

The Incidence of Spearing During a High School's 1975 and 1990 Football Seasons

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ABSTRACT: Spearing and head-first contact in football pose significant risks of cervical spine injury and concussion. Reduction in the number of catastrophic head and neck injuries in football has been attributed to the 1976 rule change banning spearing. In this study, I examine the incidence of spearing before and after the rule change. I reviewed 18 game films of a New Jersey high school football team (9 from 1975 and 9 from 1990) to determine the incidence of all types of spearing by ball carriers and tacklers. The cumulative incidence was 1/2.5 plays for 1975 and 1/2.4 plays for 1990. Over 14 ball carrier spears

and over 26 tackler spears occurred per game for both seasons. Spearing by running backs increased during the 1990 season, but the overall incidence of ball carrier spearing did not change. Tacklers were more likely to spear when a ball carrier speared and the incidence of concurrent tackler spearing increased significantly during the 1990 season. Independent tackler and defensive linemen spearing, however, decreased. Linebackers and defensive backs accounted for the most spears among tacklers. Overall, it does not appear that the rule change had a favorable impact on the incidence of spearing.

Spearing and head-first contact pose significant risks of catastrophic spine injury and concussion for football players.^{2,4,6-9,15,20-23,26,28-36} Since the 1976 rule change banning spearing in high school football, there has been a large reduction in the incidence of catastrophic head and neck injuries.^{20-23,28-33} Many authors^{26,20-23,28-34} attribute the reduction to the rule change. However, exactly why the rule change has been effective has not been explained.

One possible explanation is that the rule change caused a decrease in the incidence of spearing. A reduced incidence of the mechanism of injury would explain a reduction in axial loading injuries to the cervical spine. The purpose of this study was to gain insight into this explanation by comparing the incidence of spearing between two high school football seasons—one before and one after the rule change.

METHODS

Data were obtained from the observation of two varsity football seasons from a New Jersey high school. I observed nine regular season game films from the 1975 season and nine from the 1990 season. The selected school is representative of a highly competitive and skilled football team. The program has had the same head coach since 1972 and during that time the team has compiled a record of 140 wins, 68 losses, and 4 ties. During the 1975 season, the team was undefeated and won a state championship. Two players from that team went on to play in the National Football League. During the 1990 season, the team lost in the state playoffs.

I chose the 1990 season because it was the last complete season recorded on 16-mm film. I found that film is superior to VHS tape in clarity, which is crucial in accurately judging helmet position during contact. I did not include blocker spearing because all blockers are not always in view on the game film. The films normally follow the ball carrier, which

often leaves contact not associated with tackling the ball carrier out of view.

I viewed these films on a 16-mm Kodak projector with a Kodak .625 enhancement lens. The projector has standard slow motion and reverse mode capabilities. Each game was graded individually on its own score sheet. The score sheet consisted of total plays, ungradable plays, independent tackler spears, ball carrier spears, and concurrent tackler spears. Data were collected and reported for both teams in each game. Therefore this study included 20 different football teams.

The methods for this study have been reported previously.¹³ For continuity, I will include a brief overview of the similar methods. Ball carrier and tackler spearing were defined as lowering the head (unintentional or intentional) and initiating contact with the crown of the helmet. Incidents of ball carrier spearing were tabulated if a ball carrier speared a tackler or potential tackler. Incidents of concurrent tackler spearing were tabulated when a tackler or potential tackler speared a ball carrier who was also spearing. This was previously defined as concurrent defensive spearing.¹³

I also included incidents of independent tackler spearing in this study. An incident of independent tackler spearing was tabulated only when a tackler or potential tackler speared a ball carrier who was not spearing. This included a receiver or running back on an incomplete pass. This study only included spearing that was directly associated with a ball carrier. Spearing by blockers or defensive contacts away from the ball were excluded.

In viewing the game films, I only included plays in which a ball was carried.¹³ A single play could include numerous contacts between tacklers and a ball carrier (broken tackles, simultaneous tacklers, etc). More than one spear could also occur on a single play. A play was considered ungradable when contact by the ball carrier and tackler(s) could not be seen on the game film. I tabulated the type of ball carrier play as a running play, complete pass, incomplete pass, kick return, or turnover.

I tabulated incidents of spearing by position. Ball carriers were placed in one of six categories: running back, quarter-

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back, receiver, kick returner, offensive lineman on a fumble advance, or defensive player on a fumble or interception return. A player's starting position determined his category. For example, if a running back caught a pass and speared a tackler, I considered it a spear by a running back on a completed pass play.

