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Using the World Wide Web to Conduct Epidemiological Research: An Example Using the National Basketball Association

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Several Web sites posted detailed information about NBA player injuries during the 1999–2000 and 2000–01 seasons. From these postings, information about injuries to 311 National Basketball Association (NBA) players in 2378 games during the 2 seasons stipulated was collated. These players suffered 593 injuries that caused them to miss 5819 player games. For every cited injury, a body region was listed (eg, ankle), with a more specific diagnosis (eg, sprain) being listed 82% of the time by at least 1 Web site. The average injury prevalence (percentage of players missing through injury) was higher among the bench players (15.1%) than the 5 designated starting players (12.4%) for each team. Some of the reported injuries to bench players might have been spurious and were possibly cited for the purposes of creating space on the 12-man roster. The true injury prevalence among NBA players in season 1999–2000 was probably at least 12%. Injuries caused more missed playing time in players 30 years or older ($P < .001$) and players with a body mass index of 26 or higher ($P < .001$). The level of diagnostic detail posted on Web sites and the similarity of the injury profile to previous surveys of basketball injuries suggest that most of the injury information on Web sites is fairly accurate.

Key Words: injury, ankle sprain, patellar tendinitis, Web sites

Key Points

- This article analyzes the status (whether playing, injured, or not playing for other reasons) of 311 National Basketball Association (NBA) players in seasons 1999–2000 and 2000–01, based on public information obtained from the World Wide Web.
- The most commonly injured body areas in NBA players appear to be the knee, foot, and ankle, which is consistent with previous surveys of basketball injuries.
- Injury prevalence (the percentage of NBA players missing because of injury at any given time) is at least 12%. The apparent injury prevalence of bench players is even higher, although it is likely that some of these injuries are spurious and are cited for the purposes of manipulating roster space.
- Older players and players with a body mass index (BMI) of 26 or higher are more likely to miss playing time as a result of injury than are younger players and players with a BMI of 25 or less. Of the starting positions in the NBA, the centers miss the most playing time because of injuries, and the small forwards miss the least.

The objectives of our study were to review Web sites with information regarding injuries in the National Basketball Association (NBA) for seasons 1999–2000 and 2000–01 and to assess the detail of information that is publicly available regarding injuries in this competition.

Data Sources

An initial Web search for *NBA* and *injury* was performed with the LookSmart, Netscape, msn.com, and AltaVista search engines. The results yielded the following Web sites that consistently posted detailed summaries of injuries to players in the NBA. They are listed in alphabetical order and numbered from 1 to 13 as they appear in the reference list for the article:

1. ALL IN 1 SPORTS: http://www.allin1sports.com/pb/index2.htm
2. Basketball News: http://basketballnews.com/; http://basketballnews.com/content/fantasy/fantasy_set.asp?main=injury_110800.asp
3. USA Basketball Center Online: http://cybergsi.com/basketball/nba/schedules/nbainjury.htm
4. CBS SportsLine. Home page: http://cbs.sportsline.com/nba/index.html ; Injury page: http://cbs.sportsline.com/u/basketball/nba/injuries/injuries.htm
5. FOX Fantasy Basketball: http://www.foxsports.com/nba/home/nba_news.cfm?source=st_stat&cont_type_id=669&suppress_right_rail=true&subnav_key=nba&inset_include=&subsection=injuries
6. ESPN Fantasy Basketball. Home page: http://games.espn.go.com/cgi/fba/Request.dll?FRONTPAGE ; Injury page: http://games.espn.go.com/cgi/fba/request.dll?INJURYROOM&Param0=0
7. NBA.com (official NBA Web site). Home page: http://www.nba.com ; Injury page: No injury page, but has player-by-player status sheet of games played.
8. The Sporting News. Home page: www.sportingnews.com/nba ; Injury page: www.sportingnews.comm/nba/injuries-*P*.html
9. ESPN.com. Home page: http://sports.espn.go.com/nba/index ; Injury page: http://espn.go.com.nba/injuries/index.html
10. Yahoo!.Sports: http://sports.yahoo.com/nba/players/date.html
11. CNN/Sports Illustrated: http://sportsillustrated.cnn.com/basketball/nba/injuries
12. Rotonews. Home page: http://www.rotonews.com ; Injury page: http://www.rotonews.com/basketball/DL.cfm
13. USA Today Pro Basketball. Home page: http://www.usatoday.com/sports/nba.htm ; Injury page: http://www.usatoday.com/sports/injuries/nbainj.htm

