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Injuries in the Chinese Arena Football League

American Versus Chinese Players

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Investigation performed at the Department of Sports Medicine, Huashan Hospital, Fudan University, Shanghai, China

Background: Arena football is an indoor version of American football played in indoor arenas on a smaller field with 8 players per team. Only 1 study has evaluated injury rates in arena football, and no study had compared 2 distinct cohorts of players.

Purpose/Hypothesis: The purpose of this study was to evaluate and compare injury rates in American versus Chinese athletes in the Chinese Arena Football League. Our hypothesis was that the rate of significant injuries (≥7 days of time lost from play) would be statistically significantly higher in Chinese athletes.

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

Methods: Each of the 6 teams included in this study comprised 11 American and 11 Chinese athletes, for a total of 132 included athletes (66 Chinese, 66 American). All players stayed in the same hotel, trained and played in the same facilities, and were covered by the same medical staff. A total of 18 games were played consecutively in 6 cities from October 1 to November 6, 2016. At least 4 Chinese players had to be on the field for each team at all times during game play.

Results: American athletes were significantly older, taller, and heavier than Chinese athletes. The total exposure was 759 athlete-hours, and there were 80 reported injuries, with 74 (92.5%) occurring during games (overall injury rate, 105.4 injuries per 1000 athlete-hours). For American athletes, the exposure was 387 athlete-hours with 38 injuries observed, and the injury rate was 98.2 injuries per 1000 athlete-hours. For Chinese athletes, the exposure was 372 athlete-hours with 42 injuries observed, and the injury rate was 112.9 injuries per 1000 athlete-hours. There was no statistically significant difference in exposure or overall injury rate between American and Chinese athletes. The rate of significant injuries was 30.3 per 1000 athlete-hours; there were 17 such injuries in Chinese athletes compared with 6 such injuries for American athletes. The rate of significant injuries was 45.7 (Chinese) and 15.5 (American) injuries per 1000 athlete-hours, and the relative risk for Chinese versus American athletes for significant injuries was 3.0 (95% CI, 1.2-7.8; $P = .019$) . Binary logistic regression models were utilized to analyze whether the baseline variables (height, weight, body mass index, age, years of experience, and nationality) were potential predictors for an injury, and only years of experience (odds ratio, 1.147 [95% CI, 1.034-1.271]; $P = .009$) was found to be associated with severe injuries (>21 days of time loss).

Conclusion: The overall risk of injuries was similar between Chinese and American athletes, but Chinese athletes showed statistically higher rates of significant injuries than their American counterparts. Years of experience was the only factor that was associated with severe injuries. As professional sports become more global, medical personnel must take into account the distinct differences and levels of experience between the national and international professional athletes. The results of this study will be used to make recommendations to develop preventive training measures, including techniques to improve tackling.

Keywords: concussion; cross-sectional study; arena football

In the fall of 2016, the inaugural season of the Chinese Arena Football League (CAFL) commenced with its first 3 games played in Beijing. Arena football is an indoor version of American football. It is played in indoor arenas on a smaller field, with 8 players per team.[9] The offense consists of 3 offensive linemen (OL), a quarterback (QB), a fullback (FB), and 3 wide receivers (WR); and the defense consists of 3 defensive linemen (DL), a linebacker (LB), and 4 defensive backs (DB). Besides the number of players per team, there are multiple differences between arena football and traditional stadium American football games (Table 1). For example, on offense, 1 player is allowed to move toward the line of scrimmage before the snap of the ball, which is different from stadium football rules that prohibit any player from doing this moving toward the line of scrimmage before the snap of the ball. Arena games are dynamic and high scoring,

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TABLE 1
Comparison of Arena Football to the NFL[a]

