THE RELATIVE AGE EFFECT IN ELITE YOUTH SOCCER ACROSS THE UNITED STATES

by

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This dissertation is dedicated to my family and friends. A special note of gratitude goes to my parents Betty and Pratap Korgaokar. They have always supported me throughout my years and provided me the confidence and courage to chase my dreams. I also dedicate this dissertation to the friends who supported me on my journey through the doctoral program. Rowan Millar and Andrew Poklad kept me laughing all the way. In particular, I thank Dr. Stuart Currie for his friendship, guidance, and support through some difficult times. Lastly, this dedication would not be complete without thanking my long-time friend, mentor, and advocate, Sandy Pollock, for his help in everything I have undertaken

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ABSTRACT

The purpose of this dissertation was to determine if relative age effects (RAE) were present among elite youth soccer players across the U.S. The objective of the first study was to determine if there was an overrepresentation of boys born early in the cohort and an underrepresentation of boys born late in the cohort. The sample included 3, 218 elite male soccer players (u15/16 = 1,724; u17/18 = 1,494) competing in the U.S. Soccer Developmental Academy (USSDA) during the 2012-2013 season. When analyzed into quartiles and halves, a strong RAE was detected among the u15/16 age group indicating a bias toward the selection of older players. Maturation and competition may be the leading causes for the presence of RAEs. No RAE was found among the u17/18 age group. An overrepresentation of players born in the last quartile indicated a reverse RAE. The difference between the cut-off dates for the club and USSDA playing season, may have contributed to this RAE.

The aim of the second study was to examine the birthdate distribution among elite female soccer players for RAEs. The sample included 7,294 players (u14-u18) competing in the Elite Clubs National League (ECNL) during the 2012-2013 season. Statistically significant differences were observed among all age groups, indicating an overrepresentation of players born earlier in the cohort and an underrepresentation of players born later in the cohort. Competition may have been the key mechanism leading to a bias toward the selection of older players across the league. Taken together, the

findings from these studies indicate a bias toward the selection of the oldest in the cohort is present among elite level soccer players in the U.S. Parents, coaches, and administrators need to implement measures to reduce or eradicate the systematic discrimination against athletes born toward the end of the selection year in sport

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CHAPTER I

PROJECT INTRODUCTION

The 2006 FIFA Big Count estimated 265 million males and females of all ages participated in soccer (football) worldwide, making soccer the most popular sporting activity around the globe (“FIFA Big Count 2006,” 2013). However, research findings over the last two decades have demonstrated asymmetry in birthdate distributions among elite youth and senior professional soccer players. The evidence has demonstrated that when a child is born has a significant impact on future success in elite-level soccer. Thus, interest in this phenomenon has grown considerably among scholars, sports scientists, and athletic coaches.

Children who participate in sports are grouped according to their chronological age. The objective of this grouping strategy is to ensure safety, provide equal opportunity for participation, and promote fair competition among the participants (Musch & Grondin, 2001). A cut-off date is used to indicate the selection and competition year, with August 1st (September 1st in the UK) or January 1st commonly used to place athletes into developmentally appropriate cohorts. However, children within the same cohort may have relative age differences up to 1 year. For example, if the cut-off date is August 1st, then a child born in August is almost one year older than a child born in July, yet both will be placed in the same cohort. The difference in maturity between two children with relative age differences has been identified as a significant factor in sport performance. More specifically, those born early in the cohort are physically stronger and demonstrate more advanced cognitive ability compared to those born late in the cohort (Musch & Hay, 1999). The differences in age among athletes in the same group have been associated with short-term and long-term consequences referred to as ‘relative age effects’ (RAEs). Relative age effects have been detected in sport when asymmetry in birthdate distribution significantly differs from the distribution of the birthdates of the general population. The consequence of RAEs in certain sports such as soccer has been an overrepresentation of athletes born early in the cohort and an underrepresentation of athletes born late in the cohort, indicating a systematic bias against the selection of younger athletes.

In a number of studies on RAEs in sport, parallels between sport and education have been drawn (Cobley, Baker, Wattie, & McKenna, 2009; Musch & Grondin, 2001). Differences in cognitive development between students born early in the academic year and those born late in the academic year have been recognized for a number of years (Bisanz, Morrison, & Dunn, 1995; Morrison, Smith, & Dow-Ehrensberger, 1995). The youngest students in the classroom typically underperform when compared to their older classmates, regardless of sex or subject matter (Cobley, McKenna, Baker, & Wattie, 2009). Despite these parallels, it should be noted that education is not a choice, whereas the decision to participate and remain in sport is optional. Furthermore, RAEs in education have been shown to dissipate in later years. However, in elite level sport, a significant number of younger athletes are not selected to the highest level teams and dropout of elite competition all together.

The relationship between birthdate and the attainment of success in sport has been the subject of much research in the last two decades and also popularized in the public by Gladwell (2008), Coyle (2009), and Syed (2010). In addition, a number of studies have indicated the RAE is a prominent phenomenon among elite level youth and professional soccer players. Helsen, Starkes, and Van Winckel (1998) showed an increase in dropout among elite level youth soccer players born late in the competition year starting at the age of 12 years. Discrimination against the youngest in the cohort carries into adulthood and senior soccer teams have been overrepresented with players born early in the cohort.

Awareness of RAEs in soccer was first highlighted by Barnsley, Thompson, and Legualt (1992) when they collected the birthdates of under-17 (u17) and under-20 (u20) soccer players competing in the 1989 World Tournaments in Football. In the same study, the authors also examined the birthdate distribution of all the players representing their countries at the 1990 World Cup finals in Italy. The results indicated significant RAEs for all of the players examined. The strongest RAEs were observed among the u17 and u20 teams. Interestingly, Barnsley et al. (1992) found similar results to that of Barnsley, Thompson, and Barnsley (1985) in their study of RAEs in ice hockey. Barnsley et al. (1985) were the first to examine RAEs in sport and discovered skewed birthdate distributions among players competing in minor league ice hockey in Canada and the National Hockey League (NHL).

The logic of RAEs suggests that early born athletes have greater physical attributes compared to late born athletes in the same cohort. As a result, the most powerful athletes are regarded as potential talent and selected to elite level teams, where they receive higher level coaching, better competition, and motivation to continue in the game. In contrast, the late born are seen as lacking talent and not selected to higher level teams. Dejection among the younger youth soccer players not selected to the best soccer teams has led to a number of youth players dropping out of elite level soccer (Delorme, Boiche´, & Raspaud, 2010a). Once out of the game during the crucial developmental years, it is difficult for a young soccer player to become a professional, or represent his or her country at the international level in later years.

Although RAEs have been detected among female soccer players, the research in this area has shown mixed results. Because fewer females play soccer, the competition for spots on teams is reduced, therefore, potentially nullifying RAEs. In addition, the onset of puberty in females brings increased fatness which may result in a decrease in components of fitness for the oldest females. Also, socialization, where masculine sports such as soccer may not be socially acceptable, places pressure on the oldest in the cohort to leave the game. Consequently, the youngest girls in the cohort may end up being the majority and studies have shown reverse RAEs among female athletes (Till et al., 2010).

Thus, RAEs have been detected among male and female soccer players competing at the elite youth level. In addition, the RAEs observed at the youth level have also been found at the senior level, indicating a carry-over effect. Although no single factor has been identified as the main constraint contributing to the underrepresentation of younger soccer players, it is clear that RAEs exist among this group of elite athletes. Consequently, examining the existence of RAEs among elite level youth soccer players may provide a greater understanding of the causes that contribute to discrimination against the youngest in the cohort. Further research is needed to ensure potential talent in soccer is not lost.

Purpose

These studies were designed to examine the presence of RAEs in elite youth male and female soccer players across the United States. **The purpose of the first study** was to examine birthdate distributions of elite youth male soccer players competing in the U.S. Developmental Academy during the 2012/2013 season. The birthdates of the players participating in the under 15/under 16 and under 17/under 18 teams were compared to male births in the general population. The main objective was to determine if skewed birthdate distributions indicated the presence of RAEs. **The purpose of the second study** was to examine birthdate distributions of elite youth female soccer players competing in the Elite Clubs National League during the 2012/2013 season. The birthdates of the players participating in the under 14, under 15, under 16, under 17, and under 18 teams were compared to female births in the general population. The main objective of the second study was to determine if skewed birthdate distributions indicated the presence of RAEs or potential reverse RAEs.

Significance of Studies

A growing body of research demonstrates that RAEs exist among elite youth soccer players worldwide. Numerous studies have indicated a bias in favor of athletes born early in the cohort. The result has been an underrepresentation of younger soccer players selected to elite level teams coupled with an increase in the number of younger players dropping out of elite level sport. The majority of the research on RAEs has examined European male and female soccer players and only a handful of studies have researched this phenomenon among elite soccer players across the U.S. Current research is needed to determine the presence of RAEs among elite youth soccer players participating in the highest club level across the U.S.

CHAPTER II
PROJECT LITERATURE REVIEW

This review of literature includes justification for conducting research on the relationship between month of birth and playing level in elite youth soccer across the United States. The chapter begins with an overview of the RAE in education and sport. What follows are current theories on the causes of bias toward selection of athletes born early in the cohort. Thereafter, a description of the RAE in sport by sex is provided. The chapter is completed with an overall summary.

RAE

The term *relative age* refers to the age difference between members in the same cohort. The consequences of age differences are commonly referred to as *relative age effects* and are most often seen in children and adolescents. In education worldwide, students are grouped into cohorts based upon chronological age. The purpose of organizing students by age is to provide an appropriate developmental level of education, as well as to provide equal opportunities regardless of sex, religion, race, or socioeconomic background (Helsen, Van Winckel, & Williams, 2005). The age of entry for school varies by country with the U.K. using September 1st as the cut-off date ("Primary School Admissions," 2013). Therefore, a child that turns 5 years of age on or before September 1st can enter primary school (a child can also enter primary school in September following their 4th birthday). In the U.S., the cut-off date for entry into elementary school is set by the state or local school district and varies between early August and early September ("Department of Education," 2013). Consequently, a child born in September can be nearly 12 months older than a child born in August and both can be placed in the same school year. Research indicates that the oldest in the cohort have a cognitive advantage over the younger peers that may lead to greater attainment in education (Morrison et al., 1995).

RAE in education. Relative age effects in education were first examined in 1934 when Bigalow linked the month of birth with academic success for first-graders in the Summit school system in New Jersey, USA. In 1963, Dickinson and Larson (1963) also documented a relationship between date of birth and scholastic achievement. The authors grouped 480 fourth graders from the Sioux Falls public school system into quartiles based upon chronological age. Students in the youngest quartile achieved the lowest scores on the Iowa Test of Basic Skills (ITBS) when compared to students in the oldest quartile. Interestingly, the difference in scores on the ITBS was not due to IQ, because the youngest children had an overall higher mean IQ than the older students. The authors linked mental age as a more accurate predictor of school achievement. More recently, Cobley et al. (2009) investigated the association between date of birth and academic advancement among 657 school students aged 11-14 years located in the UK. The older pupils (born September 1^{st}-November 30^{th}) had higher scores and were overrepresented in the gifted programs. In contrast, the youngest (born June1^{st} –August 31^{st}) were more likely to require additional educational support and scored in the lowest 20% of their peers.

Why asymmetry in birth date distributions found in education leads to advantages for older students and disadvantages to younger students is not clear. However, several theories have been presented to explain this phenomenon. The gestational hypothesis suggests that those born in the summer months, i.e., younger pupils, may have had mothers exposed to winter infections potentially causing cognitive deficiencies at birth (Orme, 1963). The length of schooling hypothesis indicates that students born during the summer months have less time in school compared to pupils born earlier in the cohort (Fogelman & Gorbach, 1978). The consequence of a summer birth results in reduced life experience, which may have a negative impact on later progress. Lastly, the maturational hypothesis indicates that late born pupils are less mature compared to early born pupils in the same school year, thus providing cognitive and physical advantages to older, more mature students (Bergrund, 1967).

In summary, the discrepancy in academic achievement among younger and older students may be more complicated than looking at birth date alone. In a longitudinal study on relative age and academic success of kindergarten students, Dağli and Jones (2013) suggested sociodemographic elements such as home language, ethnicity, sex, child’s disability status, parental perceptions, and childcare cost must be included as potential confounding variables. Likewise, the effect of this chronological age difference can also extend to sport. Older athletes are at an advantage due to superior anthropometry, which is perceived as a benefit in many sports (Philippaerts et al., 2006).

RAE in Sport

Overtime, the same concept of birth month bias found in education was linked to sport and a wealth of research on the RAE in sport has increased awareness of the connection between date of birth and sporting success. In addition to potential cognitive advantages seen in older students, as noted from the education domain, there is also a physical benefit associated with an earlier birthdate. Greater height, aerobic power, endurance, and speed have provided performance advantages in older athletes (Cobley et al., 2009). Such physical precocity is also more pronounced during childhood and adolescence, a time when young athletes are scouted by coaches. Due to these physical advantages, older athletes are often seen as having greater potential in sport and selected to elite-level teams. The result is exposure to more qualified coaches, high-level training, feedback, and superior competition. These benefits, often required for achieving success in sport, are withheld from younger participants during the formative years of athlete development. The consequence has been an underrepresentation of athletes born later in the cohort in certain elite level sports.

Grondin, Deshaies, and Nault (1984) were the first to investigate the RAE in sport and examined birth month and level of play (recreation, competitive, and senior professional) in ice hockey and volleyball players in Canada during the 1981-1982 season. There was an overrepresentation of players born in the first three months of the cohort for all levels of play in ice hockey. When compared to population births in Canada, among the 10-11 and 12-13 year olds, there were nearly 20% more born in the first quartile. In contrast, those born in the fourth quartile of the selection year were significantly underrepresented compared to the general population in Canada. In addition, the authors found an overrepresentation of players born just after the cut-off date (January 1st) in competitive volleyball players aged 16 years to 19 years of age.

Barnsley et al. (1985) also found similar results in sport; the oldest in the cohort had the greatest amount of success compared to the younger counterparts. The authors collected the date of birth of players in the NHL, Western Hockey League (WHL), and the Ontario Hockey League (OHL) during the 1983-1984 season. The WHL and the OHL were Canada's main professional development leagues and a feeder system to the NHL. There were four times as many players born between January and March (cut-off date was January1st) than those born between October and December for all three leagues. The skewed distribution of birth dates indicated a strong preference for the selection of older players and a bias toward younger players in elite-level youth and professional ice hockey. Nearly three decades later, Nolan and Howell (2010) replicated the study by Barnsley et al. and included an additional league into their investigation of a RAE in elite-level ice hockey (Quebec Major Junior Hockey League). Due to the change in demographics of the leagues after nearly 30 years, the authors included country of birth as an additional variable. Despite the globalization of ice hockey since the study by Barnsley et al., Nolan and Howell also found a significant RAE in competitive junior and professional ice hockey players. In fact, several studies have indicated a strong RAE in junior and senior-level ice hockey players all over the world and not just in Canada (Baker & Logan, 2007; Bruner, Macdonald, Pickett, & Cote, 2011). However, this worldwide phenomenon goes beyond ice hockey and the RAE has been detected in other popular sports as well.

Rugby League Football is a worldwide sport played among amateur, elite youth, and senior professionals (Till et al., 2010). In a study conducted on Australian senior rugby league players, Abernethy and Farrow (2005) found that 37% of professional and 40% of representative players were the oldest in the cohort. Till et al. examined the date of birth distribution of over 15,000 male and female UK rugby league players from under 7s to senior players participating at the regional and professional levels. The older male players were more likely to be selected to the highest level of rugby league at all levels, from junior to professional, indicating the strong presence of RAE. According to the authors, the influence of a RAE increased with each level of performance, suggesting the coaches were biased toward the selection of older boys who differed physically and cognitively from their younger counterparts. No significant presence of a RAE was found among the female rugby players. However, an interesting discovery was that 71% of the u12 girls were born in the latter half of the selection year, indicating the presence of a reverse RAE and an overrepresentation of younger female rugby players. According to the authors, this may be due to the timing of puberty and menstruation in younger girls. More specifically, early maturing, older females starting their menstrual cycle may be more prone to dropout out of physical activity and sports only to return when regular menstruation has occurred.