Selection Process

Retrieval of injury information was attempted for the leading 9 players on each of the 29 teams for the 82-game NBA 1999–2000 and 2000–01 regular seasons. The 9 players were chosen by position at the start of each season. The 9 positions chosen were point guard (PG, 1), shooting guard (SG, 2), small forward (SF, 3), power forward (PF, 4), and center (C, 5), starting players, and guard (G, 6), guard/forward (GF, 7), forward (F, 8), and forward/center (FC, 9), bench players. A guard was a reserve who would usually play in either position 1 or 2; a guard/forward, position 2 or 3; a forward, position 3 or 4; and a forward/center, position 4 or 5.

The threshold definition for an injury was "any medical condition or injury that prevented a player from participating in a regular-season game." Because of this definition, the method for defining an injury was to keep a game-by-game log of the status of all players under investigation (see Table 1 for an example). If a player did not play in a given round, his status (of not playing) was assessed as a result of either injury or noninjury reasons (eg, coach's decision).

An injury was defined as having been resolved when a player returned to play in a regular-season game, with any further episode of missed games after this time (as a result of the same diagnosis) being determined as a recurrence of the initial injury.

Injury information was collated according to the following levels:

- Level 1: Determination of whether the player participated in a scheduled game, and if he did not, whether he missed the game because of injury or other reasons. Other reasons for missing a game included coach's decision (dressed to play but not given any court time), personal reasons, suspension, and a player being released or waived by the team.
- Level 2: If a player missed a game because of injury, determination of which body area was injured.
- Level 3: Determination of type of injury, in addition to body part, for example, ankle sprain, knee tendinitis. A 3+ grading was given if a specific medical diagnosis was provided (eg, ankle lateral-ligament sprain, patellar tendinitis).

Nine players per team were chosen, even though NBA teams keep a 12-man roster. This was because the bottom 3 players on the roster often do not get any court time, and it is sometimes difficult to determine whether this is because injury or selection (coach's decision). In addition, the bottom players on the roster are often rotated with players 13, 14, and 15 as part of balancing the roster, with injury sometimes used as a spurious excuse to take a player off the roster. On most occasions, when a player was taken off the 12-man roster as a result of injury, another player returning from injury immediately took his place on the roster. This practice appeared

Table 1 Lakers' Player Status for First 10 Rounds of Season 1999–2000*

	Round, Date									
Player	**1, 11/2**	**2, 11/3**	**3, 11/6**	**4, 11/7**	**5, 11/9**	**6, 11/10**	**7, 11/12**	**8, 11/14**	**9, 11/15**	**10, 11/18**
SO	played	played	played	played	played	played	SUSP	played	played	played
KB	I-hand	I-hand	I-hand	I-hand	I-hand	I-hand	I-hand	I-hand	I-hand	I-hand
GR	played	played	played	played	played	played	played	played	played	played
DF	played	played	played	played	played	played	played	played	played	played
RF	played	played	played	played	played	played	played	played	played	played
RH	played	played	played	played	played	played	played	played	played	played
AG	played	played	played	played	played	played	played	played	played	played
TL	played	played	played	played	played	played	played	played	I-knee	I-knee
RH	I-knee	I-knee	I-knee	I-knee	I-knee	I-knee	played	played	played	played

*SUSP indicates suspended, and I, injured.

to be accepted among NBA teams and expected by commentators. The following quotes from Web sites are given as examples:

> Michael Hawkins was put on the injured list Tuesday with what is being termed tendinitis in his left knee, but the Hornets needed a roster spot for Chucky Brown.[8]
>
> SG/SF James was placed on the injured list Monday (1/31) because of lower back spasms. There were also symptoms of a bad case of roster space setting in, as the Heat activated SG Rodney Buford to replace James.[6]

The same 9 players were followed throughout the season, even if they transferred to another team.

