2015

An Examination of Relative Age Effects Among Junior Elite Wrestlers

Jayla Kelly
University of Central Florida

AN EXAMINATION OF RELATIVE AGE EFFECTS AMONG JUNIOR ELITE WRESTLERS

by

JAYLA D. KELLY

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Human Performance
in the College of Education and Human Performance
and in The Burnett Honors College
at the University of Central Florida
Orlando, Florida

Spring Term 2015

Thesis Chair: David H. Fukuda, Ph.D.

ABSTRACT

The purpose of this examination was to evaluate relative age effects among junior elite wrestlers across gender, weight class, and competitive rule sets. Using biographical data, this thesis explores trends representing an oversampling of athletes born earlier in the year, accompanied by potential effects for success in sport and an impact on retention rates. Currently, the use of chronological age is the most common form of classifying sports participants, though this type of classification may have potentially negative long- and short-term implications. Thus, the results may provide an evaluation of weight categorization as a less discriminatory competitive format in junior elite wrestlers.

DEDICATIONS

For my parents and family, thank you for your encouragement and unconditional love. For my professors, thank you for your guidance and words of wisdom. For my friends, thank you for keeping my spirits high throughout this process. For Jennifer, thank you for being my strongest supporter and best friend.

ACKNOWLEDGEMENTS

I wish to thank my professors, Dr. David Fukuda, Dr. Jeffrey Stout, Dr. Dalena Dillman-Taylor, and Dr. Sherron Killingsworth-Roberts for their unwavering support throughout the course of this thesis. Thank you Dr. Fukuda for educating me in the category of combat sports, and accepting the responsibility of being my thesis chair, without hesitation. Thank you Dr. Stout and Dr. Dillman-Taylor for sharing your invaluable insights and knowledge. Thank you Dr. Killingsworth-Roberts for always being my number one cheerleader and seeing through any and every problem or concern, I honestly cannot thank you enough for your support throughout this process.

Table of Contents

Chapter One: Introduction

The use of a chronological determinant is perhaps the most common form of classifying sports participants. Chronological age is reported to influence particular performance attributes, like greater lower body outputs, as reported by Russell and Tooley in 2011, in a French development center (Russell & Tooley, 2011). Though expedient, this type of classification may have potentially negative long- and short-term implications for athlete's growth, improvement, and future successes. Specifically, a phenomenon termed the relative age effect (RAE) which illustrates an oversampling of youth athletes born in the first quarter of the birth year (Joyner, Mallon, Kirkendall, Garrett, 2012). This practice has been shown to favor the more physically and emotionally mature athletes while excluding those born in later quarters of the year, potentially placing the relatively younger cohorts at a disadvantage (Cobley, 2009; Garrett, Joyner, Mallon, Kirkendall, Mallon, 2012; Musch and Grondin, 2001). Furthermore, sports enrollment cutoff dates that dictate age groupings tend to be arbitrary and lack international standard (Garrett, Mallon, Joyner, Kirkendall, Mallon, 2012). In a society with stated goals of health and physical activity with a particular focus on inclusion among youth sports, it is hard to comprehend young children being dissuaded from sport participation based on their birthdates. This thesis will explore the relative age effects within the sport of junior elite wrestling.

Healthy People 2020, managed by the Office of Disease and Health Promotion within the U.S. Department of Health and Human Services, states that participation in physical activity during the youth stage is critical in enhancing both physical and mental health (Healthy People 2020, 2014). Such benefits include the promotion of bone health, increases in cardio and muscular fitness, decreases in body fat, and symptoms of depression. The youth stage is defined as the period from ages twelve to seventeen; during this period, both current health status and risks influencing factors for chronic adulthood diseases such as type II diabetes, cardiovascular diseases, obesity, and other associated diseases are developed, further illustrating the need to take action at an early age (Healthy People 2020, 2014; Bouchard, Malina, 2004; Gootman, Lawrence, Sim, 2009).

When the athlete selection process favors the more mature, a substantial number of players are potentially denied access to more advanced play solely due to their maturity, regardless of their skill set (Garrett, Joyner, Kirkendall, Mallon, 2012). This practice may persist based upon the hypothesis that those mature athletes gain access to superior athletic programs with better coaching, facilities, competition, and teammates (Garrett, Joyner, Kirkendall, Mallon, 2012). A steady increase in anaerobic power takes place during childhood, with a subsequent increase in improvement rates during puberty (Pearson & Torode, 2006). These attributes provide a tremendous performance advantage in a variety of sports (Cobley, 2009). Consequently, the advantages are more discernible during puberty where physical and performance differences are heightened and athletes are being compared to their annual age peers (Cobley, 2009). Thus, these advantages contribute to a relationship between younger athletes and lower retention rates (Cobley, 2009). This evidence seems to be supported by the unbalanced distribution of birthdates among elite players (Delorme, 2014).

Due to RAEs, the majority of youth may participate, but do not attain elite levels (Malina, 2009). Instead RAEs may further perpetuate the focus on performance in elite young athletes, or young athletes aspiring to elite status without taking into account biological age. In an attempt to reduce or eliminate RAEs, Wattie and colleagues suggested implementing alternative classification systems from a micro level approach consisting of detailed research over a period of time, which includes modifications to sport specific constraints. Among those suggested, classification systems based upon biological age, rotating selection dates, age quotas that require a uniform relative age distribution, and decreasing the selection year from twelve to nine months were all proposed alternatives (Baker, Schorer, Wattie, 2014). The practice of age grouping detracts from the potential importance of organized sport participation in the lives of all children and adolescents (Delorme, 2014). With the biases present due to RAEs, implementing an alternative categorization poses difficulties as well, for example many suggestions are difficult to apply, given the limited number of players in small teams and clubs (Delorme, 2014). Cobley and colleagues (2009) showed that RAEs tend to be more prevalent in more popular team sports, such as soccer, and that differential effects by skill level and chronological age are a clear pattern.

