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Article in *The Orthopaedic Journal of Sports Medicine* · September 2015

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Injury Rates in Age-Only Versus Age-and-Weight Playing Standard Conditions in American Youth Football

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Background: American youth football leagues are typically structured using either age-only (AO) or age-and-weight (AW) playing standard conditions. These playing standard conditions group players by age in the former condition and by a combination of age and weight in the latter condition. However, no study has systematically compared injury risk between these 2 playing standards.

Purpose: To compare injury rates between youth tackle football players in the AO and AW playing standard conditions.

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

Methods: Athletic trainers evaluated and recorded injuries at each practice and game during the 2012 and 2013 football seasons. Players (age, 5-14 years) were drawn from 13 recreational leagues across 6 states. The sample included 4092 athlete-seasons (AW, 2065; AO, 2027) from 210 teams (AW, 106; O, 104). Injury rate ratios (RRs) with 95% CIs were used to compare the playing standard conditions. Multivariate Poisson regression was used to estimate RRs adjusted for residual effects of age and clustering by team and league. There were 4 endpoints of interest: (1) any injury, (2) non-time loss (NTL) injuries only, (3) time loss (TL) injuries only, and (4) concussions only.

Results: Over 2 seasons, the cohort accumulated 1475 injuries and 142,536 athlete-exposures (AEs). The most common injuries were contusions (34.4%), ligament sprains (16.3%), concussions (9.6%), and muscle strains (7.8%). The overall injury rate for both playing standard conditions combined was 10.3 per 1000 AEs (95% CI, 9.8-10.9). The TL injury, NTL injury, and concussion rates in both playing standard conditions combined were 3.1, 7.2, and 1.0 per 1000 AEs, respectively. In multivariate Poisson regression models controlling for age, team, and league, no differences were found between playing standard conditions in the overall injury rate (RR_{overall}, 1.1; 95% CI, 0.4-2.6). Rates for the other 3 endpoints were also similar (RR_{NTL}, 1.1 [95% CI, 0.4-3.0]; RR_{TL}, 0.9 [95% CI, 0.4-1.9]; RR_{concussion}, 0.6 [95% CI, 0.3-1.4]).

Conclusion: For the injury endpoints examined in this study, the injury rates were similar in the AO and AW playing standards. Future research should examine other policies, rules, and behavioral factors that may affect injury risk within youth football.

Keywords: epidemiology; youth football; injury risk

American football (hereafter, football) is one of the most popular youth sports in the United States (US), with an estimated 3 million youth playing tackle football annually in the US.⁸ Football is a collision sport in which attributes such as body size, acceleration, and physical strength are important keys to physical domination of the opponent. All 3 attributes are closely tied to maturity status in youth athletes.⁶ Youth football players that are the same

chronological age can vary substantially in body size and maturity status.^{5,6} In particular, boys in the 5- to 14-year-old age group can vary in skeletal maturity by as many as 4 chronological years, notably around the onset of the male adolescent growth spurt (12-14 years).^{5,6} These imbalances between players are exacerbated by the daunting physical size of many youth football players. In fact, Malina et al⁶ estimated that 45% of youth football players are considered overweight by US Centers for Disease Control standards.

Because of these maturational differences, many youth football leagues may utilize an age-weight (AW) classification

The Orthopaedic Journal of Sports Medicine, 3(9), 2325967115603979
DOI: 10.1177/2325967115603979
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matrix in the interests of player safety and fairness of competition.¹⁰ In the AW playing standard, children may play with others of various ages provided they are matched by some combination of age and weight. For example, a child aged 12 years but of lighter weight may play with similarly weighted children that are aged 9 to 11 years.

An alternative playing standard condition is organizing children by age (or grade in school) and is commonly referred to as the age-only (AO) playing standard. Within the AO playing standard, most leagues are “restricted,” meaning that ball carriers (eg, quarterback, wide receiver, tight end) are restricted by size (ie, weight). The ball carrier size restriction is promoted under the premise of fairness of competition and player safety. Proponents of AO leagues also suggest that their model promotes player retention because they do not remove players from their age-based peer groups, as would happen for oversized or undersized children in the AW leagues.

