

# The 2015 U.S. Soccer Federation header ban and its effect on emergency room concussion rates in soccer players aged 10-13

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**Background:** *In 2015, the U.S. Soccer Federation banned heading for players aged 10-13.*

**Purpose/Question:** *To assess the change in proportion of children aged 10-13 playing soccer in the US presenting to an Emergency Department (ED) with a concussion in relation to any other injury before and after the ban.*

**Methods:** *Analysis was restricted to soccer athletes between 10-13 years that reported to a National Electronic Injury Surveillance System (NEISS) participating hospital ED following injury in 2013-2014 and 2016-2017. Multivariable logistic regression was performed to assess the association between year of injury and concussion diagnosis in relation to other injury diagnosis after adjusting for age, sex, and ethnicity.*

**Results:** *Concussion in relation to other injuries*

**Contexte :** *En 2015, la U.S. Soccer Federation a interdit le coup de tête au ballon aux joueurs de 10 à 13 ans.*

**Objectif/question :** *Déterminer le changement de proportion de jeunes joueurs de soccer américains de 10 à 13 ans arrivant en salle des urgences avec une commotion cérébrale liée à d'autres types de blessures subies avant et après l'interdiction.*

**Méthodologie :** *L'analyse s'est limitée aux jeunes joueurs de soccer âgés de 10 à 13 ans, s'étant présentés à une salle des urgences d'un hôpital participant au registre National Electronic Injury Surveillance System (NEISS), après avoir subi une blessure entre 2013 et 2014 et entre 2016 et 2017. Une régression logistique multivariée a servi à évaluer le rapport entre l'année de la blessure et le diagnostic de la commotion cérébrale et un autre diagnostic de blessure après correction pour tenir compte de l'âge, du sexe et de l'origine ethnique.*

**Résultats :** *Le rapport entre commotion cérébrale et*

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showed a significant increase in 2016-2017 when compared to 2013-2014 after adjustment (OR= 1.286, 95%CI = 1.090-1.517).

Conclusions: *These results suggest that banning heading may not reduce concussion within this population. However, significant confounders, including increased reporting, were not controlled for.*

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KEY WORDS: concussion, epidemiology, injury prevention, mild traumatic brain injury, public health

## Introduction

Soccer is the most popular and fastest growing sport with over 265 million active players worldwide, 27 million of which reside in North America.<sup>1</sup> Soccer, like other sports, carries inherent injury risks due to its competitive nature and unpredictability. Common injuries include sprains, strains, fractures, abrasions, contusions and concussions. However, unlike other sports, soccer involves the act of heading which poses its own unique risks to the player. Heading occurs when players intentionally use their head for the purpose of controlling or directing the ball and may place athletes in vulnerable positions for head injuries. It is estimated that heading is responsible for 31% to 37% of youth soccer-related concussions.<sup>2-4</sup> Although substantial, these numbers pale in comparison to the mechanism of player-to-player contact which is estimated as the cause of 51.3% of soccer-related concussions in girls and 68.8% in boys.<sup>5</sup> In addition to concussion, the role of heading in the accumulation of sub-concussive blows to an athlete is also of concern. These impacts are described as being similar to those giving rise to a concussion, but demonstrate insufficient impact forces or accelerations to produce symptoms associated with mild traumatic brain injury (mTBI). Despite lower impact and acceleratory forces from sub-concussive blows, repeated exposure can elicit changes to the gray and white matter of the brain as well as manifest in reduced neurocognitive scores on testing which is particularly concerning in youth athletes.<sup>6,7</sup>

*autres blessures a considérablement augmenté en 2016-2017 par rapport à ce qu'il était en 2013-2014 après correction (RR = 1,286, IC à 95 % = 1,090-1,517).*

Conclusions : *Ces résultats laissent supposer que l'interdiction de coups de tête au ballon peut ne pas réduire le nombre de commotions cérébrales dans cette population. Cependant, il y a eu d'importantes variables confondantes, comme l'augmentation du nombre de cas signalés, pour lesquelles aucun contrôle n'a été inclus.*

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MOTS CLÉS : commotion cérébrale, épidémiologie, prévention des blessures, traumatisme crânien léger, santé publique

Concussion and sub-concussive blows in adolescent athletes are of concern as the brain is still developing.<sup>8</sup> When the adolescent brain is exposed to these biomechanical forces, it may be more susceptible to hypoxia, ischemia and traumatic axonal injury than adult counterparts.<sup>7,9,10</sup> In August 2014, a class action-lawsuit was filed in the United States District Court of California accusing FIFA, U.S. Soccer and the American Youth Soccer Organization of negligence in dealing with head injuries. The U.S. Soccer Federation responded in 2015 by placing a ban on all headers for athletes aged 10 and under. In addition, athletes aged 11-13 were only allowed to perform headers in practice. The 2015 header ban was also accompanied by an initiative to improve concussion education and the implementation of a more uniform concussion management program for over 3 million participants registered with the U.S. Youth Soccer Association.