An example of sports that uses a determinant that is not based on chronological age, are combat sports. The term combat sport is used to define a competitive sport comprised of two combatants fighting against one another (Fukuda & Kendall, 2011). Combat sports, including the Olympic sports of wrestling, boxing, taekwondo, and judo, are often categorized into weight classes designed to ensure fair competition among athletes by matching those of equal stature and body (Close, Graeme, .Langan-Evans, Morton, 2011). Wrestling is a combat sport in which two opponents struggle hand-to-hand, in order to pin or press each other’s shoulders to the ground or mat, in respect to the style, rules, and regulations (Lanky, 1999). Other combat sports include the Korean martial art of taekwondo, and judo which based on jujitsu, and boxing. These sports employ weight categorization to classify athletes in their respective discipline. This system is put into place to protect the competitor's health by limiting the risk of injuries and leveling the playing field in terms of physical characteristics between wrestlers and reduce the maturational differences amongst youth athletes (Garcia, Lopez-Gullon, Pallares, & Torres-Bonete, 2012).

There have been only a few investigations of RAEs in combat sports and these have focused primarily on Olympic level athletes. In sports such as Olympic taekwondo, Albuquerque and colleagues (2012) found no RAEs and hypothesized that this is due to the sport's use of grouping criteria including age, level or belt, and weight classes in youth participants. However, in Olympic wrestling and judo, RAEs have been shown in male, but not female athletes, (Albuquerque, Costa, Faria 2014). Investigations is female individual sports are less common, especially hand-to-hand combat sports. Instead more highly populated female sports such as gymnastics, tennis, and swimming are among the investigated. This study explored both sexes in both Greco-Roman and freestyle wrestling styles of elite junior wrestlers.

In summary, alternate categorization systems, such as the implementation of weight classes in combat sports, may provide protection against RAEs and provide greater equity amongst participants of varying maturity levels. If the use of weight classes are an effective methods of controlling for RAEs, the result will impact the retention rates of relatively younger age participants as well as minimize the likelihood of premature dropout rates.

Rationale

I became interested in this topic because as a sport and exercise science major, it is important to understand the constraints associated with sport participation. Like many, I participated in sports for the vast majority of my life. Though I was unaware of the relative age effect years ago, I do recall witnessing coaches recruiting tall and lean female athletes to play on their basketball teams. These forms of constraints placed on youth sports need to be addressed because this selection system works against societal goals such as inclusion, availability, the right for every individual to develop certain capacities within sports, and the promotion of physical activity for all participants (Delorme, 2014). Also, current literature focusing on RAEs in female sports is less common. Research tends to focus on team sports such as basketball, football, soccer, and other popular sports for the presence of RAEs. Through my research, I look to focus on both male and female athletes as well as explore this phenomenon in junior elite wrestling for both male and female athletes.

Furthermore, RAEs are especially significant in strength and power-related sports, or sports with high demands on body size and power which are key determinants in sports utilizing bouts with a single opponent (Hildenbrandt, Müller, Raschner, 2014). Similar to male wrestlers, specific anthropometric and performance characteristics such as fat free mass values (FFM) and one repetition maximum strength (1RM), make significant contributions to the prediction of wrestlers successful (Garcia, Lopez-Gullon, Pallares, & Torres-Bonete, 2012; Garcia-Pallares, Izquierdo, Lopez-Gullon, & Muriel, 2011.). These characteristics tend to be found in more physiologically mature individuals that have more training experience such as those born early in the selection year. The existing weight categories in wrestling may help reduce maturational disparities that contribute to differences in both the size and skill level of youth male and female wrestlers.

The following chapter will outline various related research related to the physiological attributes necessary for success in the sport of wrestling at the elite junior level, applicable to a number of competitive rule sets such as male Greco-Roman and freestyle for both sexes. While Chapter Three provides information regarding the methods of data collection and statistical analysis used to execute this undergraduate thesis, so that this work may be replicated. Chapter Four discusses the observed frequencies within each respective population, relative to body mass groups, sex and or competitive rule set.

Chapter Two: Review of Literature

This section will examine topics related to this undergraduate thesis regarding the relative age effects of junior elite wrestling. Through meta-analysis, this study investigated whether or not RAEs ae present in conjunction with weight categorization at the junior elite stage of wrestling. Therefore, the following subheadings will provide salient information in this exploration.

Keys to Wrestling Success

Two wrestling styles, freestyle and Greco-Roman, are included for men in the Olympics. Freestyle wrestling includes upper and lower body wrestling; while Greco-Roman style wrestling allows only upper body techniques (Demirkan, Favre, Koz, Kutlu, & Özal, 2014). Only freestyle wrestling is contested on an international level in women and the rule set is similar to men's competition (Kaya, Öztürk, Tezel, & Vardar, 2007). Specifically, anaerobic power and capacity are paramount to success due to the short-duration and high intensity nature of the sport (Kaya, Öztürk, Tezel, & Vardar, 2007). In a review by Yoon in 2002, it was noted that these attributes were pronounced in successful wrestlers and that muscular endurance, speed, and reaction time were of particular importance.

Differences in Male and Female Wrestlers

According to Vardar and colleagues (2007), peak power was significantly associated with FFM in young male wrestlers, whereas mean power and minimum power were significantly associated with FFM in both female and male wrestlers. Though there is limited analysis of RAEs in individual female sports, with the exception of gymnastics, Pallares and colleagues (2012), identified that the most important determinants of success in female Olympic wrestling success were related to fat free mass (FFM). Higher levels of FFM contributed to great absolute strength, muscle power, anaerobic metabolism, and one rep max (1RM) (Garcia, Lopez-Gullon, Torres-Bonete, Pallares, 2012). Greater chronological age is directly related to the likelihood of these more advanced attributes causing RAEs (Cobley, 2009).

There is some evidence from non-contact female sports, such as golf and gymnastics, which show RAEs are minimized (Côté, Gershon, Jean, Lidor, Maayana, 2014). This lack of RAEs may be attributed to the lack of physical contact, presenting younger athletes in with the advantage of being selected for participation provided the appropriate learning opportunities to improve their sporting skills (Lidor et al, 2014). However similar studies have not been as widely reported in female combat sports like wrestling. Similar to elite male wrestling success, elite female light and middleweight wrestlers were categorized as being older and having more training experience in comparison to amateur female wrestlers (Garcia, Lopez-Gullon, Torres-Bonete, Pallares, 2012). Such results indicate that greater strength, muscle power, and anaerobic metabolism produce a clear advantage in Olympic wrestling (Garcia, Lopez-Gullon, Torres-Bonete, Pallares, 2012). Because the attributes contributing to success in Olympic wrestling for both male and female disciplines are very similar, it is feasible that the matching of opponents based upon physical characteristics lead to similar outcomes.

