

At-Risk Tackling Techniques in American Football

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Background: In American football, fewer fatalities and severe injuries have been seen annually since 1976, after data from 1971 through 1975 were retrospectively reviewed to better understand the mechanisms involved in catastrophic cervical spine injury and rules were enacted to prohibit certain types of aggressive tackling. The National Football Head and Neck Injury Registry was established in 1975.

Purpose: To assess (1) tackling techniques that coaches were teaching at 3 levels—youth level (YL; 4th to 5th grades), middle school (MS; 6th to 8th grades), and high school (HS; 9th to 12th grades); (2) tackling techniques used during games; and (3) the successful tackle rates of these techniques.

Study Design: Descriptive epidemiology study.

Methods: Surveys were distributed via email to 500 coaches of YL, MS, and HS football teams in Texas. Coaches provided video recordings of football games, and all tackle attempts were graded by a single reviewer who watched game videos; 1000 consecutive tackles were observed for each group. Survey data included how coaches instructed their players to tackle, the types of tackles, the number of tackles versus missed tackles, the head position, and the initial contact. Data were analyzed with the chi-square test. A subset of 100 consecutive tackles at each level of play was reviewed by 2 blinded reviewers to assess intra- and interrater reliabilities.

Results: In all groups, coaches responded that they preferred to teach the at-risk “head across the bow” tackling technique (83% YL, 81% MS, 75% HS). Coaches stated that they instructed players to “keep your head up,” as currently recommended, 89% in YL, 100% in MS, and 81% in HS. During games, players used head-up, inside-shoulder tackles more successfully across all groups (97.5% YL, 99.5% MS, 98.8% HS). While intra- and interrater reliabilities were in the good range, these scores were lower in the youth group.

Conclusion: Our study supports the effectiveness of tackling with the head up and making the initial contact with the inside shoulder. Lower reliability ratings for the youth group were likely due to lower video quality and the lack of players’ tackling experience.

Keywords: tackling techniques; head-up tackle technique; “head across the bow” technique; pathomechanics of cervical spine injury

BACKGROUND

History and Statistics

American football is a contact sport and has long been associated with a variety of injuries, including brain and cervical spine injuries. It has been said that “there is probably no better experimental and research laboratory for human trauma in the world than the football fields of our nation.”¹⁰ This has led to the implementation of protective equipment and rules to decrease the player’s risk of injury. One of the most significant rule changes to protect players from cervical spine injuries and head trauma was to make

initial contact with the helmet or face mask illegal in 1976.² This led to a significant reduction in the incidence of quadriplegia in high school (HS) and collegiate football players, from 34 players in 1976 to 5 in 1984.¹² Similarly, the incidence of cervical spine fractures and dislocations in HS football players dropped almost 3-fold, from 7.72 per 100,000 in 1976 to 2.31 per 100,000 in 1987.¹² The number of football fatalities from brain or spinal injuries declined at the college and HS levels from a mean of 3.4 per year from 1990 to 2010 to 2.8 per year from 2005 to 2014.^{1,8} Implementation of rules to decrease the likelihood of athletes putting their necks in this position led to a concomitant decrease in injuries. Cervical spine fractures, subluxations, and dislocations at all levels of play decreased from 110 in 1976, when the spearing rule was implemented, to 51 in 1978 and 42 in 1984.¹⁴ The most common cause of this injury continues to be tackling with head-down contact and

The Orthopaedic Journal of Sports Medicine, 8(2), 2325967120902714
DOI: 10.1177/2325967120902714
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with the neck flexed. A recent Centers for Disease Control and Prevention analysis showed head-first/head-down contact to be the cause of 8 of 28 deaths in HS and college football from 2005 to 2014.⁸

Coaching

In addition to the rules implemented to decrease the risk to players, coaches are usually trained to teach safe techniques for making player contact while tackling. Despite improvements in coaching these measures, tackling techniques are still being taught that put the players at risk of sustaining concussions, catastrophic cervical fractures, and brachial plexus neurapraxia (stingers). One of these at-risk techniques is the “head across the bow” technique, which involves the tackler placing his head across and in front of the body of the ball carrier. This tackling position may place the head and neck in an at-risk position of axial loading, with the neck in flexion as previously discussed.^{2,13} The “head across the bow” technique may also place players at increased risk of a transient brachial plexopathy, commonly known as a “stinger” or “burner.”^{2,3,13} The currently recommended tackling technique is to initiate contact with the chest or shoulder while keeping the head up (Figure 1C).^{2,7,13} This technique allows the game to be played aggressively but with greater safety. To further train players, multiple videos have been made that demonstrate proper tackling and player contact techniques.¹¹ The Heads Up Football tackling program endorsed by USA Football provides articles, videos, and testimony of coaches and players who have implemented the heads-up technique.⁴

