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Concussion Incidence and Return-to-Play Time in National Basketball Association Players

Results From 2006 to 2014

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Background: Various research efforts have studied concussions in the National Football League, Major League Baseball, and the National Hockey League. However, no study has investigated the incidence and return-to-play trends in the National Basketball Association (NBA), which this study aims to do.

Hypothesis: Increased media scrutiny and public awareness, in addition to the institution of a league-wide concussion protocol, may have resulted in more conservative return-to-play practices.

Study Design: Descriptive epidemiology study.

Methods: All concussions to NBA players that were publicly reported in the media from the beginning of the 2006 NBA season to the end of the 2014 season were included. The incidence and return-to-play statistics were generated by synthesizing information from publicly available records.

Results: There were 134 publicly reported concussions to NBA players from the beginning of the 2006 season to the conclusion of the 2014 season, resulting in an average of 14.9 concussions per season. The incidence has not changed significantly during this time span. The average games missed after a concussion from 2006 to 2010 was 1.6, significantly less than the 5.0 games missed from 2011 to 2014, following the institution of the NBA concussion protocol ($P = .023$).

Conclusion: Although the incidence of publicly reported concussions in the NBA has not changed appreciably over the past 9 seasons, the time missed after a concussion has. While players often returned in the same game in the 2006 season, the combination of implemented policy, national coverage, medical staff awareness, and player education may have contributed to players now missing an average of 4 to 6 games after a concussion. A multitude of factors has resulted in more conservative return-to-play practices for NBA players after concussions.

Keywords: concussions; basketball; epidemiology

Estimates of the annual incidence of sports-related concussions in the United States range from 300,000 to more than 3 million.¹¹ Concern persists, however, that unreported and undiagnosed concussions result in these reported ranges

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underestimating the true incidence. Concussions have been brought to the forefront of the media as those that are suffered in sports have become an area of growing concern. Studies have shown sports-related concussions to be an issue in every major sport, including at the high school and collegiate levels.⁷ Furthermore, recent investigations using national databases have demonstrated increasing incidences of sports-related concussions at the high school and collegiate levels for both sexes.^{15,18,22,24} A national study revealed that the high school sports-related concussion incidence more than doubled from 2006 to 2012, including a statistically significant increase in basketball.¹⁸

Research and public awareness for concussion prevention and treatment have expanded dramatically in professional sports over the past decade. Several investigations have demonstrated the magnitude of the neuronal damage incurred after mild traumatic brain injury.^{17,19-21} Specifically, metabolic cascades and ionic balance within neurons

are disrupted, leading to increased energy demand to repair the cell.^{17,19} This increased demand is met with decreased cerebral blood flow, however, resulting from overall homeostatic dysregulation after traumatic brain injury.^{1,20,21} This dysregulation results in patients being even more vulnerable to secondary concussive events as they recover.^{17,21} If sustained, a secondary concussion is more damaging both intracellularly and with regard to gross cognitive defect than the initial concussion.^{12,17,19} Therefore, player protection after a concussive event is paramount to allowing proper neuronal recovery.

Although the media have relayed this message from the medical community, much of this awareness has been directed toward the National Football League (NFL) and National Hockey League (NHL) due to the high incidences of concussions in these sports.^{4,5,23} Little, if any, research has investigated concussions in the National Basketball Association (NBA), and the total number of studies in the NBA lags well behind its counterparts in the NHL, NFL, and Major League Baseball (MLB).¹⁴ Notably, a recent study of concussions in the MLB revealed approximately 20 concussions per season with an average return-to-play time of 9 days.⁹