A detailed explanation of the link between menstruation and dropout rate among female athletes was not provided by Till et al. (2010). However, according to Malina, Spirduso, Tate, and Baylor (1978), early menarche may be a contributing factor to dropout in sports among female athletes. Malina et al. suggested two theories to explain the association between menarche and sport. First, early maturing girls have more weight for height and more relative fatness than younger girls. In contrast, late maturing females tend to have longer legs and narrower hips; traits conducive for sports performance. The second theory relates to the socialization of early maturing girls. Because early maturing girls are not in the same developmental phase as late-maturing girls and boys of the same age, the early maturing female may seek to socialize with older groups and move away from peers and sports groups within the same chronological age. The result of both theories is an increased dropout among early maturing female athletes.

In a more recent study, Till, Cobley, O'Hara, Cooke, and Chapman (2013) also looked at the influence of the RAE in rugby. The authors published the findings of a longitudinal study on anthropometric measures and relative age over time in elite junior male rugby league players from the UK. The authors examined 81 boys with a mean age of 13.62 years for maturation using peak height velocity, along with anthropometry (height, sitting height, body mass) and components of fitness (upper body power, speed, change of direction speed, and maximal aerobic capacity [VO_{2max}]). The authors revealed that maturation and relative age had a positive effect on fitness during the adolescent years, which may provide the older boy an advantage in rugby. However, during adolescence, the late maturing player can catch up to the early maturing athlete within 2 years, which can nullify the initial advantages of relative age differences demonstrated by the older boys. In addition, this pattern of the late born athlete catching up to the early born athlete, with regard to anthropometry and physical fitness components, can carry into adulthood. According to Till et al. (2010), this brings into question the benefit of early selection in elite youth sports. As noted by Delorme et al. (2010a), early selection in sport can lead to a high dropout rate for younger athletes. More significantly, Till et al. (2010), pointed out that early born athletes may not exhibit their talents and abilities until late adolescence or early adulthood and may have notable undiscovered promise in their respective sport. This places a greater emphasis on the importance of long-term player development in youth sports as a way to combat the constraints associated with relative age differences during the early participation years.

The notion of a RAE in sport decreasing overtime was supported by Schorer, Cobley, Büsch, Bräutigam, and Baker (2009) from their study of male and female youth and adult handball players in Germany. In one part of the study, the authors examined adult male professional handball players to determine if the RAE decreased over the course of their careers. The results indicated the presence of a RAE at the younger ages of player development, yet a normal distribution for age was seen during the middle years of their careers. More intriguing was the discovery that in the later adult years, professional handball teams were overrepresented with players born in the second and fourth quartiles of the birth date distribution. More specifically, males born early in the selection year, who were overrepresented on elite level teams during the developmental stages, were less likely to continue playing professional handball in Germany after the age of 30 years. The reasons for this phenomenon are not clear. However, the authors suggested injury, aging, and physical and mental fatigue may contribute to the older players leaving the game, which may provide an opening for a younger player who has stayed in the game.

Men's basketball became an official Olympic sport during the 1936 games in Berlin and it was in the 1976 Olympic Games in Montreal that women's basketball made its debut ("Basketball Equipment and History," 2013). Since this time, basketball has become a sport played all over the world and is one of the few team sports that provide a professional league for men and women (National Basketball Association [NBA] and Women's National Basketball Association [WNBA]).

Height is one of the most important variables in youth basketball. For this reason, it would not be unreasonable to think younger, less developed athletes may not be attracted to basketball or may choose to leave the game more readily than their taller counterparts. This process of self-elimination by younger players from basketball may lead to an overrepresentation of older players at the youth level signifying the presence of a RAE. Delorme and Raspaud (2009b) tested this notion on 151,259 male and 107,101 female French basketball players aged seven to 18 years of age across the country during the 2005-2006 season (cut-off date January 1st). The authors found a significant RAE for both boys and girls of all ages. As noted by Delorme and Raspaud, the RAE began at the early age of 7 years for basketball across France, and height was a contributing factor to the RAE. Athletes born in the first two quartiles of the cohort were taller than those born in the last two quartiles and the tallest boys and girls were overrepresented during the 2005-2006 season in France.

In another study on the RAE in basketball, García, Aguilar, Romero, Lastra, and Oliveira (2012) inspected the date of birth of male and female u17, u19, and u21 basketball players that competed in the World Championships between 2005-2010. Height, date of birth, and playing position were collected from 472 males and 482 females. In addition, the authors recorded information on the following game components: number of games played, number of minutes played, number of converted field goals, percentage of effectiveness, number of two point field goals, number of three point field goals, number of offensive and defensive rebounds, number of assists, number of personal fouls, number of times the ball was stolen from opponents, number of blocked passes, and the number of points per game for each player.

The presence of a RAE was found in the u17 and u19 age groups for both males and females, but no RAE was detected in the u21 age group for either sex. Early born males in the u17 age group had higher three point field goals compared to the younger players. Among the u19 males, those born in the latter half of the year scored fewer overall points than their teammates born in the first half of the cohort. In addition, a relationship between relative age differences and playing position was also found for males in the u17 and u19 age groups. Among the male basketball players, the center and power forward positions, which typically require the greatest height, were overrepresented with those born early in the cohort, but no such pattern existed in the point guard and shooting guard positions. The impact of a RAE on playing position was not found among the female athletes and no significant differences in performance were found for the u17 females. In u19 age group, an interesting finding was detected among the female athletes. Those born in the latter half of the cohort had higher two point field goal two percentages than those born earlier in the cohort, but it is not clear why. Among the u21 females, no significant difference in performance was found based upon date of birth.

American football is considered one of the most popular sports in the U.S. with approximately 2,000 players in the National Football League (NFL), 100,000 participating in college football, 1.3 million high school football players, and approximately 3.5 million youth players (Daniel, Rowson, & Duma, 2012). Yet, unlike soccer and ice hockey, birthdate does not seem to be an obstacle to achieving the highest level in football. Stanaway and Hines (1995) also investigated the notion of biological maturation and birth date as a potential advantage in sport and collected the date of birth of 167 athletes from the 1993 American Football Hall of Fame. The authors hypothesized that no RAE would exist among this elite group of players. They believed that any football player achieving such an accolade as the Hall of Fame would have overcome any maturational disadvantage faced along his path to success. The results of the study confirmed their theory and revealed no presence of a RAE for this group of highly skilled athletes. When comparing their study to European research on the RAE in sport, Stanaway and Hines suggested unknown factors, other than birth date and season start date, may contribute to the RAE found in sports like soccer and ice hockey.

The result of the study by Stanaway and Hines (1995) on American football players is contradictory to the logic connected with the RAE phenomenon. A number of studies on the RAE have explained the unequal age distribution found in sport through the physical and physiological advantages associated with those born early in the cohort (Malina, Ribeiro, Aroso, & Cumming, 2007; Musch & Grondin, 2001). The rationale for the RAE suggests that older athletes are more powerful, taller, and faster than younger athletes in the same cohort (Malina et al., 2000). These benefits can result in selection to elite-level teams, exposure to qualified coaches, and higher level competition; all of which are denied to the youngest (Wattie, Cobley, & Baker, 2008). In contrast, the younger, less mature athlete may not possess the physical qualities required to compete at the highest level and is passed over for selection by the observing coach. Because physical attributes are essential skills in American football, it would not be irrational to assume a significant RAE might be present in this sport. However, the lack of the presence of a RAE from studies using professional American football players is unclear. These findings highlight the complexity of the RAE phenomenon within the sport domain.

The difficulty of this issue is further compounded when examining American college football players. University football in the U.S. is the unofficial feeder system to professional level football in American and Canada. Glamser and Marciani (1990) examined the presence of RAE among college football players competing at two different state universities during the 1989 National Collegiate Athletic Association (NCAA) Division 1 season. One of the universities was from the Southern part of the U.S. and the other from the Midwest. The authors compared the players' date of birth to the birthdate distribution for the general population of 1989. Demographic data for 1989 indicated male births were fairly evenly distributed across all months of the year. However, the results of this study indicated that being born in the last quartile of the cohort for football was a disadvantage for selection to these college football programs, unless younger athletes dropped back into an earlier year. In addition, the RAE was more pronounced for the Southern university than it was for the Midwestern college. The authors attributed this finding to the dominance of football in the South and the lack of development of minor sports such as soccer. In addition, according to the authors, the South was more economically depressed, compared to the Midwest, and parents red-shirted their children in football to gain an advantage. The benefit of this advantage might be a college football scholarship and potentially an opportunity to be scouted by the pros.

Baseball is played all over the world and still considered America's national pastime because so many people in the U.S. watch and play the sport. In 2011, there were 13,561,000 participants aged six years and older that played baseball in the United States (Sporting Goods Manufacturers Association, 2012). In addition, Major League Baseball (MLB) is considered the most prestigious professional league in the world and consists of 30 teams divided into two separate divisions (American and National leagues). Like the majority of youth sports, youth baseball leagues also use a cut-off date to group players into cohorts. In 2006, the Little League Baseball and Softball cut-off date was changed from July 31st to April 30th (www.littleleague.org).

Daniel and Janssen (1987) were one of the first to examine the RAE in baseball and found no presence of a RAE in their study of MLB players from the 1985 season. However, the authors did not provide their statistical results or the type of statistics used, which brings into question the validity of their findings (Barnsley & Stebelsky, 1991).

Barnsley and Stebelsky (1991) used the data (N = 682) from the study conducted by Daniel and Janssen (1987) along with birthdate information from an additional 837 MLB players (National and American leagues) from the 1990 season. After re-examining the data from the Daniel and Janssen study, the authors found a statistically significant RAE among MLB players from the 1985 season, in contrast to what the original authors found. In addition, a RAE was present for the players competing in the 1990 season. Month of birth was organized by each month of the playing season (August-July) and also coded into quartiles (Q1 Aug-Oct, Q2 Nov-Jan, Q3 Feb-Apr, Q4 May-Jul). The percentage of players in each birthdate quartile reduced from the start of the season to the end of the season for both the 1985 and 1990 competition years. The results indicated a strong bias toward the selection of players born earlier in the cohort for professional baseball players.

In contrast to Barnsley and Stebelsky (1991), Stanaway and Hines (1995) did not find a RAE among baseball players competing in the major leagues for the 1994 season. The authors gathered the date of birth of 600 professional baseball players from the 1994 Baseball Almanac. The birth month for each player was arranged in quartiles according to the playing season (Q1 Aug-Oct, Q2 Nov-Jan, Q3 Feb-Apr, Q4 May-Jul). There was no statistically significant difference across the birth month quartiles for this group of professional baseball players, indicating the lack of a RAE (Q1 27.5%, Q2 28.2%, Q3 22%, Q4 22.5%). When comparing their findings on the RAE in baseball players to the results found in studies in European athletes, Stanaway and Hines rejected the notion of the cut-off date as the cause of bias toward the selection of older athletes. As noted by the authors, if the cut-off date was the main reason for uneven birth distribution found in European athletes, then there is no reason why the same occurrence would not take place among American sportspersons. According to the authors, the reasons for the differences found between European and American athletes are unknown.

Abel, Kruger, and Pandya (2011) took a unique approach in their investigation of the RAE in baseball. The authors examined the birthdates of professional male and female baseball players from 1943-1954. For Mr. P.K. Wrigley (Wrigley chewing gum fame and owner of Chicago Cubs), the Second World War brought fear of empty baseball parks and suspended games, due to a shortage of major league baseball players who were entering the armed forces (Brown & McKenzie, 2001). This led to the formation of the All-American Girls Professional Baseball League to help fill the seats in baseball stadia, as well as keep up wartime moral. The authors of this study collected the date of birth of 1,323 males and 405 females who played professional baseball during the 1943-1954 seasons, and grouped player birth month into quartiles using August 1st as a cut-off date. The results indicated an almost even distribution for birth months across all four quartiles for the women, indicating no presence of a RAE during the time of the All-American Girls Professional Baseball League. The birth month distribution for males was statistically significant, indicating the presence of a RAE for this group of professional baseball players. These findings were in line with those found by Côté, MacDonald, Baker, & Abernethy (2006) in their study on MLB players.

Abel et al. (2011) believe the absence of a RAE found among the females in this study may be attributed to the lack of organized youth baseball for girls prior to 1943.

Because much of the research on the RAE indicates the cut-off date in sports as the main reason for bias against late born athletes, the authors noted that the female athletes were not part of a structured youth baseball league system prior to 1943. As a result, the female players were not subjected to the effects of relative age differences during their youth. Furthermore, Abel et al. suggested a RAE in female baseball may not have been present until the 1970s, when organized, structured baseball leagues for girls were first introduced and a cut-off date put in place for grouping players. In contrast, the males had structured youth baseball leagues prior to 1943 and it is likely a RAE existed in the youth leagues during this time and carried on into the wartime major leagues.

In summary, the research indicates visible asymmetries in birthdate distributions for youths involved in elite-level sport and this may also carry over into senior level sports. The consequences of relative age differences among peers in the same cohort have been termed relative age effects. As a result of birthdate, greater opportunities exist for athletes born earlier in the cohort compared to those born later in the competition year. Because the older athlete exhibits greater strength, power, and speed, these athletes are considered more talented than their younger counterparts. Furthermore, older athletes are selected to high-level teams and receive superior competition and coaching compared to the younger athletes who may not be perceived as talented. As the developmental gap between those training and competing at a high level compared to those who are not increases with age, the younger athletes begin to drop out of sport as competition for spots on teams increases. However, date of birth is not the only factor that may contribute to the level of success achieved in sport. As the research indicates, place of birth is also a confounding factor in sporting success. Not only when a player is born, but also where a player is born may have a significant impact on whether or not an athlete reaches the highest level in his or her sport.

RAE in sport and place of birth. Evidence suggests that not only when a person is born can have an impact on sporting success, but also where a person is born (Côté et al., 2006). The size of the city where early athlete development takes place has been shown to be a significant factor in reaching an elite level in various sports (Bruner et al., 2011; Curtis & Birch, 1987). In contrast to Delorme and Raspaud (2009a) and García et al. (2012), Côté et al. found no presence of a RAE among players participating in the NBA. The authors compiled the date of birth in addition to the place of birth for NBA basketball players, as well as those in the NHL, MLB, and the Professional Golfers Association (PGA). Côté et al. examined the birthdate distribution of 436 NBA players participating in the 2002-2003 season. The results indicated no presence of a bias toward the selection of older players on NBA teams. However, the authors found place of birth to have the most significant impact on making it to the NBA. Specifically, athletes born in cities with a population of less than 500,000 were overrepresented in the NBA compared to athletes born in cities with populations greater than 500,000. According to the authors, during the 2002-2003 season, 29% of the players in the NBA came from cities with a population equal to or greater than 500,000, while the majority of the NBA players come from areas with a population size less than 500,000.

At the time of the study by Côté et al. (2006), 52% of the U.S. population lived in cities with a population over 500,000. However, growing up in a city smaller than 1,000 residents was not a benefit either. The authors concluded that growing up in a town with less than 1,000 people was seen as detrimental to developing potential professional athletes, especially those with aspirations to play in the NBA. Smaller cities lack the infrastructure, qualified coaches, and high-level competition necessary for elite-level development. Therefore, according to Côté et al., the ideal population size for developing an NBA player is between 1,000 and 500,000. The reason for city population size affecting athlete development is based upon the characteristics of the community. As noted by Côté et al., cities with populations between 1,000-500,000 inhabitants typically have greater amounts of space and also provide an environment where young children can participate longer in unsupervised play with their peers. In contrast, cities with populations larger than 500,000 may require more structure for sport activity which may require a greater involvement on behalf of the parent(s). The latter environment consists of natural barriers to participation in sports for young children, which may have an adverse impact on athlete development.

In a similar study on the RAE and place of birth in sport achievement, MacDonald, Cheung, Côté, and Abernethy (2009) collected information on the date of birth and place of birth of 1,969 American football players registered with one of the 32 teams in the NFL during the 2004-2005 season. MacDonald et al. used July 31st as a cut-off date and grouped NFL players by month of birth into quartiles (Q1: August-October, Q2: November-January, Q3: February-April, Q4: May-July) to determine asymmetry in month of birth distribution. It should be noted that July 31st is the most common cut-off date for grouping players in youth football. However, some youth leagues across the

United States use weight as a criterion and do not organize cohorts based upon date of birth alone (“Pop Warner,” 2013). The results of this study indicated no presence of a systematic RAE for NFL players during the 2004-2005 season. The frequencies of the birthdates across all four quartiles were similar. After comparing the birthdates between the first half of the cohort and the latter half of the cohort, the effect size was still small enough to confirm no RAE existed among this group of professional football players.