There is little scientific evidence that supports the premise that the AW playing standard reduces injury risk and promotes player safety relative to the AO playing standard. Epidemiologic evidence suggests that injury incidence increases with grade level, with the injury rate among seventh and eighth graders being approximately 50% to 100% higher than that of fourth and fifth graders.^{2,7} To date, there has been no systematic comparison of playing standard conditions in youth football.

The primary purpose of this study was to compare the risk of injury across these 2 different playing standard conditions. We hypothesized that a lower injury rate would be observed in AW leagues relative to AO leagues. The secondary purpose was to provide comprehensive descriptive information regarding the incidence and nature of injuries in youth football players between the ages of 5 and 14 years.

METHODS

Design

The study utilized a prospective 2-year (2012 and 2013) observational cohort design. The sample included 210 youth team-seasons totaling 4092 athlete-seasons, derived from 3167 individual youth tackle football players from 6 states and 13 individual recreational youth football

leagues. Playing standard (AO vs AW) of the youth football league constituted the main exposure variable. Athletic trainers (ATs) were present on-site at practices and games to record injury and exposure information for the respective teams throughout the season. Teams were incentivized to participate because the ATs also provided clinical services for the identification and treatment of injury (in general, youth football teams do not have access to dedicated ATs). The study protocol was reviewed and approved by the Western Institutional Review Board (Puyallup, Washington).

League Selection

Leagues were eligible if they met the following requirements: included players between the ages of 7 and 14 years in 2012 and/or the ages of 5 and 14 years in 2013, were located within 30 miles of the university or health care system providing AT services, had multiple practice and game fields that were located in close geographic proximity (to allow the AT to be centrally located among the league's teams during practices), agreed to allow the AT to attend practices and games, allowed the AT to evaluate and manage injuries and illnesses, allowed the AT to collect player demographic information, and agreed to assist in the collection of individual game exposures and injury data.

A total of 13 leagues were included in the study. In 2012, 10 leagues participated, of which 9 also participated in 2013. An additional 3 leagues were introduced in 2013. Leagues originated from 6 states, including Arizona, Indiana, Massachusetts, Ohio, South Carolina, and West Virginia. The investigators partnered with universities and local health systems to provide ATs for each league. The ATs were required to be licensed, registered, or certified to practice in the state in which they were located. The majority of sites were selected if both playing standard conditions were represented in the community, but in separate leagues.

Injury Endpoints

There were 4 endpoints of interest: (1) any injury, defined as an injury or illness that required AT evaluation; (2) time loss (TL) injury, defined as an injury or illness that required AT evaluation and restricted participation at least 24 hours beyond the day of injury; (3) non-time loss (NTL) injury, defined as any injury or illness evaluated by the AT that did

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One or more of the authors has declared the following potential conflict of interest or source of funding: Funding for this study was provided by USA Football (Z.Y.K., R.H., T.P.D.). The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the program sponsor.

not qualify as a time loss injury (ie, overuse injuries, wounds); and (4) concussion, defined as any functional neurologic disturbance resulting from head acceleration/deceleration.

Epidemiologic Parameters

We computed injury rates for each of these 4 endpoints. An injury rate is an estimate of the incidence that includes player time exposure in the denominator. This player time exposure (ie, athlete-exposure [AE]) was defined as 1 player participating in 1 game or 1 practice. For example, the concussion injury rate is calculated as the sum of all concussions (numerator), divided by the sum of AEs. Injury rates were expressed per 1000 AEs and were reported with 95% CIs.

Additionally, the following concepts were used to define further epidemiologic outcomes of interest: team-season, defined as 1 youth team participating in 1 season; and athlete-season, defined as 1 player participating in 1 season. Players may have participated in more than 1 season but are counted separately each season. This was used as the denominator to calculate athletes at risk.

Sample Size

The sample included 4092 athlete-seasons from 13 leagues (AO, 7; AW, 6) and 210 teams (AO, 104; AW, 106), with nearly equal distribution of athlete-seasons (AW, 2065; AO, 2027) between playing standard conditions. Over the 2 years, 89 (AW, 29; AO, 60) players chose not to participate, resulting in an inclusion rate of 97.9%. Arizona contributed the most athlete-seasons ($n = 1292$) followed by Massachusetts ($n = 1015$), South Carolina ($n = 698$), Indiana ($n = 658$), West Virginia ($n = 292$), and Ohio ($n = 137$). Across both playing standard conditions, there were 3167 distinct players.

