The Effects of Playing Multiple High School Sports on National Basketball Association Players' Propensity for Injury and Athletic Performance

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Background: Athletes who specialize in their sport at an early age may be at risk for burnout, overuse injury, and reduced attainment of elite status. Timing of sport specialization has not been studied in elite basketball athletes.

Hypothesis: National Basketball Association (NBA) players who played multiple sports during adolescence would be less likely to experience injury and would have higher participation rates in terms of games played and career length compared with single-sport athletes.

Study Design: Descriptive epidemiology study.

Methods: First-round draft picks from 2008 to 2015 in the NBA were included in the study. From publically available records from the internet, the following data were collected for each athlete: participation in high school sports, major injuries sustained in the NBA, percentage of games played in the NBA, and whether the athlete was still active in the NBA. Athletes who participated in sports in addition to basketball during high school were defined as multisport athletes and were compared with athletes who participated only in basketball in high school.

Results: Two hundred thirty-seven athletes were included in the study, of which 36 (15%) were multisport athletes and 201 (85%) were single-sport athletes in high school. The multisport cohort played in a statistically significantly greater percentage of total games (78.4% vs 72.8%; $P < .001$). Participants in the multisport cohort were less likely to sustain a major injury during their career (25% vs 43%, $P = .03$). Finally, a greater percentage of the multisport athletes were active in the league at time of data acquisition, indicating increased longevity in the NBA (94% vs 81.1%; $P = .03$).

Conclusion: While a minority of professional basketball athletes participated in multiple sports in high school, those who were multisport athletes participated in more games, experienced fewer major injuries, and had longer careers than those who participated in a single sport. Further research is needed to determine the reasons behind these differences.

Keywords: professional; basketball; sport specialization; knee (general); ankle; injury prevention

Participation in organized youth sports has increased tremendously over the past several decades. According to the National Federation of State High School Associations, the number of youth participating in organized sporting activity has increased from 6 million in 1995-1996 to 7.8 million in 2015-2016.[37] Concurrent with this rise in organized sports participation has been an increase in sports injuries in the 5- to 18-year-old group.[42,43,54] Using anterior cruciate ligament (ACL) injuries as an example, the rate of surgically treated ACL injuries increased from 12.22 per 100,000 person-years in 1994 to 17.97 per 100,000 person-years in 2006 for patients under 20 years of age.[32] More recent studies have also supported a rising incidence of ACL injury and reconstruction on a population level.[9,28] The reasons for rising injury rates in the youth athlete population are complex, yet an emphasis on skill development (ie, kicking, shooting, pitching) rather than generalized fitness (ie, jumping, running, stretching) may be largely to blame.[13,14,23,48]

Furthermore, a trend toward young athletes specializing in one sport at progressively younger ages has been noted, even with multiple groups advocating for delayed specialization.[4,20,29,38] Single-sport specialization can be defined as intensive year-round training in a single sport

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at the exclusion of other sports.[35] Recently, the American Academy of Pediatrics clinical report on single-sport specialization recommended that young athletes not begin to specialize until after puberty.[5] Multiple studies have demonstrated the detrimental effects of single-sport specialization including social isolation, overdependence, burnout/dropout, manipulation, and increased injury risk.[13,23,31]

The concept of completing 10,000 hours of deliberate practice to achieve mastery of a skill, proposed by Ericsson et al,[12] has been endorsed by many in the athletic world. This arguably has led to increased emphasis on high-intensity, high-volume skill training.[7] Additionally, significant anecdotal media attention has been paid to specialized child athletes who achieved professional success, such as Tiger Woods and Andre Agassi. Limited studies have demonstrated a benefit of early specialization on achieving elite status, including a study of rhythmic gymnasts, whose athletic peak is at an earlier age than many other sports.[21] However, despite commonly held beliefs by parents, coaches, and athletes that early sport specialization and high-intensity training may facilitate attainment of elite status or college athletic scholarship,[36,41] the literature does not support this assertion.[13] Gullich[16,17] has studied multiple populations of elite European athletes and has repeatedly found that those who achieved more success tended to play multiple sports until later ages than their near-elite counterparts. Furthermore, in a study of Danish elite and near-elite athletes, Moesch et al[34] found that elite athletes specialized later in adolescence and, rather than having high-volume training at a young age, had more training hours in their teenage years than near-elite athletes. Vaeyens et al[49] discussed evidence that talent identification for prospective Olympic athletes that results in early high-volume single-sport training and competition has not necessarily resulted in international athletic success. As many parents and athletic entities (ie, club sports) justify single-sport specialization as the only means to achieve "elite" athletic potential, further study is necessary.