With regard to a birthplace effect, MacDonald et al. (2009) found similar results to that found by Côté et al. (2006). Football players from cities with populations larger than 500,000 were underrepresented in the NFL, while football players from towns smaller than 500,000 in population size were overrepresented. According to the authors, the reasons for this finding are not clear. However, it appears there are more chances for deliberate play in smaller towns, exposure to different types of sports, and the likelihood of playing against older athletes; a natural consequence of small population cities with limited numbers of players. All appear to be common characteristics associated with smaller cities. In contrast, many of the aforementioned opportunities for player development in football may not exist in communities with populations larger than 500,000.

In study on professional baseball players, Côté et al. (2006) investigated the role of birthdate and birthplace as predictors of achievement in sport. In one part of the study, the authors collected the birthdate and birthplace of 907 MLB players during the 2002-2003 season. The authors found an overrepresentation of players born in the first quartile compared to those born in the fourth quartile. With regard to place of birth, 15% of the baseball players competing in MLB during the 2002-2003 season came from cities with a population greater than 500,000. The evidence suggests that not only when an athlete is born, but also where an athlete is developed plays a significant role in future sporting success. Similar to MacDonald et al. (2009), it appears cities with populations smaller than 500,000, yet larger than 1,000, are most conducive for developing professional baseball players.

In summary, not only does birthdate impede or advance success in sport, but place of birth also seems to have an impact on whether or not an athlete achieves professional status. As the research indicates, population size may influence the type of sport available in the community, as well as the amount and type of training accessible to participants. As noted earlier, communities with populations greater than 1,000 but smaller than 500,000 seem to be the most conducive environments for sporting development. It should be noted that the constraints associated with birthdate and place of birth and sporting success have so far been limited to team sports. However, RAEs have also been detected in individual sports.

RAE and individual sports. Much of the research on the RAE has been conducted on team sports. However, the presence of a RAE has also been found in individual sports such as tennis. Tennis coverage from around the world has increased significantly since the 1970s along with the salaries and endorsements paid to the highest ranked players (Edgar & O'Donoghue, 2005). One of the first investigations into the presence of a RAE in tennis was conducted by Dudink (1994) using Dutch youth tennis players. The author found a skewed date of birth distribution for top ranked tennis players aged 12 years to 16 years of age. Half of the players investigated were born in the first quartile of the selection year indicating a significant underrepresentation of late born players.

Since 1995, the world governing body for tennis, International Tennis Federation (ITF), has used January 1st as the cut-off date for eligibility to compete in international tennis competitions ("ITF Competition," 2013). In addition, a player must be 13 years of age before her or she is permitted to participate in junior ITF sanctioned matches and tournament play. Tennis players must also be under the age of 18 years before January 1st of the current year to be considered a junior tennis player. Players older than 18 years of age are required to compete on the senior tennis circuit.

Edgar and Donoghue (2005) examined the presence of a RAE in 476 elite male and female junior tennis players. The main objective was to determine if a RAE existed in elite junior tennis players and to determine if this phenomenon continued into the senior-level. A second aim of this study was to determine if region (Southern Hemisphere or Northern Hemisphere) contributed to a RAE in elite junior and senior tennis for male and female players.

Tennis players that had accumulated 120 or greater junior ranking points in singles by the end of the 2003 season were included in the study. In addition, 448 elite male and female senior singles tennis players who competed in the first round of Grand Slam tournaments in 2002 or 2003 were examined for unequal birthdate distribution. Player nationality was also recorded to determine if region contributed to a RAE. The results indicated the presence of RAE for both sexes in junior and senior level tennis singles. The same pattern was observed across all regions, indicating the cut-off date as the cause for an overrepresentation of those born early in the cohort. For all of the elite junior tennis players, 59.5% were born in the first half of the competition year. A similar result was found for all senior players, with 58.9% born in the first half of the selection year.

In addition, a significant RAE was found among all senior tennis players who came from countries located in the Southern Hemisphere, with 39% of males and females born in the first quartile of the cohort compared to 25.6% for senior males and females located in the Northern Hemisphere. According to the authors, the discrepancy between the Hemispheres may be due to the academic calendar. The cut-off date for school entry in most countries located in the Northern Hemisphere is August/September, whereas many countries in the Southern Hemisphere use January 1st. The matching dates for school entry and the tennis cohort, found in the Southern Hemisphere, may provide an advantage to young aspiring tennis players born in the early part of the year (January-March).

As documented by Dudink (1994) and Edgar and Donoghue (2005), a RAE persists in elite junior and senior tennis. However, handedness, whether someone is right-handed or left-handed, also appears to be a moderator for RAE in top professional tennis players from around the world. Loffing, Schorer, and Cobley (2010) examined the presence of a RAE in 1,027 tennis players listed in the top 500 of the ATP (Association of Tennis Professionals) for the 2000-2006 seasons. Player birthdates were coded into quartiles using the ITF cut-off date of January 1st. In addition, hand preference, left-handed or right-handed, was also recorded for all of the players. The results of the study indicated a RAE for right-handed tennis players with 86.56% born in the first half of the cohort. In contrast, 13.44% of the left-handed tennis players were born in the first half of the selection year, signifying the lack of a RAE for left-handed tennis players. The results of this study suggest that being left-handed may provide an advantage in tennis. According to Loffing and Schorer, left-handedness may be a benefit in interactive sports (tennis, baseball, volleyball, cricket, fencing) compared to non-interactive sports (golf, snooker, darts) due to the dueling and combative nature associated with the former.

Because left-handedness is rarer in the general population (10–13% of the Western world; Loffing, Hagemann, & Strauss, 2010), a left-handed tennis or baseball player may have a technical and tactical advantage over his or her opponents. Unfamiliarity playing against a left-handed tennis player may be problematic for many right-handers. The right-handed player may not be accustomed to the trajectory and angles of the balls hit from a left-handed player, providing the left-handed player a distinctive skill. In tennis, as in many sports, visual perception and anticipation are essential components of elite-level play. The receiver is trained to anticipate the type of serve and the direction of the opponent's serve before his or her opponent makes contact with the ball. This allows the receiver to move into the correct tactical position to return the serve. The negative perceptual frequency effect suggests that it is harder to predict the actions of a left-handed tennis player given the infrequency of playing and training against these unique opponents (Schorer, Loffing, Hagemann, & Baker, 2012). More specifically, because there are fewer left-handed players than right-handed players in tennis, familiarization with a left-handed player's serving patterns and tendencies is often limited until match time, which is often too late to make adjustments and adaptations to overcome the opponent. An anecdotal example of the difficulty in facing left-handed players was expressed by former world no.1, Pete Sampras, ‘‘the patterns of play are opposite of those you normally encounter against a righty’’ and therefore ‘‘you need to think things through because nothing is automatic’’ (Sampras, 1998).

The Olympics, for many athletes, is the pinnacle of their careers. Representing one’s country against some of the best competitors from all over the world is seen as a great honor and tradition in the sporting community. In addition to the full (adults) Olympic Games, the International Olympic Committee also hosts the winter Youth Olympic Games (YOG), with the first held in Innsbruck, Austria in January, 2012. During this 10 day event, 1,021 14 year-old to 19 year-old athletes from 69 nations competed in 15 different sports (International Olympic Committee [IOC], 2012). Based on previous research on the RAE in sport, Raschner, Müller, and Hildebrandt (2012) hypothesized a RAE would exist among this group of elite youth athletes. Using January 1st as the cut-off date, the authors collected birthdates, disciplines, and anthropometric information from all 1,021 athletes. Two-year age groups were permitted for each event with all of the athletes born between 1993 and 1997. Because the research suggests physical attributes are one of the main components that contribute to a RAE, the authors grouped each sport as either: strength-related (alpine skiing, freestyle skiing—ski cross, ice hockey, short-track, bobsleigh, luge, skeleton), endurance-related (biathlon, cross-country skiing, Nordic combined, speed skating), or technique-related (curling, freestyle skiing—half pipe, snowboard, ski jumping, figure skating), to determine any birthdate pattern among the different types of sports.

Overall, Raschner et al. (2012) found a significant overrepresentation of athletes born in the first quartile of the birthdate distribution compared to the last quartile for the 2012 winter YOG. These results included individual, as well as team sports. The same pattern existed when observing males and females separately, although a greater RAE was seen among males. The authors also found that older athletes were 11.5 times more likely to participate in elite-level sports that were considered strength-related. Whereas, in technique-related sports, where participants rely less on strength and more on sport-specific skills, older athletes were two times more likely to participate at a junior Olympic level. The authors noted that previous research on the RAE has consistently highlighted the contribution strength plays in exacerbating the RAE in sports where strength is a key component of the game. In addition, age was also a factor in the number of medals won with 24.3% of the youngest athletes winning a medal and the remaining majority given to older athletes.

In summary, there does appear to be RAEs among elite junior and senior level athletes competing in individual sports. Although only a handful of studies have indicated no RAEs among certain individual sports that have a variation in the cut-off date, such as swimming, the evidence for RAEs in individual sports is still unclear (Musch & Grondin, 2001). A RAE is thought to be most significant in sports that require strength and power and also include direct contact with an opponent (Raschner et al., 2012). The lack of a RAE has been found in sports such as golf where skill and technique are considered more important for success than strength and power (Côté et al., 2006). Overall, competition appears to be one of the most significant predictors of RAEs in sports.

RAE in females and sports. In a recent study by Cobley et al.(2009), the authors provided an extensive meta-analytical review of the RAE in sport. However, the lack of research on the RAE in female athletes was reflected in the sample size on female participants. Only 2% of the study was comprised of females from eight different sports (volleyball, swimming, tennis, gymnastics, basketball, netball, soccer, and ice hockey). Although Cobley et al. did find the presence of a RAE among the female athletes in their study, the extent of bias toward athletes born earlier in the cohort was smaller for women than for men.

In response to the lack of information on the RAE among female athletes, Goldschmied (2011) conducted a study on the RAE in the three most competitive sports played among females from Europe and North America. The author collected information on 444 professional female athletes who competed in the Danish Women's Handball League (GuldBageren Ligaen), the WNBA, and the Women's United Soccer Association (WUSA). The objective was to compare the date of birth of these athletes to past studies on the RAE in female athletes. The author tabulated the birthdates of all participants into quartiles using September-November as the first quartile. In addition, half-year distributions were analyzed for asymmetry in birthdates. The observed date of birth was compared to the expected data distribution of even quartiles and even halves (null hypothesis).

The results of this study indicated no RAE in handball, basketball, or soccer for women when analyzed by quartiles and halves. Interestingly, the birthdate distribution for women's professional handball indicated a reverse RAE. Female handball players born in the fourth quartile of the birthdate distribution were more likely to become professional athletes compared to those born in the first three quartiles of the cohort. The author also analyzed the birthdate distribution among American athletes (WNBA and WUSA) only using August as a cut-off date. August, unlike September in Europe, is the most common cut-off month for youth sports in U.S. The second analysis on the American players also indicated no RAE. Goldschmied (2011) attributed the results of both analyses in this study to competition in female sports and the effects of maturation in female athletes.

As noted by Musch and Grondin (2001) and Cobley et al. (2009) in their reviews on the RAE in sport, competition was considered a key factor that contributed to the underrepresentation of male athletes born late in the cohort. This same notion was also presented by Goldschmied (2011); because there are more males playing sports there is increased competition for spots on a team and a greater presence of a RAE. In contrast, although sports such as soccer are gaining popularity among young female athletes, there are lower numbers of females competing for spots on sports teams resulting in less competition and potentially no bias toward older players. In addition, maturation is also a key factor among female competitors and, according to Goldschmied, helps to explain the results of his study. In terms of physical attributes gained through maturation, the difference observed in females is less than the difference observed in males. The negative effect associated with maturation among female athletes was confirmed by Baxter-Jones (1995) in a study on elite female soccer players and swimmers. The author found non-significant RAEs among these elite athletes. According to Baxter-Jones, the findings are due to the earlier maturation of girls and increased differences in the maturity of boys. Furthermore, early maturation among young girls in sport may not be an advantage as it is for boys. Malina et al. (1978) indicated that with menarche comes more fatness, which is not conducive to sport performance.

Another potential reason for the lack of a RAE found among professional female athletes, according to Goldschmied (2011), are personal traits. More specifically, younger, physically weaker athletes who persist in the sport develop a resilience that is later rewarded as older athletes see their physical advantages decline and they begin to drop out of the sport. The end result may be a majority of younger females that had the discipline, resilience, motivation, and drive to stay in the sport.

Lidor, Arnon, Maayan, Gershon, and Côté (2013) examined the presence of a RAE in 389 female athletes competing in basketball, handball, soccer, and volleyball in the highest competitive league (Division 1) in Israel during the 2009-2010 season. The main objective was to determine if a RAE existed in female sports in a small country such as Israel (population approx. 7,000,000). The authors hypothesized that no RAE would exist in Israel due to its relatively small population. More specifically, the authors hypothesized the lack of competition for spots on athletic teams in Israel would nullify the effects of age differences. The results of this study confirmed the hypothesis and no RAEs were found among female athletes competing in basketball, handball, soccer, and volleyball. According to the authors, the lack of a RAE among the female athletes in the study was due to the low number of females involved in sports in Israel. As a result, coaches in this country accept young girls into sports teams regardless of their ability. As noted by the authors, the lack of competition among female peers allows the coach to focus on player development and enjoyment of the sport as opposed to selection criteria. In addition, younger, less talented female athletes can remain in sports programs and may improve later during crucial developmental phases.

In summary, although RAEs have been shown among female athletes the evidence is unclear. In addition, unlike with male athletes, a reverse RAE has been discovered among females in popular sports such as soccer. It has been suggested that the lack of RAEs found in female athletes is due to competition and maturation. In brief, there is less competition in sports among females and early maturation maybe advantageous among male athletes, but may be a hindrance among female athletes. The reasons for RAEs among female and male athletes are diverse and deserve further detail.

Summary of the RAE in sport. A wealth of research has been published on the RAE in sport since the initial studies in the early 1980s. As noted in this literature review, the research indicates the RAE is also an issue in education. However, it should be pointed out that despite the parallels drawn between education and sport on the RAE, there are distinct differences. While school attendance is compulsory by law, sport participation is voluntary (Musch & Hay, 1999). Despite the presence of a RAE in early education, cognitive ability and educational performance have been shown to level out in later years (Hauck & Finch, 1993). According to Russell and Startup (1986), a late birthdate within an academic cohort does not necessarily predict poor long-term academic achievement. Younger students who experienced learning difficulties at a younger age often go on to excel in graduate school where motivation, determination, and discipline are some of the key components to success at this level. In addition, there is typically a built-in infrastructure to help poor performing students in the academic setting. This help can often continue all the way through a terminal degree. In contrast, there is no such safety net in the sporting world and athletes that underperform are not selected to the highest levels and many will drop out of the sport all together. In summary, the majority of the studies on the RAE in sport have confirmed the presence of an uneven birthdate distribution, with a smaller number indicating no presence of a bias toward those born early in the cohort. Yet, the explanations for this phenomenon are mixed and vary according to each specific sport and sex.

Explanations for RAE in Sport

A number of researchers have sought to explain the reasons for the RAE in sport. The most pervasive and prominent theory has been the cut-off date. More specifically, athletes born earlier in the cohort may possess anthropometric and cognitive advantages over their younger counterparts, and this may lead to superior performance in many sports. However, to date, no single theory on this phenomenon has been accepted as the leading cause for birthdate asymmetry observed among elite youth athletes and senior professionals. A number of competing theories, from where a person is born to the climate during fetal development, exist to describe potential mechanisms that may contribute to the underrepresentation of athletes born late in the competition season.

Talent identification in elite level soccer has led coaches to identify traits considered predictors of attaining the highest level in the game: a professional. According to Carling, Le Gall, Reilly, and Williams (2009), anthropometric measurements and components of fitness have been incorrectly classified as characteristics associated with success in soccer. Consequently, soccer scouts may overlook technique and decision-making and interpret the fastest and most powerful youth soccer players as the ones with the most potential talent. As noted by Carling et al., differences in body size, due to RAEs, influence the coach's bias in favor of selecting the oldest in the cohort. In their study on elite youth level soccer players, Carling et al. collected information on birthdate, height, body mass, skeletal age, and biological maturation of 332 elite youth soccer players competing in the under-10 (u10) through the under-15 (u15) J League Academy teams in Japan. The results indicated strong RAEs with nearly 50% of all players born in the first quartile of the selection year (April-June). Interestingly, no significant differences were found in skeletal age, maturation, height, or body mass. The authors noted that children born late in the cohort are not necessarily late to mature and this may account for non-significant differences in the anthropometric measurements.