Minimizing RAEs with Weight Categorization

It has been found that increases across age in muscular strength during childhood and adolescence have been shown to correlate with changes in height (HT), body weight (BW), and fat-free mass (FFM) (Camic, 2010). With such physical development occurring during the period of adolescence, analyzing the likelihood of RAEs in wrestling at the elite level is pertinent.

Typically, depending on the muscle group involved, type of muscle action, sex, and training status of the subjects, body size-related variables, anthropometric measurements explain the variance in strength scores in age groups (Camic, 2010). These findings support the theory that RAEs may be perpetuated due to the advanced physical size of older individuals being directly correlated to performance (Baker, Schorer, Wattie, 2014).

RAEs in Combat Sports

Olympic judo athletes exhibit the classical RAE distribution with an over-representation of first quarter born athletes and an under-representation of third and fourth quarter born athletes (Albuquerque et al., 2012). In female boxing however, no significant odds ratios were found among the age categories of 14 to 15 years and 18 to 18+ (Delorme, 2014). This investigation was also extended to male boxers of varying ages from 12 to 18+, concluding that RAEs were unfounded and did not exist at the professional level, instead the results displayed an inverse RAE in the 18-18+ category (Delorme, 2014). Such results are consistent with relatively younger athletes shifting from one sport to another where weight categories are in place to ensure fair competition. (Delorme, 2014).

Furthermore, no RAEs were found in male and female Olympic taekwondo athletes (Albuquerque et al., 2012). However, Albuquerque and colleagues (2012) did report the presence of RAEs when analyzing heavyweight judo athletes. The authors explained these findings to be based on the relationship between specific technical characteristics of heavyweight athletes. Specific to Olympic wrestling, the presence of RAEs in male, but not female wrestlers have been identified; however, they appear to be diminished when examining only the medal winners. (Albuquerque, 2014).

Chapter Three: Methodology

This chapter will discuss possible hypotheses for RAE occurrences based on previous research, as well as the methods, categorization of athletes, and the target population used in this particular study.

Hypothesis

The hypothesis for the currently proposed investigation is that RAEs are present in wrestling as demonstrated by an uneven quarterly distribution of athletes, but not as pronounced as reported in previous research. Furthermore, it is hypothesized that female wrestlers may show less of an RAE effect due to lower participation numbers at both early ages and at the international level which is supported by the findings of Cobley (2009) in which the risk of RAEs is higher in sports with higher popularity. Additionally the proposed hypothesis for different styles of wrestling is that there should be little variation based on the fact that both styles require the same skills and characteristics in order to be competitive (Yoon, 2002). Additionally some variation may be identified among weight classes in both sexes because of weight categorization.

Target Population

All male and female participants in the junior world wrestling championship Greco-Roman and freestyle competitions from the years 2006-2014, through an archived database, were included in this investigation. The population was comprised of: 1586 male freestyle athletes, 807 female freestyle athletes, and 1661male Greco-Roman athletes, all participants in the junior world wrestling championship Greco-Roman and freestyle competitions from the years 2006-

2014, all participants were 17-19 years of age. Athletes were grouped by weight classes using the following categories for both freestyle and Greco-Roman styles:

Females [freestyle only (*n*= *807*)]	**Males [Greco-Roman (*n*= *1661)* and freestyle (*n*= *1586)*]**
• Super lightweight: 44-48 Kg	• Super lightweight: 50-55 Kg
• Lightweight: 51-55 Kg	• Lightweight: 60-66 Kg
• Middleweight: 59-63 Kg	• Middleweight: 74-84 Kg
• Heavyweight: 67-72 Kg	• Heavyweight: 96-120 Kg

Data Collection

Biographical data, such as: gender, years active in sport, coach and team affiliation, country of origin, profession, place rank in event , and dates of birth were collected for these 807 females and 3514 male athletes from a publically available source [International Wrestling Database (Edited by BIKILA team Leipzig) (http://unitedworldwrestling.org/database)]; therefore, no International Review Board (IRB), permissions were needed. All participants were separated by birth month, then further separated into quarters of the year. Those born between January 1st and March 31st were included in the first quarter, between April 1st and June 30th for the second quarter, July 1st and September 30th for the third, and the fourth quarter were between October 1st and December 31st,.

Statistical Analysis

The frequency of athletes per quarter was converted to an observed percentage of total athletes in each respective quarter. This observed percentage of total athletes in each quarter were then compared to expected percentages of athletes per quarter (~25% each) using chi squared (χ^2) goodness of fit tests. Statistical significance was set at $p \leq 0.05$. Odds ratio (OR) and 95% confidence intervals comparing both sexes to one another by the 1st (Q1), 2nd (Q2), and 3rd (Q3) quarters with the 4th quarter (Q4) were calculated as follows:

$$Odds\ Ratio_{Q1\ vs\ Q4} = \frac{Q1\ Observed\ Frequency/Q1\ Expected\ Frequency}{Q4\ Observed\ Frequency/Q4\ Expected\ Frequency}$$

$$Odds\ Ratio_{Q2\ vs\ Q4} = \frac{Q2\ Observed\ Frequency/Q2\ Expected\ Frequency}{Q4\ Observed\ Frequency/Q4\ Expected\ Frequency}$$

$$Odds\ Ratio_{Q3\ vs\ Q4} = \frac{Q3\ Observed\ Frequency/Q3\ Expected\ Frequency}{Q4\ Observed\ Frequency/Q4\ Expected\ Frequency}$$

The ORs were interpreted as effect sizes for comparative purposes with values of 1.22, 1.86, and 3.00 interpreted as small, medium, and large effects, respectively, as outlined by Olivier and Bell (2013). The ORs were considered statistically significant if the 95% confidence interval do not include a value of 1.

