examine female sport contexts where minimal samples and data are available (as highlighted). Sampling across and within these contexts will help establish a better understanding for how growth and biological development interacts with sport development systems and their psycho-social climate to affect sporting experience and behaviour. Further, moving beyond reporting RAEs in female sport to better isolate and confirm underlying causes will prove beneficial. Such work will likely inform the necessary interventions that attempt to remove RAEs and/or organisation/practitioner strategies mitigating their effects. To this end, a shift in research methodologies may also prove valuable, including qualitative investigations with sport stakeholders (e.g., athletes, coaches, parents, administrators) [20, 21, 96] to consider the influence of sport organisation processes and practitioner behaviours. Qualitative idiographic investigations examining child/athlete experiences within sporting structures at early and onward stages of participation would also strengthen understanding of how RAEs manifest and operate in the pre-maturational years.

Connected to early sporting experiences, the examination of dropout may also provide additional perspective. Growth and particularly maturation (puberty onset and duration) may contribute differentially to dropout in each sex. The relatively younger (Q4) males may disengage in greater numbers than Q1 peers, due to the early emphasis on physical dominance and performance which becomes exacerbated in the maturational years [46, 97]. Preliminary work in female athletes has been inconclusive, and the relevant factors involved may be different [46, 98]. For females, entering maturation may be associated with negative outcomes (e.g., increased body mass to height ratio, wider hips [41]) impacting performance in particular contexts; and other psycho-social concerns at play (e.g., body image). Thus, longitudinal and multivariate studies of RAEs in terms of sport participation, dropout, and positive and negative experiences are likely to be insightful. Recently, Sabiston and Pila [99] asked female adolescent sport participants to complete a questionnaire targeting their emotions and sport experience over three years. They identified that across tracking, 14% withdrew from all sporting participation and 58% disengaged from at least one sport. Negative body image emotions - derived from interactions with parents, coaches and peers - increased over the three years and were associated with lower commitment and enjoyment levels of their sport. Such work demonstrates how interactions between several biological, sport context/system and psycho-social factors are likely to affect individual sporting behaviour, whether in terms of early-age initiation, continued participation or continued progressive involvement across athlete development and professional stages.

## 5 Conclusions

Overall, RAEs have a consistent but likely small-moderate influence on female sport participation. Findings highlight the impact of interactions between athlete developmental stages, competition level, sport context demands and sociocultural factors on RAE prevalence and effect magnitudes across and within female contexts. To reduce and eliminate RAE-related inequalities in female athletic development, direct policy, organisational and practitioner intervention are required.

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## 7 Declaration of Interest

Kristy Smith, Patricia Weir, Kevin Till, Michael Romann and Stephen Cobley declare that they have no conflict of interest relevant to the content of this paper.

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## List of Figures and Tables

### List of Figures



### List of Tables

**Figure 1:** Flow diagram for screening and selection of studies according to PRISMA [57]

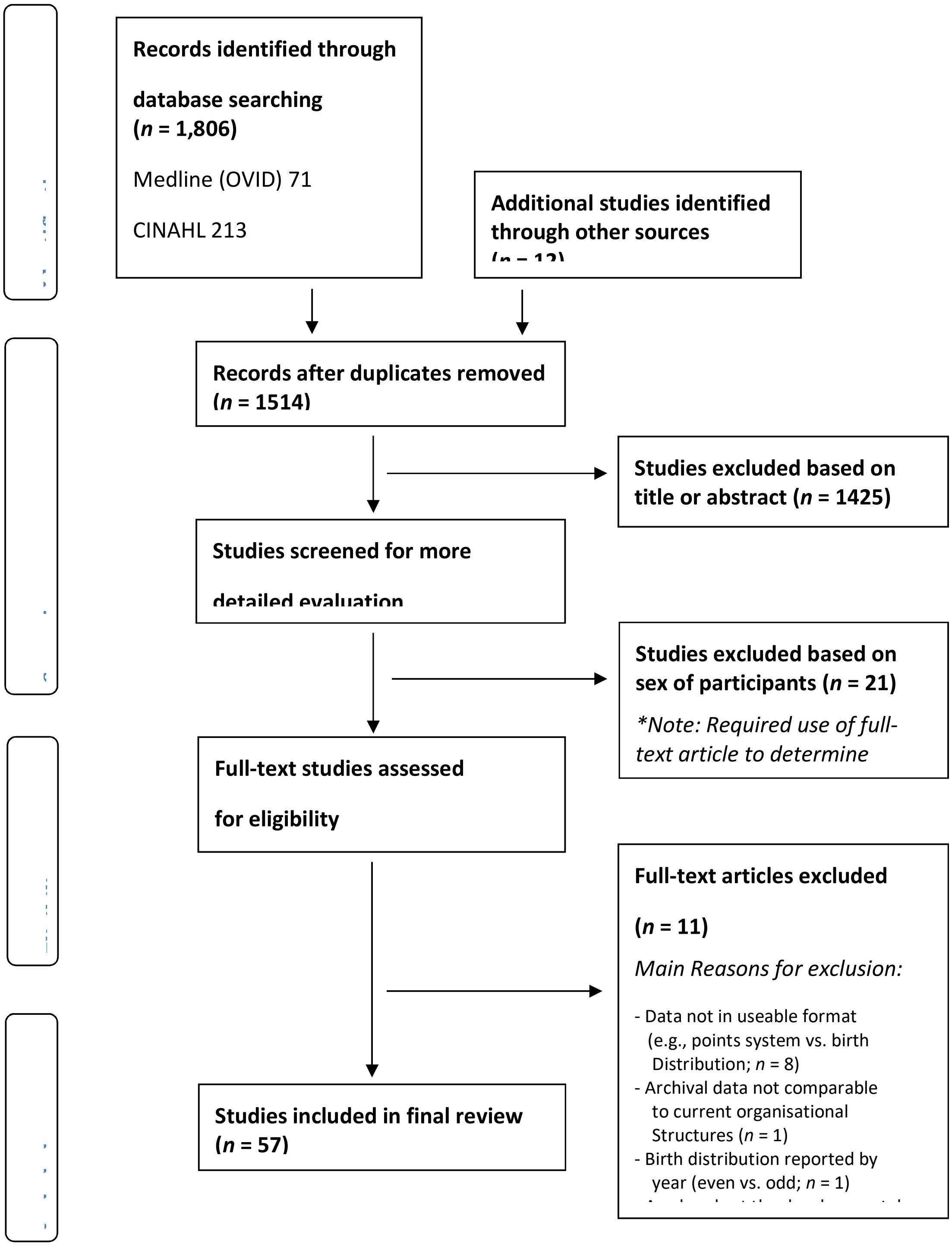

**Figure 2**: Funnel plot of standard error by log odds ratio (Q1 v Q4 OR analysis).

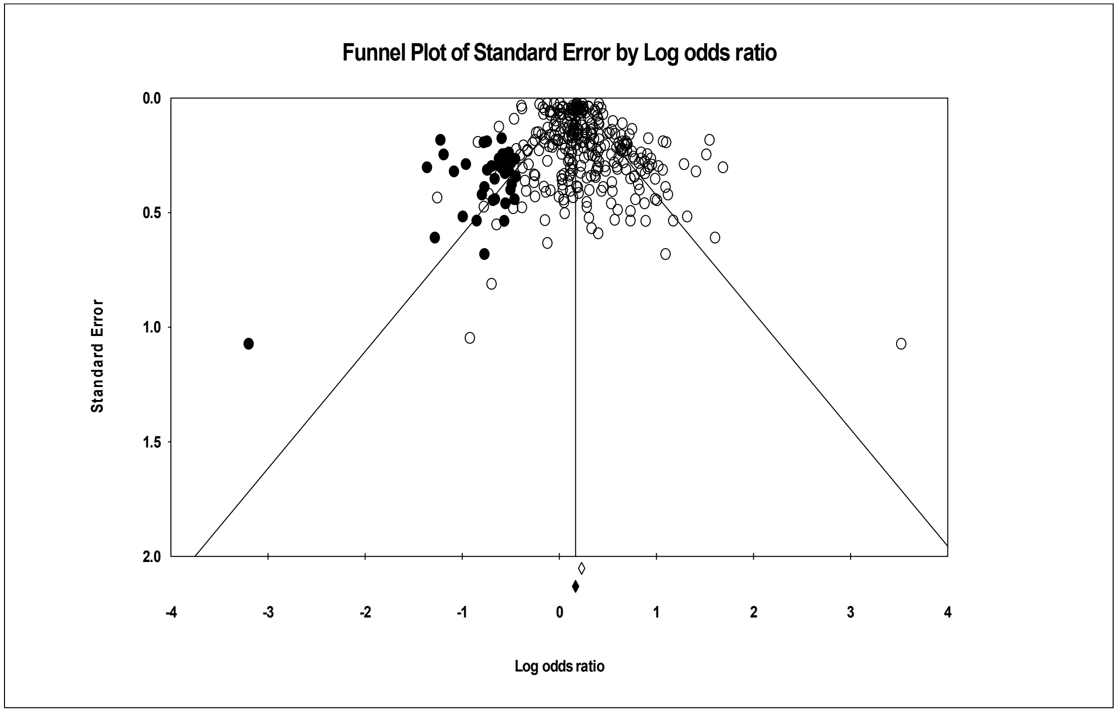


***Figure Notes***: In the absence of heterogeneity, 95% of the studies should fall within the funnel defined by the two diagonal lines. The plot assumes that those studies with higher precision (higher sample, lower estimates of error) will plot near the overall estimate (vertical line) and will cluster around the line evenly. Those studies with lower precision (lower on the graph) should also spread evenly on both sides, even though they have a smaller sample size and less precise estimates of error. Publication bias is suggested when there is asymmetry in the plot.

The results displayed taking into account the Trim and Fill adjustment. Observed studies are shown as open circles, and the observed point estimate is an open diamond. The imputed studies are shown as filled circles, and the imputed point estimate in log units is shown as a filled diamond.