The National Electronic Injury Surveillance System (NEISS) collects data on consumer product-related injuries occurring in the United States and produces nationwide estimates.<sup>11</sup> The NEISS has been used previously in epidemiological studies to show injury rates in ice hockey and muay thai kick boxing.<sup>12-14</sup> The purpose of this study is to analyze differences in concussion injury odds in children aged 10-13 in the United States playing soccer before and after the 2015 ban on headers using the NEISS database.

## Methods

### NEISS Overview

The NEISS is an American Consumer Product Safety Commission (CPSC) Database. For more than 45 years the CPSC has operated this statistically valid injury surveillance and follow-back system for the primary purpose to collect data on US consumer product-related injuries. The database collects information from approximately 100 NEISS participating hospitals for every Emergency Department (ED) visit involving an injury associated with a consumer product. The NEISS is based on a nationally representative probability sample of hospitals in the US and its territories.<sup>11</sup> In the year 2000, the CPSC expanded the NEISS to collect data on all injuries. NEISS data for the last 20 years is available online.<sup>15</sup> At the time of patient presentation, ED representatives assign a CPSC code to each patient that mirrors the products used or activity engaged in at time of injury. At the end of each day, a NEISS hospital coordinator reviews these cases, extracts pertinent clinical data and transcribes it into coded form.<sup>15</sup> We used this product-specific code in order to gather injury data in youth soccer for the calendar years of “2013-2014” and “2016-2017”. These years were categorized as such, creating two separate year categories. The year 2015 was excluded in our analysis, as this was the year the U.S. Soccer Federation instituted the rule change banning headers.

### Participants

Due to the specific age groups targeted with this rule change, we chose to only include athletes who were aged 10-13. Diagnosis of injury was obtained from the NEISS database as “concussion” and “all other injuries”. All other injuries included any injury sustained by an athlete which was not a concussion. Within the database this would include strain/sprain, fractures, dislocations, contusion, laceration and avulsions. Those who were injured without an explicit diagnosis of concussion were considered to not have a concussion and were coded as such. Sex was categorized and extracted as “male” and “female”. Finally, patient ethnicity was coded “Not Specified”, “Caucasian”, “African American”, “Asian”, “American Indian” and “Native Hawaiian”. Injuries were all soccer specific and those that occurred from a different sport were not extracted from the NEISS.

Table 1.

*Participant characteristics with regards to sex, age and injury diagnosis collected from the NEISS.*

Year 2013-2014	Total n (%)	Concussion diagnosis n (%)	Any other injury diagnosis n (%)
Sex			
Male	2150 (100%)	150 (7%)	2000 (93%)
Female	1520 (100%)	129 (8.5%)	1391 (91.5%)
Age			
10	672 (100%)	42 (6.25%)	630 (93.75%)
11	841 (100%)	64 (7.61%)	777 (92.39%)
12	1026 (100%)	75 (7.31%)	951 (92.69%)
13	1131 (100%)	98 (8.66%)	1033 (91.34%)
Year 2016-2017	Total n (%)	Concussion diagnosis n (%)	Any other injury diagnosis n (%)
Sex			
Male	2426 (100%)	200 (8.24%)	2226 (91.76%)
Female	1400 (100%)	152 (10.86%)	1248 (89.14%)
Age			
10	722 (100%)	52 (7.2%)	670 (92.8%)
11	863 (100%)	79 (9.15%)	784 (90.85%)
12	1054 (100%)	111 (10.53%)	943 (89.47%)
13	1187 (100%)	110 (9.27%)	1077 (90.73%)

### Statistical analysis

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) and alpha level was set at 0.05. Univariate analysis was performed and reported as raw numbers and percentages. Chi square test was performed to analyze categorical data at a bivariate level. Finally, multivariable logistic regression was used to assess the odds of presenting to an ED for a concussion for the years “2013-2014” compared to “2016-2017” after adjusting for age, sex and ethnicity.