Malina et al. (2005) also examined the effect of maturation on elite youth soccer players and investigated the association between puberty and soccer-specific skills. The authors had 69 elite youth Portuguese soccer players aged 13 years to 15 years conduct six soccer skills to test technical ability (controlling the ball with the body, controlling the ball with the head, dribbling the ball for speed, dribbling the ball with a pass at the end, passing, and shooting to goal). The results indicated that maturation did not contribute to dribbling speed and passing, but there was an association between maturation and controlling the ball with the body, controlling the ball with the head, dribbling the ball with a pass at the end, and shooting to goal. More specifically, the most mature soccer players performed the best on four of the six skills tests. In addition, body mass was not a predictor of success on any of the skills tests, whereas chronological age and experience in soccer (years of training) were associated with performance in the dribbling the ball with a pass and ball control using the body. According to Malina et al., albeit small, the stage of puberty among the players did contribute to the difference in scores on four of the tests, which indicates maturation may have an impact on the technical ability of elite level youth soccer players. However, the authors concluded that maturation cannot be considered a significant predictor of technical skills in soccer. Other factors such as perceptual-cognitive and anticipation play a key role in technical ability in elite level soccer players.

As noted by Malina et al. (2005), maturation may not be the most important component in predicting performance among youth soccer players. However, according to Rowland (2005), maturation does have an impact on the physical parameters associated with elite level soccer players, which contribute to game performance. For example, puberty in males results in an increase in testosterone, which results in an increase in hemoglobin concentration and finally a rise in arterial-venous oxygen difference. The end result is an improved aerobic capacity, which is a significant component of soccer performance. In addition, an increase in testosterone is coupled with a rise in aggression. Therefore, an early maturing male may not only have the capacity to last longer during a soccer game, but also demonstrate more aggression; both effective traits in a contact sport such as soccer (Rowland, 2005).

In contrast to males, by 11 years of age, VO_{2max} in female athletes plateaus (Rowland, 2005). Consequently, by the time female athletes are competing for spots on elite level teams, typically in the under-14 age group, any advantages associated with maturation, such as strength, are gone. In addition, puberty in females is linked to a rise in estrogen. And an increase in estrogen has been associated with a decrease in the tolerance of pain. According to Rowland, the decrease in pain tolerance among females may be associated with a decrease in the motivation to continue in the sport. The consequence could be an increase in dropout of early maturing females in soccer. As previous studies have indicated (Till et al., 2010), a reverse RAE has been observed in female sports, where the oldest in the cohort are underrepresented compared to the youngest.

Musch and Hay (1999) were one of the first to provide competing explanations for the unequal birthdate distributions observed in sport in their study on the RAE in soccer. Unlike previous studies, the authors compared birthdates distributions across cultures. They collected the date of birth of all players from the top professional division in Germany, Japan, Brazil, and Australia. The objective was to support their hypothesis that the cut-off date is the main factor contributing to a RAE.

Musch and Hay (1999) provided a list of alternative theories to explain the skewed birthdate distribution found in elite level sports. The first theory suggests that when a baby sits up, walks, and crawls etc., are important stages in a child's development. Any disruption during these points of early-growth may have a negative impact on motor development. Therefore, a baby born during the winter months may begin this important stage of motor learning during the summer when the weather is more conducive to outdoor activities. The outdoor activities further impact coordination, balance, and strength, all desirable components for most sports. In contrast, the summer born child may not experience the same amount of activity during the important motor learning phase, due to the winter period inhibiting outdoor activities. In brief, the summer born child may miss a critical period in early child development that is associated with sport-related skills.

The next theory outlined by Musch and Hay (1999) suggests that the number of births per season in the general population is related to socioeconomic class. Smithers and Cooper (1984) examined 280,921 British males and grouped them according to their social class: non-manual or manual workers. The results indicated a higher percentage of manual workers were born in the autumn months compared to non-manual workers. Because soccer in Europe has traditionally been a sport of the working classes, this theory suggests the majority of professional soccer players should be born during the autumn period. According to Dudink (1994), 61.7% of English professional soccer players competing during the 1991-1992 season were born between September and February compared to 38.2% born between March and August. The reasons for seasonal birth according to social class, however, are not clear.

A fourth theory links season of birth (climate) and personality traits. For example, Musch and Hay (1999) provided research to indicate a relationship between extraversion and being born in the summertime. This theory suggests climate and personality may influence choice of sport, but it is not clear which sport(s) appeals to an extravert or to an introvert. The final theory examined by the authors is the cut-off date for sport and the beginning of the academic year. Because research on the RAE in education suggests older students have a greater cognitive advantage over younger peers, and studies on the RAE in sport suggest older athletes are stronger and faster than younger counterparts, the matching of the school year with the sport season may provide an increased advantage for those born close to the cut-off date. The results of the study by Musch and Hay indicated a RAE for soccer players from Germany, Japan, Brazil, and Australia, despite the fact that all four countries had a different cut-off date for the soccer season. The authors concluded that the youngest in the cohort, regardless of which country they lived, were more likely to drop out of elite level soccer. Therefore, according to Musch and Hay, the cut-off date is the primary reason for an underrepresentation of younger athletes in elite sports such as soccer.

Musch and Grondin (2001) also provided a list of possible theories to explain the causes of the RAE in their seminal review on the RAE in sport. The authors presented alternatives to the pervasive theory of cut-off date as the only variable for discrimination against younger athletes. In their review, the authors suggested the following components associated with sport, in addition to the cut-off date, may contribute to a RAE: Competition, physical development, psychological factors, and experience.

Musch and Grondin (2001) contend the larger the pool of athletes competing for spots on a team, the greater the presence of a RAE. For example, if 18 players are competing for a roster spot on a soccer team, then almost everyone will have a chance for selection. However, if 80 players are competing for the same team, then competition for a place on the team becomes much greater. The coach is then charged with scrutinizing the players and selecting those considered the best 18 of the group with the remaining 62 eliminated from playing at that particular level.

Summary of the explanations for RAE in sport. From the research and evidence provided on RAEs in sport, it is clear there is no single explanation for this phenomenon. What is clear is that the cut-off date employed in youth sport leagues plays a significant role in producing RAEs in certain sports such as ice-hockey and basketball. However, for some researchers competition for spots on the highest level teams is the major constraint associated with an underrepresentation of athletes born in the later part of the cohort. According to this theory, competition for spots in elite level youth sports teams highlights the differences among athletes. As a result, the strongest and most powerful, which are typically the oldest and most physically mature, are seen as more talented than younger athletes. The consequence of selection to higher level teams is exposure to greater competition and more qualified coaches; all necessary components for athlete development. When competition is removed as a constraint, then the presence of RAEs is minimal or non-existent. However, in sports where early maturation may be seen as a disadvantage, the presence of younger athletes has been observed. For example, increased height and mass are not considered advantageous in gymnastics. Consequently, a greater number of athletes born later in the cohort have been reported in elite level gymnastics (Cobley et al., 2009). However, in popular sports such as soccer, RAEs have been observed at the elite youth and professional levels. Because soccer is considered the most popular sport worldwide, a significant amount of research on the RAE has been conducted on male and female soccer players at all levels.

RAE in Soccer

RAE in male soccer. According to Ostapczuk and Musch (2013), the chances of becoming a professional athlete may differ significantly for two children who are born just days apart. The child born just after the cut-off date in youth sport has a far greater likelihood of becoming a professional athlete compared to the child born right before the cut-off date. The oldest in the cohort is physically more mature than the youngest and this provides an advantage in contact sports. Anthropometric components are particularly meaningful in soccer where direct physical contact with opponents is a key part of the game. The soccer player with greater strength and power is seen as potential talent compared to a younger, physically weaker player. As a result, older, stronger soccer players are selected to elite level teams, receive motivating feedback, greater competition, and more advanced training; all contributing factors to a professional pathway in sport. In soccer, the RAE has been well established as a constraint to reaching a professional status. This phenomenon has been observed in soccer in most of the countries in Europe, as well as Brazil, Japan, Australia, and the USA (Ostapczuk & Musch, 2013). According to Ostapczuk and Musch, of those soccer players that made it to the professional level in these countries, the majority had birthdates in the first half of their youth cohort. In addition, a RAE was detected among this elite group of soccer players from different hemispheres demonstrating that RAEs are independent of different cut-off dates.

A wealth of information has been published on the RAE in male soccer players of all levels and ages. One of the first studies to examine RAEs in sport outside of North America was conducted by Barnsley et al. (1992). The authors collected the birthdates of male soccer players in the under 17 (u17) and under 20 (u20) teams competing in the 1989 World Tournaments in Football. Barnsley et al. also collected birthdates of all the players from every country that competed in the 1990 World Cup finals in Italy. The results indicated the presence of RAEs across all of the players examined. However, the strongest RAEs were detected among the u17 and u20 age groups, where the number of players dropped significantly from the first quartile to the last quartile of the birthdate distribution. The outcome of this study indicated an overrepresentation among the oldest in the cohort and an underrepresentation of the youngest. It was clear from the birthdate distribution of the senior players that the trend observed among the u17 and u20 players continued into the full national teams. According to Barnsley et al., the cause for discrimination against the selection of younger soccer players to the elite level is complex and not easily understood. However, the authors believed the cut-off date could be partially responsible for the overrepresentation of older players among the teams. Another explanation was the school year coinciding with the competition year. Because the cut-off date for the youth tournaments may have been the same date used among the school systems in these countries, a double advantage may have been given to the oldest in the cohort.

Dudink (1994) was also one of the first to publish findings on RAEs in soccer and collected the birthdates of 621 professional soccer players from 36 clubs in the

Netherlands. The birthdate distribution showed a clear overrepresentation of players born between August and October, which represented the early part of the cohort for youth soccer in the Netherlands. In addition, Dudink examined the distribution of birthdates for all professional soccer players (Premier, Div 1, 2, 3) competing in England during the 1991-1992 season. The results also indicated a skewed distribution of birthdates in favor of those born at the beginning of the competition year (September). However, Dudink did not provide explanations for these findings, but did link the RAE found in education to the sport setting.

In another early study on RAEs in elite soccer, Brewer, Balsom, and Davis (1995) collected birthdates of 103 male youth soccer players who were part of the Football Association's (FA) National School. These players had resided at the FA's national school for 5 years and went on to represent the England u15 and u16 national teams. The birthdate distribution for the youth players was compared to the birthdate distribution of 1,722 senior professionals competing in the English Football League. The results indicated RAEs for both the youth and senior professional players. Among the youth players, 71.8% were born in the first four months of the cohort, which started in September. Among the senior professional players, 45.6% were born between September and December. The results of this study demonstrated the RAEs observed at the elite youth level carried into the senior professional level.

Further evidence of RAEs carrying into adulthood from the youth level was supported by Musch and Hay (1999). In their cross-cultural study, Musch and Hay collected the birthdates of senior professional soccer players from the highest leagues in their respective countries. The authors gathered information from 355 German Bundesliga players competing in the 1995-1996 season, 486 players in the highest professional league in Brazil during the 1995-1996 season, 360 professional players (Japanese only) in the J-League during the 1993 season, 207 Australian professional soccer players from the 1988-1989 season and an additional 61 players from the same league in Australia from the 1995-1996 season. The results of this study indicated RAEs in the German Bundesliga, Brazilian league, Japanese J-League, and in both samples (1988-89 & 1995-1996) for the Australian leagues. It should be noted the cut-off dates were different for each country, highlighting the effect of the competition year contributing to RAEs. According to Musch and Hay, the reason for significant RAEs across different cultures maybe more than just older players being physically stronger than younger players in the same cohort. The authors suggested that low self-esteem among younger athletes maybe just as influential as physical components in contributing to the skewed birthdate distribution observed in elite level youth and professional soccer. For Simmons and Paul (2001), the information provided by Musch and Hay raises two important questions: 1) Why do some of the oldest children at the elite youth level not make it into the professional ranks as adults? 2) Are there younger children that could have made it as professionals had they not been excluded from elite youth level teams at an early age? Interestingly, Bäumler (as cited in Musch & Grondin, 2001) discovered that with an increase in age among professional soccer players in Germany there is a decrease in RAEs.

Helsen et al. (1998) determined asymmetry in birthdates among professional soccer players started as earlier as 6 years of age. The authors collected the birthdates of four different groups of soccer players from Belgium: 1) 4,408 professional players competing in the first division during the 1993-1996 seasons, 2) 4,369 youth players aged 10 years to 16 years and selected for the 1989-1995 youth national teams, 3) 4,485 first division youth players aged 6 years to 16 years of age competing during the 1995 season, and 4) 4,483 youth players from the regular Belgium youth leagues, which began at 6 years of age. The results indicated that youth soccer players born earlier in the cohort (August-October) were more likely to be labeled as talented and selected to elite level youth teams starting in the 6 years to 8 years age groups. Consequently, the trend continued and young players considered talented were also more likely to be selected for the best clubs and progress to the youth nationals teams and finally make it as senior professionals. In contrast, the data indicated an increased rate of dropout among youth soccer players born late in the cohort. Dropout among late born players started to increase at the age of 12 years, resulting in a significant loss of potential talent. Helsen et al. (1998) provided two explanations for the underrepresentation of boys born late in the competition year and why so few late born soccer players attain the professional level. First, physical attributes may be equated with talent in elite level soccer. As a result, younger athletes are not as strong and powerful as older athletes and, therefore, are not as impressive to on-looking scouts. Second, the organizational structure of youth sports contributes to RAEs in soccer. Because older players are seen as talented they are selected to the best teams, receive better coaching, better competition, more playing time, and greater encouragement and motivation to succeed in the game. Younger players, by contrast, are not seen as talented and do not receive the motivation and high level training required for future success in the game. As evidenced in the study by Helsen et al. (1998), the amount of potential talent that has been overlooked at the younger ages due to the influence of RAEs is unclear.

Jiménez and Pain (2008) addressed the issue of RAEs and wasted talent in soccer among Spanish players. The authors noted the lack of success seen by the senior Spanish national team in international competitions, despite the accolades achieved by the Spanish national u17, u18, u19, u21 and Olympic games teams. At the time of the study, Spain's greatest achievement on the international stage was a 4th place finish in the 1950 World Cup finals (Spain was a first time champion at the 2010 World Cup finals). The authors noted that RAEs may not be the cause for the lack of success of the senior national team; however, wasted potential talent may be a contributing factor. To further investigate the role of RAEs in elite Spanish soccer and the potential loss of talent, the authors collected four data sets. The first was the birthdates of 1,012 professional soccer players competing in the Spanish Liga de Futbol Profesional (LFP). At the time of the study, and to this day, the LFP was considered one of the most prestigious professional soccer leagues in the world. The second set of data was the birthdates for 2,053 youth players from 109 youth teams associated with the professional clubs. The third data set was comprised of 86 players who competed for the u17 to u21 Spanish national teams between 2001 and 2007. The final data set consisted of 56 players selected to the senior Spanish national team between 2001 and 2007. The results of this study indicated the presence of a RAE among all age groups and levels. As noted by the authors, RAEs were prevalent in elite Spanish soccer from the grassroots to the professional level. Jiménez and Pain noted that late born boys are at a great disadvantage compared to those born early in the cohort in elite level soccer. In addition, the clubs considered the strongest and most successful in Spain had the strongest RAEs. These were also the clubs where the majority of the national team players came from; perpetuating RAEs into the national teams.

Jiménez and Pain (2008) concluded that the lack of success seen at the senior international level by Spain may be, in part, due to RAEs. More specifically, those born early in the cohort are selected to elite level teams based upon physical precocity. Because younger players are rewarded for their physical attributes they neglect to develop technical and tactical skills. Furthermore, as youth players get older the physical components of the game even out and technical and tactical skills become most important to succeed at the highest level (Schorer et al., 2009). By the time these players reach the senior national teams, they have not developed the necessary skills required for success on the international stage. Consequently, Jiménez and Pain suggested implementing a research-based identification and selection program, where emphasis is placed on long-term development and not short-term success. According to the authors, talent identification and player development are multidisciplinary and multivariable and, therefore, require a completely different approach to ensure player selection is not simply a matter of birthdate.