**Table 1**: Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) [59]

| **Study** | **#1.** In the abstract an informative and balanced summary of what was done and what was found is provided. | **#2.** Explain the scientific background and rationale for the investigation being reported. | **#3.** State clear, specific objectives and/or any prespecified hypotheses.- | **#4.** Describe the setting, locations, and relevant dates for data collection. This must include information on sport context, type, level of competition, and competition year(s) for data collected to be scored as a '1'. | **#5a.** Give characteristics of study participants (must include: age, gender, skill level, overall number, and nationality). **#5b.** Describe the procedure for selecting and grouping athletes in the context under examination (e.g., by birthdate or weight) and how participants were categorised for study purposes (e.g., application of a cut-off date to determine birth quartile). **#5c.** Describe the source and procedure for obtaining the sample (e.g., obtained from an online roster, provided by a sport governing body, etc.). | **#6.** Explain and report the reference baseline distribution (e.g., equal distribution vs. population birth rate). | **#7a.** Clearly describe all statistical methods, including specific analytical methods used to examine subgroups. **#7b.** Explain how duplicates (if applicable) and missing data were addressed or incomplete data were handled. | **#8.** Report the number or percentage of participants found in each quartile/semester (and subcategory if applicable). | **#9.** Provide statistical estimate(s) and precision (e.g., 95% confidence interval) for each sample or subgroup group examined. | **#10a.** Post-hoc comparisons between quartiles (e.g., Q1 vs. Q4) are provided when appropriate (i.e., overall test is significant). **#10b.** A measure of effect size is provided (e.g., Cramer's V, phi coefficient, Cohen's w, etc.). | **#11.** A summary of key results with reference to study objectives is provided. | **#12.** Discusses limitations of the study, taking into account sources of potential bias, confounding factors or imprecision. | **#13.** A cautious overall interpretation of results considering objectives and relevant evidence. | **#14.** Discusses the generalizability of the study results to similar or other contexts. | **Quality Score Total / 14** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Albuquerque et al., 2012 [100] | 0 | 1 | 1 | 0 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,0) 0 | 1 | 0 | 0 | 1 | 7 |
| Albuquerque et al., 2014 [101] | 1 | 1 | 1 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,0) 0 | 1 | 1 | 0 | 1 | 10 |
| Albuquerque et al., 2015 [70] | 0 | 1 | 0 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 1 | 0 | 1 | 8 |
| Arrieta et al., 2016 [80] | 0 | 0 | 1 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,0) 0 | 1 | 0 | 0 | 1 | 7 |
| Baker et al., 2009 [52] | 1 | 1 | 1 | 1 | (1,1,0) 0 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 1 | 11 |
| Baker et al., 2014 [78] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 1 | 12 |
| Bidaurrazaga-Letona et al., 2014 [102] | 1 | 1 | 1 | 0 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,0) 0 | 1 | 0 | 1 | 1 | 11 |
| Brazo-Sayavera et al., 2016 [103] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 0 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 0 | 1 | 0 | 10 |
| Chittle et al., 2016 [104] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,1) 1 | 1 | 0 | 1 | 1 | 13 |
| Costa et al., 2013 [28] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 0 | (1,0) 0 | 1 | 1 | (0,0) 0 | 1 | 1 | 1 | 1 | 11 |

| Study | #1 | #2 | #3 | #4 | #5a,b,c | #6 | #7a,b | #8 | #9 | #10a,b | #11 | #12 | #13 | #14 | Score /14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Delorme & Raspaud, 2009 [36] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,0) 0 | 0 | 0 | 1 | 1 | 11 |
| Delorme & Raspaud, 2009 [105] | 0 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,0) 0 | 0 | 0 | 1 | 1 | 10 |
| Delorme et al., 2009 [34] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,0) 0 | 0 | 0 | 1 | 1 | 11 |
| Delorme et al., 2010 [56] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (0,0) 0 | 1 | 0 | 1 | 1 | 11 |
| Delorme, 2014 [106] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,0) 0 | 1 | 1 | 1 | 1 | 13 |
| Dixon et al., 2013 [107] | 0 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 12 |
| Edgar & O'Donoghue, 2005 [29] | 1 | 1 | 1 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,0) 0 | 1 | 1 | 1 | 1 | 11 |
| Fukuda, 2015 [108] | 1 | 1 | 1 | 1 | (0,1,1) 0 | 0 | (1,1) 1 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 1 | 11 |
| Giacomini, 1999 [30] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (0,0) 0 | 1 | 1 | 0 | 0 | 10 |
| Gorski et al., 2016 [109] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 13 |
| Grondin et al., 1984 [18] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (0,0) 0 | 0 | 1 | (1,0) 0 | 1 | 1 | 1 | 1 | 11 |
| Hancock et al., 2013 [84] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 0 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 0 | 1 | 1 | 10 |
| Hancock et al., 2015 [110] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 14 |
| Helsen et al., 2005 [23] | 1 | 1 | 1 | 1 | (1,1,0) 0 | 1 | (1,0) 0 | 1 | 1 | (0,0) 0 | 0 | 0 | 1 | 1 | 9 |
| Lemez et al., 2016 [25] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 14 |
| Lidor et al., 2014 [111] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 0 | 1 | 1 | 11 |
| Liu & Liu, 2008 [112] | 1 | 0 | 1 | 0 | (0,0,0) 0 | 0 | (0,0) 0 | 0 | 0 | (0,0) 0 | 1 | 1 | 1 | 0 | 5 |
| Muller et al., 2015 [32] | 0 | 1 | 1 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 0 | 1 | (1,0) 0 | 1 | 1 | 0 | 1 | 8 |
| Muller et al., 2015 [82] | 1 | 1 | 1 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 0 | 10 |
| Muller et al., 2016 [69] | 0 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 13 |
| Nagy et al., 2015 [113] | 0 | 1 | 0 | 0 | (1,0,1) 0 | 0 | (0,0) 0 | 1 | 1 | (0,0) 0 | 1 | 0 | 1 | 1 | 6 |
| Nakata & Sakamoto, 2012 [33] | 0 | 1 | 0 | 1 | (0,1,0) 0 | 1 | (0,1) 0 | 1 | 1 | (0,1) 0 | 1 | 0 | 0 | 0 | 6 |
| O'Donoghue, 2009 [114] | 1 | 1 | 1 | 1 | (0,1,1) 0 | 0 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 0 | 1 | 1 | 9 |
| Okazaki et al., 2011 [81] | 0 | 1 | 1 | 1 | (1,1,1) 1 | 0 | (1,0) 0 | 1 | 1 | (0,0) 0 | 0 | 0 | 1 | 1 | 8 |
| Raschner et al., 2012 [68] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,0) 0 | 1 | 1 | 1 | 1 | 13 |
| Romann & Fuchslocher, 2011[115] | 1 | 1 | 1 | 1 | (1,1,0) 0 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 0 | 1 | 1 | 11 |
| Romann & Fuchslocher, 2013 [116] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 13 |
| Romann & Fuchslocher, 2014 [61] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 0 | 1 | 1 | 12 |
| Romann & Fuchslocher, 2014[31] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 0 | 1 | 1 | 12 |

| Study | #1 | #2 | #3 | #4 | #5a,b,c | #6 | #7a,b | #8 | #9 | #10a,b | #11 | #12 | #13 | #14 | Score /14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Saavedra-García et al., 2014 [79] | 1 | 1 | 1 | 1 | (1,0,1) 0 | 0 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 0 | 1 | 1 | 10 |
| Saavedra-García et al., 2015 [117] | 0 | 1 | 1 | 0 | (1,0,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 0 | 1 | 1 | 8 |
| Saavedra-García et al., 2016 [118] | 0 | 1 | 1 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 0 | 0 | 0 | 8 |
| Schorer et al., 2009 [55] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,1) 0 | 1 | 0 | 1 | 1 | 12 |
| Schorer et al., 2009 [119] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 1 | 13 |
| Schorer et al., 2010 [120] | 0 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 1 | 12 |
| Schorer et al., 2013 [121] | 0 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 1 | 12 |
| Schorer et al., 2015 [53] | 1 | 1 | 1 | 1 | (0,1,1) 0 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 1 | 1 | 1 | 11 |
| Sedano et al., 2015 [122] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 0 | 0 | 1 | 11 |
| Smith & Weir, 2013 [20] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 14 |
| Stenling & Holmstrom, 2014 [21] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 14 |
| Till et al., 2010 [10] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,0) 0 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 13 |
| van den Honert, 2012 [123] | 0 | 1 | 0 | 0 | (1,1,0) 0 | 1 | (1,0) 0 | 1 | 1 | (0,1) 0 | 1 | 0 | 1 | 0 | 6 |
| Vincent & Glamser, 2006 [124] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,0) 0 | 0 | 0 | 1 | 1 | 11 |
| Wattie et al., 2007 [22] | 1 | 1 | 1 | 1 | (0,1,1) 0 | 1 | (1,1) 1 | 1 | 1 | (0,0) 0 | 1 | 0 | 1 | 0 | 10 |
| Wattie et al., 2014 [98] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (1,1) 1 | 1 | 1 | 1 | 1 | 14 |
| Weir et al., 2010 [85] | 1 | 1 | 1 | 1 | (1,1,1) 1 | 1 | (1,1) 1 | 1 | 1 | (0,1) 0 | 1 | 0 | 1 | 1 | 12 |
| Werneck et al., 2016 [125] | 1 | 1 | 1 | 1 | (1,0,1) 0 | 1 | (0,0) 0 | 1 | 1 | (0,0) 0 | 1 | 1 | 0 | 1 | 10 |

***Tables Notes:*** 0 = Item criterion is absent or insufficiently information is provided; 1 = Item criterion is explicitly described and met.