Chapter Four will discuss the results of the analysis **f**or the weight class comparison, in both male freestyle and Greco- Roman participants, as well as female freestyle participants.

Chapter Four: Results

This thesis focused on the examination of relative age effects among junior elite wrestlers across gender, weight class, and competitive rule sets. Using publicly available biographical data such as anthropometric measurements, birthdates, number of years active in sport, team and coach affiliations, profession, and country of origin. This thesis explored trends representing an oversampling of athletes born earlier in the year, accompanied by potential effects for success in sport and an impact on retention rates.

The observed frequency in annual age distribution was significantly different from the expected frequency for the individual sex and wrestling style comparisons (Tables 1-4; Figures 1-4).

For the weight class comparison, in both male freestyle and Greco- Roman participants, all body mass groups, with the exception of the lightweight groups, there were significant differences between the observed and expected frequency. However, there were no differences noted in any of the body mass groups for the female freestyle athletes.

For Q1-Q4 comparisons, small effect sizes were observed for the male freestyle and Greco-Roman athletes. While medium effect sizes were shown for the lightweight freestyle and heavyweight Greco-Roman categories, with small effects for both light and middleweight freestyle and middle and heavy weight Greco-Roman categories. Overall, comparisons for female freestyle athletes displayed observable effect sizes.

Frequency for each comparison by quarter (Q1, Q2, Q3, Q4) with odds ratios (OR) and 95% confidence intervals (CI)

Δ: difference between observed and expected values

	Age (yrs ± SD)	Q1	Q2	Q3	Q4	Total	χ^2	p	Q1 vs Q4 OR (CI)	Q2 vs Q4 OR (CI)	Q3 vs Q4 OR (CI)
Female Freestyle	18.9 ± 0.9	216	208	209	174	807	8.145	0.043	1.32 (1.00-1.74)	1.26 (0.95-1.67)	1.20 (0.91-1.59)
	Δ	*21*	*11*	*2*	*-33*						
Male Freestyle	19.3 ± 0.9	393	288	275	249	1205	49.530	<0.001	1.68 (1.34-2.10)	1.22 (0.97-1.54)	1.10 (0.88-1.39)
	Δ	*101*	*-6*	*-35*	*-61*						
Male Greco-Roman	19.3 ± 0.9	364	302	271	265	1202	29.528	<0.001	1.46 (1.16-1.83)	1.20 (0.95-1.51)	1.02 (0.81-1.29)
	Δ	*73*	*9*	*-38*	*-44*						

Table 1: Overall Annual Age Distribution

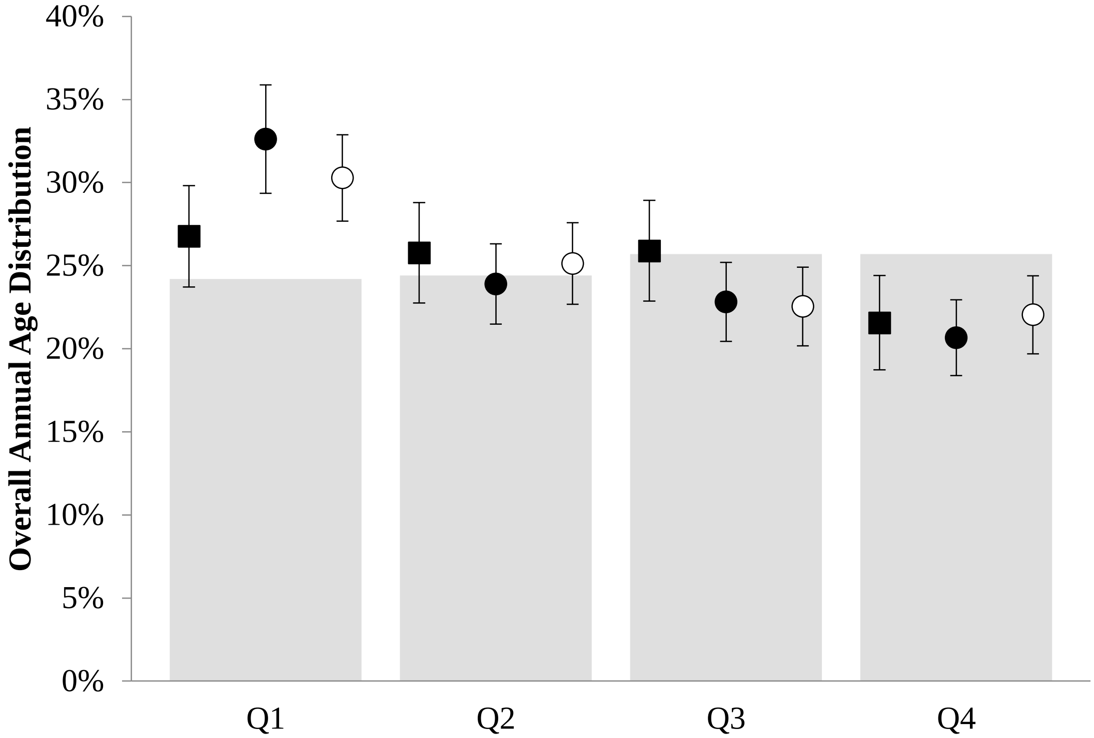

Figure 1: Overall Annual Age Distribution

Percentage of athletes by quarter (Q1, Q2, Q3, Q4) with 95% confidence intervals (error bars) for the male freestyle ■, male Greco-Roman ●, and female freestyle ○ athletes. The gray vertical bars represent the expected distributions for each quarter.

