[Primary Care]

Repeat Concussions in the National Football League

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Background: Repeat concussion is an important issue in the National Football League (NFL). An initial description of repeat injuries was published for 6 years (1996-2001).

Hypothesis: The characteristics and frequency of repeat concussion in the NFL have not changed in the subsequent 6 years (2002-2007).

Study Design: Case control.

Methods: From 1996 to 2007, concussions were reported using a standardized form documenting signs and symptoms, loss of consciousness and medical action taken. Data on repeat concussions were analyzed for the 12 years and compared between the 2 periods.

Results: In 2002-2007, 152 players had repeat concussions (vs 160 in 1996-2001); 44 had 3+ head injuries (vs 52). The positions most often associated with repeat concussion in 2002-2007 were the defensive secondary, kick unit, running back, and linebacker. The odds for repeat concussion were elevated for wide receivers, tight ends, and linebackers but lower than in the earlier period. During 2002-2007, over half of players with repeat concussion were removed from play, and fewer immediately returned (vs 1996-2001). The average duration between concussions was 1.25 years for 2002-2007 and 1.65 years for the 12-year period. Over 12 years, 7.6% of all repeat concussions occurred within 2 weeks of the prior concussion.

Conclusions: The defensive secondary, kick unit, running back, and linebacker have the highest incidence of repeat concussion. During 2002-2007, more than half of players with repeat concussion were removed from play, and only a fraction immediately returned. Although concussion was managed more conservatively by team physicians in the recent 6 years, repeat concussions occurred at similar rates during both periods.

Keywords: concussion; traumatic brain injury; injury surveillance; epidemiology; repeat or multiple concussions; sport; head injury

Since 1996, National Football League (NFL) team physicians and athletic trainers have been collecting data on the clinical signs and symptoms, medical action, and management of concussion to provide a basis for improvements in player safety.[2-4,7-11] The major findings of the earlier study on repeat concussions in NFL players were that there were no cases of second-impact syndrome,[7,10] there were no major clinical differences between single and repeat concussions, the incidence of repeat concussion was 24.6%, and the median interval between repeat concussions was slightly longer than 1 year, with sparse repeat injuries occurring within the first few weeks following concussion.[8-10] Since 2001, there have been a number of rule changes, improvements in protective gear, and ongoing educational efforts aimed at medical personnel as well as players and team officials.[4,11] In addition, medical treatment of concussion in the NFL has become more conservative during 2002-2007.[4] This study addresses repeat concussions in the recent 6 years; it compares the data to the earlier 6-year period and analyzes the 12 years of data.

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MATERIALS AND METHODS

NFL team physicians and athletic trainers used a simple form to report the signs and symptoms of concussion on initial and follow-up examinations.[2-4,7-11] All players were examined by team physicians who made the management decisions. Players' names were not included on the forms, to maintain confidentiality; each was identified by a 6-digit number.

Operational Definitions

A reportable concussion is a traumatically induced alteration in brain function that is manifested by

1. alteration of awareness or consciousness, including but not limited to being dinged, dazed, stunned, woozy, foggy, or amnesic or, less common, being rendered unconscious or, even more rare, experiencing seizure and
2. signs and symptoms commonly associated with postconcussion syndrome, including persistent headaches, vertigo, light-headedness, loss of balance, unsteadiness, syncope, near syncope, cognitive dysfunction, memory disturbance, hearing loss, tinnitus, blurred vision, diplopia, visual loss, personality change, drowsiness, lethargy, fatigue, and inability to perform usual daily activities.[4,5,7-11]

This definition is an extension of the Ad Hoc Committee to Study Head Injury Nomenclature, of the American Congress of Rehabilitation Medicine.[1]

Signs and Symptoms

The signs and symptoms of concussion were grouped into 6 categories: general symptoms, somatic complaints, cranial nerve findings, cognitive abnormalities, memory problems, and unconsciousness. A large and inclusive list was selected to capture all possible clinical signs and symptoms with concussion in professional football players. The rationale for the various signs and symptoms can be found in earlier studies.[4,7,8]

Return to Play

NFL team physicians clear a player for return to play after they are asymptomatic and have a normal neurologic examination.[2,3,8-10]

Return immediately. The player returns after an evaluation by the team physician demonstrates that he is asymptomatic. Depending on the game, the period of rest may be minutes or possibly an hour or so before the player gets back on the field.