	Arena Football	NFL
Field	85 ft wide and 50 yd long, resulting in faster, higher scoring competitions	160 ft wide and 100 yd long
Goal posts	9 ft wide with a 15 ft–high crossbar	18.5 ft wide with a 10 ft–high crossbar
Roster	20- to 22-man rosters; 8 men on the field; many players play both offense and defense	53-man roster; 11 men on the field
Scoring	Mostly the same as the NFL, but a successful drop kick earns 2 points on the extra point and 4 points for a field goal	
Rebound nets	Kickoffs and passing plays that bounce off the nets are still in play	
Passing	Receivers can catch a pass against the sideboards; only 1 foot needs to be inbounds	Both feet must be inbounds when a receiver catches a pass
Man in motion	One player may be moving toward the line of scrimmage	Can only move parallel or away from the line of scrimmage
Punting	Not allowed	
Overtime	15 minutes, with at least 1 guaranteed possession for each team	15 minutes; each team has 1 guaranteed possession unless a team scores a touchdown or safety on its first overtime possession; then, sudden death is used until a winner is determined

[a]NFL, National Football League.

with an increased amount of passing versus running plays because of the smaller size of the field and fewer players on the field as compared with the outside version.[9]

The CAFL introduced arena football to China 5 years before the inaugural season and began sponsoring teams at universities over the previous 3 years. Those Chinese players interested in playing in the CAFL before the draft for the league were then invited to open tryouts/combines.

Herbenick et al[9] conducted a retrospective review of the injury rate of players on the 12 teams in the American Arena Football League from 2004 to 2008. Since then, no additional studies have been published. The CAFL presented a unique opportunity and allowed the medical staff to prospectively and accurately collect data on injuries. The purpose of this study was to evaluate and compare the rates of minor and significant injuries in American arena football athletes with Chinese athletes during the inaugural season of the CAFL. Our hypothesis was that the rate of significant injuries would be statistically significantly higher in Chinese athletes.

METHODS

Athletes

Institutional review board approval was obtained for this study. Each of the 6 teams in the CAFL were made up of 11 American and 11 Chinese athletes, thus a total of 132 athletes (66 Chinese athletes, 66 American athletes) were included in this study. All players were drafted by the CAFL in June 2016. The Chinese players were drafted from the pooled players who had prior American football experience and/or displayed their skills in 2 tryouts/combines in China before the draft. The American players who were drafted either had prior football experience in arena or other professional football leagues or participated in tryouts/combines in the United States and registered themselves for consideration in the draft. During the training camp and the season, all players stayed in the same hotel, trained on the same grounds, and played in the same arenas. Notably, a double room accommodated 1 Chinese athlete and 1 American athlete, with the intent to facilitate communication and camaraderie between the 2 groups of athletes.

Medical Team and Coaching Staff

The medical team consisted of 5 certified athletic trainers and 5 sports medicine physicians: 4 from the United States (US) and 1 from China. The league supplied the athletes with helmets and pads from the same company. Furthermore, a well-equipped training room was set up in each hotel with the same equipment and supplies used and expected in a standard training room in the US. The coaching staff consisted of US coaches as well as 1 Chinese assistant coach.

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Ethical approval for this study was obtained from the Department of Sports Medicine, Huashan Hospital, Fudan University, Shanghai, China.

Training Camp and Game

The Chinese players underwent a week of training camp without pads or contact before the arrival of the American athletes on September 18, 2016. Training camps for individual teams were then started. No standardized practice program was utilized, and as a result, each team ran its own practices, with the drills and amount of contact determined by the coaching staff.

Instead of using the routine format of playing home and away games, a total of 18 games were consecutively played in 6 cities (Beijing, Dalian, Qingdao, Guangzhou, Shenzhen, and Shanghai) from October 1 to November 6, 2016. In the first 5 cities, the 6 teams played against each team once (15 games). In the last city (Shanghai), all 6 teams were seated according to their record and competed for the championship and for third and fifth places. Three games were played each weekend, usually with 2 games on Saturday and 1 game on Sunday. All games were played on the same field material (FieldTurf; Tarkett), which was transported in and set up in each arena. At any time during a game, at least 4 Chinese players had to be on the field for each team. All the games were covered and all the players were treated by the same medical team. All the players, coaching staff, medical team, and other working staff lived and traveled together to the 6 different cities.

Data Collection

All players signed a contract to participate in the league. The contract stipulated that preparticipation and postparticipation medical examinations were required, and the players gave permission for the collection of information about any injuries during the season. For all players, demographics were collected. Experience for Chinese players was determined by the number of years that they had played any type of organized American football, including arena as well as stadium football. Experience for American players was calculated by the number of years that they had played football from high school to the present. The Chinese players underwent a preparticipation examination by the sports medicine team on September 10. No player was disqualified from playing. The majority of American athletes underwent their preparticipation examination before their arrival, with a limited number undergoing the examination in China.