In another study evaluating RAEs in youth national soccer team players, Helsen et al. (2005) examined birthdate asymmetries across 10 European countries. Birthdates from the u15, u16, u17, and u18 national teams of Belgium, Denmark, England, France, Germany, Italy, The Netherlands, Portugal, Spain and Sweden from the 1999-2000 season were collected and analyzed. The results indicated a clear RAE among all of the age groups. As noted by Helsen et al., selecting the strongest players to youth national teams maybe be problematic further down the road when physical components are no longer an advantage and technical skills are coveted. According to Helsen et al., technical gifted, yet less physically developed, youth soccer players are often overlooked and not identified and selected to the top teams. The long-term consequence of this bias against younger players is lost potential and denied access to the professional and senior national teams. In addition, the authors contend that the structure of youth soccer in 24-month age groups emphasizes physical attributes over skills. Consequently, the oldest players will be the strongest and will be selected to the youth national teams. Lastly, Helsen et al. indicated that athletes in soccer, compared to other sports, are exposed to high-level competition at an early age. The reason for this early exposure to competitive games is due to the pressure on professional clubs to identify and develop the best talent at the earliest time possible in order to ward off competitors. A youth player that comes through a professional clubs' developmental system not only helps to attract the best talent in the area, but those that make it to the senior professional side are seen as extremely valuable commodities to the organization.

The FIFA u17 World Cup competition is the pinnacle event for young soccer players. In effort to gain insight of RAEs over time, Williams (2010) collected the birthdates from rosters of each country that qualified for this tournament over a 10 year period (1997-2007). The data consisted of birthdates from 1,985 players from 53 nations over six tournaments. Many of the teams competing in the u17 World Cups had underage players, which were analyzed as a separate group. Since 1997, FIFA implemented January 1st as the cut-off date for all international competitions. The results of the study indicated a significant RAE for all countries that participated in the u17 World Cup between 1997 and 2007. Players born early in the calendar year were more likely to represent their country at the FIFA u17 World Cup competition compared to those born later in the year. Although the overall analysis was significant, indicating RAEs, Williams observed that some of the African countries exhibited a reverse RAE. For the African nations, players born in the later part of the calendar year were more likely to be represented on their national youth soccer teams compared to those born earlier in the cohort. Williams explained the reasons for a reverse RAE among the African nations were not clear. However, a large percentage of the birthdates among the African players could not be confirmed and the author suggested mistakes in recording birthdates may have been made. According to Williams, the significant RAEs found among many of the nations competing in the u17 World Cup maybe due to early selection of older players. The most mature boys were labeled as potential talent and recruited to high-level teams. As a result, they were provided the appropriate developmental pathway for selection to the national teams. Another possible explanation is the reduced pool of players as the cohort ages. According to Williams, by the time the cohort reaches the u17 level and prepares for the u17 World Cup, the number of late born players have already dropped out of the game in great numbers. Consequently, the majority of players up for selection to u17 national teams were born in the early part of the cohort. It is clear from these results that biological maturation played a key role in the overrepresentation of elite youth soccer players. For this reason, further investigation into the relationship between maturation and talent identification is required.

Vandendriessche et al. (2012) investigated morphology, fitness, and motor coordination among 78 Belgian international youth soccer players aged 15 years to 16 years of age, while also taking into consideration biological maturation. The main objective of the study was to determine if there was a relationship between the components of fitness, motor skills, and maturation. Because players born early in the cohort are often described as talented, Vandendriessche et al. wanted to determine if the difference in ability between early born and later born elite level soccer players was based on physical attributes alone. All of the players were divided into four groups: u16, u16 futures, u17s, and u17 futures. The futures teams were made up of late maturing soccer players and the other teams consisted of early maturing players. Anthropometric measurements along with static strength (hand-grip), flexibility, explosive strength (standing broad jump), agility (T-test), and sprint tests (30m with 5 m splits) were conducted and measurements recorded. In addition, the motor coordination tests consisted of a soccer dribbling test, which is also required the participants to run through the dribbling course without the ball, and the Körper-Koordinationstest für Kinder test, which consisted of sideways jumping over a wooden slat, sideways movement on boxes, and walking backwards on a balance beam. The results of the study indicated that the most mature players had higher morphological attributes and also scored the highest on all of the fitness tests in both age groups compared to the least mature (futures) players. However, there was no difference among the most mature and least mature on the motor coordination tests for both age categories. The authors concluded from their findings that biological maturity was a confounding factor in the selection process of elite level youth soccer players.

According to Vandendriessche et al. (2012), this demonstrated that soccer coaches mistake current physical ability with potential future talent. Interestingly, the motor coordination tests demonstrated that maturity does not have an impact on soccer-specific skills. The authors suggested that the inclusion of soccer-specific tests that do not rely on physical components may highlight the potential talent of late maturing soccer players. Furthermore, the inclusion of soccer-specific motor skill tests may help correct the underrepresentation of late born athletes at the elite level. According to the authors, a talent identification strategy that does not rely on physical precocity may not only reduce the bias against late born athletes, but may also capture previously lost talent.

Despite the wealth of information on RAEs in elite youth male soccer players from Europe and other parts of the world, there are relatively few studies that have examined RAEs among elite youth male soccer players across the U.S. (Glamser & Vincent, 2004; Musch, 2002; Vincent & Glamser, 2006). Vincent and Glamser (2006) investigated RAEs among Olympic Development Players (ODP) players, which, excluding the U.S. national teams, was the highest level of soccer in the U.S.at the time. However, growth of soccer in the U.S., United States Youth Soccer Association (USYSA) lists over 3,000,000 registered youth players ("USYSA," 2013), and the development and expansion of the U.S. Soccer Developmental Academy league, warrants further investigation into the RAE phenomenon among this group of elite soccer players. Additional research into RAEs among this group of players will add to the body of knowledge on RAEs in youth soccer and may also provide new insights into the cause for bias against the youngest in the cohort. Since the inception of the league in 2007, the U.S. Soccer Developmental Academy has become the highest level of club soccer available for youth males in the U.S. In addition, the league acts as identification program for the U.S. Soccer youth national soccer teams.

Although the overwhelming majority of research on the RAE in sport and soccer has been conducted on male athletes, there has been a rise in the amount of literature published on RAEs among female athletes. In particular, there has been an interest in investigating RAEs in female soccer players and its potential consequences.

RAE in female soccer. Between the years 2000-2006, participation in women's soccer had increased by 54% (youth and senior levels) compared to 21% among males ("FIFA Big Count 2006," 2013). Despite the increasing popularity of soccer among female athletes around the world (4.1 million in 2006), the wealth of literature on the RAE in soccer has focused on male soccer players. To date, only a handful of published studies have investigated the RAE in women's soccer.

The social pressure experienced by female athletes around menarche has clearly been shown to be a confounding factor in female sports such as soccer. For that reason, explanation of this phenomenon is required at the beginning of this section on RAEs among female soccer players. According to Koivula (2001), four features of a sport considered traditionally masculine are: 1) overpowering an opponent through body contact, 2) direct use of bodily force, 3) projection of the body through space over distances, and 4) face-to-face competition where body contact may happen. According to Kiovula, sports associated with beauty and visual pleasure, such as rhythmic gymnastics and figure skating, are considered appropriate for females and also adhere to stereotypical expectations of femininity. In contrast, soccer would be considered a masculine sport and does not obey feminine stereotypes. Put simply, athletic girls may be embarrassed by their physical attributes and drop out of contact sports.

Vincent and Glamser (2006) were some of the first to publish their findings on the RAE in women's soccer. The authors gathered birthdates from the rosters of female ODP state and regional teams. At the time of the study, the ODP state and regional teams were considered some of the best talent in the country and both programs served as a feeder system to the U.S. national teams. The regional teams consisted of the four regions under the U.S. Youth Soccer Federation (USYS): East, Midwest/North, South, and West. In addition, the birthdates for all of the female players selected to the under-19 (u19) USA national team were also included as part of the study. It should be noted that the authors only selected players born in 1984 for the ODP state and regionals teams. At the time of the study, players born in 1984 were mainly seniors in high school, a critical time for exposure to college soccer coaches, and preparing for the next highest level. Consequently, these players were considered to be dedicated to the sport of soccer and not likely to drop out of the game before entry into college. The u19 national team consisted of females born in 1983, 1984, and 1985. In total, the birthdates of 804 female ODP state players, 71 ODP regional players, and 39 national team players, were arranged in quartiles to detect RAEs. The quartiles were organized using January 1st as the cut-off date in accordance with FIFA regulations. The results of this study indicated no RAEs for the ODP state, regional, or national u19 teams.

Vincent and Glamser (2006) explained their findings as a consequence of early maturation among some of the female players. More specifically, the onset of puberty in female athletes, in comparison to males, brings constraints that hinder athletic performance. According to the authors, menarche in females may result in shorter legs, wider hips, and a plateau in anaerobic and aerobic capacities, as well as a plateau in such motor skills as agility, jumping, and kicking. Consequently, late maturing females may display greater athletic performance compared to their early maturing teammates, which would nullify any RAEs. In addition, Vincent and Glamser also noted the impact of socialization on female athletes compared to male athletes. Because society does not value athletic performance in females in the same way as it does males, a greater number of early maturing female athletes may choose to leave sports such as soccer and pursue interests considered more socially appropriate for younger girls. The impact of early maturing females leaving the game provides an opportunity for late maturing female athletes to continue in the sport and attain the highest level.

Delorme, Boiche´, and Raspaud (2009) also examined the presence of RAEs among females and investigated senior soccer players competing in the French professional championship during the 2005-2006 season. Only those players that had played at least one competitive match during the season were included in the study. The authors analyzed the birthdate distribution of 242 players using January 1st as the cut-off date. Birthdates were grouped into quartiles with January-March indicated as Q1. The results indicated no RAEs for this group of elite-level soccer players. According to the authors, the limited competition for spots on the teams in this league may explain the lack of a RAE among these elite female athletes. More specifically, because there are more males participating in soccer, there is more competition for spots on soccer teams. In contrast, the lower number of females participating in soccer reduces the competition for spots on teams and the coaches are left with a smaller pool to select from. In addition, Delorme et al. observed the same phenomenon as that noted by Vincent and Glamser (2006); puberty among females creates pressure between being popular and being an athlete and may cause early maturing girls to drop out of competitive sports in greater numbers compared to late maturing girls. The end result is a relatively even birthdate distribution across the cohort and no RAEs.

In another study on female soccer players, Delorme, Boiche´, and Raspaud (2010b) investigated the presence of RAEs among 57,892 female soccer players (youth and senior) that participated as part of the French Soccer Federation (FSF) during the 2006-2007 season. The objective of this study was not only to detect RAEs among the different age groups (u8, u10, u12, u14, u17, and adult) during the 2006-2007 season, but also to determine if relative age was a factor among the 15,285 that dropped out of the FSF the following season (2007-2008). Because the cohort had been modified by the FSF (under FIFA regulations), the authors used August 1st as the cut-off date for players born before 1982 and January 1st as the cut-off date for players born in 1982 and later. All birthdates for the players were grouped into quartiles and compared to the general population births of France.

In contrast to previous studies on the asymmetry of birthdate distributions among female soccer players (Delorme et al., 2009; Vincent & Glamser, 2006), a RAE was detected for all age groups in this study, including the adult players. Those born in Q1 and Q2 were overrepresented among this group of female soccer players compared to players born in Q3 and Q4. These results indicated a bias towards the selection of the oldest players in the cohort. The authors pointed out that this study included players of all levels, beginner to elite, in France, whereas the studies by Delorme et al. (2009) involved only adult players competing at the elite national championship level. As noted by Delorme et al. (2010), in contrast to elite male soccer players, the RAE seems to disappear among female soccer players at the highest level of play. The reasons for the discrepancy in RAEs among males and females may be due to social pressures. Like previous researchers (Vincent & Glamser, 2006), the authors of this study suggested social pressures, most prominent among young girls, may contribute to the dropout of early maturing female athletes, which may nullify RAEs. This notion suggests the physical components required for successful athletic performance may not conform to the ideal societal representation of the female body. In addition, soccer may not be considered a feminine sport. Consequently, early maturing female athletes may drop out of sports like soccer when they reach puberty to conform to societal expectations.

The second part of the study by Delorme et al. (2010a) was to determine if the players that dropped out of soccer the following season (2007-2008) were the youngest in the cohort. The authors hypothesized that there would be an overrepresentation of younger players among this group of dropouts compared to their older peers. The authors only included the youth players and no adults for this second part of the study given relative age differences in females dissipate as they reach adulthood. As predicted, the results of the second analysis indicated an overrepresentation of younger females among those who dropped out of the u10, u14, and u17 age groups. However, a similar trend was not detected for the u8 and u12 age groups and younger players were not overrepresented among these young players. The reason for this finding is due to the significant RAE found among the u8 and u12 age groups. Consequently, there was a much smaller group of younger players in these age groups to begin with and, therefore, the number of late born players who did not participate in the following season would have been smaller.

Soccer is a growing sport among females in Switzerland, and this popularity is thought to stem from the success of the men's national teams (Romann & Fuchslocher, 2011). According the 2006 FIFA Big Count, there were 11,000 youth and senior females participating in soccer at various levels. Romann and Fuchslocher conducted a study on all of the females playing soccer in Switzerland to determine RAEs. The make-up of competitive soccer for females in Switzerland consists of three levels. The first level is the Jugend und Sport (J+S), which is an extracurricular program for all girls interested in sport. The players participating in this level range in age from 10 to 20 years of age. The next level is the national talent detection and development program of the J+S. At this level, the players receive coaching from qualified trainers and are expected to train 400 hours per season. The third and highest level are the Swiss national teams, which consist of the under-17 (u17), under -19 (u19), and the senior team (A team). The date of birth of 6,229 female soccer players was collected from the 2007–2008, 2008–2009, and 2009–2010 seasons. The distribution of birthdates was arranged into quartiles using January 1st as the cut-off date. The results of this study indicated significant RAEs for players aged 10 years to 14 years of age at the J+S level. Yet, no RAEs were found in the 15 years to 20 years age groups competing at the J+S level. Among the talent development teams there were similar findings. Significant RAEs were discovered among the 10 years to 14 years of age players and no RAEs for the 15 years to 20 years of age soccer players. In addition, no RAEs were detected for the national teams (u17 and u19). The highest RAEs were found in the u10 and u11 talent development teams, where 66.6% of the players were born in the first half of the cohort.

Romann and Fuchslochers' (2011) explanation for the lack of a RAE found among the majority of female soccer players in Switzerland is based upon female physiology. More specifically, the authors explained that anaerobic capacities, aerobic capacities, and physical performance plateau after menarche. In addition, abilities such as agility, jumping, and kicking, all important skills in soccer, also level-off with the onset of puberty. As a result, benefits typically associated with those born earlier in the cohort are diminished during the middle teenage and adult years in females. In addition, the authors pointed out that late maturing girls typically have an ectomorph build, have less body mass, and less fat tissue compared to early maturing girls; all of which provide an advantage in soccer. Like previous studies on RAEs in female athletes, the authors explained how early development in females may go against feminine stereotypes and cause the oldest in the cohort to drop out of soccer. The result of early maturing girls leaving the game provides greater opportunities for girls born late in the competition year to stay in soccer and develop.

Soccer in Australia is the second most popular team sport, behind netball, among female athletes (youth-61,000, senior-20,000) (Van Den Honert, 2012). In a study using elite youth state soccer team players (under-15 [u15], under-17 [u17]) and senior elite level females (under-20 [u20]) representing their country, Van Den Honert investigated the possibility of RAEs among these elite athletes. The youth players represented their state teams and competed in the national u15 and u17 championship tournament against other states across Australia. The birthdate distribution was grouped into quartiles using January 1st as the cut-off date. Although no statistically significant difference was found among the youth players, the results showed that girls born in the 4th quartile were underrepresented at this elite-level tournament. In contrast, a RAE was detected among the senior female soccer players, and players born in the first quartile of the selection year were overrepresented among these athletes. According to Van Den Honert, the presence of RAE in the senior players is perplexing given the lack of a RAE among the youth players. Because the senior national teams are typically selected from the youth national teams, it would be logical to assume any significant bias against younger players at the youth level would follow through to the senior level. However, this was not the case for the u20 Australian women's national team and the author's explanation for these results was, like Delorme et al. (2009a), linked to competition.

