

# Comprehensive Coach Education and Practice Contact Restriction Guidelines Result in Lower Injury Rates in Youth American Football

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**Background:** Research evaluating the effect of comprehensive coach education and practice contact restriction in youth football injury rates is sparse. In 2012, USA Football released their Heads Up Football coaching education program (HUF), and Pop Warner Football (PW) instituted guidelines to restrict contact during practice.

**Purpose:** To compare injury rates among youth football players aged 5 to 15 years by whether their leagues implemented HUF and/or were PW-affiliated.

**Study Design:** Cohort study; Level of evidence, 2.

**Methods:** Athletic trainers (ATs) evaluated and tracked injuries at each practice and game during the 2014 youth football season. Players were drawn from 10 leagues across 4 states. The non-Heads Up Football (NHUF) group consisted of 704 players (none of whom were PW-affiliated) from 29 teams within 4 leagues. The HUF+PW group consisted of 741 players from 27 teams within 2 leagues. The HUF-only group consisted of 663 players from 44 teams within 4 leagues. Injury rates and injury rate ratios (IRRs) were reported with 95% CIs.

**Results:** A total of 370 injuries were reported during 71,262 athlete-exposures (AEs) (rate, 5.19/1000 AEs). Compared with the NHUF group (7.32/1000 AEs), the practice injury rates were lower for the HUF+PW group (0.97/1000 AEs; IRR, 0.13; 95% CI, 0.08-0.21) and the HUF-only group (2.73/1000 AEs; IRR, 0.37; 95% CI, 0.26-0.53). Compared with the NHUF group (13.42/1000 AEs), the game injury rate was lower for the HUF+PW group (3.42/1000 AEs; IRR, 0.25; 95% CI, 0.15-0.44) but not for the HUF-only group (13.76/1000 AEs; IRR, 1.02; 95% CI, 0.73-1.43). Also, the HUF+PW game injury rate was lower than that of HUF-only (IRR, 0.20; 95% CI, 0.12-0.36). Higher injury rates were typically found in those aged 11 to 15 years compared with those aged 5 to 10 years. However, stronger effects related to HUF implementation and PW affiliation were seen among 11- to 15-year-olds. When restricted to concussions only, the sole difference was found between the practice concussion rates among 11- to 15-year-olds in the HUF+PW (0.14/1000 AEs) and NHUF groups (0.79/1000 AEs) (IRR, 0.18; 95% CI, 0.04-0.85).

**Conclusion:** These findings support comprehensive coach education and practice contact restrictions as effective methods of injury mitigation. Future research should continue evaluating similar programming within other levels of competition and sports.

**Keywords:** epidemiology; pediatrics; prevention

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An estimated 3 million youth aged 7 to 14 years play tackle football annually in the United States.<sup>15</sup> However, media reports have noted that participation in football has decreased in recent years.<sup>5,17</sup> It is suggested that this decline is partially due to parents' concerns over their

children sustaining concussions during youth football participation.<sup>5,17</sup>

Previous research has noted the incidence of concussion at this level. One study<sup>9</sup> estimated that practice and game concussion rates among 8- to 12-year-olds were 0.24 and 6.16 per 1000 athlete-exposures (AEs), respectively. An older study estimated an overall concussion rate of 0.5 per 1000 AEs.<sup>4</sup> Such concerns over concussion and the accumulation of subconcussive impacts have raised questions

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regarding the age at which youth should begin playing tackle football.<sup>11,13</sup> Likewise, the Institute of Medicine recently highlighted the need for more extensive incidence data on concussion in athletes aged 5 to 23 years.<sup>6</sup>

Such findings at the youth level emphasize the need to create interventions to lessen the incidence of concussion and other injury. Using a socioecological model, Kerr et al<sup>8</sup> posited that factors across multiple levels of influence affect concussion incidence and reporting, and that programming should consider these multiple levels. In 2012, USA Football instituted the Heads Up Football (HUF) program, which included educational components on equipment fitting, tackling technique, strategies to reduce player-to-player contact, and sports medicine topics such as concussion, heat illness, and sudden athlete death.<sup>16</sup> At the same time, Pop Warner Football (PW), one of the oldest youth football organizations, instituted practice guidelines in 2012 to limit the amount of practice time that includes player-to-player contact.<sup>12</sup> Thus, the HUF program and PW practice contact restriction guidelines target multiple levels across the socioecological model.