Frequency for each comparison by quarter (Q1, Q2, Q3, Q4) with odds ratios (OR) and 95% confidence intervals (CI)

Δ: difference between observed and expected values

	Age (yrs ± SD)		Q1	Q2	Q3	Q4	Total	χ^2	p	Q1 vs Q4 OR (CI)	Q2 vs Q4 OR (CI)	Q3 vs Q4 OR (CI)
Extra Light	18.8 ± 1.0		53	46	54	41	194	2.727	0.436	1.37 (0.78-2.43)	1.18 (0.66-2.11)	1.32 (0.75-2.32)
		Δ	*6*	*-1*	*4*	*-9*						
Light	18.9 ± 1.0		58	53	62	50	223	1.601	0.659	1.23 (0.72-2.09)	1.12 (0.65-1.91)	1.24 (0.74-2.09)
		Δ	*4*	*-1*	*5*	*-7*						
Middle	18.9 ± 1.0		56	60	44	47	207	4.516	0.211	1.27 (0.73-2.19)	1.34 (0.78-2.31)	0.94 (0.53-1.64)
		Δ	*6*	*9*	*-9*	*-6*						
Heavy	19.0 ± 1.0		49	49	49	36	183	3.583	0.310	1.45 (0.80-2.62)	1.43 (0.79-2.60)	1.36 (0.75-2.46)
		Δ	*5*	*4*	*2*	*-11*						

Table 2: Female Freestyle Age Distribution

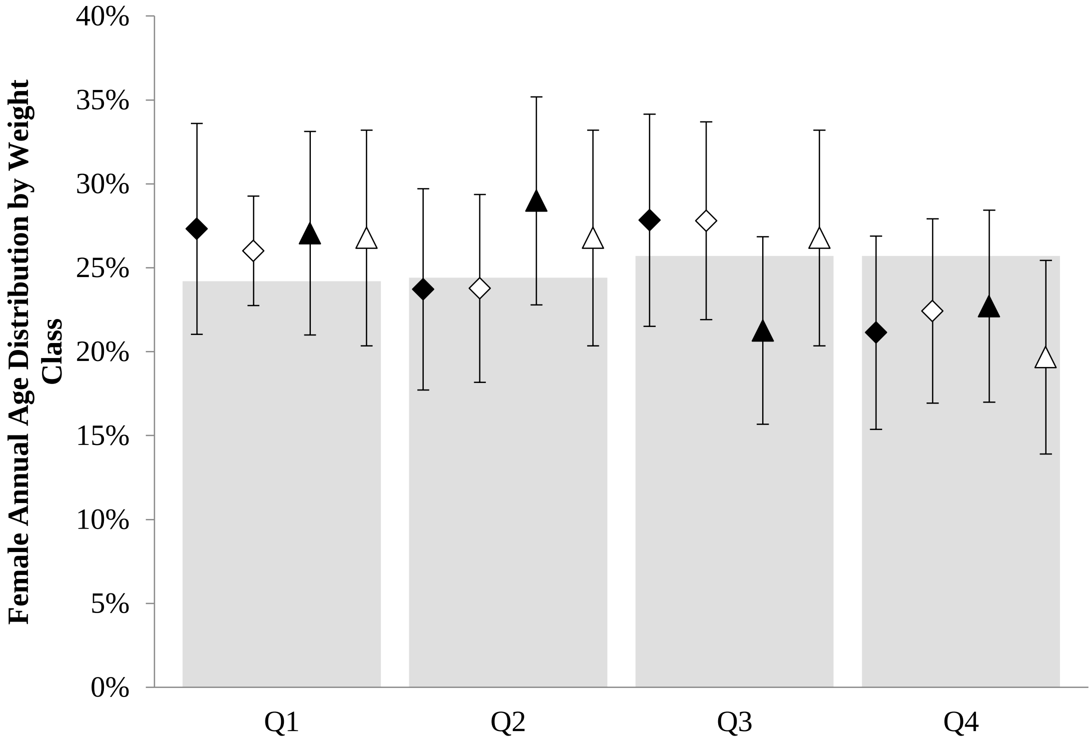

Figure 2: Female Annual Age Distribution by Weight Class

Percentage of female freestyle athletes by quarter (Q1, Q2, Q3, Q4) with 95% confidence intervals (error bars) for the extra light ♦, light ◊, middle ▲, and heavy Δ body mass categories. The gray vertical bars represent the expected distributions for each quarter.

Frequency for each comparison by quarter (Q1, Q2, Q3, Q4) with odds ratios (OR) and 95% confidence intervals (CI)

Δ: difference between observed and expected values

	Age (yrs ± SD)	Q1	Q2	Q3	Q4	Total	χ^2	p	Q1 vs Q4 OR (CI)	Q2 vs Q4 OR (CI)	Q3 vs Q4 OR (CI)
Extra Light	19.0 ± 1.0	77	70	65	67	279	2.282	0.516	1.22 (0.77-1.95)	1.10 (0.69-1.76)	0.97 (0.60-1.56)
	Δ	*9*	*2*	*-7*	*-5*						
Light	19.4 ± 0.9	121	77	85	63	346	24.656	<0.001	2.04 (1.33-3.12)	1.29 (0.82-2.01)	1.35 (0.87-2.09)
	Δ	*37*	*-7*	*-4*	*-26*						
Middle	19.4 ± 0.9	110	84	78	64	336	17.281	0.001	1.83 (1.18-2.81)	1.38 (0.89-2.16)	1.22 (0.78-1.90)
	Δ	*29*	*2*	*-8*	*-22*						
Heavy	19.4 ± 0.8	85	57	47	55	244	16.751	0.001	1.64 (1.00-2.68)	1.09 (0.65-1.82)	0.85 (0.51-1.44)
	Δ	*26*	*-3*	*-16*	*-8*						