In summary, to date, research on the RAE in women's sports has been equivocal. Because competition in sports is typically higher among males than it is for female athletes, significant RAEs are expected among popular male sports. In contrast, RAEs among female athletes is not as easily predicted. In addition, the timing of menarche in females appears to be a hindrance to athletic ability in sports such as soccer. An increase in fatness and a peak in aerobic and anaerobic capacities associated with menarche, all contribute to a decrement in performance for the oldest in the cohort. Lastly, societal expectations of females also appear to play a significant role in the increased dropout of early maturing females in soccer, nullifying any potential RAEs. Because soccer has traditionally been a male sport comprised of bodily contact, i.e. masculine traits, it is not considered feminine to play soccer. Consequently, early maturing female soccer players choose to leave the game at the time of puberty providing opportunities for girls born late in the cohort to reach the highest level in soccer.

Although several studies have been conducted on RAEs in elite female athletes, there is a limited amount of research on RAEs among elite female soccer players. In addition, there is even less information on the RAE phenomenon among elite youth female soccer players located in the U.S. Vincent & Glamser (2006) examined RAEs in ODP players, which was the highest level of club soccer at the time. However, the growth of youth soccer in the U.S. (“USYSA,” 2013) and the launch and expansion of the Elite Clubs National League (ECNL), has significantly changed the landscape of elite youth female soccer across the U.S. Since the development of the ECNL in 2009 (“ECNL,” 2013), the league has become the highest level of youth soccer for elite females. In addition, the ECNL national competitions act as scouting and identification program for the U.S. Soccer youth national teams. As a result of the developments in elite youth female soccer in the U.S., further research on RAEs is warranted. New information may provide insight into the presence and cause of RAEs in elite youth female soccer players. In addition, the findings from this study will add to the body of knowledge on RAEs in elite youth female athletes.

Summary of RAE in soccer. To summarize, RAEs in youth and professional soccer have been a subject of investigation since the 1990s. In addition, RAEs have been discovered in European and non-European countries alike indicating the cross-cultural presence of this phenomenon. The research reveals that the majority of male athletes that drop out of soccer are born in the latter part of the cohort, indicating a systematic bias toward younger soccer players. Likewise, the majority of male soccer players that reach the highest level in the game are born in the early part of the competition year. Physical attributes and competition for spots on teams are considered the main components that contribute to RAEs in soccer among males. However, bias against the youngest in the cohort has not been established among female soccer players. In fact a reverse RAE has been observed among investigations of RAEs in female soccer players. Whereas early maturation appears to be an advantage among male soccer players, menarche appears to be a limiting factor among female soccer players. The onset of puberty among female athletes is associated with a leveling off or decrement in physical performance. In addition, societal pressures of what is considered feminine also appear to contribute to the oldest in the cohort dropping out of elite level soccer. The consequence of early maturing female soccer players leaving the game provides a pathway for late maturing females to succeed in soccer.

Overall Summary

The RAE was first identified in education when it was discovered that children born earlier in the academic year consistently outperformed their peers born later in the same academic year. Later, during the 1980s, skewed birthdate distributions in favor of older athletes were also found among elite youth ice hockey players, indicating the presence of RAEs in sport. Since that time RAEs have been observed in almost every sport at the youth and senior ages and amateur and professional levels. Sports such as soccer, ice hockey, and basketball have witnessed some of the largest RAEs. In addition, RAEs have also been shown to go beyond team sports with singles tennis and alpine skiing demonstrating asymmetry in birthdate distribution in favor of older athletes. The complexity of this phenomenon has also been shown to go beyond date of birth. The research has demonstrated that not only when a person is born, but also where a person is born can impact future sporting success. According to Côté et al. (2006), the ideal community size for grooming an elite athlete is approximately between 1,000-500,000 people.

Much of the research on RAEs has focused on male athletes. However, more recently there have been a number of researchers who have examined RAEs in females and sport. Although RAEs have been discovered among female athletes, the magnitude is far less than that seen among male athletes. Interestingly, reverse RAEs have also been discovered among elite youth and professional female athletes in sports such as soccer. Studies have indicated competition, maturation, and socialization as some of the main reasons for the lack of RAEs seen in female athletes. Competition for membership on elite level teams has also been cited as one of the main causes for RAEs in males. In the case of males, increased competition for team membership has favored the strongest and fastest athletes, which has typically been the oldest in the cohort. In contrast, the lack of competition for spots on teams among female athletes is believed to be one of the reasons for reduced RAEs and even reverse RAEs. The same pattern for males and females has been shown in elite youth and senior level soccer. More specifically, a high presence of RAEs in soccer has been shown among males of all ages and levels and mixed results among elite female soccer players of all ages and levels.

To date, the majority of the research on RAEs in soccer has focused on European males, from elite youth to senior professional, with a handful of studies examining this phenomenon among European female soccer players. To our knowledge, only three studies have examined RAEs among elite youth soccer players located in the U.S., with two of the three including females (Glamser & Vincent, 2004; Musch, 2002; Vincent & Glamser, 2006). With the growing popularity of soccer in the U.S., current research is needed to examine RAEs among male and female players competing at the highest level of youth soccer.

CHAPTER III

RELATIVE AGE EFFECTS AMONG ELITE YOUTH MALE SOCCER PLAYERS ACROSS THE UNITED STATES

Introduction

Research on relative age effects (RAEs) in sport has grown significantly over the last three decades (Cobley, Baker, Wattie, & McKenna, 2009; Grondin, Deshaies, & Nault, 1984; Musch & Grondin, 2001). Studies have shown that children born at the beginning of the competitive season are overrepresented on elite sports teams and children born toward the end of the playing season are underrepresented.

The consequence of the RAE phenomenon has been a systematic bias against younger athletes and the loss of potential talent. Although no single component has been identified as the main constraining factor leading to an underrepresentation of younger athletes attaining the highest levels in sport, the structure of youth sport has widely been accepted as a key factor in producing RAEs (Cobley et al., 2009). Sport organizations group athletes into cohorts as a way of promoting safety, equality, and the chance for all to succeed. However, this structure produces relative age differences among teammates. For example, if the cohort is August 1st through July 31st, then a child born in August is almost one year older than a child born in July. As the demand for sport specificity increases, particularly during the growth spurt, early maturing boys are favored over late maturing boys for selection (Figueiredo, Gonçalves, Coelho E Silva, & Malina, 2009). Advanced maturation in males has been associated with an increased body size, power, muscular strength, speed, agility, and aerobic capacity (Malina et al., 2000; Vandendriessche et al., 2012). Consequently, the strongest players are identified as talented to the observing coach and selected to the highest level teams. Once selected to elite level teams, the oldest players receive higher level training, better competition, and a motivational support system (parents and coaches) to succeed in the sport.

A significant amount of the research on RAEs has been dedicated to soccer at the elite youth and senior professional levels (Barnsley, Thompson, & Legault, 1992; Helsen, Van Winckel, & Williams, 2005). Much of the research on RAEs in soccer has been conducted on European soccer players (Delorme, Boiche´ & Raspaud, 2010; Helsen, Starkes, & Van Winckel, 1998, Helsen, Van Winckel, & Williams, 2005; Jiménez & Pain, 2008). To date, only a handful of studies on the RAEs in elite youth soccer have been conducted on elite youth soccer players across the U.S. (Glamser & Vincent, 2004; Musch, 2002; Vincent & Glamser, 2006). Therefore, the purpose of this study is to determine if the birthdate distribution among elite male youth soccer players competing in the U.S. Soccer Developmental Academy are significantly different from the general population. An overrepresentation of players born early in the cohort and an underrepresentation of younger players would indicate the presence of RAEs among this group of elite athletes. It was hypothesized that a statistically significant RAE is present among this group of elite level youth soccer players, indicating a bias against the selection of soccer players born late in the cohort.

Methods

Participants

Amateur elite youth male soccer players competing in the u15/16 (*n* = 1,724) and u17/18 (*n* = 1,494) age groups in the USSDA during the 2012-2013 season were included in this study. The USSDA, launched in 2007, is a partnership between the United States Soccer Federation (USSF) and elite youth clubs around the U.S. Admission into the Academy is based upon club performance history. All Academy teams were scouted a minimum of 10 times/games per season by U.S. National Team coaches and the best players were recommended for selection to the U.S. Youth National Teams. For the 2012/2013 season, 80 of the highest level youth clubs across the country were selected to participate in the Academy league. Each team played approximately 30 games between September and July. The league was comprised of 3 conferences (East, Central, and West) and 7 divisions. Each club was required to have a minimum of 36 players on the roster. Before the beginning of the season, each club in the Academy held tryouts within each age group. Any male player within the specified birthdate range was eligible to tryout for an Academy team regardless of place of residence or citizenship.

Procedures

The birthdate for each player was collected from the individual team web pages from the U.S Soccer Academy web site (www.academy.demosphere.com). The birthdate of each player was public information and no private details were recorded for this study. The birthdates of each player were compared to the birthdates of males in the general U.S. population born during the same years as the players. The birthdate range for the

2012/2013 U.S Soccer Academy player was from1994-1999. The census birthdates were collected from the Center for Disease and Control and Prevention (CDC) vital statistics reports, which was retrieved from the CDC website (www.cdc.gov/nchs/vitalstats.htm). The vital statistics reports are made available to the public and contain no private information. The birthdates for the players and males in the general population were organized into quartiles based upon the U.S Soccer Academy competition year of January 1st –December 31st. All birthdates were coded as follows: Q1 = January-March, Q2 = April- June, Q3 = July-September and Q4 = October-December. In addition, half-season analyses were conducted, where the first half of the season was the combination of Q1 and Q2 and the second half of the season was Q3 and Q4.

Statistical Analyses

All data analyses were conducted using IBM SPSS predictive analytics software (Version 20; IBM Inc.,USA). A series of chi-square ($\chi 2$) goodness-of-fit tests were used to determine differences between the observed birth in the cohort and the expected birth month distributions for the births of males born in the U.S. from 1994-1999 (the same years as the players). The dependent variable for each analysis was the frequency of soccer players born in each quartile per age group. The level of significance was set at $p < .05$. Statistically significant chi-square ($\chi 2$) values were used to calculate an effect size *w* statistic to determine the strength of the RAE. According to Cohen (1992), the following *w* values indicated the effect sizes: small = 0.1, medium = 0.3, large = 0.5. Post-hoc analyses were conducted for *w* values ≥ 0.1. Lastly, for statistically significant chi-square ($\chi 2$) values, standardized residuals were used to determine which observed birthdate quartiles differed from the expected distribution (Turnnidge, Hancock, Côté, 2012). A value of ≥ 1.96 indicated an overrepresentation of births in the quartile and a value of ≤ - 1.96 indicated an underrepresentation of births in the quartile (Sheskin, 2003).

Results

The birthdate distributions for the u15/16 and the u17/18 boys competing in the U.S. Developmental Academy (USDA) and the birthdate distributions for the general population are presented in Table 1, along with the results of the chi-square test, effect size, and standardized residuals. The chi-square analysis indicated a statistical difference between the observed and expected quartile distributions for all of the age groups, indicating significant RAEs: (u15/16) $\chi 2$ (3, n = 1724) = 90.26, $p < .001$ and (u17/18) $\chi 2$ (3, n = 1494) = 34.17, $p < .001$. When compared to the general population birth distribution, the chi-square test and the post hoc analyses revealed an overrepresentation of players born at the beginning of the cohort and an underrepresentation of players born at the end of the selection year for u15/16 age group. The standardized residuals for the u15/16 age group showed an overrepresentation of players born in Q1 and an underrepresentation of players born in Q2 and Q4. Among the players in the u17/18 age group, the chi-square analyses revealed an underrepresentation of players born toward the middle of the selection year and an overrepresentation of players born at the beginning and the end of the selection year. In the u17/18 age group, the standardized residuals indicated an overrepresentation of players born in Q1 and Q4 and an underrepresentation

Table 1

Birth Quartiles for the u15/16 and u17/18 USSDA Boys' Age Groups

		Percent in quartiles							Standardized residuals			
Age group		Q1	Q2	Q3	Q4	X^2	p	w	Q1	Q2	Q3	Q4
U15/16 (n = 1,724)	OBS%	34	22	24	20	90.26*	< .001	0.23	8.13	- 2.13	- 1.84	- 4.02
	EXP%	24	25	26	25							
U17/18 (n = 1,494)	OBS%	27	19	26	28	34.17*	< .001	0.15	2.22	- 4.62	- 0.34	2.79
	EXP%	24	25	26	25							

Note. OBS = observed; EXP = expected (general population)
*p < .05
df = 3 for each chi-square test

Table 2

Half-Season Births for the USSDA u15/17 and u17/18 Boys' Age Groups

		Percent in halves					Standardized residuals	
Age groups		1st	2nd	X^2	*p*	*w*	1st	2nd
u15/16 (*n* = 1,724)	OBS	56	44	34.50*	< .001	0.14	4.19	- 4.11
	EXP	49	51					
u17/18 (*n* = 1,494)	OBS	46	54	5.88*	.015	0.06	- 1.73	1.70
	EXP	49	51					

Note. OBS = observed; EXP = expected (general population)
$*p < .05$
$df = 1$ for each chi-square test

of players born in Q2. The largest effect size was associated with the u15/16 age group (w = .23). According to the analysis, the magnitude of the effect size decreased as age increased.

In Table 2, the birthdate distribution for each half of the season (January - June and July - December) is presented, together with results of the chi-square test, effect sizes, and standardized residuals. A comparison of the birthdate distribution for the first and second halves of the playing season with the general population birthdate distribution, indicated a statistical difference for the (u15/16) $\chi 2$ (1, n = 1724) = 34.50, $p < .001$ and the (u17/18) $\chi 2$ (1, n = 1494) = 5.88, p = .015 age groups. The analysis revealed the majority of the players selected for the u15/16 age group was born between January and June. The standardized residuals for the u15/16 age group indicated an overrepresentation of players born in the first half of the cohort and an underrepresentation of players born in the second half of the cohort. In contrast, the u17/18 age group indicated the majority of players selected were born between July and December. Despite the chi-square test's significance, the residuals for the u17/18 age group did not indicate any difference between players born in the first and second halves of the cohort. The effect size for the half-season distributions of the u15/16 was small (w = .14) and a decrease in the magnitude of the effect size was observed as age increased (w = .06).

Discussion

Previous research investigating the presence of RAEs among elite male athletes has demonstrated a clear bias toward the selection of athletes born earlier in the cohort. Among elite level youth and professional soccer players across Europe, a RAE has been a consistent phenomenon (Ostapczuk & Musch, 2013; Helsen, Van Winckel, & Williams, 2005). Therefore, the purpose of this study was to determine if a RAE existed among boys competing in USSDA. It was hypothesized that boys born earlier in the cohort would be overrepresented across the league and boys born later in the cohort would be underrepresented. The hypothesis was partially supported with a RAE detected among the u15/16 boys. Players born in Q1 were overrepresented while boys born in Q2 and Q4 were underrepresented in the u15/16 age group. Among the u17/18 age group, a less clear pattern was observed with an overrepresentation of players in Q1 and Q4, and an underrepresentation of players born in Q2. Interestingly, Q4 had the highest percentage of players (28%) represented in the u17/18 age group. The effect sizes indicated the strength of the RAE was moderate in the u15/16 age group. For the u17/18 age group, the strength of the relationship was small.

In the u15/16 age group, asymmetry in the birthdate distribution demonstrated a clear bias toward the selection of older players. Boys born later in the selection year were less likely to gain an opportunity to compete in the u15/16 age group in this highly competitive league. A number of studies on RAEs among elite youth male soccer players have demonstrated similar results (for an extensive review see Cobley et al., 2009; Musch & Grondin, 2001). Helsen, Van Winckel, and Williams (2005) examined RAEs in elite youth soccer players representing 10 countries across Europe. An over-representation of players born in Q1 was detected among all of the u15, u16, u17, and u18 youth national teams. Similar to the Helsen et al. study, the highest percentage of birthdates among the u15/16 players competing in the USSDA observed was in Q1 (34%). The lowest percentage in this age group was seen in Q4 (20%). This finding represents a traditional RAE, where the oldest in the cohort are considered talented and the youngest are categorized as lacking the ability to compete at a high level. The birthdate distribution for the first and second halves of the playing season also indicated strong RAEs among the u15/16 boys. The majority (56%) of the u15/16 players selected to USSDA teams were born between January and June. The analysis showed an overrepresentation of boys born in the first half of the season and an underrepresentation of players born between July and December (44%).