To our knowledge, no study to date has evaluated the effect of the HUF program and PW practice contact restriction guidelines on the incidence of concussion in youth football players. In addition, such programming may further benefit youth football players by reducing the incidence of all types of injuries. The purpose of the current study was to evaluate the effect of the HUF program and PW practice contact restriction guidelines on the incidence of injuries, particularly concussions, within youth football players aged 5 to 15 years during the 2014 season.

## METHODS

### Design and Participants

This study employed a 1-season observational cohort design. A total of 2108 youth football players between the ages of 5 and 15 years were followed over the 2014 youth football season, including 100 teams from 10 leagues. These leagues were located in 4 states: Arizona, Indiana, Massachusetts, and South Carolina. The study protocol was reviewed and approved by the Western Institutional Review Board, Puyallup, Washington.

### League Selection

The original purpose of the study was to compare injury rates between leagues that utilized and did not utilize HUF. As a result, leagues were recruited to ensure both

HUF and non-HUF (NHUF) leagues were included. However, as the study progressed, it was considered that PW contact guidelines may be associated with injury incidence as well.

The HUF leagues were selected if they had completed the Heads Up Football program, had an identified player safety coach, and were confirmed by USA Football as a participant league. The NHUF leagues were selected if the administrators self-identified the league as having no policy or procedure for systematically educating the league's coaches. In addition, leagues were selected if they were located near a university or health system capable of providing outreach athletic trainers (ATs). The investigators partnered with universities and local health systems to provide ATs for each league. The ATs were required to be licensed or certified to practice in the state they were located.

In addition, both HUF and NHUF leagues were selected around these same universities or health systems to control bias from location-related variation. Additional criteria included leagues that (1) included players between the ages of 5 and 15 years, (2) had practice and game fields that were centrally located so that ATs were available to all players, (3) agreed to allow the AT to attend practices and games, (4) allowed the AT to evaluate injuries and illnesses, and (5) allowed the AT to collect player demographic information.

### League Programming

League programming (ie, implementation of HUF and affiliation with PW) served as independent variables. The HUF program used a top-down training approach in which "master trainers" provided the HUF program to "player safety coaches," who represented their league or organization.<sup>16</sup> The player safety coach was generally a longstanding member of the league, although he/she did not coach a specific team; instead, he/she was responsible for teaching the other coaches the components of the HUF program. Education occurred prior to the season and included hands-on training of proper equipment fitting, both didactic and participant demonstration of proper tackling technique, and strategies for reducing player-to-player contact (drill development). Education also included didactic information regarding concussion, heat illness, and recognition and immediate management of cardiac events.

The PW 2012 practice contact restriction guidelines were composed of 2 main components.<sup>12</sup> First, the guidelines forbade full-speed head-on blocking or tackling drills in which the players lined up more than 3 yards apart. Second, the amount of contact at each practice was reduced to a maximum of one-third of practice time. Contact included drills,

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including down-line versus down-line full-speed drills, and scrimmages.

## Sample

The study included 2108 youth football players who played in the 2014 season. These players were divided into 3 groups. The NHUF group consisted of 704 players from 29 teams within 4 leagues. None of the leagues within the NHUF group were also affiliated with PW. The HUF group consisted of 6 leagues, 71 teams, and 1404 players. Within the HUF group, 741 players originated from 27 teams in 2 leagues that were affiliated with PW (hereafter known as the HUF+PW group). The remaining 663 players from 44 teams and 4 leagues were not affiliated with PW (hereafter known as the HUF-only group).

## Data Collection

Athletic trainers reported all injury and exposure data on a daily basis from all games and practices that occurred during the 2014 season in the sample. At the start of the season, player demographic variables were also collected. De-identified injury and exposure information were collected using an export application that extracts common data elements from a single-injury documentation application called the Injury Surveillance Tool (IST; Datalys Center); these processes have been explained in detail previously.<sup>3,7</sup> The IST serves a dual role: first, it acts as an electronic health record that allows ATs to document their patient contacts as is common clinical practice; second, it eliminates the burden of double-data entry by extracting the de-identified common data elements directly from the application, rather than asking ATs to document injuries twice (once for their own records and once for the study). All ATs received standardized training in the use of the IST.

Injury and exposure information were exported nightly through an automated export process and reviewed by quality control staff weekly.<sup>3,7</sup> If range and consistency checks identified questionable values, the quality control staff would contact the AT to help correct any errors. Weekly conference calls between the project manager and ATs ensured consistent documentation and resolved questions as they arose.