Instruments

All data were reported by ATs. Deidentified injury and exposure information were collected using an export application that extracts common data elements (CDEs) from a single injury documentation software application called the Injury Surveillance Tool (IST; Datalys Center). This process has been described in detail previously.^{1,4} The IST serves a dual role of acting as an electronic health record to allow ATs to document their patient contacts as is common clinical practice and eliminates the burden of double data entry by extracting the deidentified CDEs directly from the application rather than asking the AT to document injuries twice (once for their own records and once for the study).

Data Collection Protocol and Data Quality

The ATs attended each practice and game during the 2012 and 2013 seasons and reported injuries and exposures daily. Each AT was trained in software use and study protocol. Player heights, weights, age, team playing standard,

TABLE 1
Youth Football Player Demographics
by Playing Standard Condition

Standard	Athlete-Seasons, n	Variable ^a	Mean \pm SD	Range
Age-weight	2065	Age	10.9 \pm 2.0	5.1-14.9
		Weight	42.7 \pm 13.0	10.9-113.9
		Height	146.7 \pm 14.2	101.6-182.9
Age-only	2027	Age	10.5 \pm 1.8	5.0-14.8
		Weight	44.1 \pm 14.9	17.6-141.1
		Height	145.6 \pm 16.3	94.0-185.4
Overall	4092	Age	10.7 \pm 1.9	5.0-14.9
		Weight	43.4 \pm 13.9	10.9-141.1
		Height	146.1 \pm 15.2	94.0-185.4

^aAge is measured in years, weight is measured in kilograms, and height is measured in centimeters.

and other demographic variables were collected at the start of the season. Coaches and parents assisted the ATs in counting the number of players at each practice and game. Injury and exposure information was transmitted nightly through an automated export process to a central data repository and reviewed by quality control staff on a weekly basis.^{1,4} Range and consistency checks were made regularly, and if they identified questionable values, the quality control staff would contact the AT for corrections. Weekly conference calls between the project manager and ATs assured consistent documentation and resolved questions as they arose.

Statistical Analysis

Aggregate data were analyzed using SAS-Enterprise Guide software (PROC GLIMIX in EG version 4.3; SAS Institute Inc). Descriptive analyses include the frequency and proportion of injuries. Comparative analyses included the calculation of injury rates and injury rate ratios (RRs) with 95% CIs. Multivariate Poisson regression with random intercepts for team and league estimated the injury RRs comparing the AO to the AW standard conditions while adjusting for residual effects of age. Residual age was defined as the chronological age of the player. We did not adjust for grade in school or any other age-based variables. Initial analyses addressed the primary endpoint of (1) any injury evaluated by the AT. Subanalyses were then conducted for more specific injury types: (2) NTL injuries only, (3) TL injuries only, and (4) concussions only.

RESULTS

Player Demographics

Players in the study ranged from 5.0 to 14.9 years of age (mean \pm SD, 10.7 \pm 1.9 years) (Table 1). The mean height and weight were 146.1 \pm 15.2 cm and 43.4 \pm 13.9 kg, respectively. Compared with the AO standard, the AW standard had a greater mean age and height (both $P < .001$).

TABLE 2
Time-Loss Distribution for Injuries Sustained by Youth Football Players by Playing Standard Condition^a

Time Loss	Injuries, n (%)		
	Age-Weight	Age-Only	Overall
<1 day (NTL)	639 (74.2)	391 (63.7)	1030 (69.8)
1-6 days (TL)	139 (16.1)	131 (21.3)	270 (18.3)
7-13 days (TL)	38 (4.4)	48 (7.8)	86 (5.8)
14-29 days (TL)	14 (1.6)	15 (2.4)	29 (2.0)
≥30 days (TL)	4 (0.5)	4 (0.7)	8 (0.5)
Remainder of season ^b (TL)	23 (2.7)	23 (3.7)	46 (3.1)
Missing	4 (0.5)	2 (0.3)	6 (0.4)
Total No. of injuries	861	614	1475

^aPercentages may not add to 100% due to rounding. NTL, non-time loss; TL, time loss.

^bThe remainder of the season could total a few days to weeks.

Compared with the AW standard, the AO standard had a greater mean weight ($P = .001$).