The growing awareness and attention given to concussions has resulted in longer absences and fewer same-game returns for professional athletes suffering concussions in both the NHL and NFL.^{4,5,23} However, to our knowledge, no such study has been performed with respect to the NBA. Prior epidemiological analysis of NBA injuries shows that approximately 5 concussions were reported in the NBA per year from 1988 to 2005.⁸ However, as of 2011, the NBA and MLB remained the only major sports that had not implemented a formal, unified concussion policy for the entire league to follow. The NBA instituted a compulsory concussion policy establishing player baseline testing and return-to-play procedures preceding the 2011-2012 NBA season. While return-to-play guidelines vary with a multitude of factors, including severity, timing, and type of recovery testing, the establishment of a formal concussion policy likely represented a response to the surge in awareness.^{2,6} As NBA players sustain high-impact injuries and falls without wearing any protective equipment, studying their concussion incidence and return-to-play trends is critical to furthering player protection. No analysis to date has inspected the effect the NBA's 2011 policy has had on concussion incidence or time missed after a concussion. We hypothesized that increased awareness and publicity in addition to the institution of a formal, league-wide concussion policy have resulted in more conservative return-to-play timing and more publicly reported player concussions in the NBA.

METHODS

Concussions sustained by NBA athletes from the start of the 2006 season to the conclusion of the 2014 season were tabulated by reviewing public media injury reports. The list of players having concussions was formulated from publicly available data, including media-generated

team injury reports and game reports. The length of time missed was found by synthesizing the information from team injury reports, national and local media releases, game reports, and media guides. The information was compiled by using national sports media, including the NBA's official website (www.nba.com), ESPN, The Associated Press, CBS Sports, and RotoWire. Team-specific websites and local game reports and media guides were used to further verify each concussion. The concussion data preceding the institution of the concussion policy (2006-2010) were contrasted with the data after the policy (2011-2014).

Injuries incurred during the preseason, regular season, postseason, and All-Star Game were included in calculating the seasonal incidence of concussions. However, to standardize the data, concussions that were incurred in the preseason, during the All-Star Game, and in the postseason were not included in calculating the average games missed after a concussion as external factors such as the weeklong All-Star break and postseason elimination may have affected the data. Preseason concussions were excluded from return-to-play data because of concerns regarding the involvement of international teams in exhibitions games, the short duration (8 games), and a potentially different level of in-game intensity. In addition, concussions experienced by players who were waived before fully recovering, players whose recovery coincided with the conclusion of the regular season, and players who had concurrent injuries (orbital fracture, hematoma, etc) were also excluded because of the potential that these players' recovery times could have been influenced by external factors.

Each concussion was tabulated independently of whether a player had incurred a previous concussion in either the same season or previous season. In addition, for the category of same-season repeat concussion and concussive symptoms, a player must have been formally diagnosed with a concussion in the same season, passed return-to-play guidelines, and played in 1 or more regular season games before missing more time due to either a second concussive event or a return of symptoms that resulted in 1 or more missed games. This definition of same-season repeat concussions was selected due to the literature consensus regarding the dangers of sustaining a second concussion before full recovery^{17,19} and that more than 90% of athletes experience symptom resolution and return to play within a month.^{12,22,23} These injuries were tabulated in an identical manner to the concussion incidence. We reviewed each season's database to assess whether the concussion was primary or repeat according to the aforementioned distinctions.

Statistical analysis was conducted using R Statistical Programming Language (version 3.1.0; The R Foundation for Statistical Computing). The *P* values reported were calculated using a parametric *t* test, with *P* < .05 indicating statistical significance.

RESULTS

From the beginning of the 2006 NBA season to the end of the 2014 season, 134 concussions were incurred, leading to an average of 14.9 concussions per season. The highest

TABLE 1
Summary of National Basketball Association Concussion Statistics (First-Time and Repeat), 2006-2014

Season	Concussions, n	Games Missed, Mean ± SD	Zero Games Missed, n ^a	Range of Games Missed, n	Repeat Concussions and Symptoms, n
2006	16	0.846 ± 0.99	6	0-18	2
2007	16	0.929 ± 1.33	8	0-4	1
2008	14	2.92 ± 3.66	3	0-12	1
2009	16	1.15 ± 1.07	5	0-27	3
2010	12	2.83 ± 2.14	2	0-5	0
2011	15	6.0 ± 10.5	2	0-32	0
2012	20	4.38 ± 4.94	1	0-20	0
2013	17	4.93 ± 4.88	1	0-20	1
2014	8	5.67 ± 5.51	0	2-12	0

^aIndicates players returning either later in the same game or in the game immediately after a concussion.

number of concussions in a season came in 2012, when there were 20, while the lowest number of concussions was in 2014, when there were 8. The tabulation for the 2006-2014 seasons is shown in Figure 1. A full summary of the data, which includes both first-time and repeat concussions, is displayed in Table 1. No significant change in the incidence of concussions was found during this interval ($P = .53$).