## Definitions

The following definitions were used to complete our study:

- Athlete-exposure (AE): One player participating in 1 game or 1 practice.
- Injury rate: An estimate of the incidence that includes player time of exposure. The injury rate is calculated as the sum of all concussions (numerator) divided by the sum of AEs. Injury rates are expressed per 1000 AEs and reported with 95% CIs.
- Injury rate ratio (IRR): The quotient of dividing 1 IR by another IR (eg,  $IR_A/IR_B$ ). A common comparison that is used is comparing the game IR to the practice IR ( $IR_{game}/IR_{practice}$ ).

- Team-season: One youth team participating in 1 season.
- Time-loss (TL) injury: An injury or illness that requires restricted participation at least 24 hours beyond the day of injury. Concussions were determined by the AT. Players were required to obtain physician approval to return to sport.

## Statistical Analyses

Data were analyzed using SAS-Enterprise Guide software (v 4.3; SAS Institute Inc). Means and SDs were calculated for demographic variables. Demographic variables were then compared using analysis of variance tests with Tukey post hoc comparisons. Frequencies, injury rates, and IRRs with 95% CIs were calculated by event type (eg, practices, competitions) to describe and compare the incidence of injury across groups. IRRs with 95% CIs not including 1.00 were considered statistically significant. To compare injury rates between conditions, we used an intent-to-treat analysis. The intent-to-treat analysis maintains classifications for players as being within HUF+PW, HUF-only, or NHUF leagues, regardless of whether the leagues adhered to those principles.

Analyses were performed that first considered all reported injuries; second, only time-loss injuries were considered; and third, only concussions were considered. Next, analyses were stratified by age. Age was categorized as 5 to 10 years ( $n = 1094$ ; 50.7%) and 11 to 15 years ( $n = 1062$ ; 49.3%). This categorization was used primarily because players in the former category would likely be in grade school whereas those in the latter category would likely be in middle school or junior high school. Finally, analyses were stratified by type of injury, such as abrasion, contusion, concussion, fracture, sprain, and strain.

## RESULTS

### Sample Demographics

**Age.** Players in the study ranged from 5.20 to 15.64 years of age (mean  $\pm$  SD,  $10.88 \pm 1.92$  years) (Table 1). The HUF+PW group had the highest mean age (11.12 years) and was older than the NHUF group (10.56 years; difference, 0.56 years; 95% CI, 0.32-0.79) (Table 1). The HUF-only group (10.94 years) was also older than the NHUF group (difference, 0.38 years; 95% CI, 0.13-0.62).

**Height and Weight.** The mean height and weight were  $145.93 \pm 14.16$  cm and  $44.54 \pm 12.23$  kg, respectively (Table 1). The HUF+PW group had the highest mean height (148.20 cm) and was taller than the HUF-only (145.67 cm; difference, 2.5 cm; 95% CI, 0.80-4.26) and NHUF groups (143.55 cm; difference, 4.65 cm; 95% CI, 2.95-6.35). The HUF-only group was also taller than the NHUF group (difference, 2.12 cm; 95% CI, 0.33-3.91). The HUF-only group had the highest mean weight (45.77 kg) and was heavier than the NHUF group (43.46 kg; difference, 2.31 kg; 95% CI, 0.75-3.87). The mean weight of the HUF+PW group (44.48 kg) did not differ from the other groups.

TABLE 1  
Youth Football Player Demographics by Group<sup>a</sup>

Group	No. of Players	Variable <sup>b</sup>	Mean ± SD	Minimum	Maximum
HUF+PW	741	Age	11.12 ± 1.98	5.20	15.29
		Height	148.20 ± 14.95	107.40	197.70
		Weight	44.48 ± 12.53	19.50	135.17
HUF-only	663	Age	10.94 ± 1.82	5.57	15.64
		Height	145.67 ± 14.29	92.89	184.39
		Weight	45.77 ± 10.21	23.59	113.49
NHUF <sup>c</sup>	704	Age	10.56 ± 1.90	5.42	15.27
		Height	143.55 ± 12.58	104.14	210.82
		Weight	43.46 ± 13.44	20.59	121.93
Overall	2108	Age	10.88 ± 1.92	5.20	15.64
		Height	145.93 ± 14.16	92.89	210.82
		Weight	44.54 ± 12.23	19.50	135.17

<sup>a</sup>HUF-only, Heads Up Football/non-Pop-Warner-affiliated; HUF+PW, Heads Up Football and Pop Warner-affiliated; NHUF, non-Heads Up Football.

<sup>b</sup>Age is measured in years, height is measured in centimeters, and weight is measured in kilograms.

<sup>c</sup>Players in the non-Heads Up Football group were also not affiliated with Pop Warner Football.