For defensive players, the positional categories included lineman, linebacker, defensive back, special team, or offensive player on a fumble advance or interception. A 5-4 defense was considered to have five linemen, two linebackers, and four defensive backs. I considered a 4-3 defense to have four linemen, three linebackers, four defensive backs and a 4-4 defense to have four linemen, four linebackers, and three defensive backs.

An independent *t* test was used for data comparison of spearing incidents and positional spearing during the 1990 and 1975 seasons.

RESULTS

Data categories include ball carrier spearing, concurrent tackler spearing, independent tackler spearing, total tackler spearing, and all spearing incidents. Total tackler spearing = concurrent tackler spearing + independent tackler spearing. All spearing incidents = ball carrier spearing + concurrent tackler spearing + independent tackler spearing.

1990 Season

The totals for the nine observed games during the 1990 season are shown in Table 1. There were an average of 105 ± 8.8 plays per game; 95% were gradable. The breakdown of types of plays and the number of those plays that included at least one spear are shown in Table 2 for both seasons.

The mean score for all spearing incidents per game was 44.2 ± 7.2. The mean score was 26.8 ± 4.3 for incidents of total tackler spearing per game and 15.2 ± 4.3 for independent

tackler spearing. The distribution of spears by defensive players are shown in Table 3 for both seasons.

The mean score for incidents of ball carrier spearing was 17.3 ± 5.8 per game. The distribution of ball carrier spears by positions for both seasons are shown in Table 4. The mean score for concurrent tackler spearing was 11.6 ± 2.6 per game.

Of a total of 945 plays, there was an incident of spearing on 398 plays (42%). Ball carriers speared on 156 plays (17%) and tacklers speared on 242 (26%). The cumulative incidences of spearing are shown in Table 5 for both seasons.

1975 Season

The totals for the nine observed games during the 1975 season are shown in Table 1. There were an average of 109 ± 8.9 plays per game; 96% were gradable. The mean score for all spearing incidents per game was 43.2 ± 8.7. The mean score for incidents of total tackler spears was 28.3 ± 5.5 and 21.4 ± 3.9 for independent tackler spearing.

For ball carrier spearing, the mean score was 14.9 ± 3.8 incidents per game. The mean score for incidents of concurrent tackler spearing was 6.8 ± 3.8 per game.

There was an incident of spearing on 389 of 982 of the total plays (40%). Ball carriers speared on 134 plays (14%) and tacklers speared on 255 (26%). There was no difference in all spearing incidents among the 1990 and 1975 seasons ($t[16] = .27, p > .05$). There also was no difference in the number of ball carrier spears between the two seasons ($t[16] = 1.38, p > .05$). There was a significant increase during 1990 in incidents of concurrent tackler spearing ($t[16] = 3.12, p < .05$). During 1990 there was a significant decrease in independent tackler spearing ($t[16] = 3.88, p < .05$).

By ball carrier position, spearing by running backs increased during the 1990 season ($t[16] = 2.31, p < .05$). There were no differences between the seasons for quarterbacks ($t[16] = 1.04, p > .05$), receivers ($t[16] = .32, p > .05$), or kick returners ($t[16] = .41, p > .05$). Defensively, linemen spearing de-

Table 1. The Number of Total Plays, Ungradable Plays, All Spearing Incidents, Total Tackler Spears, Independent Tackler Spears, Ball Carrier Spears, and Concurrent Tackler Spears

	Games									Total
	1	2	3	4	5	6	7	8	9	
1990 Season										
Total Plays	102	101	111	95	121	101	107	111	96	945
Ungradable Plays	4	2	5	4	4	6	3	7	10	45
All Spearing Incidents	41	57	39	41	53	36	44	49	38	398
Total Tackler Spears	23	35	23	25	33	25	26	27	25	242
Independent Tackler Spears	13	19	11	15	19	17	14	13	16	137
Ball Carrier Spears	18	22	16	16	20	11	18	22	13	156
Concurrent Tackler Spears	10	16	12	10	14	8	12	14	9	105
1975 Season										
Total Plays	109	111	112	114	127	101	95	105	108	982
Ungradable Plays	10	5	3	2	7	4	7	1	3	42
All Spearing Incidents	30	45	60	41	41	48	48	34	42	389
Total Tackler Spears	18	30	37	29	29	32	31	23	26	255
Independent Tackler Spears	14	27	23	24	24	23	21	20	17	193
Ball Carrier Spears	12	15	23	12	12	16	17	11	16	134
Concurrent Tackler Spears	4	3	14	5	5	9	10	3	9	62