**Table 2**: Unadjusted odds ratios for independent female samples examining RAEs in sports contexts.

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | **Q1 vs. Q4** | **Q2 vs. Q4** | **Q3 vs. Q4** |
| Grondin, Deschaies, & Nault, 1984†† [18] | 14-15 | Volleyball | Provincial Cadet[Rp] | 219 | 2.28 (1.30, 3.99) | 2.13 (1.21, 3.73) | 1.44 (0.80, 2.58) |
| | 16-17 | Volleyball | Provincial Juvenile[Rp] | 188 | 1.26 (0.70, 2.25) | 1.44 (0.81, 2.55) | 1.13 (0.62, 2.04) |
| | 17-19 | Volleyball | Provincial Junior AA[Rp] | 59 | 1.06 (0.39, 2.87) | 0.81 (0.29, 2.27) | 0.81 (0.29, 2.27) |
| Helsen, Van Winckel, & Williams, 2005†† [23] | U18 | Soccer | Union des Associations Européennes de Football (UEFA)[E] | 72 | 1.83 (0.70, 4.79) | 2.17 (0.84, 5.58) | 1.00 (0.36, 2.81) |
| Vincent & Glamser, 2006†† [124] | U19 | Soccer | Olympic Development Program (ODP) State[Rp] | 804 | 1.12 (0.85, 1.48) | 1.15 (0.87, 1.51) | 1.10 (0.83, 1.46) |
| | U19 | Soccer | ODP Regional[Rp] | 71 | 1.33 (0.52, 3.41) | 1.53 (0.61, 3.87) | 0.87 (0.32, 2.34) |
| | U19 | Soccer | National team[E] | 39 | 3.00 (0.78, 11.5) | 1.40 (0.33, 5.97) | 2.40 (0.61, 9.44) |
| Liu & Liu, 2008‡ [112] | 12 | Soccer | China Football Association[Rp] | 73 | 3.75 (1.36, 10.3) | 2.50 (0.88, 7.11) | 1.88 (0.64, 5.50) |
| | 13 | Soccer | | 115 | 3.00 (1.39, 6.46) | 1.56 (0.69, 3.52) | 1.63 (0.72, 3.65) |
| | 14 | Soccer | | 163 | 2.33 (1.25, 4.36) | 1.56 (0.81, 2.98) | 1.15 (0.58, 2.25) |
| | 15 | Soccer | | 308 | 2.02 (1.28, 3.17) | 1.35 (0.84, 2.15) | 1.24 (0.77, 1.99) |
| | 16 | Soccer | | 1081 | 1.15 (0.91, 1.45) | 0.93 (0.73, 1.18) | 0.80 (0.62, 1.02) |
| Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009† [52] | Adult | Handball | German 1st League[Rp] | 372 | 1.03 (0.69, 1.54) | 0.94 (0.63, 1.41) | 0.87 (0.57, 1.30) |
| | Adult | Handball | German 1st League[Rp] | 145 | 1.06 (0.55, 2.03) | 0.97 (0.50, 1.88) | 1.12 (0.58, 2.13) |
| | Adult | Handball | German 2nd League[Rp] | 345 | 1.07 (0.69, 1.65) | 1.22 (0.79, 1.87) | 1.38 (0.91, 2.11) |
| | Adult | Handball | German 1st League[Rp] | 100 | 0.88 (0.39, 1.98) | 1.04 (0.47, 2.28) | 1.27 (0.59, 2.74) |
| | Adult | Handball | German 2nd League[Rp] | 270 | 1.36 (0.83, 2.22) | 1.29 (0.79, 2.10) | 1.45 (0.89, 2.36) |
| | Adult | Handball | International players: German 1st League[Rp] | 110 | 1.04 (0.49, 2.20) | 0.93 (0.43, 1.98) | 1.11 (0.53, 2.34) |
| | Adult | Handball | German 1st League[Rp] | 50 | 1.40 (0.45, 4.33) | 2.00 (0.67, 5.96) | 0.60 (0.17, 2.16) |
| | Adult | Handball | German 2nd League[Rp] | 56 | 0.87 (0.30, 2.47) | 0.87 (0.30, 2.47) | 1.00 (0.36, 2.80) |
| | U15, U17, U18 | Soccer* | National team[E] | 207 | 4.17 (2.21, 7.87) | 3.44 (1.81, 6.56) | 2.50 (1.29, 4.84) |
| | U20, U23, Adult | Soccer* | National team[E] | 573 | 1.15 (0.82, 1.62) | 1.50 (1.08, 2.09) | 1.35 (0.97, 1.89) |
| Delorme, Boiché, & Raspaud, 2009†† [34] | Adult | Soccer | Professional[E] | 242 | 1.48 (0.88, 2.48) | 1.41 (0.84, 2.37) | 1.37 (0.81, 2.31) |
| | Adult | Basketball | Professional[E] | 92 | 1.13 (0.51, 2.50) | 1.04 (0.47, 2.33) | 0.67 (0.28, 1.57) |
| | Adult | Handball | Professional[E] | 154 | 1.25 (0.66, 2.38) | 1.28 (0.67, 2.44) | 1.28 (0.67, 2.44) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Q1 vs. Q4 | Q2 vs. Q4 | Q3 vs. Q4 |
| Delorme & Raspaud, 2009†† [36] | U11 | Shooting | French Federation for Shooting Sports (FFT) Rc/C | 284 | 1.11 (0.69, 1.77) | 1.22 (0.76, 1.93) | 1.05 (0.65, 1.68) |
| | 11-12 | Shooting | | 476 | 0.99 (0.69, 1.42) | 1.00 (0.70, 1.43) | 1.01 (0.70, 1.44) |
| | 13-14 | Shooting | | 510 | 1.05 (0.74, 1.49) | 1.11 (0.79, 1.58) | 1.02 (0.72, 1.44) |
| | 15-16 | Shooting | | 798 | 1.16 (0.89, 1.53) | 0.94 (0.71, 1.25) | 0.98 (0.74, 1.30) |
| | 18-20 | Shooting | | 584 | 1.14 (0.82, 1.58) | 1.07 (0.77, 1.48) | 1.06 (0.76, 1.47) |
| | Adult | Shooting | | 10171 | 1.04 (0.97, 1.13) | 1.12 (1.03, 1.21) | 1.09 (1.01, 1.18) |
| Delorme & Raspaud, 2009†† [105] | 7 | Basketball | Youth categories of the French Basketball Federation (FFBB)Rc | 7590 | 1.21 (1.10, 1.32) | 1.27 (1.16, 1.39) | 1.16 (1.06, 1.27) |
| | 8 | Basketball | | 9518 | 1.18 (1.09, 1.28) | 1.24 (1.14, 1.34) | 1.10 (1.01, 1.19) |
| | 9 | Basketball | | 11613 | 1.21 (1.12, 1.30) | 1.25 (1.16, 1.34) | 1.13 (1.05, 1.22) |
| | 10 | Basketball | | 12734 | 1.16 (1.08, 1.24) | 1.20 (1.12, 1.29) | 1.11 (1.04, 1.19) |
| | 11 | Basketball | Youth categories of the FFBBRc/C | 11078 | 1.23 (1.14, 1.32) | 1.28 (1.18, 1.38) | 1.15 (1.07, 1.24) |
| | 12 | Basketball | | 10613 | 1.29 (1.19, 1.39) | 1.32 (1.22, 1.42) | 1.18 (1.09, 1.27) |
| | 13 | Basketball | | 10832 | 1.36 (1.26, 1.46) | 1.28 (1.18, 1.38) | 1.23 (1.13, 1.32) |
| | 14 | Basketball | | 10701 | 1.26 (1.16, 1.36) | 1.28 (1.18, 1.38) | 1.14 (1.06, 1.24) |
| | 15 | Basketball | | 8780 | 1.22 (1.12, 1.33) | 1.32 (1.21, 1.44) | 1.21 (1.11, 1.32) |
| | 16 | Basketball | | 7522 | 1.23 (1.12, 1.35) | 1.32 (1.20, 1.44) | 1.14 (1.04, 1.25) |
| | 17 | Basketball | | 6123 | 1.29 (1.17, 1.43) | 1.41 (1.27, 1.56) | 1.19 (1.07, 1.32) |
| O'Donoghue (2009) †††† [114] | 13 | Tennis | ITF Junior Tour (2003)E | 59 | 2.44 (0.85, 7.05) | 1.78 (0.60, 5.29) | 1.33 (0.43, 4.11) |
| | 14 | Tennis | | 176 | 2.50 (1.36, 4.58) | 1.36 (0.71, 2.58) | 1.43 (0.75, 2.71) |
| | 15 | Tennis | | 313 | 2.33 (1.46, 3.73) | 1.87 (1.16, 3.01) | 1.76 (1.08, 2.84) |
| | 16 | Tennis | | 397 | 1.61 (1.07, 2.41) | 1.55 (1.03, 2.33) | 1.44 (0.95, 2.17) |
| | 17 | Tennis | | 343 | 1.29 (0.84, 1.98) | 1.26 (0.82, 1.94) | 1.21 (0.78, 1.86) |
| | 18 | Tennis | | 217 | 1.12 (0.66, 1.90) | 1.25 (0.74, 2.12) | 0.88 (0.51, 1.53) |
| | Senior (19+) | Tennis | Grand Slam tournament(s)E | 211 | 1.94 (1.12, 3.38) | 1.61 (0.92, 2.83) | 1.31 (0.73, 2.33) |
| O'Donoghue (2009) †††† [114] | 13 | Tennis | ITF Junior Tour (2008)E | 62 | 34.0 (4.12, 280.3) | 22.0 (2.63, 184.0) | 5.00 (0.52, 47.9) |
| | 14 | Tennis | | 195 | 2.79 (1.55, 5.01) | 1.39 (0.74, 2.61) | 1.79 (0.97, 3.29) |
| | 15 | Tennis | | 357 | 1.91 (1.24, 2.95) | 1.65 (1.06, 2.56) | 1.70 (1.10, 2.64) |
| | 16 | Tennis | | 506 | 1.44 (1.01, 2.04) | 1.33 (0.93, 1.90) | 1.15 (0.80, 1.64) |
| | 17 | Tennis | | 450 | 0.99 (0.69, 1.43) | 1.03 (0.71, 1.48) | 0.93 (0.64, 1.35) |
| | 18 | Tennis | | 214 | 0.89 (0.52, 1.53) | 1.00 (0.59, 1.71) | 1.07 (0.63, 1.82) |
| | Senior (19+) | Tennis | Grand Slam tournament(s)E | 183 | 1.83 (0.99, 3.37) | 1.86 (1.01, 3.43) | 1.62 (0.87, 3.01) |

