10.5005/jp-journals-10017-1034

RETROSPECTIVE COHORT STUDY

Relative Age Effect: Beyond the Youth Phenomenon

Patrick W Joyner MD, **William J Mallon** MD, **Donald T Kirkendall** PhD, **William E Garrett Jr** MD PhD

ABSTRACT

The relative age effect (RAE) refers to the oversampling of youth born in the first quarter of the birth year when auditioning for selected age-restricted sports. This advantage conferred to the older athlete is the result of the older athlete being more physically and emotionally mature and, therefore, assumed to be a more advanced player. Chosen players will be exposed to better coaching, competition, teammates, and facilities in their respective sport. This RAE was first described in 1988 for ice hockey, and has since been described in numerous other sports, with a vast majority of the literature demonstrating an RAE in small cohorts, as well as in team sports and sports that incorporate a ball (i.e. soccer, basketball, hockey, etc). We extended the exploration of an RAE beyond specific sports by examining the birth quarter of over 44,000 Olympic athletes birth dates, born between 1964 and 1996. Our hypothesis is that not only did an RAE exist in Olympic athletes, but that it existed across selected categories of athletes (by gender), such as team *vs* individual sports, winter *vs* summer athletes, and sports using a ball *vs* those not using a ball. The fractions of births in the first *vs* the fourth quarter of the year were significantly different ($p < 0.001$) from each other for the summer and winter Olympians, ball and nonball sports, and team as well as individual sports. This significant difference was not gender specific. We found the general existence of an RAE in Olympic athletes regardless of global classification.

Keywords: Relative age effect, Olympic, Athletes.

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.

INTRODUCTION

The development of an elite athlete is more than a combination of work ethic, genetic predisposition, and the possession of the 'heart of a champion.' There is evidence that there are secondary factors, which have an indirect effect on the success of the athlete.[1] For example, Cote et al demonstrated that place of birth and the size of the town of birth are predictors of improved NHL draft stock in elite hockey players. Furthermore, there has been considerable evidence demonstrating the relative age effect in sports such as soccer and hockey.[1,9,15] Helsen et al have also supported the argument that there is more to athletic excellence than genetics. They demonstrated a positive linear relationship between practice and excellence on the playing field.[10]

In an attempt to equalize competition among players in youth sports, governing bodies have applied cutoff dates to group players according to their age. Sports where mass is an important consideration may equalize competition based on body weight alone or a combination of age and body weight (e.g. wrestling, American football). Prior to maturity, this may not be much of an issue; but as children become adolescents and undergo puberty, this is likely to become more of a factor. An older child, relative for his age cohort, is more likely to have undergone puberty; therefore, physically developing earlier, and in turn, this would provide a physical advantage on the athletic field. Cutoff dates for sports and enrollment appear to be arbitrary and there is no standard internationally.[15] If a child is more physically mature, then they are more likely to be selected to a more elite team and, therefore, receive better coaching, competition, and training facilities. Even if the bigger child is not necessarily 'better' than the smaller child, coaches often favor the more physically mature child *vs* their prepubescent counterpart.

It has been postulated that individuals born closer to the beginning of the year, compared to those born just before the end of the year, have an indirect advantage that could predict advancing to elite status in that sport. The assumption is that the individual born 'early' in the defined birth year is older (i.e. more mature) compared to the individual born just before the end cutoff date. When the selection process favors the more mature athlete, a substantial number of players are denied access to more advance play simply because they are less mature, not because they are less skilled. This over-selection of players born early in the birth year is known as the 'relative age effect' (RAE).[12] This was first identified in Canadian hockey. The most accepted hypothesis for the 'RAE' is that older children will be more physically and emotionally mature than their relatively younger counterparts early in their athletic career. This would lend itself to the older child being more successful earlier; therefore, the older athlete would garner a better environment (coaching, competition, etc.).[1,6]

Barnesley found in his original paper in 1988 that older players, born in the first half of the year, played minor league hockey to a later age than the younger players born in the second half of the year. This was further demonstrated by the fact that almost 70% of the top tier minor league hockey players in his study were born in the first half of the year (January-June). RAE has been demonstrated in professional baseball,[14] American football,[3] first round of the NHL draft,[1] professional soccer,[7,9,15] and professional basketball.[11]

Previous studies have been conducted demonstrating the RAE; however, their focus is on individual sports. A previous meta-analysis demonstrates that this RAE exists in numerous team and ball-incorporating sports.[5] This analysis examined 42 separate studies, and only one provided evidence of a RAE in a nonball sport (gymnastics) and two studies provided evidence of a RAE in individual sports (gymnastics and golf).[15] Aside from the exception of a study of French women youth basketball players,[7] which had a population of over 100,000, all of the studies on RAE evaluate small study populations.[15] We propose that the RAE is not only present in a few select sports, but can be seen impacting all sports, and at the elite level.