A standardized single-page form was used to document injury information. The items on the form included the player's name, team, jersey number, mechanism of injury, location on the field where the injury occurred, time of game when the injury occurred, position played at the time of injury, injured site, symptoms, pain level, physical examination findings, and treatment. A trainer and usually a physician covered all practices and games, and a daily injury clinic was provided for all teams. All injuries were reported as soon as possible to trainers whether they happened during games or practices. All individual injury documentation usually was completed by the certified athletic trainer or physician.

After playing the 3 games in each city, the data were collectively registered by 1 physician, shared with all the other medical staff, and double-checked to ensure accuracy and data integrity. All players underwent a postparticipation examination before the last game, with an extra examination completed only if there were any additional injuries in the last weekend of the season.

Exposure and Injury Rate

Exposures represent the situations in which athletes' injuries may occur and hence were used to estimate the injury rate during games. Exposure of 1 athlete per unit hour was determined to be the most accurate method to evaluate the potential injury risk,[9] and it was calculated as the number of injuries per 1000 hours per athlete in this study.

We evaluated each player's playing time. For 1 athlete participating in 1 game, his game exposure was calculated as 1 athlete-hour regardless of time-outs, half-time, or clock stoppages due to a dead ball. Because there were 22 players per team (44 players total) and all the athletes played in most games, we calculated exposure as 44 athlete-hours per game. We did reduce the total number of athlete-hours by subtracting the athlete-hours of players who could not play because of injuries or other reasons during the season, and the exposure of those athletes was not counted until they returned to play. Practice time was not included, and this calculation was similar to the method used by Herbenick et al[9] in their study. Clearance for return to play was decided by the trainer and physician, especially for athletes diagnosed with a concussion.

Definition of Injury and Severity

A reportable injury was confirmed when the injury met all of the following criteria: (1) occurred during training or games, (2) resulted in time away from practices or games, (3) was confirmed by trainers and/or a physician after an examination of the athlete, (4) was given proper treatment, and (5) resulted in any cranial, cervical, or head injuries that required the athlete to leave the practice or game. Consistent with previous research,[10] injury severity was classified into 3 categories depending on the time lost from playing or the extent of injury: minor injuries (time loss, 0-6 days), moderate injuries (time loss, 7-21 days), and severe injuries (time loss, >21 days). In this study, moderate and severe injuries were considered significant injuries. The injury mechanism was first reported by the athletes and then checked by medical staff. If needed, game video was reviewed to confirm the mechanism of injury. We categorized the injury mechanism as contact, noncontact, overuse, and sideboard related. Overuse was defined as inflammation-related injuries in which players were symptomatic and functionally limited during or after games without a definite injury history.

TABLE 2
Demographics of Chinese and American Athletes[a]

	Chinese Athletes	American Athletes	P
Age, y	25.0 ± 4.4 (19.0-40.0)	28.1 ± 2.9 (22.0-36.0)	<.001[b]
Height, in	70.7 ± 3.1 (65.0-76.0)	73.2 ± 2.3 (68.0-78.0)	<.001[b]
Weight, lb	216.1 ± 49.6 (140.0-340.0)	237.3 ± 52.0 (179.0-340.0)	.018[b]
BMI, kg/m^2	30.2 ± 5.5 (19.7-45.5)	30.9 ± 5.5 (23.7-42.5)	.482
Experience,[c] y	7.00 ± 4.42 (4-22)	13.06 ± 2.93 (7-20)	<.009[b]

[a]Data are reported as mean ± SD (range). BMI, body mass index.
[b]Statistically significant between-group difference ($P < .05$).
[c]Associated with severe injuries (time loss, >21 days) per binary logistic regression model and multivariate analysis.

Statistical Analysis

For quantitative variables, the Student t test or analysis of variance was applied for data of normal distribution, and the Mann-Whitney U test or Kruskal-Wallis test was applied for data of nonnormal distribution. For categorical data, the chi-square or Fisher exact test was applied. The injury rate was compared using relative risks with 95% CIs calculated and was analyzed by the chi-square test . All analyses were performed 2-sided, and $P < .05$ was considered statistically significant.