## Results

### Concussion before and after the 2015 ban

The total number of injuries reported to a NEISS hospital was 7496 cases over the span of the four years analyzed (2013-2014/2016-2017). 49% of injury cases were reported in the years 2013 and 2014, while 51% of all cases were reported in 2016-2017. With regards to concussion, 7.6% of all injury cases resulted in a concussion diagnosis in the two years preceding the ban versus 9.2% of all injuries resulting in a concussion diagnosis in the two years

Table 2. Frequencies, adjusted odds ratios and 95% confidence intervals of sex, age, ethnicity and year as associated with diagnosis of concussion in individuals aged 10-13 while playing soccer, based on the NEISS.

Covariates	n (%)	Adjusted OR (95% CI)	p-value
Sex	7496 (100%)		
Male	4576 (61%)	Ref.	
Female	2920 (39%)	1.242 (1.053-1.497)	<b>0.011</b>
Age			
10	1394 (18.6%)	Ref.	
11	1704 (22.7%)	1.286 (.980-1.686)	0.069
12	2080 (27.8%)	1.364 (1.053-1.767)	<b>0.019</b>
13	2316 (30.9%)	1.376 (1.067-1.774)	<b>0.014</b>
Ethnicity			
Not Specified	3243 (42.3%)	Ref.	
White	3612 (48.2%)	1.387 (1.167-1.650)	<b>&lt;.001</b>
Black	499 (6.6%)	.802 (.542-1.187)	0.27
Asian	127 (1.7%)	.624 (.272-1.433)	0.266
American			
Indian	8 (0.11%)	0	0.999
Native Hawaiian	7 (0.10%)	0	0.999
Year			
2013-2014	3670 (49%)	Ref.	
2016-2017	3826 (51%)	1.286 (1.09-1.517)	<b>0.003</b>

following the ban on headers. Regardless of diagnosis, reporting to NEISS participating ED's following soccer-related injury increased by 2% between 2013-2014 and 2016-2017 (Table 1). Concussion in relation to all other injuries showed a statistically significant increase between the years 2016-2017 compared to 2013-2014 (OR= 1.286, 95%CI = 1.090-1.517) when controlling for age, sex and ethnicity (Table 2).

#### Concussion in relation to age

Overall, a general trend was noted with increased concussion in comparison to all other injuries as children got older. Concussion accounted for 6.25% of all injuries in the 10-year-old category in 2013-2014 and 7.20% of all injuries in the years 2016-2017. In 2013-2014, concussions resulted in approximately 8.66% of all injuries in the 13-year-old category, while in 2016-2017 concussion accounted for 9.27% of all injuries. Our bivariate analysis shows the highest percentage of concussions in the 12-year-old category. However, when controlling for

sex, ethnicity and year, concussions were more likely to occur in the 13-year-old category when compared to the 10-year-old age bracket. The increase with age was statistically significant in relation to 10-year-olds to 12-year-olds (OR=1.364, 95%CI = 1.053-1.767) and 13-year-olds (OR = 1.376, 95%CI = 1.067-1.774). A positive, but non-significant relationship was seen in the 11-year-old bracket (OR =1.286, 95%CI = .980-1.686) (Table 2).

#### Concussion in relation to sex

During both 2013-2014 and 2016-2017 males sustained more concussions (350) versus females (281). However, when looking at raw percentages, females were more likely to sustain a concussion injury. In 2013-2014, 7% of all injuries were a diagnosed concussion in males. This number rose to 8.24% in 2016-2017. Eight and half percent of all injuries were concussions in 2013-2014 for females. This number rose to 10.86% of all injuries being concussions for females in 2016-2017 (Table 1). Concussion in relation to all other injuries increased after the ban in both sexes, but more so for females aged 10-13 presenting to a NEISS participating ED's. This relationship was found to be statistically significant, as females were more likely to have a concussion in relation to all other injuries when compared to males (OR = 1.242, 95%CI = 1.052-1.467) after adjustment (Table 2).