Table 2. The Number of Running Plays, Passes, Incomplete Passes, Kick Returns, Interception/Fumble Returns, and the Number of Those Plays That Included at Least One Spear (More Than One Spear Can Occur on a Play)

	1990		1975	
	No. of Plays	Plays with Spear	No. of Plays	Plays with Spear
Running plays	639	234 (37%)	712	242 (34%)
Pass plays	220	14 (6%)	142	10 (7%)
Incomplete passes	133	1 (1%)	83	0 (0%)
Kick returns	66	25 (38%)	82	25 (30%)
Interception/fumble returns	20	0 (0%)	46	8 (17%)

creased significantly during the 1990 season ($t[16] = 3.00, p < .05$). There were no differences for linebackers ($t[16] = .95, p > .05$), defensive backs ($t[16] = 1.34, p > .05$), or special team players ($t[16] = .11, p > .05$) between the two seasons.

DISCUSSION

Ball Carrier Spearing

There was no statistical difference in the incidence of ball carrier spearing between the 1975 and the 1990 seasons. The study of a 1989 season reported an incidence of 1/5.1 plays for ball carrier spearing.¹³ This represents a 3% higher incidence than the 1990 season and a 6% increase over the 1975 season.

There was an increase during 1990 of spearing by running backs (Fig 1). This change may be related to a more aggressive running style. Running backs (and ball carriers in general) can approach contact in two ways: they can try to evade the tackle, or they can try to break the tackle. When the running back tries to evade a tackle (change of direction, spin, straight arm), he keeps his head out of contact in most situations. Ball carrier spearing arises most often for running backs when the player attempts to break a tackle (aggressive running). In this situation, the running back usually approached the contact with his head up. Just before contact, he began lowering his head and made contact with his helmet while his neck was going from extension to flexion. During 1975, running backs seemed to try and break a tackle when they had no other option. During the 1990 season, running backs appeared to have a more aggressive running style. It seemed they were attempting to break tackles even though they had space to maneuver away from defenders.

Running backs were responsible for the majority of the ball carrier spearing incidents for both seasons (Table 4). Kick returners accounted for 6 spears for 1975 and 9 for 1990, less

than 7% of the total ball carrier spearing incidents over both seasons. However, they did spear on 9 of the 66 kick returns (14%), which is close to matching the overall incidence of ball carrier spearing.

For offensive players, the pass was the safest regarding spearing. Receivers accounted for less than 4% of the spears over both seasons (3 for 1975 and 5 for 1990). Only 24 of the 362 passing plays (7%) involved a spear. None of the incomplete passes involved a spear by a receiver. However, the ball carrier spearing distribution in this study does not completely match the incidence of catastrophic injuries between 1977 and 1992.²² By the distribution of ball carrier spears I observed in this study, I would have expected running backs to have far more catastrophic injuries than receivers or quarterbacks.

The rule change appears to have had no association with decreasing the incidence of ball carrier spearing in this study. Prior research focusing on head and neck injuries in football emphasized tacklers and blockers.^{1,4,6,7,9,15,20,21,23,28-34} The high school spearing rules do not specifically mention ball carriers at all.²⁴ These factors have allowed the techniques of ball carriers to be overlooked and the dangers of ball carrier spearing to go unrecognized. During the 1992 season, two ball carriers were paralyzed as a result of spearing.²² Being tackled has always been one of the leading causes of fatalities in football.²⁰ Spearing by ball carriers is an extremely dangerous contact technique.¹¹⁻¹³ Fortunately, authors^{8,10-14,22} have begun to recognize ball carriers regarding contact techniques, catastrophic injuries, and penalty enforcement.

Table 3. The Number of Spears by Defensive Backs, Linebackers, Linemen, Special Team Players, and Offensive Players Tackling on a Turnover Return

	1990	1975
Defensive backs	87 (36%)	70 (28%)
Linebackers	89 (36%)	77 (30%)
Linemen	38 (16%)	71 (28%)
Special team players	28 (12%)	28 (11%)
Offensive players on turnover	0 (0%)	7 (3%)
Total	242 (100%)	255 (100%)



Fig 1. Spearing by running backs increased during the 1990 season.