Furthermore, binary logistic regression models were utilized to analyze whether the baseline variables (height, weight, body mass index [BMI], age, years of experience, and nationality) were potential predictors for an injury and a severe injury. The score test was used to include the variables, and the conditional parameter-estimated likelihood-ratio test was applied to remove the variables. A variable was entered if $P < .05$ and was removed if $P > .10$. A forward stepwise algorithm was applied. Statistical analyses were performed using SPSS 19.0 software (IBM).

RESULTS

Demographics

The overall mean age of the athletes was 26.5 ± 4.0 years (range, 19-40 years). American athletes had a mean age of 28.1 ± 2.9 years (range, 22-36 years) and were significantly older than the Chinese athletes, with a mean age of 25.0 ± 4.4 years (range, 19-40 years) ($P < .001$). The overall mean height of the athletes was 72.0 ± 3.0 inches. American athletes were significantly taller, with a mean of 73.2 ± 2.3 inches (range, 68-78 inches), compared with the Chinese athletes, with a mean of 70.7 ± 3.1 inches (range, 65-76 inches) ($P < .001$). The overall mean weight of the athletes was 226.7 ± 51.7 lb (range, 140-340 lb), with American athletes weighing a mean of 237.3 ± 52.0 lb (range, 179-340 lb), which was significantly more than the Chinese athletes, with a mean of 216.1 ± 49.6 lb (range, 140-340 lb) ($P = .018$). The mean BMI of the athletes was 30.5 ± 5.5 kg/m^2 (range, 19.7-45.5 kg/m^2). There was no significant difference in BMI between the Americans (mean, 30.9 ± 5.5 kg/m^2) and the Chinese (mean, 30.2 ± 5.5 kg/m^2) ($P = .482$) (Table 2).

Analysis by player position showed a significant difference in the height and weight of OL/DL and WR/DB players between the Chinese and American athletes. The mean height of American OL/DL players was 75.24 inches (range, 73-78 inches) compared with Chinese players, with a mean of 72.59 inches (range, 68-76 inches) ($P = .001$). The American OL/DL players weighed a mean of 301.05 lb (range, 255-340 lb) compared with Chinese players' mean weight of 266.35 lb (range, 198-340 lb) ($P < .006$). The American WR/DB players' mean height of 71.33 inches (range, 68-76 inches) was not significantly different from the Chinese players, with a mean of 69.47 inches (range, 66-74 inches) ($P = .0675$), but the American WR/DB players weighed significantly more with a mean of 195.67 lb (range, 179-238 lb) compared with the Chinese players' mean weight of 177.59 lb (range, 140-210 lb) ($P < .0147$).

The mean years of experience was significantly greater in American athletes (13.06 ± 2.93 years; range, 7-20 years) than Chinese athletes (7.00 ± 4.42 years; range, 4-22 years) ($P < .009$). Some Chinese players had played in the US, but they were all OL or DL players, and none of these athletes played skill positions such as QB, WR, DB, or kicker. It should be noted that years of experience does not take into account the difference in levels of coaching and play in Chinese athletes, which could be substantially different from American athletes.

By multivariate analysis, no covariate entered into the model, except for years of experience (odds ratio, 1.147 [95% CI, 1.034-1.271]; $P = .009$), which was found to be associated with severe injuries. Nationality ($P = .957$), age ($P = .520$), height ($P = .158$), weight ($P = .194$), and BMI ($P = .479$) were not associated with severe injuries.

Injury Rate

The total exposure was 759 athlete-hours. There were 80 reported injuries, and the injury rate was 105.4 injuries per 1000 athlete-hours. For American athletes, the exposure was 387 athlete-hours with 38 injuries observed, and the injury rate was 98.2 injuries per 1000 athlete-hours. For Chinese athletes, the exposure was 372 athlete-hours with 42 injuries observed, and the injury rate was 112.9 injuries per 1000 athlete-hours. The relative risk of Chinese versus American athletes for all injuries was 1.15 (95% CI, 0.76-1.74; $P = .509$).