We were unable to identify any recent studies on football tackling techniques taught by coaches. Heck⁵ looked at how often head-down tackles were performed in 1975 and 1990, but we did not find any additional studies on the tackling techniques that players are using during games. We considered it important to analyze how tackling is taught to players from youth league (YL) football through HS football and if the coaches’ reports of the tackling technique they are teaching translate into how players are executing tackling in games. This study therefore aimed to assess (1) which tackling techniques coaches were teaching players, (2) what tackling techniques the players used during games, and (3) the success rates of these techniques. We also assessed the reliability of the tackle-grading system used.

METHODS

Surveys

A total of 500 coaches in Texas were contacted via email and were provided a link to an online survey website. These surveys (Appendix 1) were sent to coaches of YL, middle school (MS), and HS football teams playing the 2012-2013 season. All survey participants were assured anonymity. Question 4 on the survey assessed the relation of tackler to the ball carrier’s waist and allowed only 1 answer. Questions 6 and 7 assessed phrases (with common football terminology) that the coaches use to teach tackling and allowed more than 1 answer.

Videos

We asked participating coaches to voluntarily provide us with game film of their teams. Game films were provided for us in a digital online format. All game films were converted to an .mp4 format, which allowed for slow motion and reverse capabilities.

Tackles

Game films from participating schools from the 2012 and 2013 seasons were retrospectively reviewed by a single orthopaedic resident (R.B.). Three age levels were assessed: YL (4th to 5th grades), MS (6th through 8th grades), and HS (9th through 12th grades). Using the criteria described in Appendix 2, the reviewer assessed films for each full game until 1000 consecutive tackle attempts were evaluated. Every tackle attempt was analyzed and the type of the tackle recorded on an Excel spreadsheet. To be scored as a tackle attempt, a defensive player had to try to tackle the ball carrier, and there had to be sufficient view of the attempt to rate the tackle in all grading categories. Unsuccessful attempts were rated according to 4 categories: tackle method, head position, relation to waist at point of contact, and success of tackle attempt (Appendix 2).

The reliability of our tackle grading was also assessed. Two reviewers (blinded to the original gradings) were assigned to review the same 300 randomly chosen tackles (100 from each of the 3 levels of play). The tackles were rated with the same method as outlined above. Each reviewer scored the 100 tackles at each level on 2 separate occasions. They were required to space the second rating

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Final revision submitted October 30, 2019; accepted November 6, 2019.

One or more of the authors has declared the following potential conflict of interest or source of funding: This study was funded in part by the Houston Methodist Concussion Center via support from the Swanson family. D.W.S. has received hospitality payments from Globus Medical and Medtronic. R.B. has received educational support from Arthrex, Gentleman Orthopedic Solutions, and Smith & Nephew and hospitality payments from Stryker. R.A.W.M. has received consulting fees from Aesculap, DePuy/Medical Device Business Solutions, Globus Medical, Nuvasive, and Stryker and speaking fees from Globus Medical. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was waived by the University of Texas Committee for the Protection of Human Subjects (HSC-MS-13-0910).