Data Extraction

The major Web sites were regularly checked (at least once every 4 days) for player-injury details. When contrasting information was posted on different Web sites, the site with the most detail was used as the study diagnosis, based on the presumption that the most detailed information was likely to be the most accurate. For example, if a player was listed as being out injured with a navicular stress fracture that was scheduled for surgery, it is most likely that this information was accurate, because it was probably a specific quote from a medical source associated with the team. If a player was listed as being out injured with a foot injury, it is probable that this was his true status, but it is less certain because it is more likely to have been a quote from a nonmedical person. In football, it is well known that teams might lie about the details of an injury in order to protect the player from body contact to the injured part. This is not thought to be as much of a factor in basketball, because player contact (other than accidental) is illegal, so players cannot "target" an injured body area in an opponent.

Obviously, the gold standard of diagnosis is one made by the player's personal physician, and this is the usual standard of information provided for an injury-surveillance system. There is no limit to the amount of detail that can theoretically be known by the team physician (eg, right navicular vertical stress fracture of 4 mm length with 1 mm displacement of fragments and evidence of marginal sclerosis). However, even in injury surveys with access to this information, the injury will be more generally classified for the purposes of reporting. The most detailed reports of injury surveys create general diagnoses (eg, number of ankle-sprain injuries), and many injury surveys report diagnoses only by body part (level-2 information), for example, the work of Messina et al.[14]

There is also a "law of peripheral accuracy" in sports medicine, in that medical diagnoses are very objective for peripheral body parts (eg, knee, foot, ankle, hands), but in central parts of the body (eg, lumbar spine, groin)

there is often great disagreement among physicians about the actual diagnosis. This applies even when there is full access to imaging studies. Some authorities believe that the vast majority of lumbar spine pain should be diagnosed in a very general fashion, because there is rarely any evidence for a specific tissue diagnosis, for example of L5/S1 discogenic pain.[15]

Results

The Web sites that regularly contained the most injury detail (those with a 3 or 3+ level of diagnosis, that is, body area and specific injury type) were ESPN Fantasy Basketball,[6] The Sporting News,[8] USA Today Pro Basketball,[13] Rotonews,[12] and FOX Fantasy Basketball.[5]

There were 29 teams followed over 2 seasons, with 9 players per team selected, representing a total of 522 player seasons. The regular season lasted 82 games, so there was a total of 42 804 possible games played by these players. The total number of individual players studied was 311, with average height of 2.01 ± 0.095 m, weight 99.5 ± 12.6 kg, age 27.6 ± 4.57 years, and BMI 24.7 ± 1.87. These were tabulated in the format seen in Table 2 (eg, weight to the nearest 5 kg). For every player game, the status of the player was posted on at least 1 Web site to at least a level-2 degree of detail (played / missed because of injury / missed for other reasons, and, when injured, a body part was listed).

There were 593 new injuries recorded during the season. There were 48 preexisting injuries at the start of round 1 over the 2 seasons, with 545 injuries occurring during the season between rounds 1 and 81, inclusive. No injuries could occur during round 82, according to the definition of the study, because an injury must have caused a player to miss a subsequent game, and round 82 was the final game for each team. The seasonal injury incidence was 1.13 new injuries per player per season.

Table 2 Injury Prevalence by Player Weight

Weight (kg)	Injury Prevalence
80 or less	12.8%
85	11.1%
90	17.7%
95	12.3%
100	13.8%
105	11.4%
110	13.1%
115	20.4%
120	10.8%
125 or more	7.9%

The vast majority (82.4%) of injury diagnoses were of a level-3 or -3+ degree of detail, meaning that the diagnosis included type of injury, as well as body part (Table 3).

The common injuries in the following body areas were knee (patellar tendinitis, arthroscopy for cartilage tear, ligament sprain, quadriceps tendinitis), ankle (sprain, bone spurs, Achilles tendinitis), foot (stress fracture, ligament sprain, plantar fasciitis), thigh (hamstring strain, groin strain), low back (muscle spasms), lower leg (calf strain), hand (finger fracture), and medical illness (flu).

The incidence of new injuries is presented in injuries per 1000 athlete exposures, with a player game counting as 1 exposure. Because the onset of injury was not known (ie, whether an injury occurred during a game or training), the concept of an exposure with respect to this report should include the training sessions leading up to a game.