Table 3: Male Freestyle Annual Age Distribution by Weight Class

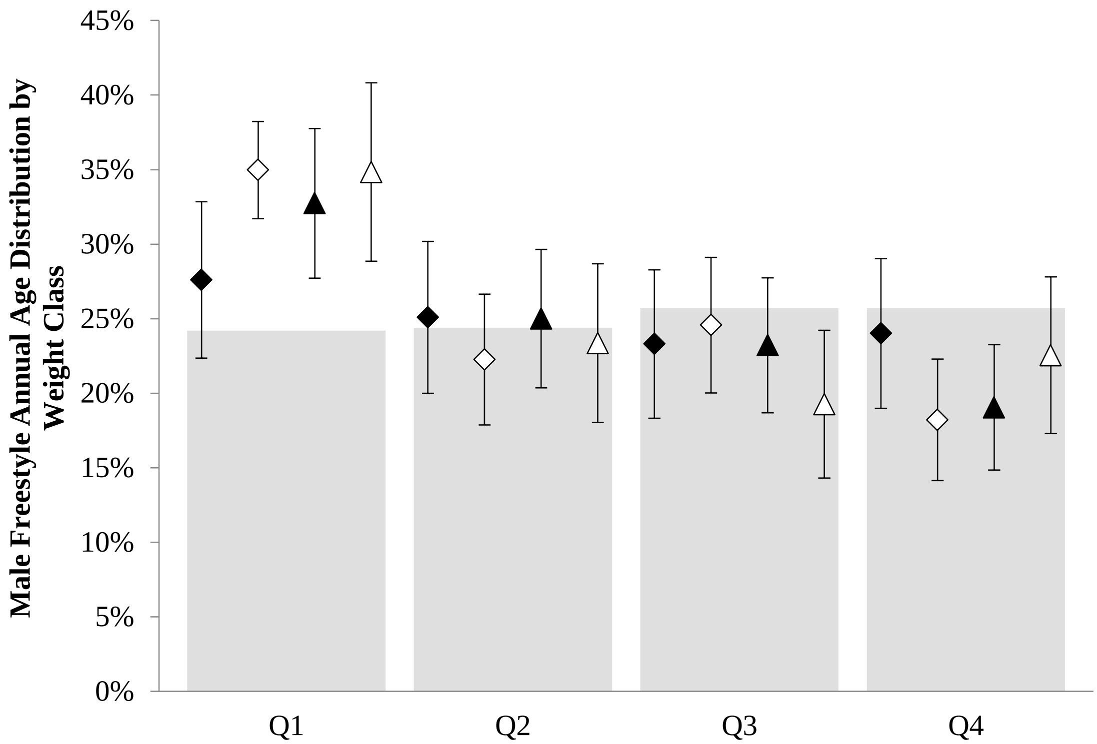

Figure 3: Male Freestyle Annual Age Distribution by Weight Class

Percentage of athletes by quarter (Q1, Q2, Q3, Q4) with 95% confidence intervals (error bars) for the extra light ♦, light ◊, middle ▲, and heavy Δ body mass categories. The gray vertical bars represent the expected distributions for each quarter.

Frequency for each comparison by quarter (Q1, Q2, Q3, Q4) with odds ratios (OR) and 95% confidence intervals (CI)

Δ: difference between observed and expected values

	Age (yrs ± SD)	Q1	Q2	Q3	Q4	Total	χ^2	p	Q1 vs Q4 OR (CI)	Q2 vs Q4 OR (CI)	Q3 vs Q4 OR (CI)
Extra Light	18.9 ± 1.0	59	59	62	83	263	4.633	0.201	0.75 (0.47-1.22)	0.75 (0.46-1.21)	0.75 (0.47-1.20)
	Δ	*-5*	*-5*	*-6*	*15*						
Light	19.3 ± 0.9	102	83	87	69	341	8.485	0.037	1.57 (1.02-2.41)	1.27 (0.82-1.96)	1.26 (0.82-1.94)
	Δ	*19*	*0*	*-1*	*-19*						
Middle	19.4 ± 0.9	115	103	61	74	353	27.015	<0.001	1.65 (1.09-2.50)	1.47 (0.96-2.23)	0.82 (0.53-1.29)
	Δ	*30*	*17*	*-30*	*-17*						
Heavy	19.3 ± 0.9	88	57	61	39	245	23.611	<0.001	2.40 (1.43-4.02)	1.54 (0.90-2.64)	1.56 (0.92-2.66)
	Δ	*29*	*-3*	*-2*	*-24*						

Table 4: Male Freestyle Annual Age Distribution by Weight Class

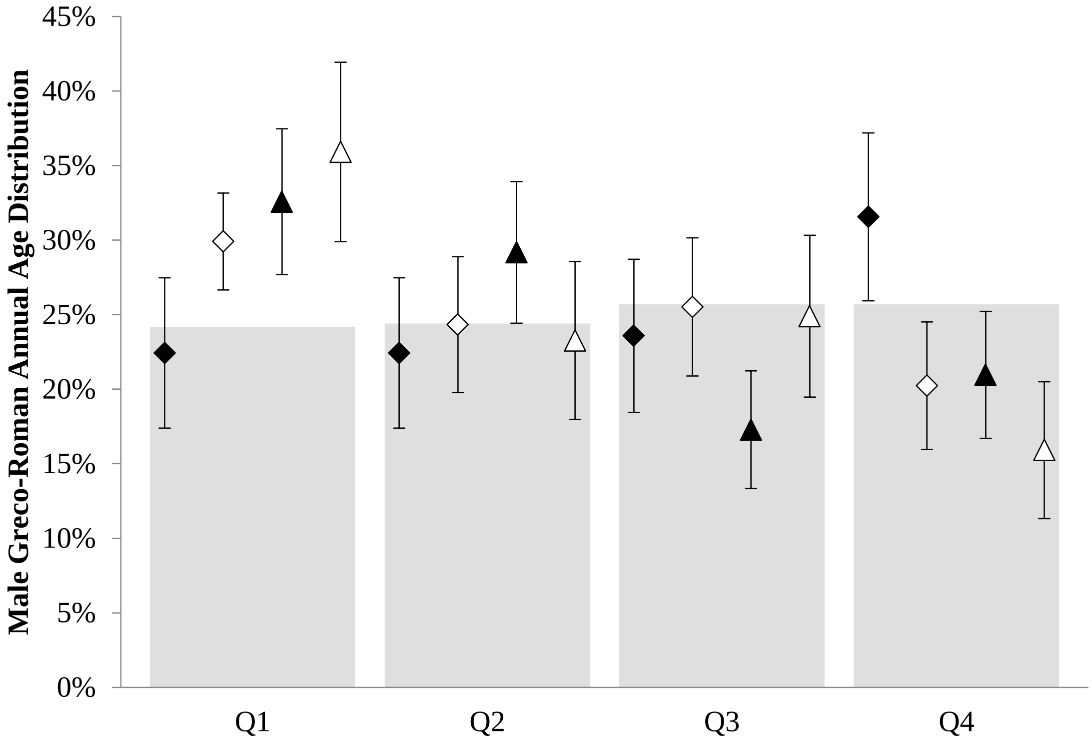

Figure 4: Male Greco-Roman Annual Age Distribution

Percentage of athletes by quarter (Q1, Q2, Q3, Q4) with 95% confidence intervals (error bars) for the extra light ♦, light ◊, middle ▲, and heavy Δ body mass categories. The gray vertical bars represent the expected distributions for each quarter.