Table 4. The Number of Ball Carrier Spears by Running Backs, Quarterbacks, Receivers, Kick Returners, Defensive Players on a Turnover Return, and Offensive Linemen on Fumble Advance

	1990	1975
Running backs	132 (85%)	101 (75%)
Quarterbacks	10 (6%)	19 (14%)
Receivers	5 (3%)	3 (2%)
Kick returners	9 (6%)	6 (5%)
Defensive players on turnover return	0 (0%)	4 (3%)
Offensive linemen on fumble advance	0 (0%)	1 (1%)
Total	156 (100%)	134 (100%)

Concurrent Tackler Spearing

During 1990, tacklers were almost 4 times more likely to spear when a ball carrier speared. During 1975, tacklers were 2 times more likely to spear when tackling a spearing ball carrier. In most situations, the tackler reacts to the ball carrier when making a tackle.^{11,13} Tacklers often react to a spearing ball carrier by making contact in a similar manner (Fig 2) or attempting a tackle below the waist.^{11,13} Drake⁸ found that tacklers who tackle below the waist are more likely to make contact with their heads down, or in the spearing position. The results from this study agree with that conclusion. On the basis of all this information, I strongly suggest that ball carrier spearing influences the use of spearing techniques by tacklers.

The incidence of concurrent tackler spearing was 21% higher during the 1990 season than the 1975 season. This increase was statistically significant and was associated with an increase in spearing by running backs during 1990. The incidence reported during 1989 for concurrent tackler spearing¹³ was almost identical to the incidence in this study for the 1975 season. The common factor in all three seasons is that tacklers were reacting in similar ways when a ball carrier speared.

Concurrent tackler spearing has caused catastrophic injuries to tacklers. Two spearing tacklers who were paralyzed in 1992 were associated with ball carriers who were spearing.²² In the video "Prevent Paralysis: Don't Hit with Your Head,"²⁷ there are 19 hits that resulted in paralysis. Four of those hits (hits 7, 14, 15, 16) were concurrent tackler spears as defined in this study.

Total Tackler Spearing

The incidence of total tackler spearing was virtually identical for 1975 and 1990. There were over 26 tackler spears per game during both seasons. These numbers match up well with Drake's⁸ study of 809 high school tackles where 21% of the

tacklers speared. Considering that spearing presents the greatest risk to tacklers,^{1,15,18-23,28-34} these numbers appear alarmingly high. The one type of spearing that did significantly decrease in 1990 was independent tackler spearing. Independent tackler spearing decreased by 5%. This was one area where the rule change appears to be associated with a significant decrease in the incidence of spearing (Fig 3).

There appeared to be general differences in the tackler's intentional and unintentional spearing techniques between the two seasons (although this data was not tabulated). In 1975, there seemed to be more tacklers hitting with their necks flexed (intentional spear). With this type of spear, the tackler approached contact with his head lowered and already in the spearing position. It also could include the tackler who speared players who were already down (late hit). This description of spearing is consistent with Torg's^{32,34} emphasis upon the axial loading mechanism being related to deliberate use of the head as a battering ram. It is also consistent with the 1976 rule change that banned deliberate use of the helmet. A different spearing technique seemed more common during the 1990 season. It appeared that more tacklers were using an unintentional spearing technique similar to ball carriers. The tackler approached contact with his head up. At the last instant, he lowered his head and initiated contact with the top of his helmet while his neck was moving from extension to flexion. This type of spearing matches the difficulties coaches have described in teaching players to play heads-up football.^{21,22}

During both seasons, linebackers accounted for the most spears (Table 3). This coincides with the fact that linebackers usually lead the defense in overall tackles. Defensive backs were slightly behind linebackers for both seasons. There was no change in the incidence of spearing between the two seasons for linebackers or defensive backs. The incidence of spearing by defensive linemen, however, decreased during 1990 by 12%. The spearing rule appears to have had a favorable impact on the spearing of these players in this study. The incidence of special team spears was basically the same for both seasons.

All Spearing Incidents

The incidence of spearing did not change significantly between the two seasons (Table 5). The decrease in 1990 of independent tackler spearing was offset by the increases in running back spearing and concurrent tackler spearing. There were over 40 spears per game for both seasons.