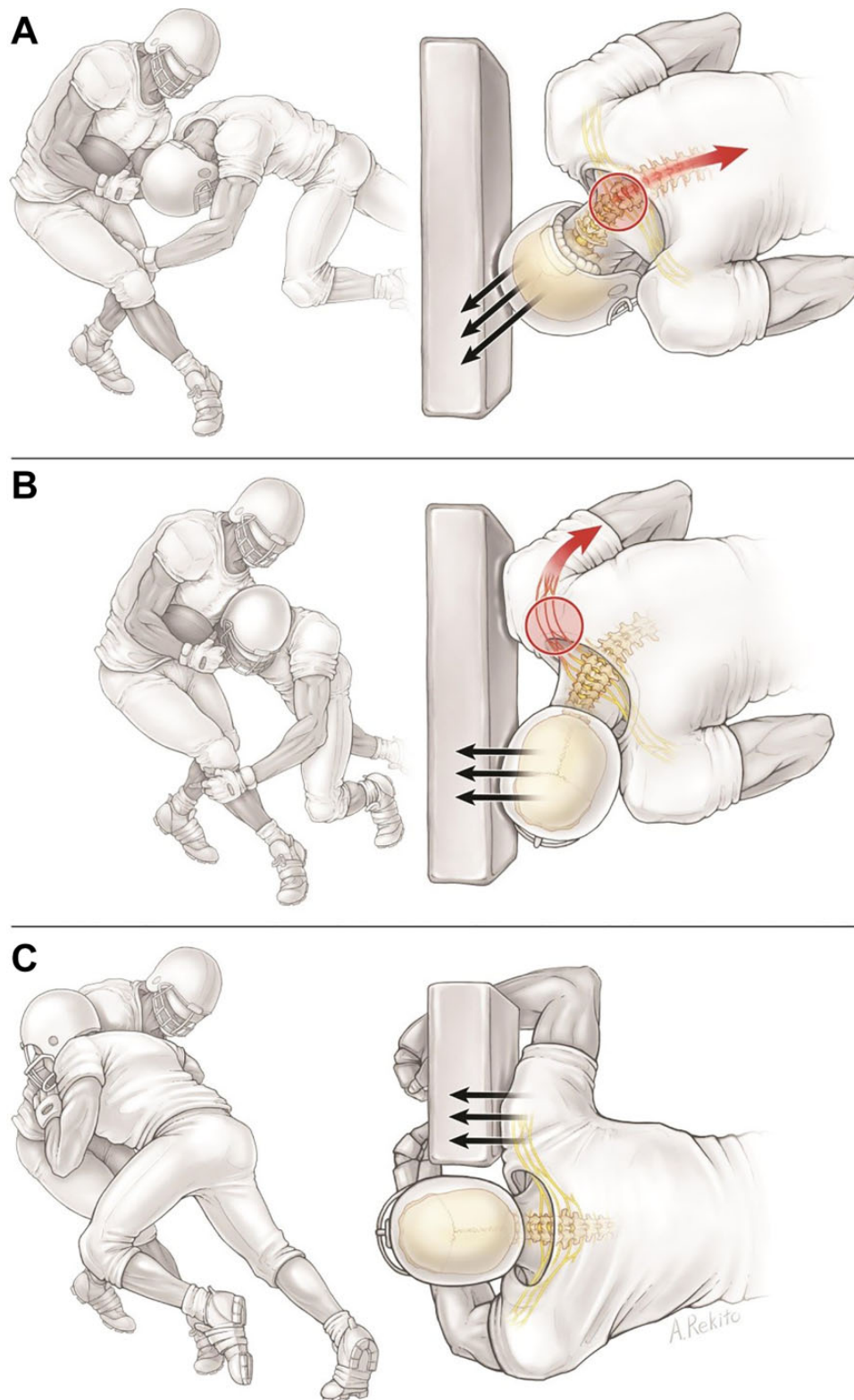


Figure 1. Pathomechanics of an axial loading injury to the cervical spine. (A) Head-down tackling: Forces are transferred into the spinal column, which can result in catastrophic vertebral body failure. (B) Head across the bow: Brachial plexus stretch injury in which the head is forced away from the affected side and the ipsilateral shoulder is depressed. (C) Head-up shoulder tackle: The force is dispersed by the shoulder girdle and torso.

TABLE 1
Results From Coaches' Survey^a

	Youth League (n = 36)	Middle School (n = 32)	High School (n = 68)
Players should try to tackle			
Above waist?	19	59	62
Around waist?	75	31	35
Below waist?	6	9	3
Which tackling techniques do you prefer to teach? (May choose multiple responses)			
Head across the bow	83	81	75
Split the number	11	13	22
Facemask through the near shoulder	22	13	13
Which phrases do you use when teaching tackling? (May choose multiple responses)			
See what you hit	78	56	78
Keep your head up	89	100	81
Take your facemask through the near shoulder	11	6	9
Head across the bow	61	81	66
Hit, wrap, and drive	83	56	59
Get low	56	63	18
Take your facemask through the numbers	17	25	19
Hit, wrap, drive, and lift	44	50	44

^aValues are presented as percentages.

session at least 1 week after the initial session to minimize the chance of recall. The ratings of these reviewers were then analyzed for intra- and interrater reliability.