The average number of games missed after a first-time concussion was also tabulated for this time period. The first season studied, 2006, represented the year with the lowest average number of games missed after a concussion at 0.85. The 2006 and 2007 seasons represented the only years in which less than 1 game, on average, was missed after a concussion. The highest number of average games missed was 6.0, in the 2011 season. The next 3 highest values were consecutive seasons from 2012 to 2014, and the full range is displayed in a box-and-whisker plot in Figure 2. Each of the 4 seasons after the institution of the NBA concussion policy led to players missing an average of 4 or more games after a concussion, while not one of the previous 5 seasons placed within that range. From 2006 to 2010, an average of 1.6 games were missed after a first-time concussion. However, after the establishment of the NBA concussion protocol preceding the 2011 season, an average of 5.0 games were missed after a concussion from 2011 to 2014. The increase in games missed after a concussion in the 2011 to 2014 NBA seasons compared with the 2006 to 2010 seasons was statistically significant ($P = .023$).

In addition to calculating the incidence of concussions and number of games missed after a concussion, the number of players returning either in the same game or in the game immediately after a concussion was tabulated. The highest number of players who returned after missing zero games was 8, in 2007. This season also represented the highest proportion of players missing zero games, at 50%. In the 2014 season, the last season studied, zero players returned without missing at least 1 game, as shown in Figure 3. Notably, this season was the first and only season when zero players returned without missing at least 1 game.

The number of players returning to play without missing a game after a concussion was contrasted with the number of same-season repeat concussions. From 2006 to 2010, 7 publicly reported same-season repeat concussions

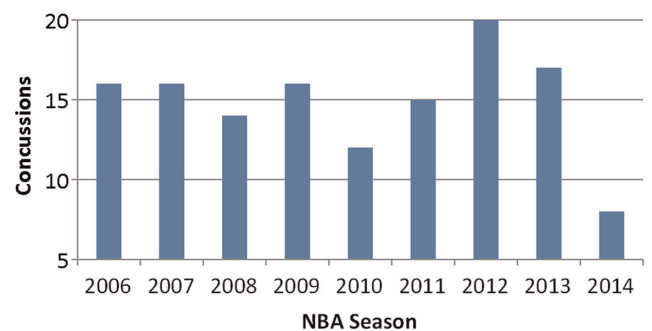


Figure 1. Concussions per season in the National Basketball Association (NBA) from 2006 to 2014.

were reported. Of note, however, only 1 player had a publicly reported same-season repeat concussion since the concussion policy was instituted preceding the 2011 season. The decrease in repeat concussion and concussive symptom incidence from 2006 to 2010 compared with 2011 to 2014 was not statistically significant in the small sample size accrued thus far ($P = .11$).

Last, a team-specific analysis was conducted to identify if organizational trends were present. The 134 NBA concussions publicly reported between 2006 and 2014 were sustained by players from 28 different NBA teams. From 2006 to 2010, 80% of teams reported that at least 1 player returned from a concussion without missing a game. Of the 21 teams that reported a player concussion from 2011 to 2014, 8 (38.1%) teams reported having a player return without missing a game. Of this subset, 1 team did not report a concussion during the 2006 to 2010 NBA seasons. For the remaining 7 teams, 6 (86%) also reported that a player returned to play without missing a game before the institution of the NBA concussion policy (2006-2010).