Rest and return. The player is evaluated, and a determination is made that there should be some protracted time before a return to play.

Removed from play. The player is not allowed to return to the game or session in which he was injured.

Hospitalized. The player is admitted to the hospital for evaluation and head radiograph, computed tomography, or magnetic resonance imaging.

Days Out

Days out is defined as the time between the date of injury and the return to full and unlimited participation.[4,7,9] The player must be able to perform all activities of the session at the same intensity as teammates. The recent 6 years of data and the full 12 years were evaluated for the time between repeat injuries—including the mean, median, minimum, and maximum days between concussions.

Statistics

Descriptive statistics were used to characterize those players who had a single concussion and those who had repeat concussion during the 6-year study. Chi-square analyses were used to compare the presence of individual signs and symptoms, the medical action, and the management of those with repeat concussion to those with a single concussion. Furthermore, *t* tests were used to compare the mean number of signs and symptoms for those with single and repeat concussion. Odds ratios (ORs) with 95% confidence intervals were used to summarize the magnitude of associations. Paired *t* tests and McNemar tests were used to compare those same items for players on their first and second concussions within the 6-year study.

RESULTS

Repeat Concussion in the 1996-2007 Seasons

Out of 1200 concussed players, 353 (29.4%) experienced repeat concussion (Table 1). Twelve players experienced 5+ concussions and 126 experienced 3+ concussions in the 12 years. When repeat concussion occurred, the majority of players (64.3%, 227 of 353) had only 2 concussions. The total number of concussions was 1741 over the 12 years, with 48.7% being single injuries.

The repeat injury patterns were similar between the two 6-year periods. There were 854 concussions during 2002-2007, compared with 887 during 1996-2001, in practice and preseason, regular season, and postseason games. During 2002-2007, 155 players (24.2%) had repeat concussion; 44 players (6.9%) experienced 3+ injuries and no player had more than 5 concussions. In contrast during 1996-2001, 160 players (24.7%) had repeat concussion; 52 (8.0%) experienced 3+ concussions; and 1 player had 7 concussions.

During the 12 years, the offense had a higher frequency of single and repeat concussions. With > 3 concussions, the defense was more involved (Table 2). Individually, the position groups most often associated with repeat concussion were the

Table 1. Repeat concussions in National Football League players: 1996-2007, 1996-2001, 2002-2007.

	Players				Concussions			
	n	%			n	%		
Concussions, n	1996-2007				1996-2007			
1	847	70.6			847	48.7		
2	227	18.9			454	26.1		
3	85	7.1			255	14.6		
4	29	2.4			116	6.7		
5	6	0.5			30	1.7		
6	3	0.3			18	1.0		
7	3	0.3			21	1.2		
Total	1200	100			1741	100		
	1996-2001		2002-2007		1996-2001		2002-2007	
1	489	75.3	486	75.8	489	55.1	486	56.9
2	108	16.6	111	17.3	216	24.4	222	26.0
3	37	5.7	33	5.1	111	12.5	99	11.6
4	8	1.2	8	1.2	32	3.6	32	3.7
5	4	0.6	3	0.5	20	2.3	15	1.8
6	2	0.3	0	0.0	12	1.4	0	0.0
7	1	0.2	0	0.0	7	0.8	0	0.0
Total	649	100	641	100	887	100	854	100

defensive secondary (17.3%), kick unit (15.0%), wide receivers (11.3%), and running backs (10.2%). The ORs were not statistically significant from 1.00; however, the odds for repeat concussion were highest for the quarterbacks (OR = 1.55), tight ends (OR = 1.25), and wide receivers (OR = 1.22).

The signs and symptoms of a third injury were as follows: headaches (62.7%), dizziness (41.3%), problems with immediate recall (18.3%), and blurred vision (15.1%) (Table 3). These frequencies were not much different from those with a first or second concussion. Loss of consciousness was slightly higher with a third injury compared with a single concussion (8.7% vs 5.7%).

The most common action with a third injury was rest and return (45.2%), which was similar to removal from play (42.9%) (Table 4), and both of which were similar to the action taken on the first and second injuries. A slightly lower percentage of players returned immediately with a third concussion compared to a single or first repeat concussion (10.3% vs 12.3% and 14.2%).