Of the 593 new injuries, 130 suffered a recurrence later in the season, meaning that a subsequent game was missed with the same diagnosis after the player had returned to game participation.

A total of 5819 player games were missed because of injury for the season, yielding an average injury point prevalence (referred to hereafter as injury prevalence) of 13.6%. That is, at any given time in each season, an average of 13.6% of the 261 players were missing as a result of injury (Table 4). The other common reasons for missing games were coach's decision, in

Table 3 Injury Frequency by Region and Level of Diagnostic Detail

	Level of Diagnostic Detail					
Region	**2**	**3**	**3+**	**All**	**% of all injuries**	**Recurrence rate (%)**
Head/neck	3	5	13	21	3.5%	14.3%
Shoulder	3	10	8	21	3.5%	4.8%
Elbow/arm	2	8	4	14	2.4%	21.4%
Hand/wrist	2	32	10	44	7.4%	20.5%
Trunk			3	3	0.5%	0.0%
Back	22	24	5	51	8.6%	29.4%
Groin/hip	3	14	18	35	5.9%	22.9%
Thigh	1	13	16	30	5.1%	23.3%
Knee	29	52	26	107	18.0%	28.0%
Lower leg	6	4	20	30	5.1%	6.7%
Ankle	21	86	18	125	21.1%	27.2%
Foot	10	14	15	39	6.6%	28.2%
Illness	2	47	24	73	12.3%	9.6%
Total	104	309	180	593	100.0%	21.9%

Table 4 Player Status and Injury Prevalence by Position*

Position number	Position	Games played	DNP, CD	DNP, PERS	DNP, SUSP	DNP, other	DNP, injured	Total player games	Injury prevalence
1	point guard	4 159	30	7	7	36	517	4 756	10.9%
2	shooting guard	3 979	15	14	10	53	685	4 756	14.4%
3	small forward	4 284	15	16	2	18	421	4 756	8.9%
4	power forward	4 090	62	6	18	0	580	4 756	12.2%
5	center	3 820	94	2	90	4	746	4 756	15.7%
6	guard	3 822	95	10	3	2	824	4 756	17.3%
7	guard/forward	3 889	161	6	0	50	650	4 756	13.7%
8	forward	3 789	149	22	8	2	786	4 756	16.5%
9	forward/center	3 897	222	17	8	2	610	4 756	12.8%
1–5	starters	20 332	216	45	127	111	2 949	23 780	12.4%
6, 7	bench	15 397	627	55	19	56	2 870	19 024	15.1%
1, 2, 6, 7	guards	15 849	301	37	20	141	2 676	19 024	14.1%
3, 4, 8–10	forwards	19 949	609	67	36	72	3 047	23 780	12.8%
5, 9	centers	7 717	316	19	98	6	1 356	9 512	14.3%
1–9	all players	35 729	843	100	146	167	5 819	42 804	13.6%

*DNP indicates did not play; CD, coach's decision; PERS, personal reasons; and SUSP, suspension.

which the player dressed to play but was not given any game time by the coach (843 missed games); personal reasons such as family bereavement (100 missed games); and suspension from either the league or the team (146 missed games).

The injury incidence or prevalence for 2 different groups was compared using chi-square tests to see whether injury rates appeared to differ significantly between groups.

Small forwards had the lowest injury prevalence, whereas of the starting players, centers had the highest. Small forwards had a lower injury prevalence ($P < .001$) than other starting players, whereas centers had a higher injury prevalence ($P < .001$). Injury prevalence is determined by a combination of incidence and severity. Because centers did not have a higher injury incidence than the other starting players ($P > .10$; Table 5), their injuries were slightly more severe (ie, caused a greater number of missed games per injury). Starting players had a lower prevalence of injury than bench players did ($P < .001$; Table 4). Because starting players had more court time, it would be expected that they would be injured more often. Some of the injuries to bench players might have been spurious or exaggerated as a means to free up space on the 12-man roster.

The average injury caused a player to miss 9.8 games (Table 6), with foot and shin injuries being the most severe on average (some of these injuries were stress fractures, which result in a large number of games being missed).