The Olympics is the pinnacle of amateur sports. The massive numbers of participants over decades at both the summer and winter Olympics presents a valuable opportunity to determine just how widespread this RAE might be. We hypothesized that all Olympic sports, regardless of the age of the athlete when competing at the Olympics, will demonstrate this RAE. Thus, we propose that more Olympians will be born in the first quarter of the year (January-March) compared to those athletes born in the last quarter of the year (October-December). Furthermore, we hypothesize that this effect will be present regardless of the specific Olympics (summer, winter), gender, and sport classification (team, individual; ball sport, nonball sport).

MATERIALS AND METHODS

This study was approved by our institutional review board. Our data was collected from the International Olympic Committee's database on Olympic athletes. The data ranges from 1896 to 1996, and includes a total of 112,152 athletes and their corresponding birth dates. Each athlete was entered into our database according to their first Olympic participation. Their respective birthdate, gender and sport were assembled in our database. Olympians who competed in more than one Olympiad, or who competed in more than one event (i.e. multiple events in track and field, swimming, etc), were listed as only competing once. Therefore, our database registers every registered Olympian dating back to the first Olympics in the modern era, 1896, and ends in 1996.

We started our birth year in January, as that is the start for a majority of the sports already documented in the literature.[3-5,7,8] Additionally, some of the literature compares the birth dates from the first half of the year to the last half;[3] however, a majority of the literature separates and compares the birth dates by quartiles.[5] Thus, we decided to also use quartiles for our athletes birth date evaluation. The quartiles where divided as follows: First—January-March, second—April-June, third—July-September and fourth—October-December. Although quartiles are distributed equally by month, they are not distributed equally by day when using a standard 365.25 day calendar (0.25 day allows for leap year athletes). This is evident by the fact that not every month has the same number of days; therefore, the quartiles would not necessarily have the same number of days. We calculated the number of days in each quartile, and by dividing them by the number of days in the year, we found the percentage of the year each quartile of months represented: First quartile—24.2%, second quartile—24.4%, and third and fourth quartile—25.7% each. These percentages represented our control, and what we would expect our birth date percentages to equal, assuming all of the birth dates where equally distributed throughout the year. However, the distribution according to the day of the month showed a greater than expected number of births for the first day of the month. Therefore, we dropped all born on the 1st of the month due to arbitrary assignment of the 1st as the birthday in many lesser developed countries.

The exact date of when children started to be grouped by age cohort for sports competition is not well-documented, it is likely different for most sports. However, Barrow and McGee document that separation of children by age for sports competition helps to facilitate instruction, promote program continuity and promotes safety. Given this data, and the fact that with each Olympiad more athletes were competing, we decided to not use all of the athletes birth dates, as this may skew our sample. There is no guarantee that age cutoff dates for sports participation were used in 1896. However, we concluded that it was reasonable to use the last 30 years of our sample data. Using these 30 years of birth data, we would also have a large enough sample size for statistical comparison. Consequently, our final sample included a total of 44,087 birth dates in our data set.

The data were summarized by birth quarter (Jan 1-Mar 31, etc) and presented as percentages with 95% confidence intervals, observed distribution tested *vs* theoretical distribution (number days in each quarter/365.25), and tested using Chi-square goodness of fit with a significance level of $p \leq 0.05$ considered to be significant. (JMP, SAS Institute; Cary, NC). Comparisons between birth quarters of significant distributions were compared by confidence intervals. We chose to compare birth dates of the first quarter of the year with those of the last because this has been the convention in the literature examining the RAE.

RESULTS

Our original data set spanned from 1896 to 1996. The total number of athletes and birth dates is 112,152. Our statistical measurements were derived from the period between 1964 and 1996. Therefore, all birth dates prior were not used (n = 67,419). Finally, the first date in each month was subtracted, as the distribution according to the day of the month showed a greater than expected number of births for the first day of the month. Therefore, we dropped all born on the 1st of the month due to arbitrary assignment of the 1st as the birthday in many lesser developed countries (n = 646). This difference was a total of 44,087 Olympic athletes and their respective birth dates in our study sample.

