



Dangers beyond drowning: craniomaxillofacial trauma in adult water activities

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Abstract

Purpose Water recreation is one of the most popular activities for both fitness and leisure. The dangers of water activities have mostly been examined in the context of drowning and general bodily injuries. Despite the existing research, little is known about adult maxillofacial injuries in these settings.

Methods We accessed the National Electronic Injury Surveillance System in order to identify adult patients presenting to emergency departments with traumatic maxillofacial injuries secondary to a water-based sport or activity over the most recent 10-year period (2009–2018). Data collected included demographical information, anatomical location, mechanism of injury, and visit circumstances, as well as visit disposition.

Results A total of 1350 total patients were identified as appropriate for study inclusion. Young, Caucasian male adults were the most common age group to present with maxillofacial injuries secondary to water sport activities. Surfing and water skiing were associated with lacerations, while diving board incidents posed a higher fracture risk. Patients participating in all water activities were more likely to be treated and released rather than admitted.

Conclusion There appears to be a distinct pattern profile for individuals who sustain maxillofacial trauma while participating in water sports: young, Caucasian males in particular. Additionally, specific activities may be associated with varying injury types. The results of this study may increase interest in legislature and patient counseling when seeking such activities.

Keywords Water sport activities · Water recreation · Maxillofacial trauma · Craniofacial · Craniomaxillofacial

Introduction

Water recreation is one of the most popular activities for both fitness and leisure [1]. Every year, about 45 million people in the USA participated in water-based sports or activities. Between 13.4 and 14.5% of Americans have participated in water sports or activities each year between the years 2013 and 2018 [2]. When stratified based on age, 7.3% of the “Baby Boomer” generation (born between 1945 and 1964), 11.3% of the “Gen X” generation (born between 1965 and 1979), and 15.4% of the “Millennial” generation (born between 1980 and 1999) participate in water sports or activities [3]. Of the adult American population that does not currently participate in physical activity, those in the 25 to 34 and 35 to 44 age groups listed “stand-up paddling” and “swimming for fitness” as the top two activities they were most interested in engaging in [3]. As such, this interest and participation in water-based sports and activities is likely to persist.

A few of the more popular water-based sports and activities include those related to a pool setting and diving board, water

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skiing, water tubing, surfing, and scuba diving. Injuries are common among participants in these sports and activities. Despite the existing research, little is known about adult maxillofacial injuries in these settings. In the pool setting, orofacial injuries occur frequently, particularly when involving waterslides [4]. Additionally, more eye injuries occur from water and pool activities than any other sport or activity. Eye injuries from water activities include, but are not limited to, corneal abrasions, fractures of the eye socket, and traumatic cataracts [5]. Injuries from water skiing have been documented, with strains and sprains being the leading diagnoses [6]. Small contusions, lacerations, fractures, and spinal cord damage have also been reported from water skiing [7]. Similar to water skiing, sprains and strains account for the largest portion of injuries related to water tubing [8]. Fractures, splenic contusions, atlantoaxial subluxations, and penetrating head injuries have also been reported from water tubing [9, 10]. Injuries related to surfing have been widely documented with the most common being lacerations and soft tissue injuries [11]. Numerous contusions, sprains, and fractures have also been reported [12, 13]. The head, face, and spine are the most commonly reported areas of injury in surfing [14]. In scuba diving, few studies have looked at trauma-related injuries, but lacerations, fractures, non-fracture musculoskeletal injuries, electrocutions, and traumatic eye injuries have been reported [15–17].

Several studies have investigated the injuries associated with water-based sports and activities. However, the majority of these studies have either been single-sport or activity specifically focusing on the pediatric population [18, 19], or chronic, wear-and-tear injuries [20–25] rather than acute traumatic events. Additionally, these studies have mainly detailed orthopedic and spinal injuries. There has not been a comprehensive study analyzing maxillofacial traumatic injuries resulting from water-based sports or activities in the adult population. The educational objective of this study is to detail the maxillofacial traumatic injuries resulting from water-based sports or activities presenting to emergency departments (ED) across the USA. Specifically, the injury type and disposition, anatomical location of the injury, and patient demographics were analyzed.

Methods

The National Electronic Injury Surveillance System (NEISS) is a public database maintained by The United States Consumer Product Safety Commission that collects patient information from approximately 100 emergency departments (ED) across the USA. Patient and injury data is publicly available, including demographical information (age, sex, and ethnicity), presentation details, such as etiology, injury type, and injury location, and as well as patient disposition following

ED presentation. A short narrative describing details surrounding the antecedent event is generally included.

The NEISS was accessed in November 2019 in order to identify adult patients (> 18 years of age) presenting to the ED with traumatic maxillofacial injuries secondary to a water-based sport or activity over the most recent 10-year period (2009–2018). These included activities related to a pool setting, diving board, water skiing, water tubing, surfing, and scuba diving. Patients were also categorized by age in years (y) broken down by young adults (19–35), middle-aged adults (13–64), and elderly (> 65). Patient ethnicity and sex were also noted. Hospital disposition was collected, including treatment and release, hospital admission, transferral, and patients who signed out against medical advice (AMA). The diagnosis was collected and divided into fractures, lacerations, contusions/abrasions, and dental injuries. Finally, anatomical location of injury was noted, including scalp, orbital, oral, auricular, and facial (excluding orbit, oral, and auricular). Patients of pediatric age (below 19 years of age) were excluded. Additionally, patients who suffered from internal organ injuries, such as concussions, were excluded from analysis. Finally, patients suffering non-traumatic injuries, such as chemical- and sunburns, were also excluded.