Most spears occurred during running plays in both seasons (Table 2). Kick returns included a spear as often as running plays. During 1990, there was one spear for every 1.8 kick

Table 5. The Cumulative Incidence of All Spearing, Total Tackler Spearing, Independent Tackler Spearing, Ball Carrier Spearing, and Concurrent Tackler Spearing for Both Seasons

	1990	1975
All spearing	1/2.4 plays	1/2.5 plays
Total tackler spearing	1/3.9 plays	1/3.8 plays
Independent tackler spearing	1/5.7 plays	1/4.4 plays
Ball carrier spearing	1/6.1 plays	1/7.3 plays
Concurrent tackler spearing	1/1.5 ball carrier spearing	1/2.2 ball carrier spearing

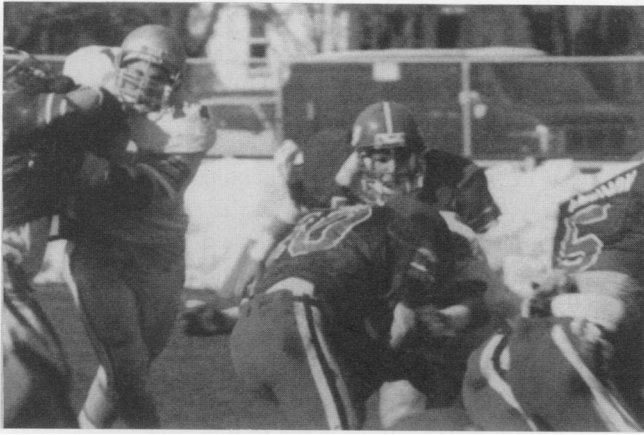


Fig 2. Tacklers were more likely to spear when a ball carrier speared (concurrent tackler spearing).



Fig 3. Independent tackler spearing decreased during 1990.

returns. This incidence was the highest observed in this study. Special teams' players have been one of the leading positional players associated with catastrophic injuries.^{22,34} This is probably the most dangerous play in football considering that kicking plays account for only approximately 7% of the total plays involving a ball carrier per game.

In 1990, 13,900 high schools offered varsity football in the United States (phone communication with the National Federation of State High Schools Association, November 1995). In this study, during 1990, a team averaged 199 spears per season. If these schools are representative of other high schools, then, nationally there are approximately 2,766,100 spears associated with contact between tacklers and ball carriers during a 9-game season. During 1990, there were 11 catastrophic injuries to high school players. If all of these injuries were associated with varsity players tackling or being tackled, there was approximately one catastrophic injury for every 251,464 spears.

Further Research

This study raises a few important questions. Why has the number of injuries resulting in paralysis dramatically decreased since the rule change if the incidence of spearing has not changed? It is important to note that the number of cervical spine fractures/dislocations occurring without quadriplegia have not been reduced as significantly.^{2,21,28} Spinal cord injury is secondary to vertebra damage and each incident of fracture/dislocation has the potential for paralysis. Therefore, the reduction in the incidents of quadriplegia may also be due to improvements in surgical techniques^{32,33} and better on-the-field management of these injuries.^{2,21-23}

An area for future research is to explore whether a change in tacklers' spearing biomechanics may be responsible for the reduction in catastrophic injuries. Has there actually been a change from intentional spearing (approaching contact with the neck preflexed) to unintentional spearing (dropping the head from extension at the last instant)? After viewing these films, I believe this explanation holds merit, although this opinion cannot be substantiated by the data collected in this study. Biomechanics may also explain why there have been so many more catastrophic injuries to tacklers than to ball carriers. The

constant for catastrophic injuries to ball carriers is that they have been consistently low even before the rule change.^{30,34} It appeared that ball carriers consistently dropped their heads at the last instant when spearing, during both seasons in this study. Further study is also needed examining whether ball carriers' spearing biomechanics have been consistent before and after the rule change.

The possibility exists that it is more difficult to place an axial load on the cervical spine when the neck is in transition from extension to flexion. The experimental research that has reproduced the axial loading mechanism with both cadavers and models have placed energy loads on the cervical spine when the neck is already fixed in flexion.^{3,5,17,25,37,38} Even the studies examining the cervical spine under unfixed conditions place the neck in the spearing position before impact forces are placed on the cervical spine. An area for future research may be to explore the difficulty in reproducing an axial load while the neck is in motion from extension to flexion.