Comparing Repeat Concussion Between 1996-2001 and 2002-2007

During 2002-2007, the offense had a higher frequency of single and repeat concussions, but with > 3 concussions, the defense was higher: defensive secondary (16.8%), kick unit (12.9%), running back (11.6%), and linebacker (11.6%) (Table 5). None of the ORs was statistically significant from 1.00; however, the odds were elevated for wide receivers (OR = 1.44), tight ends (OR = 1.31), and linebackers (OR = 1.21). During 1996-2001, the highest ORs were for the quarterback (2.32), tight ends (1.24), and linebackers (1.23). The odds for multiple concussion was significantly lower in quarterbacks for the recent 6 years (0.73 vs 2.32).

During 2002-2007, the highest frequency of 3+ concussions involved the secondary (25.0%), wide receivers (15.9%), and linebackers (13.6%). The highest involvement during 1996-2001

Table 2. Incidence of single and first repeat concussions by player position from 1996 to 2007.[a]

	Single Concussion		First Repeat Concussion				> 3 Concussions	
1996-2007	n	%	n	%	Odds Ratio	95% Confidence Interval	n	%
Offense								
Wide receiver	81	9.6	40	11.3	1.22	0.80-1.84	19	15.1
Running back	83	9.8	36	10.2	1.04	0.69-1.58	7	5.6
Quarterback	44	5.2	27	7.6	1.55	0.92-2.62	8	6.3
Offensive line	88	10.4	20	5.7	0.56	0.36-0.87	6	4.8
Tight end	49	5.8	25	7.1	1.25	0.75-2.10	10	7.9
Subtotal	345	40.7	148	41.9	1.05	0.82-1.05	50	39.7
Defense								
Secondary	140	16.5	61	17.3	1.06	0.76-1.47	27	21.4
Defensive line	70	8.3	30	8.5	1.03	0.66-1.62	9	7.1
Linebacker	69	8.1	29	8.2	1.01	0.64-1.59	15	11.9
Subtotal	279	32.9	120	34.0	1.05	0.81-1.37	51	40.5
Special team								
Kick unit	131	15.5	53	15.0	0.97	0.68-1.36	14	11.1
Return unit	37	4.4	13	3.7	0.84	0.45-1.57	5	4.0
Carrier	28	3.3	12	3.4	1.0	0.52-2.06	4	3.2
Punter	6	0.7	2	0.6	0.8	0.18-3.71	0	0.0
Kicker, FGA	2	0.2	0	0.0			0	0.0
Kicker, PAT	1	0.1	0	0.0			0	0.0
Holder	1	0.1	0	0.0			0	0.0
Kicker, kickoff	0	0.0	0	0.0			0	0.0
Special team	16	1.9	4	1.1			2	1.6
Subtotal	222	26.2	84	23.8	0.47	0.36-0.63	25	19.8
Unknown	1	0.1	1	0.3			0	0.0
Total	847		353				126	

[a]FGA, field goal attempt; PAT, point after touchdown.

Table 3. Signs and symptoms of the first, second, and third concussion from 1996 to 2007.

			Repeat Concussions					
	Single Concussion		First		Second		Third	
	n, 847		n, 353		n, 353		n, 126	
1996-2007	n	%	n	%	n	%	n	%
General symptoms	542	64.0	227	64.3	218	61.8	90	71.4
Headache	472	55.7	208	58.9	197	55.8	79	62.7
Nausea	83	9.8	30	8.5	28	7.9	12	9.5
Vomiting	16	1.9	3	0.8	3	0.8	0	0.0
Neck pain	104	12.3	42	11.9	48	13.6	17	13.5
Back pain	5	0.6	0	0.0	1	0.3	1	0.8
Syncope	18	2.1	6	1.7	6	1.7	6	4.8
Seizures	1	0.1	1	0.3	0	0.0	1	0.8
Somatic complaints	166	19.6	74	21.0	86	24.4	31	24.6
Irritability	27	3.2	12	3.4	16	4.5	6	4.8
Anxiety	31	3.7	17	4.8	22	6.2	7	5.6
Depression	3	0.4	1	0.3	5	1.4	2	1.6
Personality change	51	6.0	16	4.5	24	6.8	3	2.4
Fatigue	79	9.3	39	11.0	40	11.3	14	11.1
Sleep disturbance	11	1.3	1	0.3	0	0.0	1	0.8
Loss of libido	0	0.0	0	0.0	0	0.0	0	0.0
Loss of appetite	6	0.7	0	0.0	0	0.0	1	0.8
Cranial nerve symptoms	442	52.2	189	53.5	209	59.2	69	54.8
Dizziness	337	39.8	141	39.9	156	44.2	52	41.3
Vertigo	33	3.9	17	4.8	13	3.7	6	4.8
Tinnitus	17	2.0	9	2.5	7	2.0	7	5.6
Nystagmus	12	1.4	3	0.8	7	2.0	1	0.8
Hearing loss	1	0.1	0	0.0	0	0.0	1	0.8
Diplopia	19	2.2	11	3.1	10	2.8	0	0.0
Photophobia	42	5.0	17	4.8	25	7.1	9	7.1
Blurred vision	133	15.7	61	17.3	61	17.3	19	15.1
Pupil response	3	0.4	2	0.6	0	0.0	1	0.8