The purpose of our study was to (1) determine the incidence of single-sport specialization among National Basketball Association (NBA) players during adolescence, (2) identify differences in the rate of injury between those who were multisport athletes in adolescence versus single-sport athletes, and (3) determine whether there were differences in games played or career length in multisport athletes versus single-sport athletes. We hypothesized that NBA players who played multiple sports during adolescence would be less likely to experience injury and would have higher participation rates in terms of games played and career length compared with single-sport athletes.

METHODS

The first-round draft picks for all NBA teams from 2008 to 2015 were identified. To be included in the study, participants had to have played in at least 1 regular season NBA game. Our initial search yielded 240 players, 3 of whom did not play in any NBA game. Thus, our sample size was 237 athletes. Only first-round draft picks were used as they represented a more "elite" pool of athletes and this subgroup of NBA players was more likely to have information available on the internet with regard to past sporting participation and injury history due to increased media coverage.

Using publically available information on the internet, we collected the following data for each player: (1) participation in high school sports other than basketball (type and number), (2) major injuries incurred during basketball-related activities at the NBA level (type and number), (3) number of games played in the NBA, and (4) whether the player was currently still active in the NBA. In addition, age, height, weight, and body mass index (BMI) when drafted were collected as was position played in the NBA. Positions were grouped into center, forward, and guard due to the fluidity between small/power forward and shooting guard/point guard. In addition to major sports news reporting websites such as www.espn.com, www.nba.com, www.foxsports.com, and www.si.com, the following websites were used to collect data for the study: www.basketball-reference.com, www.athletic.net, www.rivals.com, www.MaxPreps.com, and www.draftexpress.com.

To consider a player to have been a "multisport" athlete during his adolescence, we required evidence that the player did indeed participate in a sport in addition to basketball during his time in high school. This was determined through a search of all publicly available information on the internet including but not limited to high school sports statistics databases (ie, athletic.net), newspaper and magazine articles, and online biographies. An athlete's participation in sports played recreationally or before high school (ie, during elementary and/or middle school) did not count toward the data.

The tracking of a player's injuries hinged on the type, severity, circumstances, and timing of injury. With regard to the injury type, an injury was counted toward the data set if it affected one of the following areas of the body: the neck, back, groin, torso, legs, and feet. Therefore, injuries such as upper extremity fractures, concussions, and jaw fractures were not counted toward this study. As well, the injury had to have occurred due to basketball-related activities at the professional level. For this reason, injuries that manifested themselves due to other activities (such as falling down the stairs or getting into a fight) were not recorded. Additionally, an injury had to have been severe enough to constitute either an acute 10-game absence or a cumulative 10-game absence over the course of a season (ie, chronic recurring injury). Last, the injury had to have occurred while the player was still employed by an NBA team. All documentation about these injuries was acquired through standard internet web searches.

For each player, we gathered both the total number of games played (from www.Basketball-Reference.com) and the number of *possible* games played. The number of possible games played for each player was determined by looking into the player's employment history; if a player was employed by the team then he was considered as being able to participate in those team's games. For example, if a player missed an entire 82-game season due to injury

TABLE 1
Differences Between Single-Sport and Multisport Cohorts in Age, Height, Weight, and Body Mass Index When Drafted[a]

2008-2015 Draft Classes (Aggregate)	Age, y	Height, in	Weight, lb	Body Mass Index
Multisport	21.0 ± 1.4	79.4 ± 3.3	215.9 ± 26.0	24.2 ± 1.8
Single sport	20.8 ± 1.3	78.8 ± 3.5	217.8 ± 25.6	24.4 ± 1.9
P value	.35	.33	.69	.63

[a]Data are reported as mean ± SD unless otherwise noted.

but was still part of the team, then the 82 missed games *did* indeed count toward his possible games played. This is due to fact that the player technically could have played in some or all of those 82 games but did not due to a health impediment. Contrarily, if a player missed an entire 82-game season due to some other reason (ie, retirement or having signed a contract to play overseas), then the 82 missed games *did not* count toward his possible games played. This is due to the fact that the player made a choice to leave the NBA. It must be noted that only participation in regular season games was counted; preseason and playoff games were excluded from this study.

Finally, the players' still-current status in the NBA was determined by their current contract status. If the player was found to still be on contract with an NBA team, he was designated as active. If the player in question was found to not be on contract with an NBA team, he was designated as inactive.