TABLE 2  
Injury Rates in Youth Football Teams, by Implementation of Heads Up Football, Affiliation With Pop Warner Football, and Event Type<sup>a</sup>

	HUF+PW		HUF-only		NHUF <sup>b</sup>		Rate Ratio (95% CI)		
	n	Rate <sup>c</sup>	n	Rate <sup>c</sup>	n	Rate <sup>c</sup>	HUF+PW vs NHUF	HUF-only vs NHUF	HUF+PW vs HUF-only
<b>Practice</b>									
All injuries	20	0.97	42	2.73	148	7.32	0.13 (0.08-0.21) <sup>e</sup>	0.37 (0.26-0.53) <sup>e</sup>	0.36 (0.21-0.61) <sup>e</sup>
Time-loss injuries <sup>d</sup>	14	0.68	29	1.89	56	2.77	0.25 (0.14-0.44) <sup>e</sup>	0.68 (0.43-1.07)	0.36 (0.19-0.68) <sup>e</sup>
Concussions	4	0.19	10	0.65	12	0.58	0.33 (0.11-1.02)	1.10 (0.47-2.54)	0.30 (0.09-0.96) <sup>e</sup>
<b>Game</b>									
All injuries	15	3.42	55	13.76	90	13.48	0.25 (0.15-0.44) <sup>e</sup>	1.02 (0.73-1.43)	0.20 (0.12-0.36) <sup>e</sup>
Time-loss injuries <sup>d</sup>	10	2.28	24	6.01	35	5.24	0.43 (0.22-0.88) <sup>e</sup>	1.15 (0.68-1.93)	0.38 (0.18-0.79) <sup>e</sup>
Concussions	3	0.68	6	1.50	10	1.46	0.46 (0.13-1.66)	1.39 (0.60-3.22)	0.37 (0.09-1.50)

<sup>a</sup>HUF-only, Heads Up Football/non-Pop Warner-affiliated; HUF+PW, Heads Up Football and Pop Warner-affiliated; NHUF, non-Heads Up Football.

<sup>b</sup>Players in the non-Heads Up Football group were also not affiliated with Pop Warner Football.

<sup>c</sup>Rate per 1000 athlete-exposures, defined as 1 athlete's participation in 1 practice or 1 competition.

<sup>d</sup>Time-loss injuries are those injuries that restrict participation for at least 24 hours.

<sup>e</sup>Significant differences between groups analyzed.

## Injury Counts

In total, there were 370 injuries reported by ATs (Table 2), of which 35 (9.5%), 97 (26.2%), and 238 (64.3%) originated from the HUF+PW, HUF-only, and NHUF groups, respectively. There were 105 (28.4%) injuries to individuals aged 5 to 10 years and 265 (71.6%) injuries to individuals aged 11 to 15 years.

Most injuries were reported during practices (56.8%; n = 210). However, whereas most injuries occurred in practice within the HUF+PW (57.1%; n = 20) and NHUF groups (62.2%; n = 148), most injuries in the HUF-only group occurred during games (56.7%; n = 55). Time-loss injuries accounted for 168 (45.4%) of these. The HUF+PW group had the largest proportion of time-loss injuries

(68.5%; n = 24), followed by the HUF-only (54.6%; n = 53) and NHUF groups (38.2%; n = 91).

**Types of Injuries.** A total of 45 concussions were reported overall, comprising 12.2% of all injuries. Most concussions were reported in the NHUF groups (48.9%; n = 22), followed by the HUF-only (35.6%; n = 16) and HUF+PW groups (15.6%; n = 7). Other common injuries included contusions (26.0%; n = 168), sprains (20.3%; n = 75), abrasions (7.3%; n = 27), strains (7.0%; n = 26), and fractures (6.5%; n = 24). An additional 77 miscellaneous injuries were reported; these included: environmental-related condition (eg, heat exhaustion, heat syncope; n = 10), inflammation (n = 9), fatigue-related conditions (n = 8), tendonitis (n = 6), subluxation (n = 4), spasm (n = 3), laceration (n = 3), epistaxis (n = 3), bursitis (n = 3), and knee pain (n = 2).