Injury Frequencies

Over 2 seasons and across both playing standard conditions, 1475 injuries were reported by 915 players (Table 2). The greatest number of injuries reported by an individual player was 8. Most injuries in both playing standard conditions were NTL (69.8%). Within the 4092 player-seasons, 77.6% did not result in injuries. In other words, the injury risk per season for the average player was 22.4%.

In the AO standard, 497 players reported 614 (41.6%) injuries. In the AW standard, 418 players reported 861 injuries (58.4%). The proportion of injuries that were NTL in the AW standard (74.2%) was 1.2 times that of the AO standard (63.7%; 95% CI, 1.1-1.3). The most common injuries were contusions (34.4%), ligament sprains (16.3%), concussions (9.6%), and muscle strains (7.8%) (Table 3). The proportion of injuries that were concussions in the AO standard (12.9%) was 1.8 times that of the AW standard (7.2%; 95% CI, 1.3-2.5). In addition, over the 2 seasons, there were no reports of catastrophic head or spine injuries or exertional heat stroke.

Injury Rates and Rate Ratios

Across both playing standard conditions, there were 142,536 AEs documented for an overall injury rate of 10.3 per 1000 AEs (95% CI, 9.8-10.9) (Table 4). Playing standard conditions combined, the game rate (21.2/1000 AEs) was greater than the practice rate (7.2/1000 AEs; RR, 3.0; 95% CI, 2.7-3.3). The TL and NTL injury rates in both playing standard conditions combined were 3.1 and 7.2 per 1000 AEs, respectively. In addition, the concussion rate in both playing standard conditions combined was 1.0 per 1000 AEs.

In multivariate Poisson regression models controlling for age, team, and league, no differences were found between playing standard conditions in the overall injury

TABLE 3
Diagnoses of Injuries Sustained by Youth Football Players by Playing Standard Condition

Diagnosis	Injuries, n (%)		
	Age-Weight	Age-Only	Overall
Contusion (bruise)	307 (35.7)	201 (32.7)	508 (34.4)
Ligament sprain	129 (15.0)	112 (18.2)	241 (16.3)
Concussion	62 (7.2)	79 (12.9)	141 (9.6)
Muscle strain	69 (8.0)	46 (7.5)	115 (7.8)
Abrasion/lacerations	45 (5.2)	22 (3.6)	67 (4.5)
Nervous system (stinger)	50 (5.8)	12 (2.0)	62 (4.2)
Fractures	31 (3.6)	28 (4.6)	59 (4.0)
Overuse (tendinitis)	31 (3.6)	19 (3.1)	50 (3.4)
Muscle spasm	28 (3.3)	18 (2.9)	46 (3.1)
Respiratory (fitness, asthma)	25 (2.9)	18 (2.9)	43 (2.9)
Heat illness	20 (2.3)	8 (1.3)	28 (1.9)
Dislocation/subluxation	8 (0.9)	5 (0.8)	13 (0.9)
Illness/other	56 (6.5)	46 (7.5)	102 (6.9)
Total No. of injuries	861	614	1475

rate (RR_{overall}, 1.1, 95% CI, 0.4-2.6) (Table 5). Rates for the other 3 endpoints were also similar (RR_{NTL}, 1.1 [95% CI, 0.4-3.0]; RR_{TL}, 0.9 [95% CI, 0.4-1.9]; RR_{concussion}, 0.6 [95% CI, 0.3-1.4]). Findings were similar when limited to games or practices.

DISCUSSION

This is the first study to specifically compare 2 forms of playing standard conditions in American youth football. In addition, this is also one of the largest epidemiological studies conducted that employed trained health care providers (ie, ATs) to evaluate and document injury information in the youth sport setting at both practices and games. Previous research has demonstrated that ATs are the most reliable source of injury information in a sport setting,¹³ and this is a strength of this study. This study is responsive to recent recommendations by the Institute of Medicine³ to better describe injury incidence (specifically concussion) in youth athletes.

We hypothesized that the players participating in AW youth football leagues would be at lower risk of injury compared with those in AO youth football leagues. However, we found that the injury rates were very similar in both AW and AO playing standard conditions. We note that there may be 2 tentative indicators of a possible beneficial effect of the AW standard. First, the time loss distribution suggested a slightly larger proportion of NTL injuries in the AW standard. Second, we found the concussion rate to be lower in the AW standard compared with the AO standard (RR, 0.6). However, this effect was minor relative to the imprecision of the estimate (confidence limit ratio, 4.7).⁹ As a result, despite our large cohort of 4092 player-seasons, effects may have been too small to be definitively observed. The study would need to be expanded to include a much larger number of AO and AW leagues to have sufficient power to define these effects with good precision.