TABLE 3
Injury Rates of Chinese and American Athletes[a]

	American Athletes		Chinese Athletes		
	n	Injury Rate	n	Injury Rate	*P*
All injuries	38	98.2	42	112.9	.509
Minor injuries	32	82.7	25	67.2	.491
Significant injuries	6	15.5	17	45.7	.019[b]

[a]Injury rate was defined as the number of injuries per 1000 athlete-hours. Minor injuries: time loss, 0-6 days; significant injuries: time loss, ≥7 days.
[b]Statistically significant between-group difference ($P < .05$).

The significant injury rate was 30.3 per 1000 athlete-hours; there were 17 such injuries in Chinese athletes compared with 6 for American athletes. The significant injury rate was 45.7 (Chinese) and 15.5 (American) injuries per 1000 athlete-hours, and the relative risk of Chinese versus American athletes for significant injuries was 3.0 (95% CI, 1.2-7.8; $P = .019$).

For the 6 American athletes with significant injuries, the injuries consisted of 1 concussion, 1 medial collateral ligament sprain, 1 lumbar strain, 1 hamstring strain, 1 sternoclavicular joint dislocation, and 1 cervical strain/radiculopathy. For the 17 Chinese athletes with significant injuries, there were 7 concussions, 3 anterior cruciate ligament injuries, 1 posterior cruciate ligament injury, 1 ankle/deltoid ligament sprain, 1 navicular/medial cuneiform contusion, 1 Bennett fracture/dislocation, 1 hamstring strain, 1 groin strain, and 1 abdominal wall strain.

The concussions were all suffered during the impact of a tackle. Analysis of game video showed that 3 of the players were being tackled while the other 5 players initiated the contact of the tackle. One player was an FB, 1 was a QB, 2 were OLs, and the remaining 4 were WRs (n = 2) or DBs (n = 2) (Table 3) .

Injured Body Part

Generally, the most commonly injured body part was the hand (16.3%), followed by the thigh (15.0%), head (concussion) (12.5%), and knee (12.5%). For significant injuries, the most commonly affected body part was the head (concussion) (34.8%), followed by the knee (21.7%). For minor injuries, the most commonly injured body part was the hand (21.1%), followed by the thigh (15.8%). The most commonly injured body parts for Chinese athletes were the hand (19.0%) and head (concussion) (19.0%), while it was the thigh (21.1%) for American athletes. There was a statistically significant variation of injured body parts between significant and minor injuries in the 2 groups ($P = .030$), but there was a minimal statistical difference of injured body parts between the Chinese and American athletes ($P = .245$) (Table 4).

TABLE 4
Injured Body Part[a]

	Chinese Athletes	American Athletes	*P*
Back	1 (2.4)	1 (2.6)	.245
Chest	1 (2.4)	4 (10.5)	
Elbow	1 (2.4)	1 (2.6)	
Foot	3 (7.1)	0 (0.0)	
Forearm	0 (0.0)	2 (5.3)	
Hand	8 (19.0)	5 (13.2)	
Head	8 (19.0)	2 (5.3)	
Knee	6 (14.3)	4 (10.5)	
Lower leg	0 (0.0)	3 (7.9)	
Neck	3 (7.1)	2 (5.3)	
Shoulder	2 (4.8)	2 (5.3)	
Thigh	4 (9.5)	8 (21.1)	
Waist	1 (2.4)	2 (5.3)	
Wrist	2 (4.8)	1 (2.6)	
Ankle	2 (4.8)	1 (2.6)	
	Significant Injuries	**Minor Injuries**	***P***
Back	1 (4.3)	1 (1.8)	.030[b]
Chest	1 (4.3)	4 (7.0)	
Elbow	0 (0.0)	2 (3.5)	
Foot	1 (4.3)	2 (3.5)	
Forearm	0 (0.0)	2 (3.5)	
Hand	1 (4.3)	12 (21.1)	
Head	8 (34.8)	2 (3.5)	
Knee	5 (21.7)	5 (8.8)	
Lower leg	0 (0.0)	3 (5.3)	
Neck	1 (4.3)	4 (7.0)	
Shoulder	0 (0.0)	4 (7.0)	
Thigh	3 (13.0)	9 (15.8)	
Waist	1 (4.3)	2 (3.5)	
Wrist	0 (0.0)	3 (5.3)	
Ankle	1 (4.3)	2 (3.5)	

[a]Data are reported as n (%).
[b]Statistically significant difference between number of significant injuries (time loss, ≥7 days) and minor injuries (time loss, 0-6 days) ($P < .05$).