Statistics

Coaching survey and game tackle data were entered into a database developed with SPSS (v 20.0; IBM). Data were analyzed according to the chi-square test. We compared how coaches instructed their players to tackle at the 3 levels of competition. Game film data were grouped by level of competition. The types of tackles, the number of tackles versus missed tackles, the head position, and the initial contact were compared among the 3 levels of competition. We utilized the statistics software R (v 3.3.1) and performed Cohen kappa (κ) calculations for intra- and interrater reliability. We utilized the Landis and Koch⁹ breakdown for kappa values: ≤ 0.2 , poor; 0.21-0.4, fair; 0.41-0.6, moderate; 0.61-0.8, good; and 0.81-1.0, very good.

RESULTS

Survey Data

Table 1 summarizes survey results. Of the 500 surveys sent out, 136 (27.2%) were completed: 36 from the YL level, 32 from the MS level, and 68 from the HS level.

When asked which tackling technique they preferred to teach, 83% of YL, 81% of MS, and 75% of HS coaches said that they instructed players to use the "head across the bow" approach. All coaches (100%) at the MS level instructed players to "keep their heads up," as opposed to only 89% of YL and 81% ($P < .05$) of HS coaches.

Game Tackle Data

Table 2 presents the results of the tackle grading. HS players had the smallest percentage of missed tackles, at 11.9%. YL and MS teams missed 25.3% and 26.6% (chi-square, $P < .001$ vs HS) of all tackles. Players in the YL made 935 tackle attempts with the head-up technique; this number was the highest of all 3 groups. YL players also tackled above the waist significantly more than players in the other 2 groups (chi-square, $P < .001$). Head-up tackling occurred in 2246 of 2445 (91.9%) tackles at or above the waist, as opposed to 392 of 555 (70.6%; $P < .001$) tackles below the waist. Head-up tackle attempts were successful in 2133 of 2638 tackles (80.8%) as compared with head-down attempts at 229 of 362 tackles (63.2%; $P < .001$).

We identified 75 of 1000 (7.5%) attempted tackles involving the head-across-the-bow technique for YL players, which was significantly less than that observed among MS (17.3%; $P < .001$) and HS (15.0%; $P < .001$) players. Players who attempted head-across-the-bow tackles dropped their heads (flexion) in 217 of 398 tackles (54.5%), while players who tackled using an arm or inside-shoulder tackle dropped their heads in 115 of 2523 (4.6%; $P < .001$) tackles. Players who attempted head-across-the-bow tackles missed 140 of 398 tackles (35.2%), as opposed to 23 of 1122 (2.0%; $P < .001$) missed inside-shoulder tackles. Players who attempted to tackle with an arm tackle missed 472 of 1412 tackles (33.4%; $P < .0001$ vs inside-shoulder tackles).

Rater Reliability

The statistical program R was used to analyze the rating results from the 2 blinded independent reviewers. Table 3 shows the intrarater reliability of reviewer A; good to very good results were obtained.

Table 4 shows the interrater reliability of raters A and B; moderate to good reliability was seen in all groups except YL. The mean interrater reliability across all groups was good, with a kappa of 0.66.

DISCUSSION

The current study aimed to assess (1) which tackling techniques were being taught by coaches, (2) what tackling techniques the players used during games, and (3) the success rates of these techniques. We also assessed the reliability of the tackle-grading system that we used. The coaches' survey was geographically limited to Texas, and the response rate was low at 27%. This low rate of completion may be related to the fact that most coaches at these levels of play have other obligations outside of coaching. The low

TABLE 2
Summary of Tackles at the Youth, Middle School, and High School Levels (1000 Tackles per Level)