TABLE 4
Injury Rates of Youth Football Players by Event Type and Playing Standard Condition^a

Standard	Games			Practices			Overall		
	Injuries, n	AEs, n	Injury Rate (95% CI)	Injuries, n	AEs, n	Injury Rate (95% CI)	Injuries, n	AEs, n	Injury Rate (95% CI)
Any reported injury									
Age-weight	367	14,700	25.0 (22.4-27.5)	494	60,674	8.1 (7.4-8.9)	861	75,374	11.4 (10.7-12.2)
Age-only	310	17,169	18.1 (16.0-20.1)	304	49,993	6.1 (5.4-6.8)	614	67,162	9.1 (8.4-9.9)
Overall	677	31,869	21.2 (19.6-22.8)	798	110,667	7.2 (6.7-7.7)	1475	142,536	10.3 (9.8-10.9)
Non-time loss injury									
Age-weight	279	14,700	19.0 (16.8-21.2)	361	60,674	5.9 (5.3-6.6)	640	75,374	8.5 (7.8-9.1)
Age-only	212	17,169	12.3 (10.7-14.0)	178	49,993	3.6 (3.0-4.1)	390	67,162	5.8 (5.2-6.4)
Overall	491	31,869	15.4 (14.0-16.8)	539	110,667	4.9 (4.5-5.3)	1030	142,536	7.2 (6.8-7.7)
Time loss injury									
Age-weight	88	14,700	6.0 (4.7-7.2)	133	60,674	2.2 (1.8-2.6)	221	75,374	2.9 (2.5-3.3)
Age-only	98	17,169	5.7 (4.6-6.8)	126	49,993	2.5 (2.1-3.0)	224	67,162	3.3 (2.9-3.8)
Overall	186	31,869	5.8 (5.0-6.7)	259	110,667	2.3 (2.1-2.6)	445	142,536	3.1 (2.8-3.4)
Concussion									
Age-weight	32	14,700	2.2 (1.4-2.9)	30	60,674	0.5 (0.3-0.7)	62	75,374	0.8 (0.6-1.0)
Age-only	45	17,169	2.6 (1.9-3.4)	34	49,993	0.7 (0.5-0.9)	79	67,162	1.2 (0.9-1.4)
Overall	77	31,869	2.4 (1.9-3.0)	64	110,667	0.6 (0.4-0.7)	141	142,536	1.0 (0.8-1.2)

^aInjury rate calculated as number of injuries per 1000 athlete-exposures (AEs).

TABLE 5
Adjusted Rate Ratios in Youth Football Players by Event Type and Playing Standard Condition^a

Standard	Rate Ratio (95% CI)		
	Games	Practices	Overall
Any reported injury			
Age-weight	1.0 (0.4-2.4)	1.4 (0.5-4.1)	1.1 (0.4-2.6)
Age-only	1.0 (reference)	1.0 (reference)	1.0 (reference)
Non-time loss injury			
Age-weight	1.1 (0.4-3.0)	1.5 (0.5-4.7)	1.1 (0.4-3.0)
Age-only	1.0 (reference)	1.0 (reference)	1.0 (reference)
Time loss injury			
Age-weight	0.8 (0.3-1.9)	1.1 (0.5-2.8)	0.9 (0.4-1.9)
Age-only	1.0 (reference)	1.0 (reference)	1.0 (reference)
Concussion			
Age-weight	0.6 (0.2-1.8)	0.8 (0.4-1.9)	0.6 (0.3-1.4)
Age-only	1.0 (reference)	1.0 (reference)	1.0 (reference)

^aAdjusted rate ratios estimated from multivariate Poisson regression models that controlled for age and that included random intercepts for team and league.