*Includes participant sample from Edgar & O'Donoghue, 2005[29]*

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Q1 vs. Q4 | Q2 vs. Q4 | Q3 vs. Q4 |
| Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009† [55] | 12-15 | Handball | German: D-Squad (regional development system)[Rp] | 333 | 1.90 (1.21, 3.00) | 2.00 (1.27, 3.15) | 1.63 (1.02, 2.58) |
| | 15-17 | Handball | D/C-Squad (youth national)[E] | 502 | 3.01 (2.05, 4.41) | 2.39 (1.62, 3.53) | 1.94 (1.31, 2.89) |
| | 18-20 | Handball | C-Squad (junior national)[E] | 327 | 1.89 (1.21, 2.96) | 1.75 (1.12, 2.75) | 1.20 (0.75, 1.92) |
| | 19+ | Handball | B-Squad (national team)[E] | 138 | 2.70 (1.34, 5.41) | 1.45 (0.69, 3.03) | 1.75 (0.85, 3.61) |
| | 19+ | Handball | A-Squad (national team)[E] | 434 | 0.97 (0.68, 1.39) | 0.71 (0.49, 1.03) | 0.59 (0.40, 0.87) |
| *Sample overlaps with Schorer et al., 2013 [121]* | | | | | | | |
| Schorer, Baker, Busch, Wilhelm, & Pabst, 2009† [119] | 13-15 | Handball* | German national youth tryouts[Rp] *Note: Participants passed regional selection* | 238 | 2.19 (1.29, 3.70) | 1.81 (1.06, 3.09) | 1.25 (0.72, 2.18) |
| *Includes participant sample from Schorer et al., 2010 [120], 2015 [53]* | | | | | | | |
| Delorme, Boiché, & Raspaud, 2010†† [56] | U8 | Soccer | French Soccer Federation (FSF)[Rc/C] | 5434 | 1.29 (1.16, 1.43) | 1.24 (1.12, 1.39) | 1.15 (1.03, 1.28) |
| | U10 | Soccer | | 7520 | 1.17 (1.06, 1.28) | 1.22 (1.11, 1.33) | 1.14 (1.04, 1.25) |
| | U12 | Soccer | | 7774 | 0.99 (0.90, 1.08) | 1.09 (1.00, 1.19) | 1.04 (0.95, 1.14) |
| | U14 | Soccer | | 5616 | 1.15 (1.04, 1.28) | 1.17 (1.06, 1.30) | 1.14 (1.02, 1.26) |
| | U17 | Soccer | | 8784 | 1.03 (0.95, 1.12) | 1.12 (1.03, 1.22) | 1.06 (0.97, 1.15) |
| | Adult (18+) | Soccer | | 22764 | 0.95 (0.91, 1.01) | 1.04 (0.99, 1.09) | 1.01 (0.96, 1.06) |
| Till, Cobley, Wattie, O'Hara, Cooke, & Chapman, 2010†† [10] | U14 | Rugby | Rugby Football League[Rc] | 190 | 1.15 (0.66, 2.02) | 1.04 (0.59, 1.85) | 0.93 (0.52, 1.67) |
| | U16 | Rugby | | 174 | 1.49 (0.82, 2.69) | 0.89 (0.48, 1.67) | 1.32 (0.73, 2.41) |
| | Senior (17+) | Rugby | | 261 | 1.03 (0.64, 1.66) | 1.00 (0.62, 1.62) | 0.87 (0.53, 1.41) |
| Weir, Smith, Paterson, & Horton, 2010† [85] | U18 | Ice hockey | Provincial team[Rp] | 369 | 1.54 (1.01, 2.35) | 1.77 (1.16, 2.69) | 1.37 (0.89, 2.11) |
| | U18, U22, Senior | Ice hockey | National team[E] | 291 | 1.72 (1.05, 2.80) | 2.22 (1.38, 3.57) | 1.39 (0.84, 2.29) |
| *Includes participant sample from Wattie et al., 2007[22]* | | | | | | | |
| Okazaki, Keller, Fontana, & Gallagher, 2011ǂ [81] | 13 | Volleyball | Brazilian national youth tournament[Rp] | 58 | 5.00 (1.50, 16.7) | 3.80 (1.12, 12.9) | 1.80 (0.48, 6.69) |
| | 14 | Volleyball | | 62 | 3.25 (1.13, 9.38) | 2.38 (0.80, 7.03) | 1.13 (0.34, 3.68) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | **Q1 vs. Q4** | **Q2 vs. Q4** | **Q3 vs. Q4** |
| Romann & Fuchslocher, 2011 [115] | 10-14 | Soccer | *J&S*[Rc] | 2987 | 1.21 (1.05, 1.40) | 1.24 (1.07, 1.43) | 1.11 (0.96, 1.29) |
| *Jugend & Sport (J&S) ††* | 15-20 | Soccer | | 3242 | 1.01 (0.88, 1.16) | 1.11 (0.96, 1.27) | 1.07 (0.94, 1.23) |
| *Talent development & national team†††* | 10-14 | Soccer | Talent development[C] | 450 | 1.85 (1.26, 2.72) | 1.68 (1.14, 2.49) | 1.63 (1.10, 2.41) |
| | 15-20 | Soccer | | 617 | 1.22 (0.89, 1.67) | 1.18 (0.85, 1.62) | 1.11 (0.80, 1.53) |
| | U17 | Soccer | National team[E] | 87 | 1.33 (0.54, 3.26) | 1.93 (0.82, 4.57) | 1.53 (0.64, 3.70) |
| | U19 | Soccer | | 80 | 1.71 (0.69, 4.24) | 1.43 (0.57, 3.59) | 1.57 (0.63, 3.91) |
| | Senior | Soccer | | 72 | 2.09 (0.79, 5.52) | 1.55 (0.57, 4.21) | 1.91 (0.72, 5.08) |
| Albuquerque, Lage, da Costa, Fereira, Pena, et al., 2012† [100] | Not specified | Taekwondo | Olympic Games[E] | 139 | 1.45 (0.74, 2.82) | 1.14 (0.57, 2.26) | 1.21 (0.61, 2.38) |
| Nakata & Sakamoto, 2012†† [33] | Not specified | Softball | Japan Softball Association[E] | 530 | 1.23 (0.87, 1.73) | 1.37 (0.97, 1.93) | 1.18 (0.83, 1.67) |
| | Not specified | Soccer | Japan Women's Football League[E] | 238 | 1.30 (0.78, 2.18) | 1.22 (0.73, 2.05) | 1.24 (0.74, 2.08) |
| | Not specified | Volleyball | V-League[E] | 138 | 2.09 (1.05, 4.18) | 2.18 (1.09, 4.35) | 1.00 (0.47, 2.13) |
| | Not specified | Basketball | Women's Japan Basketball League (WJBL)[E] | 172 | 1.62 (0.87, 3.03) | 1.86 (1.00, 3.46) | 1.45 (0.77, 2.73) |
| | Not specified | Track & field | Japan Industrial Track & Field[E] | 124 | 1.03 (0.51, 2.08) | 1.16 (0.58, 2.32) | 0.81 (0.39, 1.66) |
| | Not specified | Badminton | Badminton Nippon League[E] | 133 | 0.71 (0.35, 1.44) | 1.21 (0.62, 2.34) | 1.00 (0.51, 1.97) |
| van den Honert, 2012 †† [123] | U15, U17 | Australian football | Football Federation Australia (FFA) – State team[Rp] | 268 | 1.41 (0.86, 2.31) | 1.27 (0.77, 2.10) | 1.57 (0.96, 2.55) |
| | U20, Senior | Australian football | FFA – National team[E] | 52 | 2.09 (0.73, 5.99) | 0.73 (0.22, 2.39) | 0.91 (0.29, 2.87) |
| Costa, Marques, Louro, Ferreira, & Marinho, 2013† [28] | 12 | Swimming | Portuguese Swimming Federation (Top 50 in individual events)[Rp] | 624 | 4.72 (3.29, 6.78) | 3.70 (2.56, 5.34) | 1.53 (1.02, 2.28) |
| | 13 | Swimming | | 650 | 1.90 (1.38, 2.63) | 2.02 (1.47, 2.78) | 1.33 (0.95, 1.85) |
| | 14 | Swimming | | 644 | 0.96 (0.69, 1.32) | 1.23 (0.90, 1.68) | 1.45 (1.06, 1.97) |
| | 15 | Swimming | | 623 | 1.39 (1.02, 1.91) | 1.19 (0.86, 1.64) | 1.11 (0.80, 1.53) |
| | 16 | Swimming | | 519 | 2.00 (1.37, 2.91) | 2.41 (1.67, 3.49) | 2.00 (1.37, 2.91) |
| | 17 | Swimming | | 392 | 1.41 (0.93, 2.13) | 2.32 (1.56, 3.45) | 0.96 (0.62, 1.48) |
| | 18 | Swimming | | 280 | 0.67 (0.41, 1.10) | 1.52 (0.98, 2.37) | 0.64 (0.39, 1.06) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Q1 vs. Q4 | Q2 vs. Q4 | Q3 vs. Q4 |
| Dixon, Liburdi, Horton, & Weir, 2013†† [107] | 19-24 | Softball | National Collegiate Athletic Association (NCAA) – Division I[Cp] | 380 | 4.57 (2.81, 7.43) | 4.50 (2.77, 7.33) | 2.60 (1.57, 4.33) |
| Hancock, Seal, Young, Weir, & Ste-Marie, 2013† [84] | 4 | Ice hockey | Ontario Hockey Federation: Minor Pre-Novice[Rc/C] | 719 | 1.69 (1.25, 2.28) | 1.73 (1.28, 2.34) | 1.24 (0.91, 1.70) |
| | 5-6 | Ice hockey | Major Pre-Novice[Rc/C] | 3879 | 1.27 (1.12, 1.44) | 1.35 (1.19, 1.54) | 1.24 (1.09, 1.42) |
| | 7 | Ice hockey | Minor Novice[Rc/C] | 3279 | 1.58 (1.37, 1.82) | 1.59 (1.38, 1.83) | 1.31 (1.13, 1.44) |
| | 8 | Ice hockey | Major Novice[Rc/C] | 4525 | 1.46 (1.29, 1.64) | 1.45 (1.29, 1.64) | 1.28 (1.13, 1.44) |
| | 9 | Ice hockey | Minor Atom[Rc/C] | 5807 | 1.45 (1.30, 1.61) | 1.51 (1.36, 1.67) | 1.32 (1.19, 1.47) |
| | 10 | Ice hockey | Major Atom[Rc/C] | 6536 | 1.28 (1.16, 1.41) | 1.47 (1.33, 1.62) | 1.24 (1.12, 1.37) |
| | 11 | Ice hockey | Minor Peewee[Rc/C] | 7279 | 1.29 (1.17, 1.42) | 1.42 (1.30, 1.56) | 1.24 (1.13, 1.36) |
| | 12 | Ice hockey | Major Peewee[Rc/C] | 7180 | 1.25 (1.13, 1.37) | 1.39 (1.27, 1.53) | 1.19 (1.08, 1.31) |
| Romann & Fuchslocher 2013† [116] | U17 | Soccer | FIFA World Cup[E] | 672 | 1.34 (0.99, 1.82) | 1.25 (0.92, 1.70) | 1.15 (0.84, 1.57) |
| Smith & Weir, 2013† [20] | U8 | Ice hockey | Ontario Women's Hockey Association: Novice A/AA/AAA[C] | 156 | 2.18 (1.12, 4.28) | 2.50 (1.29, 4.87) | 1.41 (0.70, 2.85) |
| | U8 | Ice hockey | Novice B/BB[C] | 266 | 2.15 (1.30, 3.57) | 1.75 (1.04, 2.93) | 1.75 (1.04, 2.93) |
| | U8 | Ice hockey | Novice C/CC[C] | 405 | 1.36 (0.92, 2.01) | 1.11 (0.74, 1.65) | 1.14 (0.76, 1.69) |
| | U8 | Ice hockey | Novice house league[Rc] | 2626 | 1.19 (1.01, 1.39) | 1.36 (1.17, 1.59) | 1.25 (1.07, 1.47) |
| | U10 | Ice hockey | Atom A/AA/AAA[C] | 494 | 2.92 (2.01, 4.24) | 2.01 (1.36, 2.95) | 1.54 (1.03, 2.29) |
| | U10 | Ice hockey | Atom B/BB[C] | 894 | 1.73 (1.31, 2.28) | 1.83 (1.39, 2.41) | 1.57 (1.19, 2.07) |
| | U10 | Ice hockey | Atom C/CC[C] | 669 | 1.41 (1.03, 1.93) | 1.45 (1.06, 1.98) | 1.41 (1.03, 1.93) |
| | U10 | Ice hockey | Atom house league[Rc] | 2854 | 1.12 (0.97, 1.30) | 1.18 (1.02, 1.37) | 1.14 (0.98, 1.32) |
| | U12 | Ice hockey | Peewee A/AA/AAA[C] | 942 | 2.13 (1.63, 2.78) | 1.92 (1.46, 2.51) | 1.55 (1.17, 2.04) |
| | U12 | Ice hockey | Peewee B/BB[C] | 1269 | 1.51 (1.20, 1.90) | 1.60 (1.27, 2.00) | 1.33 (1.05, 1.67) |
| | U12 | Ice hockey | Peewee C/CC[C] | 865 | 1.39 (1.06, 1.83) | 1.55 (1.18, 2.04) | 1.36 (1.03, 1.80) |
| | U12 | Ice hockey | Peewee house league[Rc] | 3502 | 1.15 (1.01, 1.32) | 1.29 (1.13, 1.48) | 1.20 (1.05, 1.38) |
| | U14 | Ice hockey | Bantam A/AA/AAA[C] | 1368 | 1.92 (1.55, 2.40) | 1.82 (1.46, 2.27) | 1.31 (1.04, 1.65) |
| | U14 | Ice hockey | Bantam B/BB[C] | 1353 | 1.40 (1.12, 1.75) | 1.68 (1.35, 2.09) | 1.41 (1.13, 1.76) |
| | U14 | Ice hockey | Bantam C/CC[C] | 850 | 1.21 (0.92, 1.59) | 1.49 (1.14, 1.96) | 1.18 (0.89, 1.55) |
| | U14 | Ice hockey | Bantam house league[Rc] | 3232 | 1.04 (0.91, 1.20) | 1.26 (1.10, 1.45) | 1.23 (1.07, 1.41) |
| | U17 | Ice hockey | Midget A/AA/AAA[C] | 1659 | 1.74 (1.43, 2.13) | 1.85 (1.52, 2.26) | 1.40 (1.14, 1.71) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Q1 vs. Q4 | Q2 vs. Q4 | Q3 vs. Q4 |
| Smith & Weir, 2013† [20] | U17 | Ice hockey | Midget B/BB[C] | 1485 | 1.19 (0.97, 1.46) | 1.40 (1.14, 1.71) | 1.15 (0.93, 1.42) |
| | U17 | Ice hockey | Midget C/CC[C] | 941 | 1.16 (0.90, 1.52) | 1.44 (1.11, 1.86) | 1.25 (0.96, 1.62) |
| | U17 | Ice hockey | Midget house league[Rc] | 2431 | 1.01 (0.86, 1.19) | 1.14 (0.98, 1.34) | 1.10 (0.94, 1.29) |