(continued)

Table 3. (continued)

			Repeat Concussions					
	Single Concussion		First		Second		Third	
	n, 847		n, 353		n, 353		n, 126	
1996-2007	n	%	n	%	n	%	n	%
Pupil size	2	0.2	0	0.0	0	0.0	1	0.8
Cognitive problems	192	22.7	94	26.6	84	23.8	25	19.8
Not oriented to person	16	1.9	11	3.1	12	3.4	1	0.8
Not oriented to place	32	3.8	16	4.5	18	5.1	2	1.6
Not oriented to time	55	6.5	26	7.4	30	8.5	5	4.0
Immediate recall	174	20.5	86	24.4	77	21.8	23	18.3
Memory problems	326	38.5	139	39.4	127	36.0	31	24.6
Attention problems	117	13.8	49	13.9	48	13.6	12	9.5
Information processing problems	163	19.2	66	18.7	66	18.7	17	13.5
Anterograde amnesia delayed	86	10.2	33	9.3	31	8.8	5	4.0
Retrograde amnesia delayed	145	17.1	61	17.3	51	14.4	14	11.1
Unconscious > 1 min	35	4.1	14	4.0	19	5.4	1	0.8
All loss of consciousness	48	5.7	21	5.9	29	8.2	11	8.7
All cases	401	47.3	196	55.5	168	47.6	85	67.5

Table 4. Actions taken with players experiencing single and repeat concussions from 1996 to 2007.

			Repeat							
	Single Concussion		First		Second		Third		Total	
Action Taken	n	%	n	%	n	%	n	%	n	%
Return immediately	104	12.3	50	14.2	32	9.1	13	10.3	200	11.5
Rest and return	272	32.1	127	36.0	130	36.8	57	45.2	615	35.3
Removed	446	52.7	161	45.6	174	49.3	54	42.9	864	49.6
Hospital	17	2.0	10	2.8	14	4.0	2	1.6	46	2.6
Unknown	8	0.9	5	1.4	3	0.8	0	0.0	16	0.9
	847		353		353		126		1741	

Table 5. Incidence of single, first repeat, and > 3 concussions by player position: 1996-2001 and 2002-2007.[a]

	Single Concussion		First of Repeat Concussions				> 3 Concussions	
2002-2007	n	%	n	%	Odds Ratio	CI	n	%
Offense								
Wide receiver	39	8.0	17	11.0	1.44	0.76-2.73	7	15.9
Running back	53	10.9	18	11.6	0.99	0.56-1.76	2	4.5
Quarterback	29	6.0	8	5.2	0.73	0.34-1.58	2	4.5
Offensive line	46	9.5	8	5.2	0.53	0.27-1.03	2	4.5
Tight end	33	6.8	13	8.4	1.31	0.65-2.64	2	4.5
Subtotal	200	41.2	64	41.3	0.93	0.64-1.34	15	34.1
Defense								
Secondary	95	19.5	26	16.8	0.86	0.54-1.36	11	25.0
Defensive line	34	7.0	11	7.1	1.04	0.51-2.12	3	6.8
Linebacker	49	10.1	18	11.6	1.21	0.67-2.19	6	13.6
Subtotal	178	36.6	55	35.5	0.99	0.68-1.44	20	45.5
Special team								
Kick unit	58	11.9	20	12.9	1.19	0.69-2.08	3	6.8
Return unit	32	6.6	8	5.2	0.8	0.38-1.70	3	6.8
Carrier	9	1.9	6	3.9	2.5	0.75-8.32	3	6.8
Punter	4	0.8	0	0.0			0	0.0
Kicker, FGA	3	0.6	1	0.6	1.07	0.11-10.77	0	0.0
Kicker, PAT	1	0.2	0	0.0			0	0.0
Holder	0	0.0	0	0.0			0	0.0
Kicker, kickoff	1	0.2	1	0.6	3.27	0.20-52.62		
Subtotal	108	22.2	36	23.2	1.13	0.73-1.75	9	20.5
Unknown	0	0.0	0	0.0			0	0.0
Total	486		155				44	