	Tackles Made / Tackles Attempted, No. (% Successful)		
	Youth League	Middle School	High School
All tackles			
Total tackles	747/1000 (74.7)	734/1000 (73.4)	881/1000 (88.1)
Head across the bow tackle	60/75 (80)	88/173 (50.9)	110/150 (73.3)
Inside shoulder tackle	273/281 (97.2)	405/415 (97.6)	421/426 (98.8)
Arm tackle	383/612 (62.6)	209/380 (55.0)	348/420 (82.9)
Helmet to helmet	31/32 (96.9)	32/32 (100.0)	2/4 (50.0)
Above the waist	521/683 (76.3)	390/495 (78.8)	488/526 (92.8)
At the waist	120/175 (68.6)	249/300 (83.0)	225/266 (84.6)
Below the waist	106/142 (74.6)	95/205 (46.3)	168/208 (80.8)
Head-up tackles			
Total tackles	702/935 (75.1)	643/825 (77.9)	788/878 (89.7)
Head across the bow tackle	29/42 (69.0)	54/87 (62.1)	39/52 (75.0)
Inside shoulder tackle	269/276 (97.5)	377/379 (99.5)	414/419 (98.8)
Arm tackle	374/586 (63.8)	207/354 (58.5)	335/405 (82.7)
Helmet to helmet	30/31 (96.8)	5/5 (100.0)	0/2 (0.0)
Above the waist	498/643 (77.4)	353/455 (77.6)	466/494 (94.3)
At the waist	107/162 (66.0)	227/259 (87.6)	206/233 (88.4)
Below the waist	97/130 (74.6)	63/111 (56.8)	116/151 (76.8)
Head-down tackles			
Total tackles	45/65 (69.2)	91/175 (52.0)	93/122 (76.2)
Head across the bow tackle	31/33 (93.9)	34/86 (39.5)	71/98 (72.4)
Inside shoulder tackle	4/5 (80.0)	28/36 (77.8)	7/7 (100.0)
Arm tackle	9/26 (34.6)	2/26 (7.7)	13/15 (86.7)
Helmet to helmet	1/1 (100.0)	27/27 (100.0)	2/2 (100.0)
Above the waist	23/40 (57.5)	37/40 (92.5)	22/32 (68.8)
At the waist	13/13 (100.0)	22/41 (53.7)	19/33 (57.6)
Below the waist	9/12 (75.0)	32/94 (34.0)	52/57 (91.2)

TABLE 3
Intrarater Reliability: Rater A^a

Grading Category	κ
Tackle type	
Youth	0.686
Middle	0.783
High	0.864
All	0.782
Head position	
Youth	0.642
Middle	0.799
High	0.716
All	0.739
Waist	
Youth	0.647
Middle	0.642
High	0.832
All	0.727
Success	
Youth	0.759
Middle	0.94
High	0.913
All	0.871

TABLE 4
Interrater Reliability for Raters A and B^a

Grading Category	κ
Tackle type	
Youth	0.385
Middle	0.617
High	0.669
All	0.563
Head position	
Youth	0.599
Middle	0.723
High	0.596
All	0.673
Waist	
Youth	0.582
Middle	0.442
High	0.671
All	0.595
Success	
Youth	0.788
Middle	0.89
High	0.868
All	0.85

^aInterpretation of κ: ≤0.2, poor; 0.21-0.4, fair; 0.41-0.6, moderate; 0.61-0.8, good; 0.81-1, very good.

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response rate and sole surveillance of Texas coaches limit the generalizability of the data, although we have no reason to suspect regional variation in coaching technique. Fortunately, most coaches identified the head-up position as an important technique. At the MS level, 100% of coaches identified this as important, versus 89% of YL coaches and 81% of HS coaches. Given the emphasis, it is possible that coaches consider head-up tackling to be well ingrained in players and thus not something that they need to spend as much time practicing. Regardless, we believe that coaches at all levels should reinforce safe tackling technique. We were surprised to see that 75% to 83% endorse the “head across the bow” technique versus only 13% to 22% teaching “facemask through the near shoulder” (shoulder tackling). This finding may reflect the fact that our survey was conducted before the release of the 2012 Heads Up Football program. It would be interesting to readminister the survey to see if attitudes and tackling techniques taught by coaches have changed since the initiation of Heads Up Football. Additionally, coaches may not be aware that players drop their heads >50% of the time while attempting “head across the bow” tackling.

When looking at how coaching translates into game-time tackling, we found that despite 100% of coaches at the MS level citing the head-up technique as important, only 82% of graded tackles demonstrated that technique. In comparison, 94% of YL players ($P < .001$ vs MS) and 88% of HS players ($P < .001$ vs MS) utilized head-up tackling. The reason may be that most YL and HS coaches teach a combination of “see what you hit” and “head-up tackling” at 77% and 78%, versus 56% of MS coaches. It may also simply reflect a level of football experience/maturity that takes time and practice to develop. Using the phrase “see what you hit” may more effectively reinforce having players keeping their heads up when tackling.