Injury Mechanism

Contact was the most common injury mechanism (75%), followed by noncontact (21.3%) and overuse (2.5%). Injuries that were caused by collision with the sideboards occurred only once, resulting in a minor wrist sprain. Notably, contact was responsible for the more significant (73.9%) and minor (75.4%) injuries as well as most injuries among Chinese (81.0%) and American (68.4%) athletes. All 3 anterior cruciate ligament injuries and the 1 posterior cruciate ligament injury were contact related. No statistical difference relating to the injury mechanism existed between American and Chinese athletes ($P = .521$) or between significant and minor injuries ($P = .845$) (Table 5).

Time of Injury

Four injuries occurred during practices; 2 developed from overuse, and the remaining 74 (92.5%) injuries occurred

TABLE 5
Injury Mechanism[a]

	Chinese Athletes	American Athletes	P
Noncontact	7 (16.7)	10 (26.3)	.521
Contact	34 (81.0)	26 (68.4)	
Overuse	1 (2.4)	1 (2.6)	
Sideboard related	0 (0.0)	1 (2.6)	
	Significant Injuries	**Minor Injuries**	**P**
Noncontact	6 (26.1)	11 (19.3)	.845
Contact	17 (73.9)	43 (75.4)	
Overuse	0 (0.0)	2 (3.5)	
Sideboard related	0 (0.0)	1 (1.8)	

[a]Data are reported as n (%). Minor injuries: time loss, 0-6 days; significant injuries: time loss, ≥7 days.

TABLE 6
Time of Injury During Games[a]

	Chinese Athletes	American Athletes	P
1st quarter	9 (22.5)	2 (6.9)	.285
2nd quarter	15 (37.5)	15 (51.7)	
3rd quarter	7 (17.5)	4 (13.8)	
4th quarter	9 (22.5)	8 (27.6)	
	Significant Injuries	**Minor Injuries**	**P**
1st quarter	3 (14.3)	8 (16.7)	.511
2nd quarter	12 (57.1)	18 (37.5)	
3rd quarter	2 (9.5)	9 (18.8)	
4th quarter	4 (19.0)	13 (27.1)	

[a]Data are reported as n (%). Minor injuries: time loss, 0-6 days; significant injuries: time loss, ≥7 days.

during games. All 23 significant injuries occurred during games. Despite unavailable data in 5 cases, the in-game time of injury was documented in 69 cases to the quarter in which it occurred. Generally, the most common time of injury was the second quarter (43.5%), followed by the fourth quarter (24.6%). Furthermore, the second quarter saw most injuries for both American (51.7%) and Chinese (37.5%) athletes as well as for both significant (57.1%) and minor (37.5%) injuries. There were no statistically significant differences for the time of injury between American and Chinese athletes ($P = .285$) or between significant and minor injuries ($P = .511$) (Table 6).

Injury by Player Position

There was no significant difference in the distribution of players except for QB players and kickers, who were predominantly American athletes. Overall, the injury risk in CAFL games was the highest for the running back (RB)/LB position (400.0 injuries per 1000 athlete-hours), followed by the RB/WR position (333.3 injuries per 1000 athlete-hours).

TABLE 7
Player Position[a]