Statistical Analysis

All data were pooled. The unpaired Student *t* test was used to determine significant differences between the single-sport and multisport cohort in regard to age, height, weight, and BMI. The 2-tailed Fisher exact test was used to determine differences in position played between both cohorts. The 1-tailed chi-square test with Yates correction was used to determine statistically significant differences between the multisport and single-sport cohort in regard to percentage of total games played during their NBA careers. The 1-tailed Fisher exact test was used to determine whether significant differences existed between the 2 patient cohorts in regard to major injuries sustained and active status in the NBA. One-tailed tests were used in the statistical analysis due to the preexisting evidence that single-sport specialization has been associated with an increased injury risk. A power analysis was performed and indicated that to detect a 16% difference in major injuries sustained between the cohorts, with an alpha of .05 and a beta of .20, a minimum of 36 athletes were needed in each cohort.

RESULTS

During the time period examined, 237 athletes were identified as first-round draft picks who played in the NBA. Of these 237 athletes, 36 (15%) were multisport athletes in high school and 201 (85%) were involved in a single sport. The multisport cohort was involved in the following sports: football (n = 15), track and field (n = 13), soccer (n = 4), baseball (n = 3), golf (n = 2), tennis (n = 2), mixed martial arts (n = 1), and Australian rules football (n = 1). The percentage of multisport athletes per draft class fluctuated from year to year: 2008 (3.3%), 2009 (23.3%), 2010 (3.3%), 2011 (6.7%), 2012 (23.3%), 2013 (26.7%), 2014 (16.7%), and 2015 (13.3%). No significant differences (Tables 1 and 2) were seen between the multisport and single-sport cohort in regard to age, height, weight, and BMI when drafted as well as position played in the NBA.

TABLE 2
Differences Between Single-Sport and Multisport Cohorts in Percentage of Players Playing Specific Positions in the NBA

2008-2015 Draft Classes (Aggregate)	Center	Forward	Guard
Multisport, % (n)	25 (9)	31 (11)	44.4 (16)
Single sport, % (n)	18.4 (37)	24.9 (50)	57.0 (114)
P value	.36	.53	.2

The multisport cohort played in a statistically significantly greater percentage of total games (78.4% vs 72.8%, $P < .001$; Table 3).

A total of 10 major injuries were incurred by the multisport cohort compared with 116 major injuries for the single-sport cohort. Even with a greater percentage of games played, the multisport cohort was less likely to have sustained at least 1 major injury (25% vs 43%, $P = .03$; Table 4).

The most common injuries sustained in both groups included ACL, collateral ligament, meniscal, ankle, and back injuries (Table 5).

Finally, a greater percentage of multisport athletes were still active in the league compared with the single-sport cohort (94% vs 81.1%; $P = .03$).

DISCUSSION

This is one of the first studies of timing of sport specialization and outcomes in American professional athletes. While media attention and academic study of timing of sport specialization have increased recently, few studies have compared outcomes in athletes who have specialized at an early age versus a late age. Those studies that exist have relatively small sample sizes, rely on patient reporting of participation in other sports, and have focused on

TABLE 3
Differences Between Single-Sport and Multisport Cohorts in Percentage of Total Games Played

2008-2015 Draft Classes (Aggregate)	Games Played, n	Games Missed, n	Total Possible Games, n	% of Games Played
Multisport	9220	2544	11,764	78.4[a]
Single sport	47,901	17,903	65,804	72.8[a]
Total	57,121	20,447	77,568	73.6

[a]$P < .001$.

TABLE 4
Differences Between Single-Sport and Multisport Cohorts in Percentage of Players With At Least One Major Injury

2008-2015 Draft Classes (Aggregate)	Sustained At Least 1 Major Injury, n	Sustained No Major Injuries, n	% Major Injury	% No Major Injury
Multisport	9	27	25.0	75.0[a]
Single sport	86	115	42.8	57.2[a]
Total	95	142	40.1	59.9

[a]$P = .03$.

collegiate, national team, and Olympic athletes rather than professional athletes.[16,34,49]

In this study, early specialization was defined as lack of participation in multiple sports in high school. The American Academy of Pediatrics position statement has defined early specialization in sport as limiting participation to a single sport at the exclusion of other sports for a majority of the year before the onset of puberty.[5] According to the National Health and Nutrition Examination Survey, the average age of initiation of pubarche for boys is approximately 12 years, and sexual maturity is reached on average at 15.5 years.[46] The average age of starting high school in the United States is 13 to 14 years, which is around the time of puberty for the majority of boys. Hence, by using multiple sport participation in high school as an indication of late specialization (ie, after onset of puberty) and single-sport participation in high school as early specialization, we anticipated that the groups in this study roughly represented pre- and postpubertal specialization. This method may be a helpful designation in future research examining timing of sport specialization, but it may be more applicable to male athletes rather than female athletes given the earlier age of puberty in girls.