Maturation and competition may be the two principal mechanisms responsible for the RAE observed among the u15/16 age groups in the USSDA. Players born closer to the cut-off date within a cohort typically mature earlier than players born toward the end of the cohort. Puberty among boys results in an increase in testosterone, which leads to an increase in strength, power, and aerobic capacity. Boys with the greatest physical attributes are seen as potential talent and selected to elite-level teams (Malina et al., 2000). As a result, these players receive advanced training, increased competition, motivation, and feedback; all contributing factors to a developmental pathway in sport. In contrast, late maturing boys are identified as having inferior ability and limited potential. The consequence of a late birthdate is exclusion from participating in elite level soccer. Furthermore, highly trained soccer players with similar anthropometric and physical performance profiles at age 12 years, have shown to be dissimilar by 16 years of age (Buchheit & Mendez-Villanueva, 2013). This highlights the limitation of physical precocity as a worthwhile predictor of future talent.

Competition has been identified as a necessary component for RAEs to occur (Musch & Grondin, 2001). The greater the competition for spots on a team the larger the magnitude of RAEs (Cobley et al., 2009). The USSDA is seen as the highest level of youth soccer for males across the country. The league has become the main recruiting ground among college soccer coaches and players compete for a national championship. To highlight the competitiveness of the USSDA, the U.S. Soccer youth national teams consist primarily of players from the USSDA: u15 (71%), u17 (68%), and u18 (88%) ("US Soccer," 2013). The consequence of a competitive structure at a young age is an early identification process. This places pressure on coaches to select players considered good enough to compete at the highest level. It appears the criteria used for selection of young players may be based on characteristics observed in adults. More specifically, because strength, power, and speed are integral components observed at the senior elite level, youth coaches may interpret physical precocity in youth players as a predictor of future talent.

Among the u17/18 age group players, an atypical age distribution pattern was observed. A relatively even distribution of players was seen among Q1 (27%), Q3 (26%) and Q4 (28%), with the fewest number of players represented in Q2 (19%). The results indicated an overrepresentation of players born between January and March and between October and December, and an underrepresentation of players born between April and June. The reasons for these findings were not clear. Therefore, additional analyses were conducted to provide insight into the birthdate pattern observed among this age group. Many of the players participating in the u17/18 USSDA had been selected from club teams. The USSDA league complies with Fédération Internationale de Football Association (FIFA) rules and uses January 1st as the cut-off date, whereas the cut-off date for the club system in the U.S. is August 1st. Analysis of the birthdate distribution for u17/18 age group using August 1st as a cut-off date revealed a statistically significant traditional RAE. Between Q1 and Q4, a linear decline in birthdate distribution was observed. Under the club system cohort analysis, the majority of the players were born in Q1 (30%) and the least number of players were born in Q4 (18%). Furthermore, players in Q1 and Q2 were overrepresented and players from Q4 were underrepresented.

The U.S. club system uses two-year age bands and a player born between August 1st and December 31st in 1996, for example, and a player born between

January 1st and July 31st of 1997, would be on the same team. However, under the USSDA cohort, club players born between August 1st and December 31st in 1996 are required to participate only with players born in the same year. Consequently, a club player selected to a USSDA team born between August 1st and December 31st would be classified as one of the younger players. A club player born between January 1st and July 31st would be considered one of the older players in the USSDA. When applying an August 1st cut-off date to the USSDA u17/18 age group, almost 60% of the boys were born between August and January. It is assumed the majority of these players would be selected to a USSDA team, given they were the best players in their club teams. Therefore, this may shed some light on the unusual birthdate distribution observed in the u17/18 USSDA. It should be noted that when the August 1st cut-off date was applied to the u15/16 age group, a traditional RAE was not observed.

The results from this study on the USSDA u17/18 age group are in contrast to those found among 17 year old male Olympic Development Program (ODP) state and regional team players and U.S. national team soccer players (Vincent & Glamser, 2006). Like the current study, the players examined by Vincent and Glamser also came from a club system that used August 1st as a cut-off date and were placed into a cohort (ODP state and regional, and U.S. national team) that used January 1st as a cut-off date. However, the authors found strong RAEs among all levels examined. Vincent and Glamser attributed advanced maturation among the oldest players in the cohort as the key mechanism contributing to RAEs among this group of elite level athletes.

The birthdate distribution for the first and second halves of the playing season for the u17/18 age group were statistically different. The majority of the players (54%) were born in the latter half of the cohort. However, the difference was not enough to indicate a clear overrepresentation or underrepresentation of either half. The lack of a RAE found among the u17/18 age group players may again be due to the difference in the cut-off date from club level to the USSDA. These results, however, are in contrast to the majority of studies conducted on RAEs among elite youth soccer players worldwide (Cobley et al., 2009; Helsen et al., 2005; Helsen et al., 1998). A RAE was detected among elite male Australian u14, u15, u17, and u20 soccer players (Van den Honert, 2012). It is believed boys born at the end of the selection year may experience reduced opportunities to reach the highest level in the game in Australia. Asymmetry in birthdate distribution was also identified among elite youth Spanish players, where an overrepresentation of players born toward the beginning of the selection year was detected (Del Campo, Vicedo, Villora, & Jordan, 2010). Earlier maturation among the oldest in the cohort was considered one of the main causes for a bias toward the selection of older Spanish youth players. In addition, it was believed that elite level clubs in Spain have a superior identification and selection system. As a result, competition for spots on the professional Academy teams in Spain contributed to the RAEs discovered.

Although no RAE was detected among the u17/18 age group players in the current study, there is concern that the RAE found among the u15/16 players will have a carry-on effect when these players reach the u17/18 age group. Relative age effects have been shown to perpetuate from elite youth players to senior professionals (Cobley et al., 2009). The lack of a RAE found among the u17/18 age group is unclear and the correlation between the club cut-off date (August 1st) and the USSDA cut-off date (January 1st) may be a factor. Helsen, Starkes, and Van Winckel (2000) observed RAEs among elite level youth soccer players aged 10-18 years of age after the cut-off date had been changed from August 1st to January 1st in Belgium. Since 1997, FIFA, which is the international governing body for soccer worldwide, changed the selection cut-off date from August 1st to January 1st. Helsen et al. found RAEs among the 10-16 year old players that were placed under the January 1st selection year. However, among players aged 16-18 years, who previously followed the August 1st cut-off date, no RAE was detected when using January 1st as the new start of the selection year. It's possible, according to Helsen et al., that players born between January and July, under the previous cut-off date of August 1st, may have dropped out of the sport before 1997, nullifying any RAEs.

As the USSDA expands in the 2013-2014 season with the addition of a u13/14 age group, further research is required to determine the influence of RAEs. Given the growth of the USSDA since its inaugural season in 2007, and the growth of soccer across the U.S. ("USYSA," 2013), it's possible the RAE trend found among

European soccer players may be replicated in the U.S. For that reason, it is important that coaches and administrators of soccer are educated on the deleterious effects of the RAE phenomenon and find ways to combat against discrimination against players born at the end of the selection year.

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CHAPTER IV

RELATIVE AGE EFFECT AMONG ELITE YOUTH FEMALE SOCCER PLAYERS ACROSS THE UNITED STATES

Introduction

The relative age effect (RAE) in sport refers to a bias in distribution of athletes selected to elite level teams. More specifically, there is an overrepresentation of athletes born at the beginning of the competition year and an underrepresentation of athletes born at end of the competition year. The RAE phenomenon has been examined in sport since the early 1980s (Grondin, Deshaies, & Nault, 1984). The majority of studies on RAEs have been conducted on male athletes and soccer has been characterized as a sport associated with significant RAEs (Cobley, Baker, Wattie, & McKenna, 2009).

The existence of RAEs among female athletes has yet to be confirmed. Furthermore, despite the growth in women's soccer around the world and the wealth of research published on RAEs in soccer (Delorme, Boiche´ & Raspaud, 2010; Helsen, Starkes & Van Winckel, 1998, Helsen, Van Winckel & Williams, 2005; Jiménez & Pain, 2008), there are significantly fewer studies that examine this phenomenon among female soccer players. Between 2000 and 2006, the number of registered females playing soccer had increased 54% to a total of 26 million players.

The discrepancy in the findings on RAEs among females is highlighted by the results of Delorme, Boiche´, and Raspaud (2010) and Goldschmied (2011). Delorme et al. discovered RAEs among female youth and senior soccer players competing in France. In contrast, Goldschmied found no RAEs among players competing in the Women's United Soccer Association (WUSA). The advantages of early maturation, such as improved speed and increased aerobic capacity, observed among male youth soccer players, is not necessarily beneficial to early maturing female athletes. Maturation among females is associated with an increase in fatness and a peak in aerobic capacity, which may contribute to a decrement in athletic performance (Rowland, 2005).

In addition, although women's soccer has increased in popularity, competition for spots on elite level teams is less when compared to males. As a result, the selection pool is reduced and competition is decreased resulting in a reduced bias toward the oldest in the cohort. Socialization has also been identified as a potential cause for the lack of RAEs found among females athletes. Because soccer is considered a masculine sport and puberty among females highlights their femininity, the two are not compatible within society (Delorme et al., 2010). In some cases, early maturing female athletes drop out of soccer due to societal pressures associated with maturation. This allows late maturing female athletes an opportunity to succeed in the game and may explain, in part, the mixed results found in RAEs among females.

Therefore, the purpose of this study was to determine if the birthdate distribution among elite female youth soccer players competing in the Elite Clubs National League (ECNL) is significantly different from the general population. An overrepresentation of players born early in the cohort and an underrepresentation of younger players would indicate the presence of RAEs among this group of elite athletes. It was hypothesized that a statistically significant RAE would be present among this group of elite level youth soccer players, indicating a bias against the selection of soccer players born late in the cohort.

Methods

Participants

Amateur elite youth female soccer players competing in the u14, u15, u16, u17, and u18 (N = 7,294) age groups in the ECNL during the 2012-2013 season were used in this study. The ECNL is considered the highest level of club soccer in the U.S. and is made up of 73 clubs across the country. Individual clubs are accepted to the ECNL based upon performance history. The ECNL also acts as a platform for identification of players to the U.S. youth national teams. The season for ECNL teams started in September, 2012 and culminated in the championship finals on July 10-15, 2013. The players competing in the ECNL range in age from 13 to 18 years of age and have all been selected and placed on a team after a series of trials. Any female player within the specified birthdate range is eligible to tryout for an ECNL team regardless of place of residence or citizenship.

Procedures

The birthdate for each player was collected from the individual team web pages from the ECNL web site (www.eliteclubsnationalleague.com). The u14-u17 age groups can roster a maximum of 26 players and the u18 age group can roster a maximum of 30 players. The birthdate of each player is public information, and no private details were recorded. The birthdates of each player were compared to the birthdates of females in the general U.S. population born during the same years as the players. The birthdate range for the 2012/2013 ECNL players is 1992-1999. It should be noted that a player born between 8/1/1992 and 7/31/1993 can participate in the u18 age group as long as she is still in high school. The census birthdates were collected from the Center for Disease and Control and Prevention (CDC) vital statistics reports, which can be found on the CDC website (www.cdc.gov/nchs/vitalstats.htm). The vital statistics reports are made available to the public and contain no private information. The birthdates for the players and females in the general population were organized into quartiles based upon the ECNL competition year of August 1st – July 31st. All birthdates were coded as follows: Q1 = August-October, Q2 = November- January, Q3 = February-April and Q4 = May-July.

Statistical Analyses

All data analyses were conducted using IBM SPSS predictive analytics software (Version 20; IBM Inc.,USA). Each age group was analyzed for asymmetry in birthdate distributions. A series of chi-square ($\chi2$) goodness-of-fit tests were used to determine differences between the observed birth months across the playing season (August-July) and expected birth month distributions for the births of females born in the U.S. from 1992-1999 (the same years as the players). The dependent variable for each analysis was the frequency of soccer players born in each quartile per age group. The level of significance was set at $p < .05$. Statistically significant chi-square ($\chi 2$) values were used to calculate an effect size *w* statistic to determine the strength of the RAE. According to Cohen (1992), the following *w* values indicate the effect sizes: small = 0.1, medium = 0.3, large = 0.5. Post-hoc analyses were conducted for *w* values ≥ 0.1. Lastly, for statistically significant chi-square ($\chi 2$) values, standardized residuals were used to determine which observed birthdate quartiles differed from the expected distribution (Turnnidge, Hancock, & Côté, 2012). A value of ≥ 1.96 indicates an overrepresentation births in the quartile and a value ≤ -1.96 indicates an underrepresentation of births in the quartile (Sheskin, 2003).

Results

The birthdate distributions for the u14-u18 girls competing in the ECNL and the birthdate distributions for the general population are presented in Table 1, along with the results of the chi-square test, effect sizes, and standardized residuals. The chi-square analysis indicated a statistical difference between the observed and expected quartile distributions for all of the age groups, indicating significant RAEs: (u14) $\chi 2$ (3, n = 1,443) = 133.30, $p < .001$; (u15) $\chi 2$ (3, n = 1,423) = 103.47, $p < .001$; (u16) $\chi 2$ (3, n = 1,458) = 82.01, $p < .001$; (u17) $\chi 2$ (3, n = 1,456) = 70.00 , $p < .001$;

(u18) $\chi 2$ (3, n = 1,514) = 17.09, $p < .001$. When compared to the general population birth distribution, the chi-square test and the post hoc analyses revealed an overrepresentation of players born at the beginning of the cohort and an underrepresentation of players born at the end of the selection year for all age groups. The standardized residuals showed an overrepresentation of players born in Q1 and an underrepresentation of players born in Q4 for the u14, u15, u16, and u17 age groups. In the u18 age group, the residuals indicated an overrepresentation of players born in Q2 and an underrepresentation of players born in Q4. The effect sizes ranged from small (.10) to moderate (.30) with the largest effect sizes associated with the u14 age group (.30). According to the analysis, the magnitude of the effect size decreased as age increased.

In Table 2, the birthdate distribution for each half of the season (August-January and February-July) is presented, together with results of the chi-square tests, effect sizes, and standardized residuals. A comparison of the birthdate distribution for the first and second halves of the playing season with the general population birthdate distribution, indicated a statistical difference for the following age groups: (u14) $\chi 2$ (1, n = 1,443) = 113.40, $p < .001$, (u15) $\chi 2$ (1, n = 1,423) = 85.48, $p < .001$; (u16) $\chi 2$ (1, n = 1,458) = 53.62, $p < .001$; and (u17) $\chi 2$ (1, n = 1,456) = 47.26 , $p <$ .001. The analysis revealed the majority of the players selected for the u14-u17 age groups were born between August and January. No statistical significant difference was observed in the (u18) $\chi 2$ (1, n = 1,514) = 3.63, $p = .056$ age group. The standardized residuals for the u14, u15, u16, and u17 age groups showed an overrepresentation of players born in the first half of the cohort and an underrepresentation of players born in the second half of the cohort. The effect sizes for the half-season distributions for the u14-u17 age groups were small to moderate and a decrease in the magnitude of the effect size was observed as age increased.