DISCUSSION

The incidence and return-to-play data regarding publicly reported concussions in the NBA demonstrate trends that support increased player protection in the years following

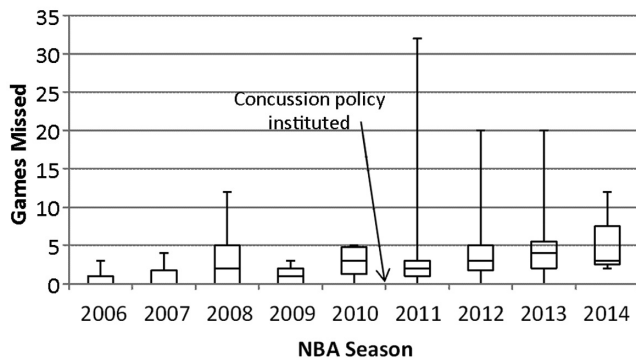


Figure 2. A box-and-whisker plot of games missed following a first-time concussion spanning the 2006 to 2014 National Basketball Association (NBA) seasons.

the institution of a formal concussion protocol. While the data accrued represent publicly reported information and not official data from the NBA, the trends are important to analyze and comprehend to further player protection.

During the 9 seasons analyzed, the incidence of publicly reported concussions in the NBA has not changed significantly ($P = .53$), with an average of 15 concussions per season. At least 12 concussions were reported per season from the 2006 through 2013 seasons. However, only 8 concussions were recorded in the 2014 season, likely representing an anomalous value as no significant rule or diagnostic changes were implemented preceding the season. The incidence in this interval does appear to reflect a distinct increase compared with the incidence from the previous 2 decades, however. The average concussion incidence over the time period analyzed, 2006 to 2014, is more than 3 times greater than the value reported from 1988 to 2005.⁸

Notably, the number of games a player missed after a concussion following the institution of the NBA concussion policy has increased in a statistically significant fashion as players missed 3 times as many games from 2011 to 2014 as they did from 2006 to 2010 ($P = .023$). Strikingly, while an average of 0.85 games were missed after a concussion in the 2006 season, 5.67 games were missed after a concussion in the 2014 season. In addition, while 31 players (42%) from 2006 to 2010 returned either in the same game or the game immediately after a concussion, that number decreased to 14 players (23.3%) from 2011 to 2014. Most important, these trends coincided with a decrease in repeat concussions and concussive symptoms. While 7 players had repeat concussions in the same season or missed additional games due to a return of concussive symptoms from the 2006 through the 2010 seasons, only 1 player has sustained a same-season repeat concussion since the concussion policy was instituted. The lack of statistical significance in demonstrating this trend ($P = .11$) is likely indicative of the small sample size, since, at the time the study was conducted, only 4 NBA seasons had been completed after the concussion policy was instituted.

Concussions in the NBA have received significantly less media coverage and national publicity than concussions in other major sports. This deficit, in addition to the relatively

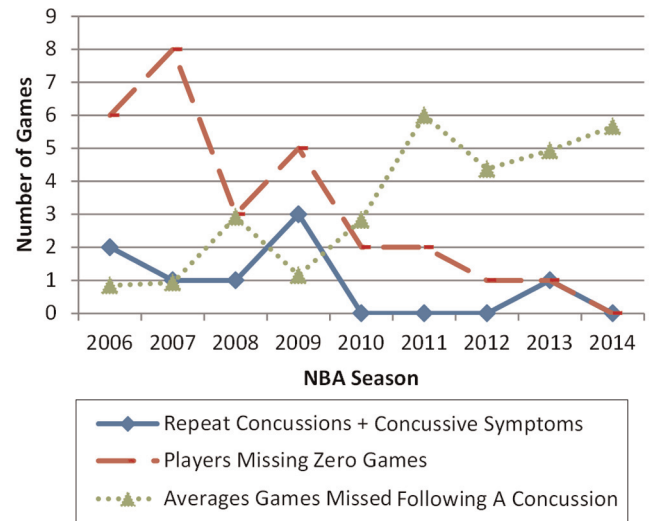


Figure 3. Averages games missed after a concussion, number of players missing zero games, and number of players having repeat concussions from the 2006 to 2014 National Basketball Association (NBA) seasons.

low incidence of concussions with respect to the NFL and NHL, may have resulted in the NBA being the last major American sport to institute a league-wide formal concussion policy. A succinct summary of the concussion policy can be found on the NBA's official website (http://www.nba.com/official/concussion_policy_summary.html).