| | U21 | Ice hockey | Intermediate A/AA/AAA[C] | 696 | 1.78 (1.31, 2.42) | 1.87 (1.37, 2.54) | 1.34 (0.97, 1.85) |
| | U21 | Ice hockey | Intermediate B/BB[C] | 132 | 1.12 (0.57, 2.18) | 1.00 (0.51, 1.97) | 0.76 (0.38, 1.54) |
| | U21 | Ice hockey | Intermediate C/CC[C] | 86 | 1.23 (0.54, 2.79) | 0.82 (0.34, 1.94) | 0.86 (0.37, 2.03) |
| | U21 | Ice hockey | Intermediate house league[Rc] | 1656 | 0.97 (0.80, 1.18) | 1.16 (0.96, 1.41) | 1.11 (0.91, 1.34) |
| | Adult | Ice hockey | Senior A/AA/AAA[C] | 880 | 1.31 (1.00, 1.72) | 1.32 (1.01, 1.73) | 1.28 (0.98, 1.68) |
| | Adult | Ice hockey | Senior B/BB[C] | 1086 | 1.18 (0.93, 1.50) | 1.16 (0.91, 1.47) | 1.01 (0.79, 1.29) |
| | Adult | Ice hockey | Senior C/CC[C] | 580 | 1.11 (0.80, 1.54) | 1.00 (0.72, 1.40) | 1.18 (0.85, 1.63) |
| | Adult | Ice hockey | Senior house league[Rc] | 3178 | 1.03 (0.89, 1.18) | 1.15 (1.00, 1.32) | 1.04 (0.90, 1.19) |
| Albuquerque, Teoldo da Costa, Oliveria, et al., 2014† [101] | Not specified | Wrestling | Olympic Games[E] | 146 | 2.00 (0.58, 2.16) | 1.00 (0.51, 1.95) | 1.30 (0.68, 2.48) |
| Baker, Janning, Wong, Cobley, & Schorer, 2014† [78] | Born in 1970 or later | Ski jump | International competitions[E] | 165 | 1.47 (0.79, 2.74) | 1.47 (0.79, 2.74) | 1.22 (0.65, 2.30) |
| | | Cross country ski | | 2571 | 1.49 (1.27, 1.73) | 1.18 (1.00, 1.38) | 1.16 (0.99, 1.36) |
| | | Alpine ski | | 5828 | 1.23 (1.11, 1.36) | 1.21 (1.09, 1.34) | 1.08 (0.97, 1.20) |
| | | Snowboard | | 915 | 1.09 (0.84, 1.42) | 1.05 (0.81, 1.37) | 1.30 (1.00, 1.68) |
| | 14-28 | Figure skating | National team[E] | 91 | 0.78 (0.34, 1.83) | 1.13 (0.50, 2.54) | 1.04 (0.46, 2.36) |
| | 12-15 | Gymnastics* | Junior national team[E] | 120 | 1.56 (0.73, 3.36) | 1.94 (0.92, 4.09) | 1.75 (0.82, 3.72) |
| | 15-24 | Gymnastics* | Senior national team[E] | 148 | 1.06 (0.52, 2.12) | 2.11 (1.10, 4.04) | 1.39 (0.71, 2.73) |
| Delorme, 2014†† [106] | 14-15 | Boxing | French Boxing Federation (FBF) - Amateur[C] | 124 | 1.73 (0.84, 3.56) | 1.14 (0.53, 2.43) | 1.77 (0.86, 3.65) |
| | 16-17 | Boxing | | 168 | 1.13 (0.62, 2.06) | 0.95 (0.51, 1.76) | 1.13 (0.62, 2.06) |
| | 18-18+ | Boxing | | 416 | 0.76 (0.52, 1.13) | 1.10 (0.76, 1.59) | 0.79 (0.54, 1.16) |
| Lidor, Arnon, Maayan, Gershon, & Côté, 2014† [111] | 18-36 | Basketball | Division I – Professional[E] | 46 | 0.89 (0.25, 3.12) | 1.11 (0.33, 3.75) | 2.11 (0.68, 6.59) |
| | 16-38 | Handball | Division I – Semi-Professional[Rp] | 107 | 0.86 (0.40, 1.84) | 1.07 (0.51, 2.25) | 0.89 (0.42, 1.91) |
| | 16-35 | Soccer | | 156 | 1.16 (0.62, 2.15) | 0.89 (0.47, 1.70) | 1.05 (0.56, 1.97) |
| | 16-36 | Volleyball | | 80 | 1.05 (0.44, 2.51) | 0.90 (0.37, 2.19) | 1.05 (0.44, 2.51) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | **Q1 vs. Q4** | **Q2 vs. Q4** | **Q3 vs. Q4** |
| Romann & Fuchslocher, 2014a [61]<br>*J&S††*<br>*Talent development †††* | U11 | Fencing | J&S[Rc] | 327 | 1.48 (0.95, 2.30) | 0.86 (0.53, 1.38) | 1.86 (1.20, 2.86) |
| | U12 | Fencing | | 276 | 1.85 (1.11, 3.08) | 2.23 (1.35, 3.69) | 2.00 (1.20, 3.33) |
| | U13 | Fencing | | 351 | 1.81 (1.18, 2.77) | 1.71 (1.12, 2.63) | 1.05 (0.66, 1.65) |
| | U14 | Fencing | | 438 | 1.27 (0.86, 1.86) | 1.13 (0.77, 1.67) | 1.47 (1.01, 2.14) |
| | U15 | Fencing | | 387 | 0.94 (0.63, 1.40) | 1.12 (0.76, 1.66) | 0.85 (0.57, 1.27) |
| | U16 | Fencing | | 315 | 0.81 (0.52, 1.28) | 0.89 (0.57, 1.39) | 1.19 (0.77, 1.82) |
| | U17 | Fencing | | 351 | 1.87 (1.23, 2.83) | 1.00 (0.64, 1.56) | 1.22 (0.79, 1.88) |
| | U18 | Fencing | | 330 | 0.94 (0.61, 1.43) | 0.74 (0.48, 1.15) | 0.87 (0.57, 1.33) |
| | U19 | Fencing | | 249 | 2.58 (1.53, 4.35) | 1.33 (0.76, 2.33) | 2.00 (1.17, 3.41) |
| | U20 | Fencing | | 348 | 0.65 (0.42, 1.00) | 0.77 (0.50, 1.19) | 1.32 (0.89, 1.98) |
| | U12-U17** | Fencing | Talent development[C] | 143 | 0.78 (0.40, 1.50) | 0.98 (0.51, 1.85) | 0.83 (0.43, 1.59) |
| | U18-U19** | Fencing | | 52 | 0.53 (0.18, 1.56) | 0.58 (0.20, 1.69) | 0.63 (0.22, 1.81) |
| | U11 | Alpine ski | J&S[Rc] | 23763 | 1.51 (1.44, 1.59) | 1.39 (1.32, 1.46) | 1.21 (1.15, 1.28) |
| | U12 | Alpine ski | | 17742 | 1.20 (1.13, 1.27) | 1.14 (1.08, 1.21) | 1.09 (1.03, 1.16) |
| | U13 | Alpine ski | | 20961 | 1.28 (1.21, 1.35) | 1.14 (1.08, 1.21) | 1.11 (1.05, 1.17) |
| | U14 | Alpine ski | | 25140 | 1.20 (1.14, 1.26) | 1.14 (1.09, 1.20) | 1.18 (1.13, 1.25) |
| | U15 | Alpine ski | | 25836 | 1.01 (0.96, 1.06) | 1.07 (1.02, 1.12) | 1.13 (1.08, 1.19) |
| | U16 | Alpine ski | | 24147 | 0.89 (0.84, 0.93) | 0.97 (0.92, 1.02) | 1.05 (1.00, 1.10) |
| | U17 | Alpine ski | | 19491 | 0.82 (0.77, 0.87) | 0.90 (0.85, 0.95) | 0.99 (0.94, 1.04) |
| | U18 | Alpine ski | | 13008 | 0.68 (0.63, 0.73) | 0.80 (0.75, 0.86) | 0.93 (0.87, 0.99) |
| | U19 | Alpine ski | | 7320 | 0.68 (0.62, 0.75) | 0.79 (0.72, 0.87) | 0.99 (0.90, 1.08) |
| | U20 | Alpine ski | | 9060 | 0.85 (0.78, 0.92) | 0.87 (0.80, 0.95) | 0.97 (0.89, 1.05) |
| | U11-U14** | Alpine ski | Talent development[C] | 573 | 2.51 (1.77, 3.56) | 2.03 (1.42, 2.89) | 1.63 (1.13, 2.33) |
| | U15-U16** | Alpine ski | | 313 | 2.12 (1.34, 3.36) | 1.86 (1.17, 2.96) | 1.28 (0.79, 2.08) |
| | U17-U18** | Alpine ski | | 245 | 1.45 (0.88, 2.39) | 1.32 (0.80, 2.18) | 0.85 (0.50, 1.45) |
| | U19-U20** | Alpine ski | | 95 | 0.48 (0.21, 1.11) | 0.64 (0.29, 1.40) | 0.76 (0.35, 1.64) |
| | U11 | Table tennis | J&S[Rc] | 591 | 1.29 (0.93, 1.78) | 1.55 (1.12, 2.13) | 0.86 (0.61, 1.21) |
| | U12 | Table tennis | | 483 | 1.15 (0.80, 1.65) | 1.38 (0.97, 1.98) | 1.21 (0.84, 1.74) |
| | U13 | Table tennis | | 504 | 0.78 (0.54, 1.12) | 1.07 (0.76, 1.52) | 1.24 (0.88, 1.75) |
| | U14 | Table tennis | | 531 | 1.10 (0.78, 1.55) | 1.18 (0.83, 1.65) | 1.15 (0.82, 1.62) |
| | U15 | Table tennis | | 438 | 0.86 (0.59, 1.26) | 1.06 (0.73, 1.53) | 1.14 (0.79, 1.65) |
| | U16 | Table tennis | | 378 | 0.69 (0.46, 1.05) | 0.83 (0.56, 1.24) | 0.97 (0.66, 1.44) |
| | U17 | Table tennis | | 285 | 0.57 (0.35, 0.93) | 0.71 (0.45, 1.14) | 1.11 (0.71, 1.72) |
| | U18 | Table tennis | | 186 | 0.69 (0.38, 1.25) | 1.00 (0.57, 1.77) | 1.19 (0.68, 2.08) |
| | U19 | Table tennis | | 96 | 0.29 (0.12, 0.67) | 0.50 (0.23, 1.08) | 0.50 (0.23, 1.08) |
| | U20 | Table tennis | | 183 | 0.50 (0.27, 0.93) | 0.61 (0.34, 1.11) | 1.28 (0.74, 2.20) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | **Q1 vs. Q4** | **Q2 vs. Q4** | **Q3 vs. Q4** |
| Romann & Fuchslocher, 2014a [61] | U11 | Table tennis | Talent development^C | 102 | 2.29 (1.04, 5.06) | 1.65 (0.73, 3.72) | 1.06 (0.45, 2.50) |
| *J&S††* | U12-U13** | Table tennis | | 129 | 0.77 (0.38, 1.59) | 1.06 (0.53, 2.13) | 1.32 (0.67, 2.60) |
| *Talent development †††* | U14-U15** | Table tennis | | 105 | 0.92 (0.42, 2.02) | 1.21 (0.56, 2.60) | 1.25 (0.58, 2.68) |
| | U16-U18** | Table tennis | | 80 | 0.68 (0.27, 1.75) | 1.21 (0.51, 2.88) | 1.32 (0.56, 3.11) |
| | U11 | Tennis | J&S^Rc | 9207 | 1.50 (1.38, 1.63) | 1.36 (1.25, 1.48) | 1.18 (1.08, 1.29) |
| | U12 | Tennis | | 5700 | 1.19 (1.07, 1.32) | 1.16 (1.04, 1.28) | 1.07 (0.96, 1.19) |
| | U13 | Tennis | | 6552 | 1.17 (1.06, 1.29) | 1.15 (1.05, 1.27) | 1.05 (0.95, 1.16) |
| | U14 | Tennis | | 6972 | 1.14 (1.03, 1.25) | 1.00 (0.91, 1.10) | 1.05 (0.96, 1.16) |
| | U15 | Tennis | | 6699 | 1.09 (0.99, 1.21) | 1.08 (0.98, 1.19) | 1.13 (1.02, 1.24) |
| | U16 | Tennis | | 6204 | 0.86 (0.78, 0.96) | 1.05 (0.95, 1.16) | 1.08 (0.98, 1.19) |
| | U17 | Tennis | | 5508 | 1.01 (0.91, 1.13) | 0.94 (0.85, 1.05) | 1.04 (0.94, 1.16) |
| | U18 | Tennis | | 4122 | 0.91 (0.81, 1.03) | 0.94 (0.83, 1.06) | 0.98 (0.87, 1.11) |
| | U19 | Tennis | | 3222 | 0.85 (0.74, 0.98) | 0.97 (0.84, 1.11) | 1.01 (0.88, 1.16) |
| | U20 | Tennis | | 3969 | 0.94 (0.83, 1.06) | 0.93 (0.82, 1.05) | 0.92 (0.81, 1.04) |
| | U11-U12** | Tennis | Talent development^C | 215 | 3.63 (2.05, 6.42) | 1.81 (0.99, 3.32) | 1.52 (0.82, 2.81) |
| | U13-U14** | Tennis | | 102 | 3.08 (1.34, 7.07) | 2.15 (0.91, 5.07) | 1.62 (0.67, 3.91) |
| | U15-U18** | Tennis | | 89 | 2.69 (1.13, 6.40) | 1.77 (0.72, 4.35) | 1.38 (0.55, 3.49) |
| | U11 | Snowboard | J&S^Rc | 81 | 2.20 (0.92, 5.24) | 1.60 (0.66, 3.90) | 0.60 (0.21, 1.68) |
| | U12 | Snowboard | | 93 | 2.75 (1.15, 6.60) | 2.00 (0.81, 4.92) | 2.00 (0.81, 4.92) |
| | U13 | Snowboard | | 141 | 1.33 (0.67, 2.64) | 1.22 (0.61, 2.44) | 1.67 (0.85, 3.25) |
| | U14 | Snowboard | | 198 | 1.77 (1.01, 3.09) | 1.23 (0.69, 2.19) | 1.08 (0.60, 1.94) |
| | U15 | Snowboard | | 300 | 0.72 (0.46, 1.14) | 1.10 (0.72, 1.70) | 0.62 (0.39, 0.99) |
| | U16 | Snowboard | | 345 | 0.91 (0.60, 1.37) | 0.94 (0.62, 1.42) | 0.75 (0.49, 1.15) |
| | U17 | Snowboard | | 324 | 0.72 (0.46, 1.13) | 1.14 (0.75, 1.73) | 0.86 (0.56, 1.33) |
| | U18 | Snowboard | | 306 | 1.22 (0.78, 1.91) | 1.09 (0.69, 1.71) | 1.13 (0.72, 1.78) |
| | U19 | Snowboard | | 192 | 2.43 (1.27, 4.64) | 3.00 (1.59, 5.66) | 2.71 (1.43, 5.15) |
| | U20 | Snowboard | | 198 | 1.50 (0.82, 2.75) | 1.90 (1.05, 3.44) | 2.20 (1.23, 3.95) |
| | U11-U14** | Snowboard | Talent development^C | 99 | 1.04 (0.47, 2.30) | 0.88 (0.39, 1.96) | 1.21 (0.56, 2.63) |
| | U15-U16** | Snowboard | | 98 | 0.71 (0.32, 1.59) | 0.79 (0.36, 1.73) | 1.00 (0.46, 2.15) |
| | U17-U18** | Snowboard | | 80 | 1.06 (0.43, 2.58) | 1.11 (0.46, 2.70) | 1.28 (0.53, 3.06) |
| | U11 | Track & field | J&S^Rc | 8094 | 1.55 (1.42, 1.69) | 1.30 (1.18, 1.42) | 1.21 (1.11, 1.32) |
| | U12 | Track & field | | 5400 | 1.16 (1.05, 1.30) | 1.17 (1.05, 1.30) | 1.09 (0.98, 1.21) |