Table 1

Birth Quartiles for the u14-u18 ECNL Girls' Age Groups

		Percent in quartiles							Standardized residuals			
Age group		Q1	Q2	Q3	Q4	X^2	*p*	*w*	Q1	Q2	Q3	Q4
u14 (*n* = 1,443)	OBS%	36	28	20	15	133.30*	< .001	0.30	7.62	2.90	- 3.06	- 7.58
	EXP%	26	25	24	25							
u15 (*n* = 1,423)	OBS%	34	29	22	16	103.47*	< .001	0.27	5.78	3.40	- 1.74	- 7.45
	EXP%	26	25	24	26							
u16 (*n* = 1,458)	OBS%	34	26	23	17	82.01*	< .001	0.23	6.30	0.92	- 0.88	- 6.40
	EXP%	26	24	24	26							
u17 (*n* = 1,456)	OBS%	34	26	23	18	70.00*	< .001	0.22	5.60	1.17	- 0.76	- 6.07
	EXP%	26	24	24	26							
u18 (*n* = 1,514)	OBS%	25	28	25	22	17.09*	< .001	0.10	- 0.67	2.63	1.08	- 2.93
	EXP%	26	24	24	26							

Note. OBS = observed; EXP = expected (general population)
$*p < .05$
$df = 3$ for each chi-square test

Table 2

Half-Season Births for the ECNL u14-u18 Girls' Age Groups

		Percent in halves					Standardized residuals	
Age group		1st	2nd	X^2	*p*	*w*	1st	2nd
u14 (*n* = 1,443)	OBS%	65	35	113.40*	< .001	0.28	7.48	- 7.57
	EXP%	51	49					
u15 (*n* = 1,423)	OBS%	63	37	85.48*	< .001	0.24	6.50	- 6.56
	EXP%	50	50					
u16 (*n* = 1,458)	OBS%	60	40	53.62*	< .001	0.19	5.15	- 5.20
	EXP%	50	50					
u17 (*n* = 1,456)	OBS%	59	41	47.26*	< .001	0.18	4.83	- 4.88
	EXP%	50	50					
u18 (*n* = 1,514)	OBS%	53	47	3.63	.056	0.04	1.34	- 1.35
	EXP%	50	50					

Note. OBS = observed; EXP = expected (general population)
$*p < .05$
$df = 1$ for each chi-square test

Discussion

Previous research investigating the presence of RAE among female athletes has been inconclusive. Therefore, the objective of this study was to determine if a RAE existed among girls competing in the ECNL during the 2012-2013 season. It was hypothesized that girls born earlier in the cohort would be overrepresented across the league and girls born later in the cohort would be underrepresented. The hypothesis was supported among all age groups (u14-u18) in the ECNL. Girls born closer to the beginning of the selection year were more likely to be selected to teams in the ECNL. In contrast, girls born toward the end of the selection year were less likely to be offered a spot on a team in the ECNL during the 2012-2013 season. Among the u14-u17 age groups, a traditional RAE existed with an overrepresentation of players born in Q1 and an underrepresentation of players born in Q4. In the u18 age group, players born in Q2 were overrepresented while the youngest in the cohort, players born in Q4, were underrepresented. The effect sizes indicated the strength of the RAEs were most prominent during the early stages of player development and decreased as players aged.

The results of this study indicate strong RAEs exists among elite level youth female soccer players in the U.S. To our knowledge, this is the first study on RAEs to demonstrate such a pattern among elite youth female soccer players. Romann and Fuchslocher (2013) found significant RAEs among female soccer players competing in the 2008 and 2010 FIFA U-17 Women's World Cups, when the countries were grouped and analyzed into geographical zones (Europe, North and Central America). However, a RAE was observed in only four of the 22 individual countries competing in these events.

In contrast to the current study, Vincent and Glamser (2006) found weak RAEs among female state and regional ODP players and u19 U.S. national team players. Despite soccer being the second most popular sport in Australia among females, no RAEs were observed among u15 and u17 girls competing in the National Championships (Van den Honert, 2012).

The reason for the systematic RAEs observed in this study is unclear. Traditional explanations for RAEs in sport have linked birthdate with maturation. More specifically, traditional RAEs among males indicate that those born earlier in the cohort are assumed to mature earlier than the youngest in the cohort. Maturation among males is associated with an increase in testosterone and muscle mass, resulting in an increase in power, strength, and speed; all beneficial for athletic performance (Rowland, 2005). Among females, however, maturation is associated with a decrement in athletic performance due to an increase in fat mass and a peak in aerobic capacity. The oldest females in a cohort have been shown to be disadvantaged in sport and reverse RAEs have been documented (Goldschmied, 2011; Till et al., 2010). The only anthropometric benefit gained with early maturation among females is height. The average peak height velocity for girls is 12 years of age and girls that go through an early growth spurt may have an advantage in sport (Beunen & Malina, 1998). Although speculative, when two soccer players look similar in skill level, it’s possible the coach may perceive the taller of the two players as more talented.

Competition for spots on teams may be the leading cause for the RAEs detected among all of the age groups in the ECNL. Competition is a necessary component for

RAEs to occur in sport and the strongest RAEs have been detected among the most popular sports worldwide (Cobley et al., 2009; Musch & Grondin, 2001; Schorer et al., 2009). More specifically, the greater the number of potential players vying for selection to teams, the more likely there will be RAEs. According to the United States Youth Soccer Association (USYA), which registers approximately 85% of all youth soccer players (aged 5-19 years of age) in the U.S., there are 3,000,000 youth soccer players competing across the country ("USYSA," 2013). Almost half of these players are female, underlining the popularity of soccer in the U.S among girls. Grondin et al. (1984) showed strong RAEs among youth ice hockey players from the largest cities in Canada where competition was the highest. In contrast, weak RAEs were detected among volleyball players in Canada, where the selection pool was much smaller. Lidor et al. (2013) found no RAEs among female basketball, handball, soccer, and volleyball players in Israel. The authors hypothesized the lack of competition, due to the small population size, would nullify any RAEs. Yet, in Brazil, where volleyball is considered a highly competitive sport, strong RAEs were found among elite female volleyball players competing at the highest level of play (Ozaki et al., 2011).

The ECNL is considered the highest level of elite youth soccer among females in the U.S. Selection to an ECNL team can provide increased competition, where players get the opportunity to compete on a national level. In addition, the ECNL has become the primary setting for player identification and recruitment among college soccer coaches. As a result, young female soccer players with aspirations to compete at the collegiate level may feel the ECNL is the most effective way to gain exposure to college soccer coaches nationwide. The consequence is an increase in competition among the players for selection to the teams and the outcome is an overrepresentation of players from Q1 and an underrepresentation of players from Q4. To further highlight the competitiveness of this league, the majority of girls listed among the player pools for the 2013 U.S. National u15, u17, u18, and u20 teams (u15 [64%], u17 [72%], u18 [71%], and u20 [82%]) were selected from ECNL clubs ("US Soccer," 2013).

The birthdate distribution for the first and second halves of the playing season also indicated strong RAEs among the u14-u17 age groups. However, no statistically significant difference was found among the u18 age group. Players born between August and January were overrepresented among the u14-u17 teams, while players born between February and July were underrepresented, indicating a preference for the selection of older players. The proportion of players born in the first half of the season was highest among the u14s (65%) and decreased as age increased. The data also showed that the magnitude of the RAE decreased over time. The strength of the relationship was the largest among the u14s and the smallest among the u18s. Schorer, Cobley, Büsch, Bräutigam, and Baker (2009) observed a similar pattern among elite level handball players competing in Germany, where handball is a popular sport. It appears that the greatest level of bias against players born later in the cohort occurs during the early years of competition. However, this trend seems to dissipate as players get older.

The bias towards the selection of players born during the first half of the cohort among u14-u17 teams might be due to the coaches' perception that older players are more talented than their younger counterparts (Helsen, Starkes, & Van Winckel, 1998; Romann & Fuchslocher, 2011). As a result, players selected to elite-level soccer teams receive the benefits of increased competition, feedback, and higher levels of coaching (Baker, Horton, Robertson-Wilson, & Wall, 2003; Wattie, Cobley, & Baker, 2008). Subsequently, players selected to elite teams at a younger age may have an advantage in future selections, as these players gain greater exposure to more high-level coaches, perpetuating the RAE during the formative years. In addition, self-motivation is highest among athletes who perceive themselves as competent in their sport (Ward et al., 2007). Highly motivated athletes typically invest a greater amount of time and effort into developing their skills compared to athletes who do not perceive themselves as competent to compete at a high level in sport (Harter, 1978; Vincent & Glamser, 2006).

The evidence from this study indicates a clear bias toward the selection of older girls among teams participating in the ECNL. Girls born late in the cohort are less likely to be given an opportunity to participate in this elite level league. The consequence is a loss of potential talent and emphasizes the need for additional research to examine the mechanisms contributing to RAEs among females in sport. Helsen and colleagues have suggested coaching education as one approach to combat against the negative impact of RAEs in elite youth soccer (Barnsley et al., 1992; Helsen, Starkes, & Van Winckel, 2000; Helsen et al., 2005; Musch & Grondin, 2001). Cobley et al. (2009) suggested player identification and selection place greater reliance on skill and movement rather than anthropometric components. However, as evidenced in professional soccer in Europe, despite 10 years of research on RAEs, there seems to be no change in the prevalence on this phenomenon among elite athletes (Helsen et al., 2012).

Chapter IV References

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CHAPTER V

PROJECT CONCLUSIONS

Most school systems organize students into annual cohorts or grades based upon chronological age. A cut-off date is specified for each grade to avoid significant differences among students and provide equal opportunity for success (Musch & Grondin, 2001). However, if the school year cut-off date is August 1st, then a student born on August 3rd is almost one year older than a student born on July 31st, and both students are placed in the same cohort. The difference in age between two students in the same cohort has been called *relative age*. The consequence of the difference has been referred to as RAEs and studies have indicated the youngest in the cohort underperform academically compared to their older peers (Cobley et al., 2009). The main reasons attributed to RAEs observed in education are not clear and several theories exist from the gestational hypothesis, length of schooling, and the maturational hypothesis (Bergrund, 1967; Fogelman & Gorbach, 1978; Orme, 1963). In brief, the youngest in the cohort are believed to be disadvantaged compared to older students.

Relative age effects have also been observed in the sport domain. The prevalence of RAEs among elite athletes worldwide is robust and has led to a large body of research addressing this phenomenon (Cobley et al., 2009; Musch & Grondin, 2001). The organization of athletes into annual age groups, based upon chronological age, has resulted in disparity. The consequence of the differences has led to a bias in favor of athletes born closer to the beginning of the selection year. Evidence of skewed birthdate distributions among elite athletes has indicated a systematic discrimination against athletes born toward the end of the cohort. Variations in growth and development have been highlighted as some of the key mechanisms leading to RAEs in sport (Baxter-Jones, 1995). In addition, the magnitude of RAEs has been influenced by skill level (elite or non-elite), competition, and sport context. The strongest RAEs have been observed in elite-level ice hockey, soccer, and basketball (Cobley et al., 2009). Weak RAEs and reverse RAEs have been observed in individual sports such as gymnastics, dance domain, and shooting sports (Cobley et al., 2009; Delorme & Raspaud, 2009b; Musch & Grondin, 2001). For many researchers, competition is a necessary component for RAEs to occur (Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009).

A significant amount of the research on RAEs has been conducted on soccer players worldwide (Cobley et al., 2009). Because soccer is the most popular sport in most countries across Europe and South America, strong RAEs have been detected among elite level male players as young as 12 years of age (Helsen et al., 1998). However, the research on RAEs among female athletes is less clear. To date, only a handful of studies have examined the presence of RAEs among elite female soccer players, and only three studies have researched players in the U.S. Therefore, the purpose of this dissertation was to examine the birthdate distribution of elite male and female soccer players across the U.S.

The main objective of the first study was to examine the birthdate distribution of elite male soccer players competing in the USSDA and determine if RAEs existed. A total of 3,218 players (u15/16:1,724; u17/18:1,494) were included in the analysis. It was hypothesized that a strong RAE would exist among all of the age groups. Similar to previous research on RAEs among male soccer players (Delorme et al., 2010a; Glamser & Vincent, 2004), it was predicted that players born earlier in the cohort would be overrepresented and players born later in the cohort would be underrepresented. The results indicated a strong RAE among the u15/16 age group when analyzed into quartiles and halves. A bias toward the selection of older players was present in this age group. Maturation and competition may be the key mechanisms that contributed to the strong RAEs discovered among these boys. In contrast, no RAE was found among the players in the u17/18 age group. Interestingly, the largest percentage of players in the u18 age group was born in the last three months of the cohort. The difference between the club season cut-off date (August 1st) and the USSDA cut- off date (January 1st) may have contributed to the unusual birthdate distribution pattern observed in the u17/18 age group.

The purpose of the second study was to determine if a RAE was present among female soccer players aged 13-18 years of age competing in the ECNL during the 2012-2013 season. The sample consisted of 7,294 players. It was hypothesized that players born earlier in the cohort would be overrepresented and players born toward the end of the cohort would be underrepresented, when compared to the birthdate distribution of the general population. The results indicated a statistically significant difference in the birthdate distribution across the league and RAEs were detected among all of the age groups. A traditional RAE was observed among the u14-17 age groups, where players born between August and October were overrepresented and players born between May and July were underrepresented. Among the u18 age group, a non-traditional pattern was identified. Players born between November and January were overrepresented while players born between May and July were underrepresented. A RAE was also detected among the u14-u17 age groups when the first and second halves of the seasons were compared. However, no significant RAE between the first and second half of the season was determined among the u18 age group.

The reasons for the RAEs found among the female players are not clear, although it is believed that competition for spots on a team in the ECNL was a significant factor in producing RAEs. However, the advantage of being born earlier in the cohort is less clear among females. Unlike males, maturation among female athletes does not provide a physical or physiological advantage (Malina et al., 1978).

Current data confirm the RAE phenomenon is present among elite-level soccer players across the U.S. The oldest in the cohort may be perceived by coaches as more talented than their younger counterparts. Subsequently, the older players receive better competition, increased amount of training, and higher level coaching, all of which contribute to a persistent advantage over late-born players. Previous research has indicated that early-born players have demonstrated superior technical skills and decision-making in sport, due to early exposure to better competition and practice (Ward & Williams, 2003). Furthermore, the same cut-off date for the school year and the soccer season may have increased the magnitude of the RAE among the girls. Yet, despite the awareness of RAEs in the literature, the results of this study suggest this phenomenon still persists. Lastly, compared to other sports, competition in soccer starts at an earlier age, as young as 8 years of age, which encourages close examination of players for identification and selection. The result of early identification is the promotion of the oldest in the cohort and the potential increase in dropout among the youngest.

Parents, coaches, and administrators need to be aware of the systematic discrimination against boys and girls born toward the end of the selection year. Persistent inequalities in identification and selection have been associated with soccer since the first study was published in 1992 (Barnsley et al., 1992). The consequence of RAEs is the loss of potential talent and an increase in dropout rate starting at 12 years of age. Given the growth of soccer in the U.S. ("USYSA," 2013), it is essential the mechanisms leading to RAEs continue to be researched, so measures can be implemented to reduce or prevent this phenomenon. Skill, commitment, and determination should be some of the key factors that contribute to success in sport and not when a person is born.

Several changes to the structure of youth soccer have been recommended to eliminate, or at least, reduce the occurrence of RAEs. One suggestion has been to rotate the cohort cut-off date based upon a 15-month cycle (Musch & Grondin, 2001). Under this scenario, every child would have the opportunity to be the oldest in the cohort during the crucial developmental years. A shorter rotation system of 9 months has also been recommended to ensure the same group is not disadvantage every playing season (Boucher & Mutimer, 1994). Under a 9 month cohort, the potential disadvantage for those born toward the end of the selection year is reduced when compared to a 12 month season. However, rotating the cut-off date may be confusing to players, parents, and administrators. Because anthropometric components have played a significant role in

RAEs, especially among boys, one suggestion has been to use biological age instead of chronological age to determine cohorts (Musch & Grondin, 2001). Using weight to determine classification appears to have been a practical and workable solution in boxing and wrestling. Lastly, player quotas based upon age is another proposed solution to prevent the overrepresentation of older players in a cohort (Barnsley & Thompson, 1988).

To summarize, the current research indicated that the youngest in elite soccer are disadvantaged when organized into annual age-groups. The moderating factors contributing to RAEs appear to be the difference in chronological age, maturity, skill level, and competition. Future research should focus on key factors contributing to RAEs in sport. Furthermore, structural changes designed to reduce or eliminate RAEs should be examined, evaluated, and implemented where appropriate.

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Appendix A

Institutional Review Board Approval Letter

June 11, 2013

Ajit Korgaokar
Middle Tennessee State University
1301 East Main Street
Murfreesboro, TN 37132

Dear Ajit,

Thank you for your inquiry regarding Institutional Review Board approval for your proposed study titled "The Relative Age Effect in Elite Youth Soccer across the United States." Based on the information you supplied, you will be obtaining data including birthdates from a publicly available website. Since you are not interacting or intervening with participants and the data is public information, according to 45 CFR 46.102(f), your study does not constitute "human subjects" research. Thus, it does not require IRB approval.

Please let me know if I can be of further service, and I wish you great success in your research endeavors.

Sincerely,

Kellie Hilker
Compliance Officer
Middle Tennessee State University