Limitations

A limitation of this undergraduate thesis is the evaluation of only dates of birth in the junior elite world championships. Further analysis of: BMI, psychological experience, self-efficacy, sport specific skill performance would likely produce a more formative conclusion.

The last chapter of this thesis provides conclusions and discusses the implications of these results as well as whom it affects.

Chapter Five: Discussion and Conclusions

Contrary to previous investigations, however, RAEs were found to be present in the current, large sample of youth wrestling athletes. However, when examined by weight class groupings, the female wrestlers and the lightest male athletes appear to be unaffected by this phenomenon. While similar overall RAE results were shown between male freestyle and Greco-Roman wrestlers, the weight class effects differed between the two styles.

According to previous research by Raeschner and colleagues (2012), RAEs are increasingly likely to present in adolescent age competitive years and may be attributed to pubertal development in reference to cognitive, physical, emotional, and motivational variance between athletes. Since the age differences in sporting activities with annual age cutoff criteria, such as, annual enrollment cutoff dates, age differences can be as great as one year. The impact of variability of the timing and progression of puberty in adolescent athletes can be vastly different, thus influencing sport performance, experience, training, and competition. The development of sport-specific skills are fundamental in activities with high demands on body size and power involving direct competition against a single opponent, and tend to be greatest in technique related events (Raschner, 2012). Though the risk of RAE correlates have been shown to increase with skill level, the highest risk lies at the pre-elite stage (Cobley et al, 2009). In reference to RAEs at the senior and elite levels on the other hand, the effects may decrease, potentially due to either the absence of annual age groupings or the physiological variability among athletes being diminished.

The presence of RAEs in male wrestlers and not in female wrestlers in the current investigation support the findings of Cobley (2009), seemingly due to the theory that the risk of RAEs is higher in sports with higher popularity. Female athletes tend to populate sports that are less likely to exhibit abnormalities in annual age distribution (Lidor et al, 2014). For example, non-contact activities may provide younger athletes with the appropriate learning opportunities to improve their sporting skills (Lidor et al, 2014). In gymnastics, for example, a delayed maturation may be favorable and an inverse RAE, where an overrepresentation of Q4 athletes, has been reported (Wattie, 2014). Furthermore, females may be dissuaded from participating in sports like wrestling due to the sport being deemed masculine. For instance, great amounts of muscular strength, courage, fighting spirit, and of course, combat elements, are essential to success in the sport of wrestling (Kristiansen & Sisjord, 2009). Such factors have been reported to contradict social norms and traditional perceptions of femininity, thus potentially dissuading women and girls from participation, limiting the number of participants and decreasing the likelihood of RAE presence.

The prevalence of RAEs may be greater in male youth sports compared to female sports for a variety of additional reasons, including earlier maturation in females, and the variable nature of maturity in males (Glamser & Vincent, 2007). However, research by Delorme in 2014, showed no RAEs in French male or female youth boxers (Delorme, 2014). Furthermore, a lack of RAEs has been reported in male and female Olympic taekwondo athletes (Albuquerque et al., 2012). In contrast, Albuquerque et al. (2012) found the presence of RAEs when analyzing heavyweight judo athletes and Fukuda (2015) showed RAEs in both male and female elite youth judo athletes. Some of the conflicting results in combat sports may be due to the distinction between grappling sports, such as wrestling and judo, and striking-based sports, like taekwondo and boxing, which are based upon differing skill sets and physiological requirements (Fukuda, 2015).

Youth wrestlers have been shown to exhibit increases across age in muscular strength during childhood and adolescence, which are correlated with changes in anthropometric variables such as, height, body weight, and fat-free mass (Camic, 2010). Collectively, anaerobic power and capacity are paramount to wrestling success, due to the short duration and high intensity nature of the sport, regardless of style or sex (Vardar et al, 2007). Attributes such as training background, body composition anthropometric and physical characteristics, as well as aerobic power, are similar between Greco-Roman and freestyle wrestling (Demirkan, 2013). However, Dermikan et al. (2013) found that Greco-Roman athletes have higher anaerobic power and capacity in their upper extremities which may be due to the elements of lifting, throwing, and resisting opponents specific to that rule set, while freestyle athletes were shown to have greater flexibility. These differences may partially explain the variable nature of the effects of RAEs between the two wrestling styles when examining the weight class groups in the current study.

The lack of RAEs in the lightest male athletes are similar to those found in youth judo athletes (Fukuda 2015), and may be due to pre-existing advantages for those individuals with lower body mass and stature. The finding that the greatest odds ratios were found in the heavyweight Greco-Roman athletes may be similar to those reported by Albuquerque et al. (2012), which were explained to be based on the relationship between specific technical characteristics of heavyweight athletes. Further support was provided by Basar et al (2013), via direct comparison of junior Greco-Roman and freestyle wrestlers, who noted greater absolute lean body mass in Greco-Roman athletes, which has a positive relationship with body mass, and greater strength relative to lean body mass in freestyle athletes, which has a negative relationship with body mass. The latter may partially explain the greater effect sizes with decreasing body weight in freestyle wrestlers (excluding the lightest athletes).

Conclusion

The purpose of this examination was to evaluate relative age effects among junior elite wrestlers across gender, weight class, and competitive rule sets. The present study showed that even in their respective weight classes, wrestlers were still susceptible to RAEs. Though the results showed no significant findings among females, RAEs were present among male athletes.

Implications

Parents, coaches and athletes alike should be aware of the potential to favor the more physically and emotionally mature athletes as a result of this phenomenon. The effects of RAEs in grappling sports should be further analyzed for correlates in factors such as anthropometric measurements, (height and weight), number of years active in international competition, in conjunction with medals rewarded from junior world championships, and athlete retention.