| | U13 | Track & field | | 6321 | 1.24 (1.12, 1.37) | 1.21 (1.09, 1.33) | 1.10 (1.00, 1.22) |
| | U14 | Track & field | | 5832 | 1.15 (1.04, 1.27) | 1.22 (1.10, 1.35) | 1.09 (0.98, 1.21) |
| | U15 | Track & field | | 5832 | 1.23 (1.11, 1.37) | 1.10 (0.99, 1.22) | 1.21 (1.09, 1.34) |
| | U16 | Track & field | | 4632 | 0.91 (0.81, 1.02) | 0.99 (0.89, 1.12) | 0.96 (0.86, 1.08) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Q1 vs. Q4 | Q2 vs. Q4 | Q3 vs. Q4 |
| Romann & Fuchslocher, 2014a [61] | U17 | Track & field | J&S[Rc] | 3744 | 1.32 (1.16, 1.50) | 1.10 (0.97, 1.25) | 1.04 (0.91, 1.18) |
| *J&S††* | U18 | Track & field | | 2877 | 0.92 (0.79, 1.06) | 1.05 (0.90, 1.21) | 1.02 (0.88, 1.18) |
| *Talent development †††* | U19 | Track & field | | 2199 | 1.35 (1.14, 1.60) | 1.21 (1.02, 1.44) | 1.13 (0.96, 1.35) |
| | U20 | Track & field | | 2649 | 1.12 (0.96, 1.30) | 1.25 (1.08, 1.46) | 1.09 (0.93, 1.27) |
| | U15-U16** | Track & field | Talent development[C] | 257 | 2.33 (1.39, 3.93) | 2.28 (1.35, 3.84) | 1.53 (0.89, 2.63) |
| | U17-U18** | Track & field | | 218 | 2.61 (1.47, 4.63) | 2.21 (1.24, 3.97) | 1.96 (1.09, 3.54) |
| | U19 | Track & field | | 87 | 1.16 (0.49, 2.72) | 1.47 (0.64, 3.39) | 0.95 (0.39, 2.28) |
| Romann & Fuchslocher, 2014b†† [31] | U8 | Alpine ski | Migros Ski Grand Prix – | 747 | 1.17 (0.87, 1.56) | 1.30 (0.97, 1.73) | 1.15 (0.86, 1.54) |
| | U9 | Alpine ski | Qualification Finisher[C] | 897 | 1.06 (0.81, 1.37) | 1.07 (0.82, 1.39) | 0.99 (0.76, 1.29) |
| | U10 | Alpine ski | | 1097 | 0.95 (0.75, 1.20) | 0.96 (0.76, 1.21) | 0.95 (0.75, 1.21) |
| | U11 | Alpine ski | | 1065 | 1.11 (0.88, 1.42) | 1.06 (0.83, 1.35) | 1.04 (0.81, 1.32) |
| | U12 | Alpine ski | | 1021 | 0.98 (0.76, 1.25) | 0.98 (0.77, 1.25) | 0.95 (0.75, 1.22) |
| | U13 | Alpine ski | | 917 | 0.89 (0.69, 1.15) | 0.88 (0.68, 1.14) | 0.91 (0.71, 1.18) |
| | U14 | Alpine ski | | 688 | 0.81 (0.60, 1.09) | 0.77 (0.57, 1.04) | 0.88 (0.66, 1.18) |
| | U15 | Alpine ski | | 574 | 0.91 (0.66, 1.25) | 0.81 (0.59, 1.13) | 0.87 (0.63, 1.20) |
| Saavedra-García, Gutiérrez Aguilar, Fernández Romero, Fernández Lastra, & Eiras Oliveira, 2014† [79] | U17 | Basketball | World Championships[E] | 144 | 2.17 (1.11, 4.27) | 1.74 (0.87, 3.47) | 1.35 (0.66, 2.74) |
| | U19 | Basketball | | 194 | 2.54 (1.40, 4.58) | 2.04 (1.11, 3.72) | 1.36 (0.72, 2.55) |
| | U21 | Basketball | | 144 | 1.46 (0.74, 2.88) | 1.81 (0.93, 3.52) | 1.27 (0.64, 2.53) |
| Stenling & Holmström, 2014† [21] | 5-6 | Ice hockey | Licensed youth players[Rc/C] | 458 | 1.92 (1.32, 2.80) | 1.42 (0.96, 2.09) | 1.46 (0.99, 2.14) |
| | 7-9 | Ice hockey | | 693 | 1.17 (0.86, 1.58) | 1.36 (1.01, 1.84) | 1.28 (0.95, 1.74) |
| | 10-12 | Ice hockey | | 495 | 1.52 (1.06, 2.17) | 1.41 (0.99, 2.02) | 1.18 (0.81, 1.70) |
| | 13-15 | Ice hockey | | 460 | 1.29 (0.88, 1.88) | 1.60 (1.11, 2.31) | 1.22 (0.84, 1.79) |
| | 16-20 | Ice hockey | | 705 | 1.65 (1.21, 2.24) | 1.52 (1.12, 2.07) | 1.47 (1.08, 2.00) |
| | U18 | Ice hockey | U-18 regional tournament[Rp] | 399 | 1.98 (1.32, 2.99) | 1.75 (1.16, 2.65) | 1.50 (0.98, 2.28) |
| | Adult | Ice hockey | National championship; Riksserien league[E] | 688 | 2.07 (1.51, 2.83) | 1.96 (1.43, 2.69) | 1.59 (1.15, 2.19) |
| Albuquerque, Franchini, Lage, et al., 2015† [70] | 16+ | Judo | Olympic Games[E] | 665 | 1.21 (0.89, 1.65) | 1.14 (0.84, 1.56) | 1.23 (0.90, 1.67) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | **Q1 vs. Q4** | **Q2 vs. Q4** | **Q3 vs. Q4** |
| Fukuda, 2015† [108] | U17-U20/21 | Judo | International Judo Federation; Junior World Championships$^{E}$ | 710 | 1.39 (1.03, 1.87) | 1.16 (0.85, 1.57) | 1.32 (0.97, 1.77) |
| Hancock, Starkes, & Ste-Marie, 2015 | U15 | Gymnastics | Regional$^{Rp}$ | 387 | 1.14 (0.76, 1.71) | 1.28 (0.86, 1.91) | 1.08 (0.72, 1.62) |
| [110] | 15+ | Gymnastics | | 74 | 0.46 (0.18, 1.18) | 0.62 (0.25, 1.51) | 0.77 (0.32, 1.83) |
| *U15 Regional†* | U15 | Gymnastics | Provincial$^{Rp}$ | 208 | 1.10 (0.64, 1.89) | 1.12 (0.65, 1.92) | 0.94 (0.54, 1.63) |
| *All other samples†††* | 15+ | Gymnastics | | 62 | 0.63 (0.24, 1.62) | 0.42 (0.15, 1.16) | 0.54 (0.20, 1.44) |
| | U15 | Gymnastics | Elite provincial$^{Rp}$ | 85 | 2.42 (0.98, 5.96) | 1.92 (0.76, 4.82) | 1.75 (0.69, 4.43) |
| | 15+ | Gymnastics | | 28 | 0.50 (0.10, 2.46) | 0.75 (0.17, 3.33) | 1.25 (0.31, 5.07) |
| | U15 | Gymnastics | National$^{E}$ | 56 | 1.50 (0.47, 4.79) | 2.75 (0.92, 8.24) | 1.75 (0.56, 5.48) |
| | 15+ | Gymnastics | | 21 | 0.40 (0.05, 3.07) | 2.20 (0.44, 10.97) | 0.60 (0.09, 3.91) |
| Müller, Hildebrandt, & Raschner, 2015 | 7 | Alpine ski | Kids Cup (Provincial races)$^{C}$ | 71 | 1.78 (0.62, 5.07) | 2.33 (0.84, 6.48) | 2.78 (1.02, 7.60) |
| [82] | 8 | Alpine ski | | 96 | 1.55 (0.70, 3.44) | 1.15 (0.50, 2.62) | 1.10 (0.48, 2.52) |
| *Age 7-11†* | 9 | Alpine ski | | 108 | 1.22 (0.57, 2.62) | 1.22 (0.57, 2.62) | 1.26 (0.59, 2.71) |
| *Age 12-15†††* | 10 | Alpine ski | | 144 | 1.39 (0.71, 2.72) | 1.39 (0.71, 2.72) | 1.36 (0.69, 2.66) |
| | 11 | Alpine ski | | 161 | 2.00 (1.08, 3.69) | 1.13 (0.59, 2.17) | 1.06 (0.55, 2.05) |
| | 12 | Alpine ski | Teenager Cup (Provincial races)$^{C}$ | 102 | 1.20 (0.56, 2.58) | 1.20 (0.56, 2.58) | 0.68 (0.30, 1.55) |
| | 13 | Alpine ski | | 110 | 1.37 (0.62, 3.03) | 1.63 (0.75, 3.55) | 1.79 (0.83, 3.87) |
| | 14 | Alpine ski | | 97 | 1.74 (0.78, 3.85) | 1.11 (0.48, 2.55) | 1.26 (0.55, 2.88) |
| | 15 | Alpine ski | | 78 | 1.00 (0.43, 2.35) | 0.78 (0.32, 1.89) | 0.61 (0.24, 1.52) |
| Müller, Müller, Kornexl, & Raschner, 2015†/†† [32] | 9-10 | Alpine ski | Ski boarding school entrance exam$^{C}$ | 194 | 1.61 (0.89, 2.90) | 1.64 (0.91, 2.95) | 1.64 (0.91, 2.95) |
| | 14-15 | Alpine ski | | 185 | 1.82 (1.01, 3.28) | 1.45 (0.80, 2.66) | 1.33 (0.73, 2.45) |
| Nagy, Okros, & Sos, 2015ǂ [113] | 11-26 | Swimming | Champions of Future; National team$^{Cp/E}$ | 183 | 2.92 (1.57, 5.42) | 2.33 (1.24, 4.38) | 1.38 (0.71, 2.68) |
| Sedano, Vaeyens, & Redondo, 2015†† [122] | U10, U12, U14 | Soccer | Spanish Royal Federation of Soccer (SRFS): First division$^{C}$ | 936 | 1.42 (1.09, 1.85) | 1.74 (1.34, 2.25) | 1.12 (0.86, 1.48) |
| | U10, U12, U14 | Soccer | Second division$^{C}$ | 1711 | 1.26 (1.04, 1.52) | 1.33 (1.10, 1.61) | 0.92 (0.75, 1.12) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Q1 vs. Q4 | Q2 vs. Q4 | Q3 vs. Q4 |
| Sedano, Vaeyens, & Redondo, 2015†† [122] | U10, U12, U14 | Soccer | Third division[C] | 870 | 1.21 (0.93, 1.57) | 0.88 (0.67, 1.15) | 1.04 (0.80, 1.36) |
| | U17, U19, U21, Senior | Soccer | National team[E] | 232 | 2.42 (1.41, 4.18) | 2.21 (1.28, 3.83) | 1.39 (0.78, 2.48) |
| | U17, U19 | Soccer | Regional team[Rp] | 286 | 1.95 (1.23, 3.09) | 1.62 (1.01, 2.59) | 0.64 (0.37, 1.09) |
| Arrieta, Torres-Unda, Gil, & Irazusta, 2016 †† [80] | U16 | Basketball | European Basketball Championships[E] | 396 | 2.03 (1.36, 3.02) | 1.58 (1.05, 2.37) | 0.97 (0.63, 1.50) |
| | U18 | Basketball | | 407 | 2.01 (1.36, 2.98) | 1.24 (0.82, 1.88) | 1.24 (0.82, 1.88) |
| | U20 | Basketball | | 299 | 1.50 (0.95, 2.38) | 1.34 (0.84, 2.15) | 1.31 (0.82, 2.09) |
| Brazo-Sayavera, Martínez-Valencia, Müller, Andronikos, & Martindale† [103] | U15 | Track & field | Spanish National Athletics Federation (RFEA) – Selected[Rp] | 407 | 1.96 (1.32, 2.90) | 1.55 (1.04, 2.32) | 0.99 (0.65, 1.51) |
| | U17 | Track & field | | 227 | 1.12 (0.66, 1.89) | 1.42 (0.85, 2.37) | 0.83 (0.48, 1.43) |
| *Note: Also used weighted mean scores to compare selected & unselected* | U15 | Track & field | RFEA - Unselected[C] | 9575 | 1.36 (1.25, 1.47) | 1.23 (1.13, 1.33) | 1.07 (0.99, 1.16) |
| | U17 | Track & field | | 3299 | 1.16 (1.01, 1.33) | 1.20 (1.04, 1.37) | 1.05 (0.92, 1.21) |
| Chittle, Horton, & Dixon, 2016†† [104] | 18-25 | Basketball | NCAA Division I[C] | 265 | 5.40 (2.98, 9.80) | 4.29 (2.35, 7.85) | 3.19 (1.72, 5.92) |
| Lemez, Macmahon, & Weir, 2016†††† [25] | 8-10 | Rugby | Developmental leagues (Can.)[Rc/C] | 68 | 1.36 (0.49, 3.81) | 1.91 (0.71, 5.15) | 1.91 (0.71, 5.15) |
| | 11-14 | Rugby | | 118 | 2.26 (1.08, 4.76) | 1.58 (0.73, 3.41) | 1.37 (0.63, 2.99) |
| | 15 | Rugby | | 213 | 1.51 (0.87, 2.61) | 1.49 (0.86, 2.58) | 1.20 (0.68, 2.10) |
| | 16 | Rugby | | 298 | 1.15 (0.72, 1.83) | 1.11 (0.70, 1.78) | 1.55 (0.98, 2.44) |
| | 17 | Rugby | | 386 | 1.38 (0.92, 2.07) | 1.28 (0.85, 1.92) | 1.23 (0.82, 1.85) |
| | 18-20 | Rugby | | 385 | 1.20 (0.80, 1.79) | 1.05 (0.70, 1.58) | 1.23 (0.83, 1.84) |
| | 4 | Rugby | Developmental leagues (NZ)[Rc/C] | 278 | 2.49 (1.53, 4.04) | 1.70 (1.03, 2.81) | 1.28 (0.76, 2.15) |
| | 5 | Rugby | | 519 | 1.31 (0.93, 1.85) | 1.09 (0.77, 1.54) | 1.08 (0.76, 1.53) |
| | 6 | Rugby | | 789 | 1.23 (0.93, 1.62) | 1.06 (0.80, 1.40) | 0.89 (0.67, 1.18) |
| | 7 | Rugby | | 1080 | 1.27 (1.00, 1.61) | 1.17 (0.92, 1.49) | 1.04 (0.82, 1.33) |
| | 8 | Rugby | | 1322 | 1.09 (0.88, 1.35) | 1.12 (0.91, 1.39) | 0.91 (0.73, 1.13) |
| | 9 | Rugby | | 1864 | 1.50 (1.25, 1.81) | 1.26 (1.05, 1.52) | 1.25 (1.03, 1.50) |
| | 10 | Rugby | | 2023 | 0.63 (0.53, 0.76) | 0.92 (0.77, 1.09) | 1.08 (0.91, 1.27) |
| | 11 | Rugby | | 1294 | 1.51 (1.22, 1.87) | 1.03 (0.82, 1.29) | 1.05 (0.84, 1.32) |
| | 12 | Rugby | | 1124 | 0.54 (0.42, 0.69) | 0.91 (0.72, 1.14) | 1.12 (0.90, 1.40) |
| | 13 | Rugby | | 627 | 0.84 (0.61, 1.15) | 0.99 (0.72, 1.35) | 1.07 (0.78, 1.45) |
| | 14 | Rugby | | 622 | 1.17 (0.85, 1.60) | 1.06 (0.77, 1.46) | 1.09 (0.79, 1.50) |