The population of interest for this study was first-round draft picks in the NBA from 2008 to 2015. Since 2006, athletes must be at least 19 years of age and 1 year beyond high school graduation. Approximately 30 athletes are selected in the first-round each year. By limiting the study to first-round draft picks, the study population was more homogeneous in terms of age, projected career length, and skill relative to the entire NBA population. Additionally, first-round draft picks were more likely to have robust documentation of their athletic career before their professional career given their elite status within the NBA. We used multiple internet-based sources to determine whether an athlete was multisport, including player biographies, high school athletic sites, and newspaper and magazine articles. While theoretically an athlete could have been misclassified as a single-sport athlete when in fact he was a multisport athlete, the inclusion of athlete data after the advent of the internet makes this less likely. Furthermore, the use of publically available records to collect data on injuries, games played, and career length in professional athletes has been successfully used by prior studies.[6,40,47,50,51,53]

TABLE 5
Injuries Sustained During Participation in the NBA for Multisport and Single-Sport Athletes

Injury Type	Multisport, n	Single Sport, n
Anterior cruciate ligament	3	8
Lateral collateral ligament	0	1
Medial collateral ligament	1	6
Posterior cruciate ligament	0	2
Meniscus	1	14
Fracture	1	25
Hamstring	0	2
Tendon	0	9
Muscle	0	2
Tissue scarring	0	1
Sprain	1	6
Ankle or knee injury (unspecified, but required surgery)	0	14
Back + bulging/herniated disc	1	7
Hernia	0	4
Soreness	0	1
Hip	1	4
Dislocation	0	2
Bone bruise	0	1
Shoulder (unspecified)	0	7
Nerve	1	0
Total	10	116

We found that the majority (85%) of first-round draft picks in the NBA had specialized in basketball by the

time they reached high school. Specialization rates vary widely between different sports and tend to be poorly described in team sports such as football, basketball, and baseball. Rather, individual sports and those requiring highly technical skills, such as tennis, dance, gymnastics, and swimming and diving, have been more comprehensively studied in regard to specialization.[13,22] Post et al[38] studied the specialization rates in 343 Division I athletes and found that by the senior year of high school, only 41.1% of athletes were highly specialized and not participating in another sport. However, only 13 men's basketball players were included in that investigation and their specialization patterns were not individually analyzed. DiFiori et al[8] studied collegiate athletes in a Division I program and found that the vast majority had participated in multiple sports as children and that 70% did not specialize until after age 12. No studies of sport specialization patterns in any form of elite basketball have been published. While the early specialization rate was high in the current study, it is unknown whether this rate is similar to that of all NBA players or of collegiate-level basketball players, and this is a potential area of future study.

The NBA season consists of 82 games per team over a 6- to 9-month period depending on playoff berth. In studying an athlete's performance and contribution to his team, "games played" is a commonly used proxy in the National Football League, National Basketball Association, and Major League Baseball.[11,30,33,45] In this study, this variable was calculated as a percentage of total possible games played, to account for differences in career length. Multisport athletes played in more games than single-sport athletes by approximately 5.4%, or 4.4 games per season. Several factors may have likely contributed to the increased games played by multisport athletes in this study; most notably, multisport athletes had fewer injuries that affected participation during their career, allowing them to participate more while healthy. Numerous studies have demonstrated that lower extremity and back injuries may result in fewer games played in the NBA population.[3,19,26] Future research could be performed to determine how the impact of games played translates to actual statistical performance, although multiple other confounding factors can determine statistical performance including teammate skill-set, coaching philosophy, and position.

Furthermore, Fransen et al[15] studied male athletes between ages 6 and 12 and found that participation in multiple sports had a positive influence on gross motor coordination, speed, endurance, and strength. Abernethy et al[1] found that formation of elite decision making was more facile in a group of athletes who had diverse sporting experience in their youth. It is possible that the diverse exposure to sports experienced by the multisport athlete resulted in achieving a more elite status within the first-round draft pick group, contributing to the increased games played observed in this group.

Despite participating in more competition, basketball players who played multiple sports in high school had fewer major injuries during their careers in the NBA. Previously described risk factors for injury in the NBA have included participation in competition rather than practice, game schedule, age, and prior injury.[35,44,47,52] An injury was included in the analysis if it involved the neck, back, torso, or lower extremities and resulted in a 10-game absence either acutely or over the course of the season. Upper extremity injuries and concussions were not included in the analysis because in basketball, these injuries are less likely to represent overuse or muscle imbalance–related injuries. Yet, this is an important area to examine in the future as concussions are potentially more likely to occur in overuse situations and/or fatigue situations in which the patient is not alert or able to avoid injury.