Our study was not the first to consider head position in tackling. Heck⁵ provided 2 separate reviews of HS football game footage to assess for incidence of spear tackling. His first study performed a video review of footage from 9 games during a New Jersey varsity HS football season in 1989. The study assessed the previously identified defensive spearing and also a new class of offensive spearing by the ball carrier. He defined spearing as “lowering of the head, either on purpose or as a reflex action, during the tackling process.” Defensive players were evaluated only if the offensive player speared. He found offensive spearing on 19% (167 of 854) of all scorable plays during that season.⁵ Concurrent defensive spearing was identified once per 2.3 offensive spears (43%), with zero spearing penalties called during the season.⁵ When a defender is presented with a spearing runner, he can (1) keep his head up and take the runner’s helmet to the chest or abdomen; (2) try to get lower than the offensive player, putting the head in spearing condition; or (3) take the same level as the offensive player and make helmet-to-helmet or helmet-to-shoulder contact.⁵ Heck’s takeaway recommendations were as follows: teach proper tackling technique, and educate athletes about neck injuries and the mechanisms by which they occur.

A second study by Heck⁶ compared independent tackler spearing, offensive runner spearing, and concurrent tackler spearing in 9 regular-season varsity HS football games in the

1975 versus 1990 seasons. These seasons were selected because 1975 was the last season before antispearing rules went into effect and 1990 was well after the implementation of those rules. Comparing 1975 versus 1990, the mean number of plays per game were 109 vs 105; defensive spears, 28 vs 26; independent tackler spears, 21 vs 15; offensive spears, 15 vs 17; concurrent spears, 7 vs 12; and total spears, 43 vs 44.⁶ There was a decrease in independent tackler spears from 21 to 15 but an increase in concurrent spears from 7 to 12, with no overall change (43 to 44) since the institution of the anti-spearing rules, which appears to be related to the increased incidence of offensive players dropping their heads.

We found that players who tackle with their heads up were successful on 81% of tackle attempts. In contrast, only 63% were successful with head-down tackling. The most plausible reason for this higher degree of success is that with the head-up technique, the players do not lose sight of the ball carrier, which thus gives the tackler the opportunity to compensate for change in the runner’s path. It is much harder to maintain a line of sight on the ball carrier, making misses more common, when tackling with the head down. Head-down tackling was associated with tackling below the waist, which was found to have a lower success rate. Additionally, keeping the head up allows tacklers to see when the impact is going to occur. Using this position provides the opportunity to correctly prepare the neck musculature for impact.⁵ Helmet-to-helmet tackles did not occur frequently, but they were successful 96% of the time. Even if the player is prepared for impact, we do not recommend leading with the head because of axial loading to a flexed spine. Heck⁵ recommended that contact be initiated with the shoulder while the neck is kept extended. This behavior must be practiced, as the natural inclination for players is to lower their heads to protect their eyes and face at contact.⁵ While our study was not designed to measure the safety of tackling techniques, it demonstrated head-up tackling to have a higher chance of success than head-down tackling.

We found that while 75% to 83% of coaches across all 3 levels reported teaching the “head across the bow” technique, only 398 of 3000 (13%) attempted tackles were done with this technique. Players who attempted to tackle with this technique dropped their heads 55% of the time, which could have increased the likelihood of a missed tackle. Alternatively, when players tackled using an arm or shoulder tackle, they dropped their heads only 5% of the time. This indicates that the “head across the bow” technique is more likely to result in a head-down tackle. The tendency of players to drop their heads during a head-across-the-bow tackle puts them at increased risk for an injury to the cervical spine by placing the neck in an at-risk position for axial loading while in flexion.^{2,13} The “head across the bow” technique also puts the initial point of contact between the shoulder pad and helmet, increasing the risk for brachial plexus neuropraxia, or a stinger.^{2,3,13} Subsequent research could quantify the rate of stingers with various tackling techniques.

Most successful tackles observed in our study were arm tackles or tackles made with the shoulder being the initial contact (Table 2). MS and HS players used arm tackles 38% and 42% of the time and shoulder tackles 42% and 43% of the time. In contrast, YL players used arm tackles 61%

($P < .001$) of the time and shoulder tackles 28% ($P < .001$) of the time. These differences between the youngest group of players and the 2 older groups may be attributable to increased player experience, athletic ability, and speed of the game. In actual games, arm tackles are not preferred, because they are more likely to be missed or broken tackles. This was borne out in our analysis, in which 33% of arm tackles but only 2% of inside-shoulder tackles were missed or broken ($P < .001$). Shoulder tackles may not always be feasible because of the angle of approach and the ball carrier's body position.