Examination of the relationship between injury prevalence and player morphology shows that injuries caused more missed playing time in players age 30 or older ($P < .001$) and those with a BMI of 26 or higher ($P < .001$; Tables 2 and 7–9). There was no difference in the injury prevalence between players of height of 2 m or more and those shorter than 2 m ($P > .10$).

Table 5 Injury Incidence by Player Position

Position	Incidence (injuries per 1000 player exposures)
Point guard	14.3
Shooting guard	16.2
Small forward	14.7
Power forward	16.8
Center	16.7
Guard	13.5
Guard/Forward	14.3
Forward	20.8
Forward/Center	11.7

Table 6 Injury Incidence and Severity and Missed Playing Time

Body area/condition	Incidence (injuries per 1000 athlete exposures)	Severity (average number of games missed per injury)	Contribution to all missed playing time
Concussion	0.2	3.8	0.5%
Eye	0.1	1.3	0.1%
Jaw	0.0	16.0	0.3%
Neck	0.2	3.5	0.5%
Shoulder	0.6	10.0	3.6%
Elbow	0.4	9.1	2.0%
Triceps	0.0	8.0	0.1%
Hand	1.0	9.3	5.7%
Wrist	0.2	12.1	1.7%
Rib	0.1	5.0	0.3%
Back	1.4	6.1	5.4%
Groin	0.7	10.1	4.7%
Hip	0.2	5.0	0.7%
Hamstrings	0.5	6.9	2.1%
Quad	0.2	15.0	1.8%
Thigh	0.1	1.4	0.1%
Knee	2.5	14.1	26.0%
Calf	0.5	6.7	2.3%
Leg/Shin	0.2	19.1	3.3%
Achilles	0.5	10.3	3.2%
Ankle	2.9	9.7	17.9%
Foot	1.0	17.5	11.7%
Illness	2.0	4.8	6.1%
Total	15.4	9.8	100.0%

Table 7 Injury Prevalence by Player Age

Age	Injury prevalence
22 or less	10.5%
23	16.6%
24	14.5%
25	15.3%
26	15.0%
27	12.7%
28	8.4%
29	11.2%
30	17.2%
31	17.9%
32	15.6%
33	16.7%
34 or more	11.0%

Table 8 Injury Prevalence by Player Height

Height (m)	Injury prevalence
1.80 or less	14.0%
1.85	13.4%
1.90	15.6%
1.95	13.1%
2.00	15.7%
2.05	12.4%
2.10	12.2%
2.15	10.2%
2.2 or more	22.9%

Table 9 Injury Prevalence by Body Mass Index (BMI)

BMI	Injury Prevalence
22 or less	7.9%
23	11.8%
24	14.8%
25	12.5%
26	16.0%
27	19.4%
28 or more	14.0%

Table 10 Injury Prevalence and Incidence by Stage of Season

Rounds	Prevalence	Incidence (injuries per 1000 athlete exposures)
1–10	11.4%	17.2
11–20	13.4%	17.6
21–30	14.2%	16.2
31–40	13.9%	11.3
41–50	13.4%	14.0
51–60	12.4%	13.7
61–70	13.6%	15.1
71–80	15.6%	17.6

There was a slight tendency for heavier players (>100 kg) to have a higher injury prevalence than did lighter players (100 kg or less; $P < .10$ but $P > .05$).

Over the course of the season, injury prevalence (percentage of players missing because of injury) rose gradually as chronic injuries started to accumulate. Injury incidence (the number of new injuries) was steady throughout the season, with a small drop in the middle of the season (Table 10).

Discussion and Conclusions

There is a great deal of information on injuries to NBA players available publicly on the World Wide Web. During the 1999–2000 and 2000–01 seasons, each player surveyed had "official" details posted about whether he played in each game or missed the game. When he missed the game, there was always at least a level-2 degree of information posted about his injury status (injured body part was listed), or another reason for missing the game was cited. Many injuries (82%) had a level-3 or -3+ diagnosis posted (body part and injury type, or specific medical diagnosis). The level of detail of this information compares favorably even with reports of basketball injury surveillance published in the medical literature. For example, a recent survey of basketball injuries tabulated injuries by body part and by injury part but only examined the incidence of 1 specific medical diagnosis—ACL sprains.[14] Obviously, the accuracy of Web-site information is uncertain, but it is probably accurate in circumstances when specific detail about an injury is posted, which is in most cases.