The use of a 10-game cutoff meant that chronic overuse injuries that affected a significant number of games were counted. Studies of young athletes who specialize early in their career have demonstrated increased overuse injuries,[18,24,39] but it is unknown whether the specialized group in our study had a more extensive injury history than the multisport group. Sport diversification may be injury protective to athletes from a neuromuscular standpoint. For example, female youth athletes who play multiple sports were found to be less likely to experience overuse injuries or muscle imbalance injuries of the knee.[18,27] Our findings suggest that the protective effect of being a multisport athlete in high school may persist for years into an athlete's professional career. Of note, injury types in our study were similar to those described in large epidemiologic studies of NBA athletes and most frequently included knee, ankle, and back injuries.[10,44]

In this study, a greater percentage of multisport athletes were still active in the NBA at the 2015 time point, indicating longer careers than their single-sport counterparts. Few data are available regarding causes for decreased career length among professional basketball players. The most common causes for reduced longevity in the literature are lower extremity and back injuries, including ACL injury,[26] Achilles tendon rupture,[2] and lumbar disc herniation.[3] Our results mirror the findings in these studies in that the single-sport group with increased injury rates additionally had decreased longevity compared with multisport athletes.

This study had a number of methodological limitations. Use of internet-based records to determine whether an athlete was multisport could have resulted in misclassification; however, inclusion of athletes after 2008 (when the internet was in widespread use for athletic reporting) makes this less likely. We also could not gauge the level of participation of the multisport athletes due to the web-based search we performed. In addition, ethical issues should be considered when using publically available information,[25] although we did not report any protected health information. Internet reporting of injuries has been described as an acceptable method in other studies of professional athletes.[5,49,50] Moreover, major injuries were highly likely to be discovered using internet search given that they affected game participation and were potentially season-ending. The NBA injury registry, to which we do not have access, would potentially provide the most accurate information in regard to injury risk. Our sample size of multisport athletes was relatively small, although our analyses did have statistical and clinical significance.

Another limitation of our study was exclusion of postseason games. The exclusion of data collected from the postseason can be primarily justified by the fact that not all teams in the NBA play the same number of games in the postseason or may not even reach the postseason altogether. Due to the variability in the access to postseason from team to team and season to season, there is also an inequity in the number of games played by the players, which could affect injury susceptibility during the playoffs. The logic follows that if a player logs more games during the postseason, the likelihood of getting injured is greater for that player compared with a player whose team is not playing in the postseason. Thus, to standardize the number of games played, the scope of our study was narrowed to only regular season games, to which all players hypothetically have equal access. Furthermore, the adding of playoff games to certain players' careers could artificially inflate the perception of how durable or healthy the player is. Similarly, durable players on teams that do not make the postseason would have their durability deflated due to not having the opportunity to play more games. Both of these assumptions can be drawn from the premise that the opportunity to play in and advance within the postseason is a result of collective team success, which cannot necessarily be positively correlated with any given specific player's individual durability or lack thereof. Further study that controls for postseason participation can be performed in the future. Additionally, if a player sat out a game or was benched without an injury, these games were still counted within the "possible games played" variable. The decision to not play an athlete can be multifactorial—minor injury not reported, performance related, and/or fatigue—all of which may be affected by multisport participation in high school. The goal of our study was to look at overall participation in games once drafted, with all players being subject to the same probability of being benched or not played. We believe that the data were not affected by the small, if any, percentage of games affected.

Finally, these findings can be applied to only elite male basketball players. First-round draft picks do not represent the NBA population as a whole. For the purposes of our study, they represent an "elite" level of athlete entering the NBA, and they had the most readily available information about their sports participation on the internet due to their high level of athletic achievement at a young age. It is unknown whether these findings would also apply to female athletes or those who play other sports.

Although no differences were seen in regard to age, height, weight, BMI, and position played in our study, further prospective study is necessary to look at the interplay of body type with injury risk. Certain body types and basketball positions may be less compatible with other sports and affect injury risk. For example, a very tall basketball center may be unable to play other sports (precluding multisport specialization) but may have an increased risk of foot or ankle injuries due to his height (not lack of multisport participation).

Despite these limitations, this study is the first of its kind to evaluate clinical outcomes between early and late specialization athletes in an elite professional athletic population. Our findings suggest that elite professional athletes who participate in multiple sports into high school may have more productive, healthy careers in regard to games played, avoidance of injury, and career length compared with those limited to a single sport in high school. While these findings are mainly applicable to elite, professional basketball players, their implications should promote further research in timing of sport specialization and the effects on attainment of elite status and healthy participation at the elite level.

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