#### Discussion

This is the first study, to our knowledge, evaluating the 2015 US Soccer Federation ban on headers and its association with concussion in relation to any other injury for adolescents aged 10-13. Between 2013-2014 and 2016-2017 there was a statistically significant increase in the odds of concussion in relation to all other injuries amongst US adolescent soccer players aged 10 to 13 presenting to NEISS participating ED's. This relationship was maintained when controlling for covariates such as age, sex and ethnicity. It is estimated that between 1.1 and 1.9 million sport and recreation-related concussions occur annually in children ≤18 years in the US.<sup>16</sup> Of these, between 115,479 and 166,929 cases present to an ED.<sup>16</sup> Overall, trends of concussion reporting to ED's are increasing over time. A recent review of paediatric concussion in physicians' offices and ED's showed a 4.4-fold (95% CI = 4.37-4.45) increase in concussion rate per 100,000 from 2003 to 2013.<sup>17</sup> It has also been shown that following edu-

cational interventions, rates of concussion reporting are likely to increase. A seven year trend analysis in Ontario schools showed an increase in concussion reporting and identification following an educational intervention in children aged 4 to 18 years.<sup>18</sup> As such, it can be theorized that educational and policy changes in conjunction with the 2015 header ban may have influenced the reporting rates of concussion-like symptoms in athletes to parents, coaches and trainers. The authors believe this finding of increased concussions in the years following the ban on headers is likely to reflect an increased overall trend in reporting of concussions, increased education and higher overall awareness of concussion following litigation and increased media reporting. Alternatively, player-to-player contact remains the most common mechanism of injury for concussion in adolescent soccer.<sup>5</sup> Our findings may also be interpreted with the suggestion that banning heading may not necessarily significantly reduce contact in soccer. However, this relationship was beyond the scope of this study.

Our analysis shows sex to be significantly related with the diagnosis of concussion. Although males have more concussions overall due to the higher enrollment in youth soccer, when controlling for all other factors, females are shown to have higher odds of concussion. This is consistent with findings in other published epidemiological studies.<sup>19-21</sup> Biomechanical issues such as increased ligament laxity leading to higher whiplash forces, reduced deep neck flexor strength, and smaller head/neck mass ratio are theorized to make females more likely to sustain a concussion when compared to males.<sup>22-25</sup> Therefore, the findings in our study are consistent with the trend of published work in this area.

The findings also suggest that an increase in age is accompanied by a rise in concussions. This is congruent with research identifying that the period in which the adolescent growth spurt occurs (10 to 14 years) increases the risk of sport-related injury. It has been shown that changes in limb length, mass, body composition are major contributing factors to injury.<sup>26,27</sup> These changes in anthropometrics during the adolescent years result in a strength-flexibility asymmetry contributing to the lack of muscular control at a variety of body segments including the head and neck regions.<sup>28</sup> This imbalance between strength and mass at the head and neck segment specifically, might lead to higher cranial velocities during soccer,

contributing to concussion risk. It is also plausible that increased body size and limb length changes encourage more combativeness in the sporting realm.

### *Limitations*

The limitations to this study include selection bias due to the nature of the NEISS database. The NEISS database accounts for 100 hospitals and only captures a small amount of ED data in the United States. In addition, those patients who present to hospital ED's likely represent the worst cases of injury that occurred during soccer and smaller injuries are less likely to be recorded. Patients with soccer-related injuries may have decided to visit a private medical or rehabilitation clinic and thus would not have been captured. Athletes have also been shown to consistently under-report concussion symptoms in order to return to sport.<sup>29</sup> Those who did under-report their symptoms may not be included in our sample or may have been diagnosed with a different injury due to the clinical nature of the concussion diagnosis.<sup>30</sup> When extracting data from the NEISS for the specific covariate of ethnicity, a large portion of data was coded as "not specified". This presents as a limitation of our study and may change the nature of our findings if accounted for. The 2015 header ban applied to U.S. Soccer Federation activities only and did not relate to recreational games of soccer. Therefore, it is a possibility that some reported injuries may have occurred in individuals playing in recreational settings, where heading may have occurred. Finally, a rise in concussion awareness may lead to an increase in reporting and subsequent follow-up with ED's. This presents as a significant confounder. A variety of other confounders such as skill level of play, past history of concussion, medical insurance coverage, etc., were not controlled for in the analysis.

### *Conclusions*

This paper found a significant increase in proportion of concussions in relation to any other injury after the 2015 U.S. Soccer Federation header ban (2016-2017) when compared to before the ban (2013-2014) after adjustment when analyzing injury data from the NEISS database. Although this study suggests that banning heading in soccer may not reduce concussion in adolescents aged 10-13 presenting to NEISS participating hospitals, we suspect our findings were influenced by increased reporting

due to improved concussion education and management policy implemented by the U.S. Soccer Federation. This study provides an objective analysis of the 2015 ban on headers and may be used to inform other policy and rule changes in adolescent soccer.

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