There were a total of 27,372 male Olympians and a total of 16,761 female Olympians. 36,030 Olympians competed in the summer games; whereas, 8,057 competed in the winter games. The ball sports had a total of 11,411 and the nonball sports totaled 32,676. Team sports totaled 10,169 and individual sports had a total of 33,918. Each one of these categories was further compared by gender, with male and female distributions being compared.

Our primary interest was in whether there were more athletes born in the first quarter *vs* the last quarter of the birth year. For the entire Olympic dataset, every paired comparison of birth quarters was significantly different from each other ($p < 0.001$) (Table 1). When the data is categorized by gender, the visual trend of decreasing fractions of athletes born in each quarter remains.

The general male Olympic athlete population (n = 27,372) demonstrated a distribution that was significantly different than expected ($p < 0.001$). The fractions of births in each quarter were significantly different from each other and from what was expected (Table 2). The general female Olympic athlete population (n = 16,761), demonstrated a distribution that was significantly different than expected ($p < 0.001$). There were significantly more female athletes born in the first quarter *vs* the second, third and fourth quarter. There were also significantly more female athletes born in the second quarter *vs* the fourth quarter (Table 2).

Among all summer (n = 36,030) and winter Olympians (n = 8,057), male and female, there was a distribution that was significantly different from that expected ($p < 0.001$). The fractions of births in each quarter were significantly different from each other for the summer Olympians. Among the winter Olympians the birth quartiles were only statistically significant between the first *vs* the third and fourth quarters, as well as the second *vs* the fourth quarter (Table 1).

Male summer Olympians (n = 22,294) demonstrated a distribution that was significantly different than expected ($p < 0.001$); with the fractions of births in each quarter being significantly different from each other (Table 2). Female summer Olympians (n = 13,782) demonstrated a distribution that was significantly different than expected ($p < 0.001$). There were significantly more female summer Olympians born in the first quarter *vs* the second, third and fourth. In addition, there were significantly more female summer Olympic athletes born in the second and third quarter *vs* the fourth quarter (Table 2).

Male winter Olympians (n = 5,078) demonstrated a distribution that was significantly different than expected ($p < 0.001$). Quarter one *vs* three and four, as well as, quarter two and three *vs* four, demonstrated significantly more winter male Olympians were born (Table 2). Female winter Olympians (n = 2,979) did not demonstrate a distribution that was statically significant from that expected ($p = 0.3414$) (Table 2).

When comparing all ball (n = 11,411) and nonball (n = 32,676) sports, male and female, the distribution of birth was significantly different than that expected ($p < 0.001$). There was a significant difference between the fractions of births in each quarter, except when comparing the second *vs* third quarter of ball sport athletes (Table 1).

The distribution was significantly different ($p < 0.001$), for male ball (n = 6,720) and nonball (n = 20,652) sports, as well as female ball (n = 4,737) and nonball (n = 12,024) sports (Table 2).

For male ball sports, there were significantly more athletes born in the first quarter when compared to the

Table 1: Fractional distribution (%, upper/lower 95% CI) of birth month by category

Category	*Q1*			*Q2*			*Q3*			*Q4*		
	Lower	*%*	*Upper*	*Lower*	*%*	*Upper*	*Lower*	*%*	*Upper*	*Lower*	*%*	*Upper*
Expected		24.2			24.4			25.7			25.7	
Olympic	27.2	27.6	28	25.3	25.7	26.1	24.3	24.3	24.8	22.3	22.3	22.7
Summer	27.1	27.6	28.1	25.3	25.7	26.2	24.3	24.3	24.8	22.3	22.3	22.8
Winter	26.4	27.4	28.3	24.9	25.8	26.8	23.7	24.6	25.6	21.3	22.2	23.1
Ball	27.4	28.2	29.1	25	25.7	26.6	23.7	24.5	25.3	20.8	21.6	22.3
Nonball	26.9	27.4	27.9	25.3	25.7	26.2	23.9	24.3	24.8	22.1	22.6	23
Team	27.5	28.3	29.2	25	25.8	26.7	23.6	24.4	25.3	20.6	21.4	22.2
Individual	26.9	27.4	27.9	25.2	25.7	26.2	23.9	24.3	24.8	22.1	22.6	23