References

Albuquerque, M. R., Tavares, V., Lage, G. M., de Paula, J. J., da Costa, I. T., & Malloy-Diniz, L. (2013). Relative age effect in olympic judo athletes: A weight category analysis. / L'effet de l'âge relatif sur les athlètes olympiques de judo : Une analyse des catégories de poids. *Science & Sports*, *28*(3), e59-e61.

Camic, C. L., Housh, T. J., Weir, J. P., Zuniga, J. M., Hendrix, C. R., Mielke, M., . . . Schmidt, R. J. (2010). Influences of body-size variables on age-related increases in isokinetic peak torque in young wrestlers. *Journal of Strength & Conditioning*, *24*(9), 2358-2365.

Carvalho, H. M., Coelho-e-Silva, M. J., Gonçalves, C. E., Philippaerts, R. M., Castagna, C., & Malina, R. M. (2011). Age-related variation of anaerobic power after controlling for size and maturation in adolescent basketball players. *Annals of Human Biology, 38*(6), 721-727.

Cobley, S., Baker, J., Wattie, N., & McKenna, J. (2009). Annual age-grouping and athlete development. *Sports Medicine, 39*(3), 235-256.

Davies, H. (2014). Does size matter? And where have all the arsenal six-footers gone? *New Statesman, 143*(5230), 79-79.

Delorme, N. (2014). Do weight categories prevent athletes from relative age effect? *Journal of Sports Sciences, 32*(1), 16-21.

Demirkan, E., Kutlu, M., Koz, M., Özal, M., & Favre, M. (2014). Physical fitness differences between freestyle and greco-roman junior wrestlers. *Journal of Human Kinetics, 41*, 245-251.

Fukuda, D. H. (2015). Analysis of the Relative Age Effect in Elite Youth Judo Athletes. *International Journal of Sports Physiology & Performance,* In Press.

García-Pallarés, J., López-Gullón, J. M., Muriel, X., Díaz, A., & Izquierdo, M. (2011). Physical fitness factors to predict male Olympic wrestling performance.*European Journal of Applied Physiology, 111*(8), 1747-1758.

Joyner PW, Mallon WJ, Kirkendall DT, Garrett WE Jr . Relative Age Effect: Beyond the Youth Phenomenon. The Duke Orthop J 2013;3(1):74-79.

Kendall, K. L., & Fukuda, D. H. (2011). Rowing ergometer training for combat sports. *Strength & Conditioning Journal (Lippincott Williams & Wilkins), 33*(6), 80-85.

Langan-Evans, C., Close, G. L., & Morton, J. P. (2011). Making weight in combat sports. *Strength & Conditioning Journal (Lippincott Williams & Wilkins), 33*(6), 25-39.

Lanky, R. C. (1999). Wrestling and olympic-style lifts: In-season maintenance of power and anaerobic endurance. *Strength & Conditioning Journal, 21*(3), 21-27.

Lidor, R., Arnon, M., Maayan, Z., Gershon, T., & Côté, J. (2014). Relative age effect and birthplace effect in division 1 female ballgame players—the relevance of sport-specific factors. *International Journal of Sport & Exercise Psychology, 12*(1), 19-33.

Malina, R. M. (2009). Children and adolescents in the sport culture: The overwhelming majority to the select few. *Journal of Exercise Science & Fitness, 7*(2), S1-S10.

Medic, N., Young, B. W., & Grove, J. R. (2013). Perceptions of five-year competitive categories: Model of how relative age influences competitiveness in masters sport. *Journal of Sports Science & Medicine, 12*(4), 724-729.

Mujika*, I., Vaeyens*, R., Matthys, S. P., Santisteban, J., Goiriena, J., & Philippaerts, R. (2009). The relative age effect in a professional football club setting. *Journal of Sports Sciences, 27*(11), 1153-1158.

Musch, J., & Grondin, S. (2001). Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review, 21*(2), 147-167.

Olivier, J., & Bell, M. L. (2013). Effect sizes for 2×2 contingency tables. *PloS One, 8*(3), 1-7.

Pallares, J. G., Lopez-Gullon, J., Torres-Bonete, M., & Izquierdo, M. (2012). Physical fitness factors to predict female olympic wrestling performance and sex differences. *Journal of Strength and Conditioning Research,* (3), 794.

Pearson, D., Naughton, G., & Torode, M. (2006). Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. *Journal of Science & Medicine in Sport, 9*(4), 277-287.

Raschner, C., Müller, L., & Hildebrandt, C. (2012). The role of a relative age effect in the first winter Youth Olympic Games in 2012. *British Journal of Sports Medicine*, *46*(15), 1038-1043

Russell, M., & Tooley, E. (2011). Anthropometric and performance characteristics of young male soccer players competing in the UK. *Serbian Journal of Sports Sciences,* (4), 155.

Sisjord, M. K., & Kristiansen, E. (2009). Elite women wrestlers' muscles: Physical strength and a social burden. *International Review for the Sociology of Sport, 44*(2-3), 231-246.

Turnnidge, J., Hancock, D. J., & Côté, J. (2014). The influence of birth date and place of development on youth sport participation. *Scandinavian Journal of Medicine & Science in Sports, 24*(2), 461-468.

Vardar, S. A., Tezel, S., Öztürk, L., & Kaya, O. (2007). The relationship between body composition and anaerobic performance of elite young wrestlers. *Journal of Sports Science & Medicine, 6,* 34-38.

Veldhuizen, S., Wade, T. J., Cairney, J., Hay, J. A., & Faught, B. E. (2014). When and for whom are relative age effects important? Evidence from a simple test of cardiorespiratory fitness. *American Journal of Human Biology, 26*(4), 476-480

Vincent, J., & Glamser, F. D. (2006). Gender differences in the relative age effect among US olympic development program youth soccer players. *Journal of Sports Sciences, 24*(4), 405-413.

Wattie, N., Schorer, J., & Baker, J. (2015). The Relative Age Effect in Sport: A Developmental Systems Model. *Sports Medicine*, *45*(1), 83-94.Yoon, J. (2002). Physiological profiles of elite senior wrestlers. *Sports Medicine*, *32*(4), 225-233.