The other question is, "Why have defensive backs received the majority of catastrophic injuries if linebackers have speared as frequently?" Defensively, secondary players have received the most catastrophic injuries followed by linebackers and then linemen.^{21-23,28-34} This order also follows the distance of each position from the line of scrimmage. That is, defensive backs start 8 to 10 yards off the ball, linebackers begin 3 to 5 yards off the ball and linemen are on the line of scrimmage. Therefore defensive backs potentially generate the most momentum before they make contact. Linemen have the least distance between them and the ball carrier.

This may suggest that a higher incidence of injury to defensive backs is related to spearing and the amount of momentum at contact. Special teams' players have accounted for the second largest number of catastrophic injuries behind defensive backs. Considering that there are only about 5 to 10 kick returns per game, it is obvious that they do not have nearly the opportunity to spear as other defensive players. However, they do start 40 to 60 yards away from the kick returner and have the greatest opportunity to generate momentum before a spear.

It is well established that little force is needed to cause failure of the cervical spine when it is precisely aligned in a segmented column.¹⁵ A running football player can possess

1500 ft-lb of kinetic energy, whereas, in the laboratory, cervical injury has been reproduced with as little as 150 ft-lb of kinetic energy.¹⁵ But, on the field (in vivo), do higher forces at impact compensate for less than precise positioning of the neck? This is another area that requires further study.

Reducing the Incidence of Spearing

Each time a player initiates contact with his head, he increases the risk of concussion.^{4,7,8,26} Each time a player initiates contact with the crown of his helmet, he risks quadriplegia.^{2,6,9,15,20-23,28-36} The spearing incidence observed in this study demonstrates there is still significant room for improvement in eliminating spearing. A concerted effort by coaches, officials, the medical community, and re-examining the spearing rules can further reduce the incidence of spearing and also decrease the risk of head and neck injuries in football.

Initiating contact with the shoulder while keeping the head up is the safest contact position for all players.^{11-16,20-23} Leidholt¹⁶ has emphasized that teaching correct technique will do far more to prevent injuries than exercises. Coaches have expressed that they have taught players to tackle correctly, but the players still have a tendency to lower their heads just before contact.^{21,22} This technique of unintentional spearing was observed in this study. I believe this is an obvious indicator that coaches must spend additional time practicing correct technique with ball carriers, tacklers, and blockers.

It seems that players have learned to approach contact with the head up. However, players have a fear of contact³ or the instinct to protect their eyes and face from injury by lowering their heads at impact.^{11,13} It appears the level of instruction has not overcome this fear. Practice and contact drills that focus on keeping the head up while initiating contact with the shoulder must overcome this protective instinct (Fig 4). Athletic trainers and other medical professionals must continually emphasize these concepts to coaches. Torg³⁰ indicated that it is not enough to avoid teaching head-first contact. It is my contention that a player who receives no instruction will spear with the neck in the preflexed position. A player who receives insufficient practice time with correct technique will spear unintentionally by lowering his head at the crucial instant of impact.



Fig 4. Players need additional practice time to improve the technique of keeping their heads up at contact.

The spearing rules and football officials' interpretation and enforcement of these rules also play an important role in reducing the incidence of spearing. In my opinion, the practical definition of spearing has changed and I believe this has outdated the current rules. The major restriction is that the rule limits itself to "intentional"²⁴ helmet contact. The current rules do not address unintentional or ball carrier spearing.¹⁰ A recent survey of high school officials indicated that they felt that deciding on intent made the spearing rule difficult to enforce and they were least likely to call a spearing penalty on a ball carrier.¹⁰ This survey also revealed that officials called an estimated 1 spearing penalty for every 20 games they worked. This enforcement rate appears drastically out of proportion to the 40+ spears observed per game in this study.

Rule changes that address unintentional head-down contact and ball carriers may further reduce the risk of serious head and neck injuries. It may also further reduce the consistent incidence of 4 to 10 catastrophic spine injuries that have occurred annually since 1980. However, the ultimate effectiveness of any rule is heavily dependent upon officials appropriately enforcing these rules during football games.¹⁰

CONCLUSION

In this study, it does not appear that the spearing rule had a favorable impact upon decreasing the overall incidence of spearing. In fact, the incidence of running back spearing and concurrent tackler spearing actually increased during the 1990 season. However, there were decreases during 1990 of independent tackler spearing and spearing by defensive linemen. One major limitation of this study is that it only looked at two different seasons of one school. Further research needs to be done including other high schools from different geographical areas. Other seasons, both before and after the spearing rule change, also need to be studied.

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