All distributions (Q1%, Q2%, Q3%, Q4%) were significantly different from expected (all $p < 0.001$)

Table 2: Fractional distribution (%, upper/lower 95%CI) of birth month by gender and category

Category	*Gender*	*Q1*			*Q2*			*Q3*			*Q4*		
		Lower	*%*	*Upper*	*Lower*	*%*	*Upper*	*Lower*	*%*	*Upper*	*Lower*	*%*	*Upper*
	Female	26.6	27.4	28.2	24.7	25.4	26.2	23.6	24.3	25.1	22.2	22.9	23.6
	Male	27.2	27.7	28.4	25.3	25.9	26.5	23.8	24.4	25	21.4	22	22.5
Summer	Female	26.9	27.8	28.7	24.5	25.4	26.2	23.5	24.4	25.3	21.7	22.5	23.3
Winter	Female	23.7	25.5	27.3	23.9	25.8	27.6	22.4	24.1	25.9	22.9	24.6	26.4
Summer	Male	26.9	27.6	28.3	25.3	25.9	26.6	23.7	24.3	25	21.6	22.2	22.9
Winter	Male	27.1	28.5	30	24.5	25.9	27.3	23.5	24.9	26.4	19.5	20.7	22
Ball	Female	26.6	28.1	29.6	24.6	26.1	27.5	22.2	23.5	25	21	22.3	23.7
Not ball	Female	26.2	27.1	28	24.3	25.2	26.1	23.7	24.6	25.5	22.2	23.1	24
Ball	Male	27.1	28.3	29.6	24.3	25.5	26.7	23.9	25.1	26.4	19.9	21	22.1
Not ball	Male	26.8	27.6	28.3	25.3	26	26.7	23.5	24.2	24.9	21.6	22.3	22.9
Individual	Female	26.3	27.2	28.1	24.3	25.1	26.1	23.8	24.7	25.6	22.2	23	23.8
Team	Female	26.3	27.9	29.5	24.7	26.2	27.8	21.9	23.3	24.8	21.1	22.6	24
Individual	Male	26.8	27.5	28.2	25.3	26	26.7	23.5	24.2	24.8	21.7	22.3	23
Team	Male	27.3	28.7	30	24.2	25.5	26.8	24	25.2	26.6	19.5	20.6	21.8

All distributions (Q1%, Q2%, Q3%, Q4%) were significantly different from expected (all $p < 0.001$) except for female winter ($p = 0.3414$)

second, third and fourth quarter. In addition, there were significantly more athletes in the second and third quarter when compared to the fourth quarter. When comparing male nonball sports, the fractions of births in each quarter were significantly different from each other (Table 2).

There were significantly more female ball athletes born in the first quarter of the year *vs* the third and fourth quarter, and in the second quarter when compared to the fourth quarter. When comparing female nonball athletes, there were significantly more born in the first quarter of the year compared to the remaining three quarters, as well as the second quarter compared to the fourth quarter (Table 2).

Team sports (n = 10,169) and individual sports (n = 33,918) demonstrated a distribution of birth by quartile that was significantly different than that which was expected ($p < 0.001$). There was a significant difference between the fractions of births in each quarter, except when comparing the second *vs* third quarter of team sport athletes (Table 1). This significant difference was further demonstrated in male (n = 5,935) and female (n = 4,234) team sports ($p < 0.001$), as well as male (n = 21,437) and female (n = 12,527) individual sports ($p < 0.001$) (Table 2).

Male team athletes demonstrated a significant birth quartile distribution difference from the first quarter *vs* the latter three quarters, and the second and third quarter *vs* the last quarter. There were significantly more female team athletes born in the first quarter compared to the final half of the year, and the second quarter compared to the fourth quarter (Table 2).

Male individual Olympians demonstrated fractions of birth in each quarter that were significantly different from each other. Female individual Olympians demonstrated a significant difference in birth quarters comparing the first to the remainder of the year, as well as the second to the fourth (Table 2).