(continued)

Table 5. (continued)

	Single Concussion		First of Repeat Concussions				> 3 Concussions	
2002-2007	n	%	n	%	Odds Ratio	CI	n	%
1996-2001								
Offense								
Wide receiver	57	11.7	20	12.5	1.08	0.62-1.87	7	13.5
Running back	42	8.6	14	8.8	1.02	0.54-1.92	5	9.6
Quarterback	24	4.9	16	10.0	2.32	1.08-4.95	5	9.6
Offensive line	56	11.5	9	5.6	0.56	0.32-1.02	1	1.9
Tight end	25	5.1	9	5.6	1.24	0.57-2.74	3	5.8
Subtotal	204	41.7	68	42.5	1.06	0.73-1.52	21	40.4
Defense								
Secondary	80	16.4	28	17.5	1.05	0.65-1.70	9	17.3
Defensive line	43	8.8	16	10.0	1.15	0.62-2.14	5	9.6
Linebacker	33	6.7	13	8.1	1.23	0.61-2.46	5	9.6
Subtotal	156	31.9	57	35.6	1.16	0.79-1.69	19	36.5
Special team								
Kick unit	90	18.4	26	16.3	0.86	0.54-1.37	9	17.3
Return unit	18	3.7	2	1.3	0.44	0.16-1.24	1	1.9
Carrier	9	1.8	6	3.8	2.13	0.71-7.57	2	3.8
Punter	8	1.6	0	0.0			0	0.0
Kicker, FGA	1	0.2	0	0.0			0	0.0
Kicker, PAT	1	0.2	0	0.0			0	0.0
Holder	1	0.2	0	0.0			0	0.0
Subtotal	128	26.2	34	21.3	0.77	0.51-1.16	12	23.1
Unknown	1	0.2	1	0.6	3.07	0.19-49.36	0	0.0
Total	489		160				52	

[a]FGA, field goal attempt; PAT, point after touchdown.

was the secondary (17.3%), followed by wide receivers (13.5%). There were a higher fraction of players with photophobia (9.1% vs 3.8%), blurred vision (22.7% vs 11.5%), problems with information processing (18.2% vs 5.8%), and fatigue (14.0% vs 7.7%) in 2002-2007. These trends were somewhat parallel in players with a single concussion and a first repeat concussion. The signs and symptoms with the highest frequency in players with 3 concussions were headaches (65.9%), dizziness (40.9%), and blurred vision (22.7%).

The medical action taken after concussion was compared for the 2 study periods (Table 6). During 2002-2007, the most common action with players who had a second repeat

Table 6. Medical action taken with players experiencing single and repeat concussions: 1996-2001 and 2002-2007 (in percentages).

			Repeat Concussions			
	Single Concussion		First		Second	
	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007
n	489	486	160	155	160	155
Return immediately	17.2*	7.0*	15.0	11.6	11.9	6.5
Rest and return	29.9	35.2	35.0	36.1	40.6	37.3
Removed	49.9	54.7	45.6	49.0	41.3	52.9
Hospital	1.4	3.1	1.3	3.2	4.4	3.3
Unknown	1.6	0.0	3.1	0.0	1.9	0.0

*$P < 0.001$.

concussion (ie, third injury) was to remove from play (52.9%), as it was with the first injury (54.7%) and first repeat injury (49.0%). These percentages are higher than those in the earlier study period. The number of players going immediately back to play was much lower during 2002-2007. With a second repeat concussion, only 6.5% returned immediately, compared with 11.9% in the earlier study period. Overall, few players returned to the same game during the 2002-2007 period compared with the 1996-2001 time frame. The number of players hospitalized for observation was similar between the study periods and with single and repeat injuries. With a fifth concussion, the players exhibited problems with information processing and immediate recall and fatigue, in addition to headaches and dizziness (Table 7).