We assessed the reproducibility of the grading system that we developed to score the tackles. Two independent observers rated the films, and we found that the intrarater reliability was in the good to very good range. When we assessed interrater reliability, the reliability dropped slightly but was still in the good range (κ 0.66 across all groups). Our lowest inter- and intrarater reliability values were in the YL group. The videos that we reviewed from this group were of the lowest video resolution, which limited analysis to some extent. In addition, the YL players were just beginning to learn tackling techniques and often did not conform to a single specific form of tackling. Head position and waist position were the lowest rated in reliability, likely relating to the difficulty of determining exactly the position at the moment of impact, as the ending position was often-times different than the position on impact. In future studies, it would be reasonable to consider dropping the head $\geq 30^\circ$ to be a head-down tackle versus 45° for all levels.

If we acknowledge that the head-down contact position and use of at-risk techniques such as "head across the bow" are still an issue, then the next step becomes determining how to decrease their incidence. The National Athletic Trainers' Association provided a position statement on head-down contact and spearing.⁷ It agreed that axial loading is the primary source of catastrophic cervical spine injury. Laboratory investigation has shown that fracture dislocation in the cervical spine can be replicated with 203 N·m of kinetic energy; the average running football player can possess 2034 N·m of kinetic energy.⁷ The association suggests that coaches emphasize contact with the shoulder or chest while keeping the head up, allowing the player to see and to tense neck musculature. Neck-strengthening programs are encouraged, as stronger muscles provide a better ability to help dissipate forces through controlled movement. Officials and players should receive education to emphasize that the rules are in place to protect the player initiating the head-down contact and that at-risk techniques do not need to be intentional to be dangerous.

This was an initial study on tackling techniques being taught, tackling techniques being utilized, and the success rate associated with various tackle parameters. The main limitations of the coaches' survey were the lack of clarity with terminology, the low response rate, and the limited geographic region. As this was an initial study, a national survey was not implemented, but this could be considered in the future. With the recent increased interest in football safety, we would hope that coaches' participation in the surveys will improve. Providing diagrams of tackling techniques would minimize confusion of different techniques.

The tackle-grading system we used had good reliability, which is encouraging. In a prospective study, proper position of the camera to record the games may increase reliability of tackle grading. The footage utilized for this study was video that the coaches had for general game review, not for quantitatively grading tackling technique. A prospective study would also allow tracking of injuries to better assess safety ramifications.

CONCLUSION

This study assessed tackling techniques taught by coaches and used in games. The survey suggested that coaches were teaching players the "head across the bow" technique and to "keep their heads up." The tackle-rating system that we developed was reliable. The game data review showed that head across the bow was used in $<20\%$ of tackles but that head-up tackles were in the majority at $>80\%$. Our study supports the effectiveness of using the inside-shoulder technique when tackling while keeping the head up. This tackling technique provides a higher rate of successful tackles. Sometimes players must use arm tackling to make the play. "Head across the bow" and head-down tackling techniques should be avoided, as this study has shown their poor success rates. Head-up tackling in combination with the inside shoulder technique is effective.