**TABLE 3**  
 Injury Rates in Youth Football Teams, by Implementation of Heads Up Football, Affiliation With Pop Warner Football, Event Type, and Age<sup>a</sup>

	HUF+PW		HUF-only		NHUF <sup>b</sup>		Rate Ratio (95% CI)		
	n	Rate <sup>c</sup>	n	Rate <sup>c</sup>	n	Rate <sup>c</sup>	HUF+PW vs NHUF	HUF-only vs NHUF	HUF+PW vs HUF-only
<b>Practice</b>									
5-10 years									
All injuries	8	1.25	12	2.51	41	3.91	0.32 (0.15-0.68) <sup>e</sup>	0.64 (0.34-1.22)	0.50 (0.20-1.22)
Time-loss injuries <sup>d</sup>	6	0.94	8	1.67	17	1.62	0.58 (0.23-1.47)	1.03 (0.44-2.39)	0.56 (0.19-1.62)
Concussions	2	0.31	3	0.63	4	0.38	0.82 (0.15-4.48)	1.64 (0.37-7.34)	0.50 (0.08-2.99)
11-15 years									
All injuries	12	0.85	30	2.83	107	10.52	0.08 (0.04-0.15) <sup>e</sup>	0.27 (0.18-0.40) <sup>e</sup>	0.30 (0.15-0.59) <sup>e</sup>
Time-loss injuries <sup>d</sup>	8	0.57	21	1.98	39	3.83	0.15 (0.07-0.32) <sup>e</sup>	0.52 (0.30-0.88) <sup>e</sup>	0.29 (0.13-0.64) <sup>e</sup>
Concussions	2	0.14	7	0.66	8	0.79	0.18 (0.04-0.85) <sup>e</sup>	0.84 (0.31-2.32)	0.21 (0.04-1.03)
<b>Game</b>									
5-10 years									
All injuries	3	2.20	11	8.83	30	8.66	0.25 (0.08-0.83) <sup>e</sup>	1.02 (0.51-2.03)	0.25 (0.07-0.89) <sup>e</sup>
Time-loss injuries <sup>d</sup>	3	2.20	3	2.41	12	3.46	0.63 (0.18-2.25)	0.70 (0.20-2.46)	0.91 (0.18-4.52)
Concussions	0	0.00	0	0.00	4	1.15	n/a	n/a	n/a
11-15 years									
All injuries	12	3.97	44	15.99	60	17.84	0.22 (0.12-0.41) <sup>e</sup>	0.90 (0.61-1.32)	0.25 (0.13-0.47) <sup>e</sup>
Time-loss injuries <sup>d</sup>	7	2.32	21	7.63	23	6.84	0.34 (0.15-0.79) <sup>e</sup>	1.12 (0.62-2.02)	0.30 (0.13-0.71) <sup>e</sup>
Concussions	3	0.99	6	2.18	6	1.78	0.56 (0.14-2.23)	1.22 (0.39-3.79)	0.46 (0.11-1.82)

<sup>a</sup>HUF-only, Heads Up Football/non-Pop Warner-affiliated; HUF+PW, Heads Up Football and Pop Warner-affiliated; n/a, not applicable; NHUF, non-Heads Up Football.

<sup>b</sup>Players in the non-Heads Up Football group were also not affiliated with Pop Warner Football.

<sup>c</sup>Rate per 1000 athlete-exposures, defined as 1 athlete's participation in 1 practice or 1 competition.

<sup>d</sup>Time-loss injuries are those injuries that restrict participation for at least 24 hours.

<sup>e</sup>Significant differences between groups analyzed.

Abrasions and contusions had the lowest proportion of injuries resulting in time lost (3.7% and 30.0%, respectively).

**Injury Rates**

The 370 reported injuries were sustained during 71,162 AEs, leading to an overall injury rate of 5.19 per 1000 AEs.

**Practice Rates.** The 210 reported injuries during practices were sustained during 56,099 AEs, leading to a practice injury rate of 3.74 per 1000 AEs. Compared with the NHUF group (7.32/1000 AEs), the practice injury rates were lower for the HUF+PW group (0.97/1000 AEs; IRR, 0.13; 95% CI, 0.08-0.21) and the HUF-only group (2.73/1000 AEs; IRR, 0.37; 95% CI, 0.26-0.53). Also, the HUF+PW practice injury rate was lower than that of the HUF-only group (IRR, 0.36; 95% CI, 0.21-0.61).