Days Between Repeat Concussions

The average time between concussions was 456 days, with a median of 371 for the recent 6 years (Table 8). For 12 years, the average time between concussions was 603 days, with a median of 406. The majority of players (89.8%) had more than 28 days between concussions, with only 5 players (0.9%) experiencing a repeat concussion the same day and 15 (2.8%) within a week.

DISCUSSION

The most striking finding of this report is that the incidence of repeat concussions remained the same during the 2 consecutive 6-year periods. This occurred despite the fact that, during the second 6-year period, a significantly lower percentage of players who sustained concussion returned to play on the day of the injury and a significantly higher percentage of players who sustained a concussion were held out of play for more than 7 days.[4]

The incidence of repeat concussion does not appear to be affected by the apparently more conservative management of concussion by NFL team physicians during the second 6-year period. The independence of the incidence of repeat concussion from return to play decisions is expected. The data indicate that the median time between concussions in NFL players is more than 1 year and that few repeat NFL concussions occur in the first few weeks following an initial concussion. Only 10.2% of NFL repeat concussions occurred within 28 days, 3.7% within 7 days, and only 6.7% within the first 2 weeks. These NFL results contrast with those reported in collegiate football players that suggested an increased risk of repeat concussion in the first 10 days following a concussion.[6] The reasons for this difference are unknown.

The earlier 6-year finding[4] that second-impact syndrome was not seen in the NFL is now extended to a 12-year period. During any 6-year study period of the NFL, there will be some players who began their careers before data collection began and some players who completed their careers after data collection ended. This might have artificially lowered the reported incidence of repeat concussion in NFL players. The incidence of repeat concussion during a 12-year period is less subject to these limitations because a higher percentage of players would have played their entire NFL careers within the dates of the study.

In sum, 353 players had 2 or more reported concussions during the entire 12-year period: 160 players had 2 or more from 1996 to 2001 and 155 players between 2002 and 2007 (see Table 1). Thirty-eight players had an initial concussion during 1996-2001 and sustained a repeat concussion between 2002 and 2007, which explains how 29.0% had repeat concussions during the 12-year period whereas only 24.6% had repeat

Table 7. Repeat concussions in National Football League players: 1996-2001 and 2002-2007 (in percentages).

	First		Second		Third		Fourth		Fifth	
	n, 51	n, 43	n, 51	n, 43	n, 51	n, 43	n, 15	n, 11	n, 11	n, 3
	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007
General symptoms	60.8	74.4	66.7	73.8	64.7	76.7	66.7	72.7	63.5	66.7
Headache	56.9	67.4	58.8	66.7	58.8	65.1	60.0	63.6	54.5	66.7
Nausea	9.8	4.7	5.9	4.8	5.9	14.0	6.7			
Vomiting			2.0				6.7			
Neck pain	7.8	9.3	9.8	11.9	15.7	11.6	13.3	9.1		
Back pain	0.0					4.7				
Syncope	2.0	2.3				7.0				
Seizures						2.3				
Somatic complaints	11.8	20.9	15.7	21.4	17.6	23.3	26.7	27.3	27.3	33.3
Irritability	3.9	2.3	2.0	2.4	2.0	4.7	0.0	9.1	9.1	
Anxiety	3.9		3.9		5.9	4.7	6.7			
Depression		2.3				2.3				
Personality change	2.0	2.3	2.0	7.1	2.0	2.3	13.3			
Fatigue	2.0	16.3	7.8	11.9	7.8	14.0	6.7	18.2	18.2	33.3
Sleep disturbance		2.3			2.0					
Loss of libido										
Loss of appetite						2.3				

(continued)

Table 7. (continued)