	Significant Injuries			Minor Injuries			
	n	Exposure[b]	Injury Rate[c]	n	Exposure[b]	Injury Rate[c]	P
DB	6	98	61.2	6	98	61.2	.212
DL	1	81	12.3	8	81	98.8	
OL	1	65	15.4	6	65	92.3	
OL/DL	3	116	25.9	8	116	69.0	
QB	2	69	29.0	4	69	58.0	
RB/LB	1	5	200.0	1	5	200.0	
WR	4	113	35.4	6	113	53.1	
WR/DB	2	62	32.3	8	62	129.0	
RB/WR	2	6	333.3	0	6	0.0	
FB	1	12	83.3	0	12	0.0	
Kicker	0	30	0.0	1	30	33.3	
LB	0	42	0.0	3	42	71.4	
FB/LB	0	24	0.0	4	24	166.7	
	Chinese Athletes			**American Athletes**			
	n	Exposure[b]	Injury Rate[c]	n	Exposure[b]	Injury Rate[c]	P
DB	3	36	83.3	9	62	145.2	.019[d]
DL	5	27	185.2	4	54	74.1	
OL	4	24	166.7	3	41	73.2	
OL/DL	10	86	116.3	1	30	33.3	
QB	1	12	83.3	5	57	87.7	
RB/LB	2	5	400.0	—	—	—	
WR	4	53	75.5	6	60	100.0	
WR/DB	6	39	153.8	4	23	173.9	
RB/WR	2	6	333.3	—	—	—	
FB	1	6	166.7	0	6	0.0	
Kicker	0	12	0.0	1	18	55.6	
LB	1	30	33.3	2	12	166.7	
FB/LB	3	18	166.7	1	6	166.7	

[a]Minor injuries: time loss, 0-6 days; significant injuries: time loss, ≥7 days. DB, defensive back; DL, defensive lineman; FB, fullback; LB, linebacker; OL, offensive lineman; QB, quarterback; RB, running back; WR, wide receiver.

[b]Exposure was defined as 1 athlete playing for 1 hour, recorded as athlete-hours.

[c]Injury rate was defined as the number of injuries per 1000 athlete-hours.

[d]Statistically significant between-group difference in number of injuries by player position ($P < .05$).

The lowest injury risk was for the kicker (33.3 injuries per 1000 athlete-hours).

Further analysis of significant injuries showed that the risk was the highest for the RB/WR position (333.3 injuries per 1000 athlete-hours) and lowest for the kicker, LB position, and FB/LB position (0.0 injuries per 1000 athlete-hours). For minor injuries, the risk was the highest for the RB/LB position (200.0 injuries per 1000 athlete-hours) and lowest for the RB/WR and FB positions (0.0 injuries per 1000 athlete-hours). No statistically significant differences for injuries by player position were found between significant and minor injuries ($P = .212$) (Table 7).

For American athletes, the risk was the highest for the WR/DB position (173.9 injuries per 1000 athlete-hours) and lowest for the FB position (0.0 injuries per 1000 athlete-hours), while for Chinese athletes, the risk was the highest for the RB/LB position (400.0 injuries per 1000 athlete-hours) and lowest for the kicker (0.0 injuries per 1000 athlete-hours). Statistically significant differences were found for injuries by player position between Chinese and American athletes ($P = .019$) (Table 7).

DISCUSSION

This study confirmed our hypothesis that the significant injury rate was statistically significantly higher for the Chinese athletes. In our multivariate analysis, years of experience was the only factor that proved to be significant in players who suffered severe injuries. In Chinese athletes, concussion ($n = 7$) was the most frequent injury, followed by ligament tears of the knee ($n = 4$). The position of the player injured was also significantly different between Chinese and American athletes. The most injured Chinese athletes were OL/DL players, while WR/DB players constituted the largest group of American athletes injured.

The rate or incidence of injuries in American football has been comprehensively investigated in previous studies.[2,3,7,8,10,12-17,19] Shankar et al[15] reported on the injury rate of high school and collegiate football players in the United States between 2005 and 2006. In their study, the injury rate per 1000 athlete-exposures was 12.0 in high school football games and 40.2 in collegiate football games, particularly those in which significant injuries accounted for nearly half the cases. Iguchi et al[10] reported on the injury rate of collegiate athletes playing American football in Japan from 2007 to 2009. In their prospective study, the game injury rate was 32.7 injuries per 1000 athlete-exposures, and as with Shankar et al,[15] significant injuries were observed in approximately half of the cases. Only Herbenick et al[9] previously reported on the injury pattern in professional arena football; in their retrospective study, the injury rate was 111.3 per 1000 exposures for games, and 73% of all injuries resulted in a time loss of 0 to 6 days. In other words, significant injuries accounted for about one-quarter of the cases. In the Herbenick et al[9] study, the injury rate for games and practices was 105.4 per 1000 athlete-hours, and significant injuries were observed in 28.8% of all cases. Despite the disparity regarding experimental design, the results of this study were similar to those of Herbenick et al.[9] The consistent results suggest that the proportion of significant injuries is relatively lower in professional arena football games compared with conventional stadium football games.