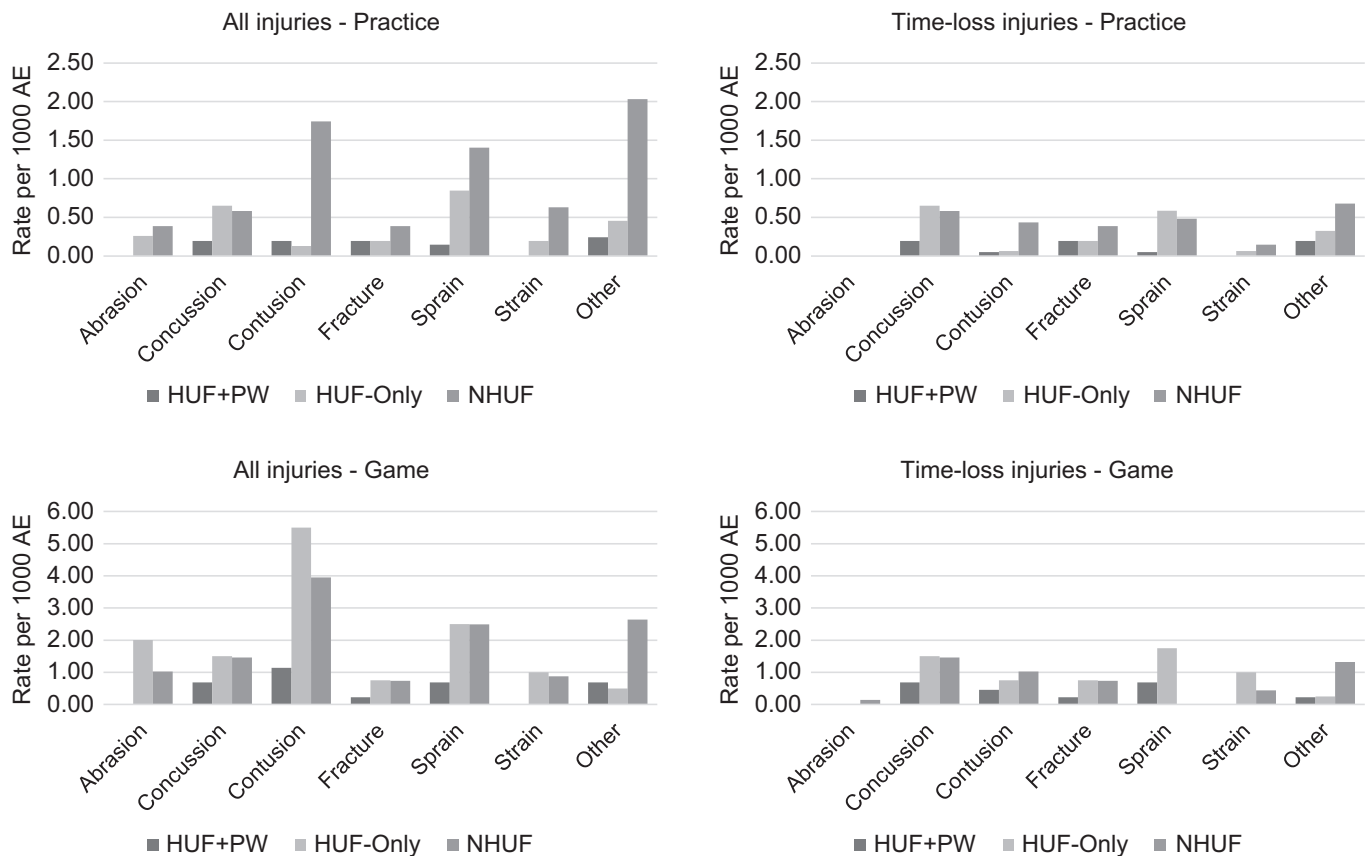
Differences were attenuated when restricted to time-loss injuries only. The HUF+PW practice time-loss injury rate (0.68/1000 AEs) remained lower than those of the NHUF (2.77/1000 AEs; IRR, 0.25; 95% CI, 0.14-0.44) and HUF-only groups (1.89/1000 AEs; IRR, 0.36; 95% CI, 0.21-0.61). However, the HUF-only time-loss practice injury rate did not differ from that of the NHUF group (IRR, 0.68; 95% CI, 0.43-1.07). The HUF+PW practice concussion rate (0.19/1000 AEs) did not significantly differ from that of the NHUF group (0.59/1000 AEs; IRR, 0.33; 95% CI, 0.11-1.02). However, the HUF+PW practice concussion rate was lower

than that of the HUF-only group (0.65/1000 AEs; IRR, 0.30; 95% CI, 0.09-0.96).

**Game Rates.** The 160 reported injuries during games were sustained during 15,062 AEs, leading to a game injury rate of 10.62/1000 AEs. Compared with the NHUF group (13.42/1000 AEs), the game injury rate was lower for the HUF+PW group (3.42/1000 AEs; IRR, 0.25; 95% CI, 0.15-0.44) but not for the HUF-only group (13.76/1000 AEs; IRR, 1.02; 95% CI, 0.73-1.43). Also, the HUF+PW game injury rate was lower than that of the HUF-only group (IRR, 0.20; 95% CI, 0.12-0.36).