There has been 1 detailed report published regarding injury incidence and prevalence in the NBA.[16] This study reported on injuries from a single NBA team over a period of 8 seasons, from 1973 to 1980. This team had a total of 490 player games missed because of injury over these 8 years, an average of 61 player games per season. The injury prevalence (calculated using the methods of the current study) was 7.6%, which is substantially lower than the injury prevalence from the current study (12.7%). This suggests that injuries are becoming more prevalent in the NBA, which warrants further study. The injury incidence for the 2 studies was not comparable, because different definitions were used. The injury profile from the study of Henry et al[16] was similar to that of the current study, although an even higher proportion of games was missed because of knee injuries (66%). The most common specific diagnoses were ankle lateral-ligament sprains and patellar tendinitis.

A more recent article reporting on eye injuries in NBA players has been published.[17] This article reviewed 59 eye injuries that were recorded by 27 NBA teams (physicians and head trainers) between February 1, 1992, and June 20, 1993. Although the article reported that NBA players on these 27 teams incurred 1092 injuries (in total) over the same time period, the detail

was not reported in the article or elsewhere in the sports-medicine literature.

The areas of greatest injury incidence and prevalence in NBA players, according to the Web-site postings, are the knee, foot, and ankle. This profile is consistent with previous reports of injuries to basketball players.[14,16,18-21] The similarity of the NBA injury profile (according to Web sites) and the expected injury profile (based on previous publications of basketball injuries) suggests a fair degree of accuracy in the Web-site postings.

Numbers of player games missed as a result of injury by NBA teams in the season 1999–2000 have been quoted by The Sporting News Web site[8] and an Athlon Sports preseason preview for season 2000–01.[22] The teams with the most player games missed because of injury in 1999–2000 were the Dallas Mavericks (332 player games), Golden State Warriors (329), New Jersey Nets (272), Chicago Bulls (246), and San Antonio Spurs (244). These figures included all players on the roster, which had a limit of 12 active men at any given time. Because injured players could be replaced on the roster, however, many more players were able to be included (eg, Golden State had 23 players with playing time for season 1999–2000). The number of player games missed as a result of injury for the 9 players in our survey in 1999–2000 for those listed teams was Dallas 163, Golden State 220, New Jersey 126, Chicago 196, and San Antonio 105. These example teams show that the "official" injury rate for players rated at position 10 or below on the roster is enormous, particularly when considering the fact that these players receive very little court time. The explanation for this is almost certainly that most of these injuries are either spurious or exaggerated as a sanctioned means for creating extra roster space.

It is difficult to determine the accuracy of this survey, but the following general conclusions can be made:

- Most of the time when a detailed diagnosis is posted, it is probably accurate. Because this occurs regularly, even for medical diagnoses that are quite personal and for severe injuries that are career threatening, it is presumed that there is a low level of medical confidentiality for NBA players.
- The most common inaccuracy of information regarding NBA injuries is probably when a fringe player (eighth man or lower) is declared "injured" by the team in order to make room on the 12-man roster for another player who is needed more by the team at that time. In this case, the injury is either a pseudoinjury (fabricated) or, perhaps more often, a minor injury that has had its severity inflated by the team (ie, an injury that exists and is limiting the player to some degree, and is perhaps affecting his selection at that time, but would not be severe enough to prevent him from playing if he were needed).
- Because the injury information for the top 5 players on each team is most likely to be accurate, a realistic estimation of the true injury prevalence for season 1999–2000 can be made. The true injury prevalence

probably fell between 12% and 13% for seasons 1999–2000 and 2000–01.

- The 12-man roster limit, with replacements allowed only when players are waived or injured, probably leads to an exaggeration of the number of injuries in the NBA in the media. The NBA should give consideration to a rule change regarding roster size if it wishes to avoid the citation of spurious injuries.
- Knee, foot, and ankle injuries are the most frequent and prevalent injuries in the NBA and warrant further study. Formal injury surveillance with disclosure (publication in the medical literature) would be the most appropriate starting point for further study.
- This study has shown that medical confidentiality should not be seen as a deterrent to formal surveillance, because enormous detail regarding injuries is already available on the World Wide Web.

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