DISCUSSION

RAE is a phenomenon initially described by Barnesly in 1988 in a study of Canadian minor league hockey players. Barnesly postulated that an athlete born after the cutoff date for sport participation is relatively older, and therefore relatively more physically and emotionally mature, compared to other athletes in the same age cohort. Accordingly, this 'relatively' older athlete is more likely to get advanced to the more elite level of competition early in their career. This will facilitate better coaching, competition and training. Additionally, in team and individual sports, the more success an athlete achieves, the more likely that athlete is to continue with their sport, and the more likely they are to become elite. We have demonstrated that this RAE exists at the most elite level; it also transcends sex and type of sport. Most notably, our data is the first to show an RAE in nonball sports and in individual sports.

Barnesly and Thompson found that 53% of the hockey players in the Edmonton Minor Hockey Association from 1983 to 1984 were born in the first 6 months of the year (January-June). The most accepted hypothesis for the RAE is that older children will be more physically and emotionally mature than their relatively younger counterparts early in their athletic career. This would lend itself to the older child being more successful earlier; therefore, the older athlete would garner a better environment (coaching, competition, etc.).[1,2,6]

Our data is in agreement with the current literature when evaluating team sports in the summer and winter Olympic games, as well as for male and female team sports. An RAE is not only present in our entire Olympic population, but it is also present for both female and male Olympians.

Additionally, our data is in agreement with the literature[5] when we evaluated team sports. Our data revealed that 28.3% of Olympic team sport athletes were born in the first quartile versus 21.4% born in the fourth quartile. Further evaluation demonstrates an RAE in male and female team sports. Male and female team sports demonstrate significant increases in births in the first quarter of the year compared to the final quarter of the year; 28.7 *vs* 20.6% and 27.9 *vs* 22.6%, respectively. This suggests that even a 6 months difference in age may allow for increased physical and emotional maturity. This can subsequently facilitate success, better training, better coaching and enhanced competition for the competitor.

Prior to 1997 the cutoff for youth soccer in Belgium was August 1, and after 1997 the cutoff for youth soccer was January 1.[15] Vaeyens et al demonstrated that the relative age effect exists in this population. Prior to 1997, 29% of the national senior soccer team was born within the months of August-October. After 1997 32% of the national senior soccer team was born within the months of January to March.

This literature analyzes team sports and sports that incorporate a ball. Our data for ball sports is in agreement with the data already presented in the literature;[2,5,15] with 28.2% of our ball athletes born in the first 3 months of the year *vs* 21.6% born in the last 3 months. Additional examination demonstrated that 28.3% of our entire Olympic male ball and 28.1% of all Olympic female ball sport athletes were born between January and March, and only 21% of male and 22.3% of female ball sport athletes were born between October and December.

In nonball sports our data shows that 27.4% of all the athletes, 27.6% male and 27.1% female, were born between January and March; whereas, 22.6% of all nonball athletes, 22.3% male and 23.1% female, were born in the final 3 months of the year. This data, when used in conjunction with our team sports data, concludes that regardless of type of sport, a RAE exists, in general, for team sports. Relatively older children, for their age cohort, may be more apt to be selected to better teams, and glean better coaching, competition and training as a result.

Analyzing the individual sports data, we find an almost identical trend with 27.4% of the athletes born during the first 3 months of the year, 27.5% male and 27.2% female; and 22.6% born between October and December, 22.3% male and 23% female. Individual nonball sports, such as wrestling and swimming, have age cutoffs for competition. If an athlete is successful early on, then they are more likely to continue with the sport. It can be inferred from our data that a child that is more physically and emotionally mature for their age may be more likely to have success in individual sports.

Musch and Grondin argue that RAE is more pronounced in male sports than in female sports. The majority of the literature is focused on male competitors. A study examining RAE in French basketball players, ages 7 to 17, demonstrated a slight RAE in their athletes comparing the births in the first half of the year compared to those in the latter half.[7] Furthermore, a recent study examining Brazilian female youth volleyball players, under the age of 14,[13] demonstrated that 74% of the athletes in their study were born in the first 6 months of year. The latter study focused on prepubescent females, and many other studies, which do not demonstrate a RAE in female sports, especially soccer, focus on postpubescent females.[11] Their hypothesis is that a postpubescent women's body habitus changes to a more endomorphic form, which is disadvantageous for sports. We also demonstrated that an RAE was present in all female sports ball and nonball, team and individual (Table 2). The only exception was, when we isolated only female winter Olympians, there was no statistically significant RAE present.