Differences were attenuated when restricted to time-loss injuries only. The HUF+PW game time-loss injury rate (2.28/1000 AEs) remained lower than those of the NHUF (5.24/1000 AEs; IRR, 0.43; 95% CI, 0.22-0.88) and HUF-only groups (6.01/1000 AEs; IRR, 0.38; 95% CI, 0.18-0.79). When restricted to concussions only, no statistical differences were found.

**Rates by Age.** When stratified by age, higher injury rates were typically found in those aged 11 to 15 years compared with those aged 5 to 10 years (Table 3). However, stronger effects related to HUF implementation and PW affiliation were in the 11- to 15-year-old group. For example, among 11- to 15-year-olds, the practice injury rates in the HUF+PW (0.85/1000 AEs) and HUF-only groups (2.83/1000 AEs) were 92% and 73% lower, respectively, than that of the NHUF group (10.52/1000 AEs). Among 5- to 10-year-olds, the practice injury rates in the HUF+PW



**Figure 1.** Injury rates in youth football teams in the 2014 season by implementation of Heads Up Football (HUF), affiliation with Pop Warner Football (PW), event type, and type of injury. Players in the non-Heads Up Football (NHUF) group were also not affiliated with Pop Warner Football. Time-loss injuries are those that restrict participation for at least 24 hours. AE, athlete-exposure, defined as 1 athlete's participation in 1 practice or 1 competition.

(1.25/1000 AEs) and HUF-only groups (2.51/1000 AEs) were 68% and 36% lower, respectively, than that of the NHUF group (3.91/1000 AEs).

Findings were further attenuated when restricted to time-loss injuries only, with significant findings retained for only 11- to 15-year-olds in the HUF+PW group. Compared with the NHUF group, time-loss injury rates in the HUF+PW group for practices and games were 85% and 66% lower, respectively. When restricted to concussions only, the sole difference was found between the practice concussion rates among 11- to 15-year-olds in the HUF+PW (0.14/1000 AEs) and NHUF group (0.79/1000 AEs; IRR, 0.18; 95% CI, 0.04-0.85).

**Rates by Type of Injury.** In general, rates specific to injury type remained highest among the NHUF group, most notably among practices (Figure 1). For example, compared with the practice contusion rate in the NHUF group (1.74/1000 AEs), the practice contusion rates were lower for the HUF+PW (0.19/1000 AEs; IRR, 0.11; 95% CI, 0.04-0.31) and HUF-only groups (0.13/1000 AEs; IRR, 0.07; 95% CI, 0.02-0.31). Rates decreased when restricted with time-loss injuries only, and in some cases, differences between the NHUF group and the HUF+PW and HUF-

only groups were attenuated. Similar patterns were found between age groups.

## DISCUSSION

Participation in various youth sports is on the decline.<sup>17</sup> This drop in participation is multifactorial, but potential factors may include concern over injury, rising insurance costs, and litigation against sports organizations. Effective strategies are needed to mitigate injury risk and alleviate concerns about youth safety. The HUF program and PW practice contact restriction guidelines aim to reduce the frequency of player-to-player contact in practices and modify coaching behaviors.<sup>12,16</sup>

This is the largest study to date to examine the epidemiology of injury between multiple practice conditions in youth football players. Our findings suggest that in the 2014 season, utilization of the HUF program and PW practice contact restriction guidelines resulted in the lowest injury rates. The HUF+PW group, which utilized both programs, saw the greatest benefit during practices. Non-PW leagues that implemented the HUF program were also effective at mitigating injuries, particularly among older

youth football players in our sample (ie, 11-15 years). However, the HUF+PW group generally had significantly lower injury rates than the HUF-only group as well. The HUF-only leagues were not required to use the tackling education drills that limited player-to-player contact in practices. Therefore, it is possible that the benefit of limiting player-to-player contact did not moderate injury as effectively. We speculate that the HUF+PW group may have been more effective due to the PW practice contact restriction guidelines that specifically limited how much player-to-player contact time could occur. Thus, as posited in the socioecological model,<sup>8</sup> addressing multiple levels of influence, as seen in the leagues utilizing the HUF program and PW practice contact restriction guidelines, may have resulted in greater reductions of injury incidence.