REFERENCES

1. Boden BP, Breit I, Beachler JA, Williams A, Mueller FO. Fatalities in high school and college football players. *Am J Sports Med.* 2013; 41(5):1108-1116.
2. Cantu RC, Mueller FO. Brain injury-related fatalities in American football, 1945-1999. *Neurosurgery.* 2003;52(4):846-852.
3. DeKosky ST, Ikonovic MD, Gandy S. Traumatic brain injury—football, warfare, and long-term effects. *N Engl J Med.* 2010; 363(14):1293-1296.
4. Heads Up Football. USA Football website. <https://usafootball.com/programs/heads-up-football/>. Accessed January 31, 2017.
5. Heck JF. The incidence of spearing by high school football ball carriers and their tacklers. *J Athl Train.* 1992;27(2):120-124.
6. Heck JF. The incidence of spearing during a high school's 1975 and 1990 football seasons. *J Athl Train.* 1996;31(1):31-37.
7. Heck JF, Clarke KS, Peterson TR, Torg JS, Weis MP. National Athletic Trainers' Association position statement: head-down contact and spearing in tackle football. *J Athl Train.* 2004;39(1):101-111.
8. Kucera KL, Yau RK, Register-Mihalik J, et al. Traumatic brain and spinal cord fatalities among high school and college football players—United States 2005-2014. *MMWR Morb Mortal Wkly Rep.* 2017;65:1465-1469.
9. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics.* 1977;33(1):159-174.
10. Schneider RC. Serious and fatal neurosurgical football injuries. *Clin Neurosurg.* 1964;12:226-236.
11. *See What You Hit* [videotape]. Atlanta, GA: Kestrel Communications Inc; 2000.
12. Torg JS, Guille JT, Jaffe S. Injuries to the cervical spine in American football players. *J Bone Joint Surg Am.* 2002;84(1):112-122.
13. Torg JS, Truex R Jr, Quedenfeld TC, Burstein A, Spealman A, Nichols C 3rd. The National Football Head and Neck Injury Registry: report and conclusions 1978. *JAMA.* 1979;241(14):1477-1479.
14. Torg JS, Vegso JJ, Sennett B. The National Football Head and Neck Injury Registry: 14-year report on cervical quadriplegia (1971-1984). *Clin Sports Med.* 1987;6(1):61-72.

APPENDIX 1



Medical School
Department of Orthopedic Surgery

Tackling Survey

Team Staff Title: Head coach, defensive assistant coach, offensive assistant coach,
other _____

Current coaching level (Circle One):

NFL NCAA High School Middle School Youth League

1. Did you play football?
2. If yes, what was the highest level you played?
3. What positions did you play?
4. Players should try to tackle (select one of the following):
 - A. Above the waist
 - B. Below the waist
 - C. Around the waist
 - D. Other. Explain
5. Please explain how you teach tackling. Circumstance may dictate certain form depending on the ball carrier's position (use reverse side if you need extra space).
6. Which tackling technique(s) do you prefer to teach?
 - A. Head across the bow
 - B. Split the numbers
 - C. Facemask through the near shoulder
 - D. Other - Explain
7. Please circle phrases that you prefer to use when teaching your players proper and effective tackling techniques. (Circle all that apply)
 - A. See what you hit
 - B. Keep your head up
 - C. Take your facemask through the near shoulder
 - D. Head across the bow
 - E. Hit, wrap, and drive
 - F. Get low
 - G. Take your facemask through the numbers
 - H. Hit, wrap, drive, and lift
 - I. Other useful phrases - Explain

APPENDIX 2

TACKLE GRADING

Tackle Methods

- **Head across the bow:** During initial impact, the head of the defender is across the path of the runner's momentum (Figure 1B).
- **Helmet to helmet:** Anytime the initial contact made is helmet to helmet; usurps other tackle categories.
- **Inside shoulder:** Initial contact made by the defender with the shoulder; the aim is at the offensive player's near shoulder, and the defender's head remains to the inside of that shoulder, not crossing in front of the runner's body and momentum (Figure 1C).
- **Arm:** Initial and substantial defensive player contact with the runner is with outstretched arm(s), *not* with shoulder or head. Tackle attempts where the defensive player lunged for but missed the offensive player were categorized as arm tackles by default.

Rating of Head Position

- **Head up:** Helmet approximately $>45^\circ$ to the ground during the initial contact.
- **Head down:** Helmet approximately $<45^\circ$ to the ground during initial contact.

Relation of Defensive Player to the Waist

- **Above:** The tackler's initial point of contact is above the offensive player's waist/belt line.
- **At:** The tackler's initial point of contact is at the offensive player's waist/belt line.
- **Below:** The tackler's initial point of contact is below the offensive player's waist/belt line. Missed tackle attempts where the defensive player did not touch the offensive player were counted as below by default.

Tackle Success

- **Successful:** The defender successfully takes the player with the ball to the ground, and the play officially ends. More than one player can be credited with a successful tackle attempt at the same time. In such a situation, the initial defender must maintain contact while another defender(s) completes the tackle. If the defensive player causes the offensive player to fumble the ball, this counts as a successful tackle. If the defensive player forces the offensive player out of bounds, this is a successful tackle.
- **Unsuccessful:** The defensive player makes a defensive move toward the runner and misses the player or does not successfully take the player to the ground to officially end the play. If the defender has contact with the runner but the runner breaks free and remains in bounds to continue the play, this is an unsuccessful tackle.