This finding may be the result of more summer Olympic sports (i.e. gymnastics, diving, swimming, etc) favoring the involvement of prepubescent females than winter Olympic sports (i.e. figure skating). Additionally, we included all team, individual, ball and nonball sports together. We did not differentiate between specific summer and winter Olympic sports. Therefore, the RAE present in the summer and winter Olympic sports (Table 1) may be masking the lack of RAE present in female winter Olympic sports. This may be further elucidated with research of each summer and winter Olympic sport.

Our data does not differentiate between pre- and post-pubescent females. However, our data does demonstrate among all Olympic females, ball and nonball sport participants, as well as female team sport and individual sport participants, there is a significant RAE between the first 3 months of the year compared to the last 3 months—27.3 *vs* 22.9%. Although our study does not stratify each sport to determine if an RAE is present, it does answer some more global questions that have not been examined in the literature with large study population. This strength to our analysis could also be considered a limitation. The larger the population of athletes, the more likely it will have a statistically significant outcome; the greater number the subjects, the more likely a significant difference will be seen. Hence, the significant results are, in some part, driven by the number of records in our analysis. However, estimates that are more 'population-based' are going to be more stable than estimates based on a subsample of a population (e.g. any specific sport).

CONCLUSION

A relative age effect likely exists in Olympic individual and nonball sports, as well as in an overall large population of female sports. All male sports, summer and winter, ball and nonball, team and individual, demonstrate a statistically significant RAE. Further research is needed to elucidate which Olympic sports demonstrate the RAE and why?

REFERENCES

1. Joseph B, Logan AJ. Developmental contexts and sporting success: Birth date and birthplace effects in national hockey league draftees 2000-2005. BJSM 2007;41:515-17.
2. Barnesly RH, Thompson AH. Birthdate and success in minor hockey: The key to the NHL. Can J Behav Sci 1988;20:167-76.
3. Barnesly RH, Thompson AH, Legault P. Family planning: Football style. The relative age effect in football. Int Rev Sociol Sport 1992;27:77-87.
4. Barrow HM, McGee R. A practical approach to measurement in physical education. Philadelphia: Lea & Febiger 1971.
5. Colby S, Baker J, Wattie N, McKenna J. Annual age-grouping and athlete development: A meta-analytical review of relative age effects in sport. Sport Med 2009;39(3):235-56.
6. Cote J, Macdonald DJ, Baker J, Abernethy B. When where is more important than 'when': Birthplace and birthdate effects on the achievement of sporting expertise. J Sports Sci 2006 Oct;24(10):1065-73.
7. Delorme N, Raspaud M. The relative age effect in young French basketball players: A study on the whole population. Scand J Med Sci Sports 2011;19:235-42.
8. Dundink A. Birthdate and sporting success. Nature 1994; 368:592.
9. Glamser FD, Vincent J. The relative age effect among elite American youth soccer players. J Sport Behave 2004;27(1): 31-38.
10. Helsen, Werner F, Starkes JL, Van Winckel J. Effect of a change in selection year on Success in male soccer players. Am J Hum Biol 2000;12:729-35.
11. Hoare D. Birthdate and basketball success: Is there a relative age effect? Paper presented at the 2000 Pre-Olympic congress, Brisbane, Australia.
12. Musch J, Grondin S. Unequal competition as an impediment to personal development: A review of relative age effect in sport. Dev Rev 2001;21:147-67.
13. Okazaki, Fabio HA, Keller B, Fontana FE, Gallegher JD. The relative age effect among female Brazilian youth volleyball players. Res Quart Exer Sport 2011 Mar;82(1):135-39.
14. Thompson AH, Barnsley RH, Steblelsky G. 'Born to play ball': The relative age effect and Major league baseball. Sociol Sport J 1991;8:146-51.
15. Vaeyens R, Philippaerts RM, Malina RM. The relative age effect in soccer: A match-related perspective. J Sports Sci 2005 July;23(7):747-56.

ABOUT THE AUTHORS

Patrick W Joyner (Corresponding Author)

Resident, Sports Medicine Section, Department of Orthopaedic Surgery Duke University Medical Center, Durham, NC 27710 USA, Phone: 919-257-8397 (Voice), Fax: 1-800-775-2671 e-mail: patrick. joyner@duke.edu

William J Mallon

Orthopaedic Surgeon, Triangle Orthopaedic Associates, PA, 120 William Penn Plaza, Durham, NC, USA

Donald T Kirkendall

Professor, Sports Medicine Section, Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC, USA

William E Garrett Jr

Professor, Sports Medicine Section, Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC, USA