	First		Second		Third		Fourth		Fifth	
	n, 51	n, 43	n, 51	n, 43	n, 51	n, 43	n, 15	n, 11	n, 11	n, 3
	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007
Cranial nerve symptoms	54.9	58.1	58.8	54.8	56.9	58.1	53.3	63.6	63.6	66.7
Dizziness	41.2	37.2	39.2	50.0	41.2	41.9	26.7	45.5	45.5	66.7
Vertigo	5.9	4.7	2.0	2.4	3.9	7.0	6.7			
Tinnitus	2.0	4.7			5.9	9.3				
Nystagmus		2.3		2.4	2.0					
Hearing loss						2.3				
Diplopia	3.9	2.3	2.0	4.8			6.7			
Photophobia	3.9	7.0	9.8	4.8	3.9	9.3	6.7	18.2	9.1	
Blurred vision	27.5	9.3	21.6		11.8	20.9	26.7	36.4	27.3	
Pupil response							6.7			
Pupil size										
Cognitive problems	27.5	14.0	17.6	16.7	19.6	20.9	20.0	9.1	18.2	33.3
Not oriented to person		2.3	3.9	2.4	2.0	2.3				
Not oriented to place	2.0		7.8	4.8		4.7	6.7			
Not oriented to time	7.8	2.3	9.8	4.8	2.0	4.7	6.7			
Immediate recall	25.5	9.3	15.7	14.3	17.6	20.9	13.3	9.1	18.2	33.3
Memory problems	39.2	23.3	25.5	21.4	23.5	23.3	26.7	18.2	45.5	33.3
Attention problems	11.8	9.3	9.8	14.3	7.8	11.6	6.7	9.1	9.1	

(continued)

Table 7. (continued)

	First		Second		Third		Fourth		Fifth	
	n, 51	n, 43	n, 51	n, 43	n, 51	n, 43	n, 15	n, 11	n, 11	n, 3
	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007	1996-2001	2002-2007
Information processing problems	11.8	20.9	7.8	11.9	5.9	18.6	13.3		27.3	33.3
Anterograde amnesia delayed	2.0	4.7	3.9	7.1		4.7		18.2		
Retrograde amnesia delayed	23.5		13.7	4.8	11.8	14.0	1.3		18.2	
Unconscious > 1 min, n	0	1	0	3	0	2	12		0	
All loss of conscious, n	3	2	6	4	5	3	2		1	
Cases reported w/o LOC, n	17		26		15		3		4	

Table 8. Length of time between repeat concussions for 6 years (2002-2007) and 12 years (1996-2007).

	2002-2007: Days Between, n				
Multiple Concussions	**Mean**	**Median**	**Minimum**	**Maximum**	**Years**
Second	472	382	0	1565	1.29
Third	444	353	3	1212	1.22
Fourth	238	56	10	778	0.65
Fifth	574	645	7	1071	1.57
Total	456	371	0	1565	1.25
	1996-2007: Days Between, n				
Second	630	421	0	2926	1.73
Third	610	405	0	3331	1.67
Fourth	420	332	7	2520	1.15
Fifth	286	310	7	1071	0.78
Sixth	719	683	100	1505	1.97
Seventh	623	421	14	1433	1.71
Total	603	406	0	3331	1.65
	1996-2007: Days Between n %				
Same day	5	0.9			
< 7	15	2.8			
8-14	21	3.9			
15-21	9	1.7			
22-28	5	0.9			
> 28	486	89.8			
Total	541	100			

concussions between 1996 and 2001 and 24.1% between 2002 and 2007. This is a small increase in the percentage of players who sustained repeat concussions. Most NFL players who sustained concussion (70.6%) did not sustain a repeat concussion at a later date.

The 12-year data also demonstrate that special-team players have a statistically increased risk of sustaining a repeat concussion (Table 2). Given the high-speed collisions that are an integral part of special-team play, this finding is not unexpected. The 12-year data also show that offensive linemen have a statistically significant lower risk of repeat concussion compared with other players (Table 2). Given the relatively low-velocity collisions seen in most offensive-line blocking activities, this finding is not unexpected.

There were no apparent clinical differences in the signs and symptoms of concussion between single and repeat concussions. There was a statistically lower incidence of anxiety and cognitive/memory problems as a result of repeat concussion during the second 6-year period compared with the first.

During the 12-year period, there were no differences regarding the percentage of players who returned to play on the day of the injury after a single, second, or third concussion. Overall, a significantly lower percentage of players with a

single concussion returned to play immediately after injury in 2002-2007 compared with 1996-2001.[4] There was a trend toward a similar decrease in players with first or second repeat concussions in the more recent period. This trend did not reach statistical significance.

SUMMARY

The defensive secondary, kick unit, running backs, and linebackers have the highest incidence of repeat concussion in professional football. There were no apparent significant clinical differences between single and repeat concussions. The incidence of repeat concussion seems to be independent of the more conservative medical management of concussions that characterizes the 2002-2007 period.

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