However, because PW affiliation was originally not considered in our recruitment of leagues in the study, we lack a group of leagues that were affiliated with PW, but did not utilize the HUF program. As a result, we cannot examine the effect of PW practice guidelines independent of the HUF program. At the same time, we did not examine whether those leagues not affiliated with PW might have complied with other guidelines that aim to limit contact exposure and/or reduce injury incidence. Research that examines manners in which to reduce injury incidence in youth football as well as other sports would benefit from continued evaluation of other programming and policy.

Because the HUF program and PW practice contact restriction guidelines were primarily targeted at modifying practice activities, it was suspected that there would not be a difference in game injury rates among groups. However, we found the all-injury and time-loss injury game rates in the HUF+PW group were lower than those in the NHUF and HUF-only groups. Players in the HUF+PW group may enter games healthier because of the PW practice contact restriction guidelines resulting in less contact exposure in practices. However, additional prospective research is needed to better understand how interventions that modify practices also affect injury incidence during games.

Analyses by age group found stronger effects in the 11- to 15-year-olds compared with the 5- to 10-year-olds, particularly for the HUF+PW group. At the same time, our findings found differences from previous research<sup>4,10,14</sup> that suggested that youth football injury rates increased with age and grade. Among games and within the NHUF group, rates were higher in the older age group. However, in the HUF+PW group, the practice injury rate among 11- to 15-year-olds was lower than that of the 5- to 10-year-olds (0.85 vs 1.25/1000 AEs). The practice injury rates in the HUF-only group were also similar between the 11- to 15-year-olds and 5- to 10-year-olds (2.83 vs 2.51/1000 AEs). These findings suggest that older youth may benefit more from the HUF program and PW practice contact restriction guidelines. It is possible that older youth produce player-to-player impacts that result in higher force,<sup>1,2</sup> and thus, increased injury risk. Or, older youth may be more apt to comply with such programming and policy, although no research on this currently exists. Further prospective research may be warranted to better examine compliance

with and the effects of programming and policy across youth age strata.

Concussions comprised 12.2% of all reported injuries. This exceeds a previous estimate of 2.7% from previous research<sup>4</sup> that utilized similar methodology in 2002 and 2003. The sole significant finding related to concussion rates was found when comparing 11- to 15-year-olds in the HUF+PW and NHUF groups during practices. However, it is possible that the lack of other statistical differences were due to insufficient power, as only 45 concussions were sustained among the 2108 players. Compared with previous research that estimated youth football concussion rates among 8- to 12-year-olds in practices (0.24/1000 AEs),<sup>9</sup> the rates in the current study were similar for the HUF+PW group but higher in the HUF-only and NHUF groups. In addition, compared with game concussion rates from the previous study (6.16/1000 AEs),<sup>9</sup> the rates in the current study demonstrated all 3 groups were lower than those reported previously. Also, rates were typically higher among older youth. The variations in our findings may be attributable to differences such as location, contact guidelines, and reporting standards. This study utilized ATs at all practices and games, whereas the former study relied mostly on coaches' reporting of concussions. Continued surveillance of concussions at the youth level, as recommended by the Institute of Medicine,<sup>6</sup> will help to better estimate youth football concussion incidence.

## Limitations

This is a single study of football leagues that were a convenience sample from 4 states and includes 1 season of data. We recruited from communities with leagues that did and did not implement the HUF program. Still, despite these efforts and large sample size, these data may not be generalizable to all youth football players. As a result, this study should be replicated by other investigators using similar or improved methodologies.

As noted earlier, our study did not include leagues that were affiliated with PW but not implementing HUF. As a result, we cannot directly assess the benefit of PW practice contact restriction guidelines independent of HUF. Also, our findings may not be generalizable to other coaching education programs. The coaching education program included in this study included proper equipment fitting, proper tackling, strategies to reduce player-to-player contact, and concussion, heat injury, and sudden athlete death education. This coaching education program may represent the higher end of the coaching education continuum, and it is unclear if simply modifying any single component alone (eg, player-to-player contact, proper equipment fitting, etc) would result in similar findings. Further research should compare the effect of the HUF program and PW practice contact restriction guidelines in comparison with other coaching education programs and policies that may exist.

## CONCLUSION

Our findings suggest that a comprehensive coaching education program combined with practice guidelines limiting

player-to-player contact may help lower injury rates. In addition, in lieu of practice guidelines, coaching education alone may also be effective at lowering injury rates. Higher injury rates were typically found in those aged 11 to 15 years compared with those 5 to 10 years old. Education and guidelines resulted in lower concussion rates in 11- to 15-year-olds during practice compared with noneducation leagues. Future research should seek to replicate and improve this study, evaluating this coaching education program compared with others, with and without practice contact restriction guidelines, and in other age ranges and populations (eg, high schools).

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