| Author(s) | Sample Age (Years) | Sport | Competition Level | (N) | Odds ratio comparisons – Quartile 1-4 (95% Confidence intervals) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Q1 vs. Q4 | Q2 vs. Q4 | Q3 vs. Q4 |
| Lemez, Macmahon, & Weir, 2016†††† [25] | 15 | Rugby | Developmental leagues (NZ) [Rc/C] | 710 | 1.01 (0.75, 1.36) | 1.04 (0.77, 1.39) | 1.13 (0.84, 1.51) |
| | 16 | Rugby | | 704 | 0.79 (0.59, 1.07) | 1.01 (0.76, 1.35) | 0.96 (0.72, 1.29) |
| | 17 | Rugby | | 504 | 0.43 (0.30, 0.63) | 0.72 (0.51, 1.02) | 1.16 (0.84, 1.62) |
| | 18 | Rugby | | 187 | 0.73 (0.41, 1.30) | 0.71 (0.40, 1.27) | 0.89 (0.51, 1.56) |
| | 19 | Rugby | | 137 | 1.03 (0.53, 2.01) | 0.85 (0.43, 1.69) | 1.15 (0.59, 2.22) |
| | 20 | Rugby | | 115 | 1.10 (0.54, 2.25) | 0.70 (0.33, 1.50) | 1.03 (0.50, 2.12) |
| | 19-43 | Rugby | World Cup[E] | 498 | 0.86 (0.61, 1.23) | 0.93 (0.66, 1.32) | 0.95 (0.67, 1.34) |
| Werneck et al., 2016 [125] | 27.1 +/- 3.9 | Basketball | Olympic Games[E] | 147 | 0.78 (0.40, 1.53) | 1.22 (0.65, 2.29) | 0.97 (0.51, 1.86) |