A multitude of factors, including this concussion policy, likely influenced the trends displayed over the past 9 seasons. National awareness regarding the deleterious effects of concussions has likely made players more willing to report concussions and team physicians more conservative in holding out players for longer periods of time. In addition, the concussion policy itself explicitly bans concussed players from returning in the same game and has implemented baseline neurocognitive testing to help guide a safe return to play. The concussion policy also mandates coach and player education regarding concussions and involves multiple physicians in the care of the players, as the team physician now collaborates with the NBA concussion program director before officially clearing a player to return to exhibition games. The increase in games missed in the 2008 and 2010 seasons, before the institution of the concussion policy, likely indicates the importance of awareness and education in addition to the influence of concussion coverage nationally. These factors, compounded with the formal concussion policy, help to explain the dramatic increase in the number of games players miss after concussions in the time span studied.

In addition, team-specific analysis indicates the further potential that awareness and formal policy can have in protecting players. Most players who returned from a concussion without missing a game after 2011 played for organizations that also had players return without missing a game before 2011. These organizations and their players

will likely benefit from the continuing publicity and increased education regarding concussions.

The challenges in continuing to improve care in the treatment of concussions in the NBA and other professional sports remain substantial. Beginning with diagnosis, previous studies have shown that less than half of players will report a concussion at the time it occurs,¹⁶ and as only a minority of concussions result in loss of consciousness, team physicians must be vigilant in monitoring for signs and symptoms. While public awareness continues to grow, both the medical staff and the sports culture must adapt to encourage players to report their symptoms promptly. Failure to do so increases the chances of further concussive events in the same season and can result in a variety of serious complications.¹⁰

After diagnosis, a comprehensive examination and longitudinal monitoring must be performed to best guide return to play. The policy the NBA has instituted helps to protect players by banning a return to play in the same game that a concussion was diagnosed, a practice that was not always upheld before this rule. While the underlying goal of the medical staff should be to protect the player with a conservative approach,³ external pressures, including the player's desire to return, must be carefully managed to optimize safety.¹³ Therefore, methodical and thorough testing must be performed. Comparing post-concussive cognitive test scores to baseline levels, preventing physical activity before symptom resolution, and astute neurological examination all assist the medical staff in ensuring an optimal return-to-play date.^{2,6}

While the data reported in this study resulted from a review of various injury reports and databases, a major limitation of this study is the inability to include concussed players who were not formally diagnosed with a concussion. In addition, as no official, central database exists to disclose NBA concussions, those that were not publicly reported could not be included in this investigation. Also, despite the methodical approach to compiling the concussion data, human error could also affect the data due to the decentralized compilation. As with studies performed in other sports,^{4,9,15,23} the incidence reported likely significantly underrepresents the true incidence of concussions in the NBA. This phenomenon consequently alters other data that were reported, including the average games missed after a concussion and the incidence of players returning after having missed zero games. This being said, significant efforts aimed toward accurate injury reporting have been instituted, including the use of an electronic medical record in the NBA in 2011.

Regardless of this limitation, however, this study shows that the concussion trends reported in other American professional sports also are present in the NBA. The number of games missed after a concussion has risen significantly after the institution of a formal concussion protocol and the number of players returning to play the game immediately after a concussion has dropped to almost zero. Further studies analyzing these trends in both the NBA and other professional sports are needed to help protect players and raise awareness regarding the importance of reporting symptoms and sitting out until the players are fully

recovered. Greater transparency and public disclosure of concussion data in professional sports could help researchers and physicians protect players of all ages.

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