We calculated the injury rate using the unit of athlete-hours and made the necessary adjustments by considering the player's individual playing time. This method allowed for more accurate measurements of the injury rate compared with athlete-exposures and other approaches.[9] Generally, Chinese athletes had a higher overall injury rate (significant and minor injuries) than their American counterparts (112.9 vs 98.2 injuries per 1000 athlete-hours, respectively; $P < .05$). There was a statistically significant difference between the groups in significant injuries, and the relative risk of Chinese versus American athletes was 3.0 (95% CI, 1.2-7.8; $P = .019$). The reason for this difference may be attributed to several distinguishing factors between the Chinese and American athletes, including height, weight, and age, but years of experience was the only factor associated with severe injuries.

The injuries per body part were compared with other reports on American stadium or arena football.[1-5,7,9,10] Of the significant injuries, Chinese athletes suffered all 4 cruciate ligament injuries and 7 of the 8 concussions. All 4 of the cruciate ligament injuries were contact related. In analyzing the reason for the high concussion rate of Chinese athletes, we noted that the height and weight of 5 of the 7 concussed athletes were less than the mean height and weight of both American and Chinese athletes in the same positions. One of the athletes (RB/WR) who suffered a concussion was the smallest athlete in the CAFL.

Similar to the results from previous reports, contact was the most common mechanism for significant and minor injuries.[1-3,5,6,11,15-17,19] Of the Chinese athletes who suffered concussions, 3 were struck by another athlete while being tackled, while the other 4 concussions resulted from the player initiating the tackle. The only American athlete who suffered a concussion was struck by another athlete (not the ball carrier) while initiating a tackle. It is almost impossible to match the height and weight of the opposing players during a game.

Years of experience was shown to be the most significant factor in determining the difference in injury rate between American and Chinese athletes, but as the Chinese athletes gain experience and improve player intelligence, this difference may be reduced. Additional measures will be undertaken to teach proper tackling techniques, such as the rugby tackling techniques popularized by the Seattle Seahawks and taught to many high school, collegiate, and professional football teams.[18]

We recognize that this study has some limitations. Chinese athletes had significantly fewer years of experience, but this number does not take into account the quality or level of coaching and play in China, which could be substantially different from that of American athletes. Second, the sample size was relatively small compared with previous reports, but we plan to collect additional data in future seasons. Last, despite a prospective design, a small portion of data was retrospectively collected by reviewing game video.

This study had the distinct advantage of comparing injuries to athletes with different levels of experience under identical circumstances. All the athletes played side by side and shared the same environment, including boarding and lodging, training, gear, games, logistics, and other aspects related to the CAFL season. The unique features of the CAFL reduced any potential bias in this study. Furthermore, the prospective design, continuous communication between medical staff, and efficient registry ensured the accuracy of injury information.

This study was also the first time that the injury rates of 2 distinct populations of professional athletes were compared. There were many significant differences between the Chinese and American athletes in the CAFL, most obviously height, weight, and years of experience. As stated previously, it is difficult to match the height and weight of opposing players during a game. Initially, it may also be difficult to match the level of experience of athletes as new professional sports are introduced in different countries. Preparing the athletes for the season should be done as best as possible. We recommend additional training and coaching for the less experienced athletes to ensure proper tackling techniques. In addition, further studies should be undertaken to compare the distinct groups of athletes who play on the same court, ice, or field, especially in contact sports such as football and hockey. In the future, it will be interesting to note whether years of experience remains the biggest factor or if the difference in sizes will begin to affect injury rates as well.

CONCLUSION

The overall risk of injuries was similar between Chinese and American athletes in arena football games, but Chinese athletes showed statistically higher rates of significant injuries than their American counterparts. Per the multivariate analysis, years of experience was the only factor that was associated with severe injuries. As professional sports become more global, medical personnel must take into account the distinct differences and levels of experience between the national and international professional athletes. The results of this study will be used to make recommendations to develop preventive training measures, including techniques to improve tackling.

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