***Table Notes:*** Odds ratio (CI) calculations were based on the assumption of an equal distribution of birth dates per quartile. The expected distribution used in each study is denoted by the use of the following symbols: † Observed distribution compared to an equal distribution of birth dates (i.e., 25% per quartile); †† Observed distribution compared to the birth rate in the general population (i.e., national birth statistics); †/†† Assumed 25% based on birth rate in the population; ††† Observed distribution compared to the birth distribution present in the selection population; †††† Observed distribution compared to a birth distribution based on the number of days per quartile; ǂ Expected birth distribution not stated; * Raw numbers were not available and ORs have been estimated based on graphical representation of the data; **Age groups were combined in accordance with age bands used in each respective sport; 0.5 added to raw data when Quartile 4 = 0, preventing odds ratio calculation. Procedure recommended by Sutton et al. [126].

**Table 3:** Summary sample and participant numbers (and percentages) according to subgroup category as applied in the meta-analyses.

| Category | N of samples (% of samples) | N of participants (% of participants) |
|---|---|---|
| **Age** | | |
| Pre-adolescent (≤ 11 years) | 51 (16.55%) | 163,292 (25.26%) |
| Adolescent (12-14 years) | 55 (17.85%) | 165,107 (25.54%) |
| Post-Adolescent (15-19 years) | 91 (29.54%) | 197,368 (30.53%) |
| Adult (> 19 years) | 32 (10.38%) | 36,051 (5.58%) |
| Not codable into above* | 79 (25.64%) | 84,565 (13.08%) |
| **Competition Level** | | |
| Recreational | 76 (24.68%) | 369,216 (57.12%) |
| Competitive | 71 (23.05%) | 47,321 (7.32%) |
| Representative | 44 (14.29%) | 12,095 (1.87%) |
| Overall – Elite | 61 (19.81%) | 23,822 (3.63%) |
| Elite Adolescent | 5 (1.62%) | 548 (0.08%) |
| Elite Post-Adolescent | 18 (5.84%) | 5,390 (0.83%) |
| Elite Adult | 12 (3.90%) | 2,186 (0.34%) |
| Elite - Combination of age | 26 (8.44%) | 15,698 (2.43%) |
| Not codable into above | 56 (18.18%) | 193,929 (30.0%) |
| **Sport Type** | | |
| Team | 154 (50.0%) | 286,208 (44.28%) |
| Individual: | | |
| Physically Demanding | 88 (28.57%) | 332,378 (51.42%) |
| Technique/Skill-Based | 59 (19.16%) | 25,429 (3.93%) |
| Weight-Categorised | 7 (2.27%) | 2,368 (0.37%) |

***Table Notes:*** * Not codable = Sample age range in studies traversed age categories.

**Table 4:** Summary of Quartile (Q1) v Quartile (Q4) subgroup analyses according to identified moderating factors.

| Random Effects Model | | Subgroup Estimates | | | Mixed effects Between subgroup analysis | | Subgroup Heterogeneity | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Moderator variable*** **Subgroup (No. samples)** | **Point Estimate** | **95%CI** | ***Z* value** | ***p* value** | ***Q* Between value** | ***p* value** | ***Q* in subgroup / *Q* Within** | ***p* in subgroup / *p* Within** | **$I^2$ subgroup** |
| ***Age*** | | | | | | | | | |
| **Pre-Adolescent (≤ 11 yrs.)** | 1.33 | 1.25-1.42 | 8.68 | 0.0001 | | | 238.13 | 0.0001 | 79.00 |
| **(51)** | 1.28 | 1.19-1.37 | 7.05 | 0.0001 | | | 241.83 | 0.0001 | 77.67 |
| **Adolescent (12-14 yrs.)** | 1.14 | 1.08-1.20 | 4.79 | 0.0001 | | | 707.57 | 0.0001 | 87.28 |
| **(55)** | 1.08 | 0.97-1.19 | 1.44 | 0.14 | | | 55.10 | 0.005 | 43.74 |
| **Post-Adolescent (15-19 yrs.)** | 1.37 | 1.29-1.46 | 9.74 | 0.0001 | 31.24 | 0.0001 | 369.12 | 0.0001 | 78.86 |
| **(91)** | | | | | | | 1611.78 | 0.0001 | |
| **Adult (>19 yrs.) (32)** | | | | | | | | | |
| **Not codable into above** | | | | | | | | | |
| **(79)** | | | | | | | | | |
| ***Competition Level*** | | | | | | | | | |
| **Recreational (76)** | 1.08 | 1.02-1.14 | 2.83 | 0.005 | | | 1028.85 | 0.0001 | 92.71 |
| **Competitive (71)** | 1.39 | 1.30-1.50 | 9.38 | 0.0001 | | | 243.92 | 0.0001 | 71.30 |
| **Representative** | 1.45 | 1.31-1.61 | 7.24 | 0.0001 | | | 126.83 | 0.0001 | 66.09 |
| **(44)** | 2.70 | 1.76-4.12 | 4.58 | 0.0001 | | | 6.64 | 0.15 | 39.81 |
| **Elite Adolescent (5)** | 1.65 | 1.41-1.92 | 6.48 | 0.0001 | | | 35.92 | 0.005 | 52.67 |
| **Elite Post-Adolescent** | 1.27 | 1.02-1.50 | 2.19 | 0.02 | | | 9.20 | 0.60 | 0.00 |
| **(18)** | 1.42 | 1.26-1.61 | 5.65 | 0.0001 | | | 56.16 | 0.0001 | 55.48 |
| **Elite Adult (12)** | 1.19 | 1.12-1.27 | 5.40 | 0.0001 | 77.09 | 0.0001 | 357.62 | 0.0001 | 84.62 |
| **Elite - Combination of age** | | | | | | | 1865.17 | 0.0001 | |
| **(26)** | | | | | | | | | |
| **Not codable into above (56)** | | | | | | | | | |
| ***Sport Type*** | | | | | | | | | |
| **Team (154)** | 1.33 | 1.27-1.39 | 12.51 | 0.0001 | | | 689.01 | 0.0001 | 77.79 |
| **Individual (154)** | 1.18 | 1.12-124 | 5.26 | 0.0001 | | | | | |
| **Physically demanding (88)** | 1.23 | 1.16-1.30 | 7.19 | 0.0001 | | | 1125.83 | 0.0001 | 92.82 |
| **Technique (Skill)-based (59)** | 1.06 | 0.97-1.16 | 1.36 | 0.17 | | | 118.20 | 0.0001 | 51.77 |
| **Weight-Categorised (7)** | 1.18 | 0.93-1.51 | 1.38 | 0.16 | 20.58 | 0.001 | 7.48 | 0.27 | 19.81 |
| | | | | | | | 2040.54 | 0.0001 | |

| Random Effects Model | | Subgroup Estimates | | | | Mixed effects Between subgroup analysis | | Subgroup Heterogeneity | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Moderator variable*** **Subgroup (No. samples)** | | **Point Estimate** | **95%CI** | ***Z* value** | ***p* value** | ***Q* Between value** | ***p* value** | ***Q* in subgroup** / ***Q* Within** | ***p* in subgroup** / ***p* Within** | **$I^2$ subgroup** |
| ***Study Quality*** | | | | | | | | | | |
| **Lower (scores 5-9)** | **(38)** | 1.63 | 1.46-1.82 | 8.55 | 0.0001 | | | 72.48 | 0.0001 | 48.95 |
| **Medium (scores 10-11)** | **(92)** | 1.29 | 1.22-1.37 | 8.72 | 0.0001 | | | 348.55 | 0.0001 | 73.89 |
| **Higher (scores 12-14)** | **(178)** | 1.19 | 1.14-1.25 | 8.46 | 0.0001 | 27.44 | 0.001 | 1596.47 | 0.0001 | 88.91 |
| | | | | | | | | 2017.51 | 0.0001 | |

***Table Notes:*** Point Estimate = Pooled overall odds ratio (Q1 v Q4) estimate; 95%CI = Lower & upper confidence interval estimates; *Z* value = Reflects the test for an overall effect; *p* = Indicating probability of significance (*p* criteria set at ≤ 0.05); *Q* Value = Dispersion of studies about the point estimate overall or within subgroup; $I^2$ = Reflects heterogeneity within subgroup.

**Table 5:** Summary of Quartile (Q1) v Quartile (Q4) subgroup analyses according to sport context.

| **Random Effects Model** | | **Subgroup Estimates** | | | |
|---|---|---|---|---|---|
| ***Sport Context Subgroup*** | **(No. samples)** | Point Estimate | 95%CI | *Z* value | *p* value |
| ***Sport Context (≥ 6 samples)*** | | | | | |
| **Alpine Skiing** | (34) | 1.09 | 1.01-1.19 | 1.96 | 0.05 |
| **Basketball** | (22) | 1.36 | 1.22-1.51 | 5.67 | 0.0001 |
| **Fencing** | (12) | 1.21 | 1.01-1.45 | 2.12 | 0.03 |
| **Gymnastics** | (10) | 1.06 | 0.80-1.41 | 0.44 | 0.65 |
| **Handball** | (16) | 1.41 | 1.19-1.68 | 3.95 | 0.0001 |
| **Ice-Hockey** | (45) | 1.39 | 1.30-1.50 | 9.11 | 0.0001 |
| **Rugby** | (27) | 1.06 | 0.95-1.18 | 1.10 | 0.26 |
| **Shooting Sports** | (6) | 1.07 | 0.87-1.32 | 0.72 | 0.46 |
| **Snowboarding** | (14) | 1.16 | 0.97-1.40 | 1.63 | 0.10 |
| **Soccer** | (33) | 1.31 | 1.19-1.45 | 5.65 | 0.0001 |
| **Swimming** | (8) | 1.67 | 1.37-2.04 | 5.10 | 0.0001 |
| **Table Tennis** | (14) | 0.85 | 0.71-1.01 | -1.81 | 0.07 |
| **Tennis** | (27) | 1.28 | 1.15-1.42 | 4.73 | 0.0001 |
| **Track & Field** | (18) | 1.26 | 1.12-1.40 | 4.07 | 0.0001 |
| **Volleyball** | (7) | 1.81 | 1.30-2.53 | 3.51 | 0.0001 |
| **Sport Context *(< 6 samples)*** | | | | | |
| **Australian Rules Football** | (2) | 1.55 | 0.89-2.70 | 1.55 | 0.11 |
| **Badminton** | (1) | 0.70 | 0.31-1.59 | -0.83 | 0.40 |
| **Boxing** | (3) | 1.02 | 0.69-1.51 | 0.12 | 0.90 |
| **Cross-Country Skiing** | (1) | 1.48 | 0.96-2.28 | 1.80 | 0.07 |
| **Figure Skating** | (1) | 0.78 | 0.30-1.99 | 0.51 | 0.60 |
| **Judo** | (2) | 1.30 | 0.91-1.85 | 1.44 | 0.14 |
| **Ski-Jumping** | (1) | 1.46 | 0.70-3.08 | 1.01 | 0.31 |
| **Softball** | (2) | 2.11 | 1.40-3.17 | 3.61 | 0.0001 |
| **Taekwondo** | (1) | 1.44 | 0.66-3.15 | 0.93 | 0.35 |
| **Wrestling** | (1) | 1.12 | 0.58-2.15 | 0.34 | 0.73 |

***Table Notes:*** Point Estimate = Pooled overall odds ratio (Q1 v Q4) estimate; 95%CI = Lower & upper confidence interval estimates; *Z* value = Reflects the test for an overall effect; *p* = Probability of significance (*p* criteria set at ≤ 0.05).

## APPENDIX B

**Appendix B is published as:**

Search Institute (2005). *Developmental assets profile: User manual* (p. 5). Minneapolis, MN: Search Institute.

**Summary of Developmental Asset Scales**

External Asset Scales

Support: Support from parents, family and other adults; parent-adolescent communication; advice and help from parents; helpful neighbours; and caring school environment.

Empowerment: Feeling safe at home, at school and in the neighbourhood; feeling valued; and having useful jobs and roles.

Boundaries and Expectations: Having good role models; clear rules at home and school; encouragement from parents and teachers; and monitoring by family and neighbours.

Constructive Use of Time: Participation in religious or spiritual activity; involvement in a sport, club, or group; creative activities; and quality time at home.

Internal Asset Scales

Commitment to Learning: Enjoys reading and learning; caring about school; doing homework; and being encouraged to try new things.

Positive Values: Standing up for one's beliefs; taking responsibility; avoiding alcohol, tobacco and drugs; valuing honesty; healthy behaviours; being encouraged to help others; and helping, respecting, and serving others.

Social Competencies: Building friendships; properly expressing feelings; planning ahead; resisting negative peer pressure; being sensitive to and accepting others; and resolving conflicts peacefully.

Positive Identity: Optimism; locus of control; and self-esteem.

## APPENDIX C

**Appendix C is published as:**

Search Institute (2005). *Developmental assets profile: User manual* (p. 58). Minneapolis, MN: Search Institute.

**Summary of Interpretative Ranges for DAP Asset Scales**

| Label | Range of Scores | Typical Item Responses | Interpretative Guidelines |
|---|---|---|---|
| Excellent | 26-30 | 2's and 3's with mostly 3's | Abundant assets, most assets experienced strongly and/or frequently |
| Good | 21-25 | 2's and 3's with mostly 2's | Moderate assets. Most assets are experienced often, but there is room for improvement. |
| Fair | 15-20 | 1's and 2's with mostly 2's | Borderline assets. Some assets are experienced, but many are weak and/or infrequent. There is considerable room for strengthening assets in many areas. |
| Low | 0-14 | Mixture of 0's, 1's and 2's | Depleted levels of assets. Few if any assets are experienced infrequently. Tremendous opportunities for strengthening assets in most areas. |

## VITA AUCTORIS

| | |
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