Potential confounders are a concern in any observational sports injury study. Overall, the football players within both playing standard conditions were similar demographically. Although statistical differences were found by age, height, and weight, these differences were not clinically meaningful. Limited research on youth football risk factors exists.^{2,7} However, there is a dearth of literature on the effectiveness of changes implemented via policy or behavioral interventions. We speculate that coach or player behavior (ie, tackling style, player-to-player contact drills, etc) may influence player safety. Parental expectations may also be influential factors. Our study lacked the resources

to quantify these psychosocial factors and thus they may be confounders of our observed RRs.

It is important to note that all teams within our AO standard were “restricted,” that is, required that ball carriers be restricted by size or weight. In AO-unrestricted leagues, players of any size are allowed to carry the ball. Thus, it is possible that null findings between the 2 playing standard conditions may have been due to the exclusion of AO-unrestricted teams. There were 2 primary reasons that unrestricted leagues were not included. First, none of the unrestricted leagues we contacted chose to participate. Second, unrestricted AO leagues are primarily located in the Southwest and are far less common than restricted leagues, thus limiting our potential player pool to a single region. Therefore, the decision was made to only include restricted leagues that are much more common and representative of a greater proportion of youth players. Future research should compare AO-unrestricted leagues with AO-restricted and AW leagues.

Similar to previous research,^{1,2,11} most injuries (69.8%) were classified as NTL. Until recently, most injury surveillance systems restricted injuries to only those requiring restriction from activity of at least 24 hours beyond the day of injury.^{1,2,4,7,11,13} The methodology used in this study, as well as others,^{1,4} captures all injuries evaluated and managed by ATs regardless of time lost from participation. This more inclusive definition better demonstrates the burden of injury on both the athletes and healthcare providers. Thus, the large NTL injury rates may be driven predominantly by minor and less severe injuries such as contusions, which are a commonly reported injury as noted in previous youth football studies.² However, at the same time, our injury definition allows for inclusion of overuse injuries such as tendinitis, contusions, and other injuries that might seem minor at the time of first evaluation but may later become significant health issues.

Further research evaluating the nature of the NTL injuries in a young population is warranted.

Last, about 1 in 10 of all reported injuries were concussions. This exceeds a previous estimate of 2.7%, which was reported from previous research² that utilized similar methodology in 2002 and 2003. Also, our concussion rate was approximately double that of the previous study (0.5/1000 AEs).² Similar patterns of higher concussion rates reported more recently have also been found at the high school level.¹² We believe that this is a positive result of the awareness campaigns and other interventions that have made parents, coaches, and players more aware of the signs and symptoms of concussion over the past decade, as well as changes driven by concussion-related legislation and policy. In addition, our findings also highlight the benefits of having ATs on-site to identify and manage injuries such as concussions. Continued education efforts related to detection and management of concussions will ensure that more populations of youth athletes receive appropriate care. Future prospective research should examine time trends in the incidence and severity of concussion.

Limitations

The sample, while the largest to date, is a convenience sample and may not be generalizable to all youth football players, particularly those in AO-unrestricted leagues. However, leagues were specifically chosen to include several regions of the United States (ie, Northeast, Midwest, Southeast, and Southwest); 2 playing standard conditions (ie, AO and AW); and urban, rural, and suburban leagues. This study was also limited by the time frame. Within the 2 years of data, temporal variation in injury rates caused by any number of reasons could result in spurious findings. However, because of the large number of teams and equal distribution among playing standard conditions, we believe any effect of annual variation would likely not affect the comparison of playing standard conditions. This study also did not examine more detailed player-level variations, as they fell outside the scope of this study. This includes how many individuals in the AW group were moved to a different level of play, or how their injury risk would have been affected had they been in the AO group and thus were not moved. More in-depth follow-up studies are warranted. Finally, exposures were not time based or play based. However, all of the youth football leagues in this study required that all players receive playing time in both the first and second halves of each game. Thus, AEs may be the most appropriate exposure measurement that can be readily collected in a large study.

CONCLUSION

We conclude that neither the AO nor the AW playing standard conditions are associated with lower injury rates among youth football players. In addition, compared with previous research,² the proportion and rate of concussion in youth football have increased, which may be indicative of better patient reporting, detection, and diagnosis. The literature related to policy and programming influences on injury

risk in youth football is limited. Continued examination of policy and programming factors will help to better protect the health and safety of youth football players and may assist in informing injury prevention efforts.

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ACKNOWLEDGMENT

The authors thank the many youth football organizers, parents, players, and athletic trainers whose support made this study possible.

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