Descriptive statistics were used to organize and present data. Categorical variables

were analyzed and compared using chi-squared testing within multi-matrix sets. A p value of $p \leq 0.05$ was established as statistically significant, with an applied Bonferroni correction utilized wherever applicable to standardize significance levels. Statistical calculations and analyses were performed using IBM SPSS® Version 25 (Armonk, NY) software.

Results

A total of 1350 total patients over a 10-year period (2009–2018) were identified as appropriate for study inclusion. Young adults were the most common age group to present with injuries (55.6%), while elderly patients were the least common (7.2%). Males composed the majority of patients who underwent maxillofacial trauma due to water activities (67.3%). Caucasians were the most frequently presenting race (56.4%), with African-Americans being the second most common (32.4%). Hispanic patients (4.6%) and patients identifying as other races were the least common (6.6%) (Table 1).

Water activity was examined alongside injury type for correlations. Patients were significantly more likely to present with laceration injuries while surfing and water skiing (73.9% and 77.5% of injuries, respectively) compared with other injury types ($p < 0.001$). Diving board incidents, however, posed a significantly higher likelihood of fractures (19.2%) compared with other water activities, although lacerations also remained the most common injury type associated

Table 1 Patient demographics

Characteristic	Frequency (<i>n</i> = 1350) <i>n</i> (%)
Age	
19–34	750 (55.6)
35–64	503 (37.2)
> 64	97 (7.2)
Sex	
Male	909 (67.3)
Female	441 (32.7)
Race	
Caucasian	762 (56.4)
African-American	437 (32.4)
Hispanic	62 (4.6)
Other	89 (6.6)

with diving board usage (55.1%). In contrast, scuba diving injuries were most likely to be contusions and abrasions (55.6%), although this was not statistically significant (Table 2).

Water activity was also examined alongside disposition following ED presentation. Patients in all activities were more likely to be treated and released rather than being admitted or transferred; especially surfing injuries (99%, $p < 0.001$). Interestingly, patients who were scuba diving had a higher rate of signing out AMA (11.1%) than patients of other water activities, but this was not statistically significant (Table 3).

Maxillofacial location was correlated with injury type in order to assess at-risk anatomical locations. The scalp, oral region, and facial region of the face—excluding the orbital, oral, and auricular regions—were all significantly more likely to suffer from laceration injuries than other types of injuries ($p < 0.001$, for all, respectively). The facial area also suffered a significantly higher rate of fractures compared with other anatomical areas (16.1%). Patients were also found to have significantly more dental injuries in the oral region (18.4%, $p < 0.001$). Finally, both the orbital (96%) and auricular

regions (52.5%) had significantly greater rates of contusions and abrasions compared with other injury types ($p < 0.001$, for both) (Table 4).

Water activity with age was correlated for maxillofacial trauma. Young adults were significantly more likely to present with water skiing-, diving board-, pool-, and water tubing-related injuries compared with other age groups ($p < 0.001$, for all). In contrast, middle-aged adults were the most commonly injured group from scuba diving, although this was not statistically significant. Elderly patients were the least affected age group for all maxillofacial trauma related to all water activities, although their rate of pool injuries (10.8% of all pool injuries) was significantly higher when compared with their rate of injury in other activities ($p < 0.001$) (Table 5).

Discussion

With water-based sports and activities being very popular for fitness and recreation amongst Americans of all ages, there is a need for healthcare providers to have a broad understanding of the associated injuries. These injuries have been documented in several studies; however, they have mainly focused on the pediatric population, orthopedic and spinal injuries, and chronic, progressive injuries. The information on maxillofacial injuries related to water-based sports and activities in the adult population has been limited.

Overall, young (19–34 years of age) Caucasian males sustained the most injuries. Other studies have similarly found that males more commonly suffer water-based sport and activity injuries [4, 7, 19]. Young adults have also been shown to be more susceptible to water-based sport or activity injuries versus middle-aged and older adults [7]. To our knowledge, there have been no other studies to comment on the race of patients sustaining water-based sport or activity injuries, but it may be that Caucasian males are more likely to participate in water sports in the USA than any other combination of ethnicity and gender. Furthermore, the young adult demographic is consistent with reported figures of sport participation based

Table 2 Water activity and injury type

Activity	Injury			
	Dental	Contusion/abrasion	Laceration	Fracture
Surfing	0% (0.01)*	14.9% (<0.001)	73.9% (<0.001)	11.2% (0.24)
Water skiing	0% (0.19)	11.8% (<0.001)	77.5% (<0.001)	10.8% (0.66)
Scuba diving	11.1% (0.02)*	55.6% (0.09)	22.2% (0.03)*	11.1% (0.87)
Diving board	2.6% (0.46)	23.1% (0.17)	55.1% (0.48)	19.2% (<0.001)
Pool	1.9% (0.25)	38.1% (<0.001)	52% (<0.001)	8% (0.02)*
Water tubing	5.9% (0.01)*	37.3% (0.25)	51% (0.24)	5.8% (0.36)

All values reported as frequency (%), *p* value

*Although $p < 0.05$, an applied Bonferroni correction led to a non-significant value

Table 3 Water activity and disposition

Activity	Disposition			
	Treated and Release	Admitted	Transferred	Signed out AMA
Surfing	99% (< 0.001)	0.3% (0.71)	0.7% (0.01)*	0% (0.02)*
Water skiing	96% (0.79)	1% (0.4)	1.2% (0.62)	1.8% (0.79)
Scuba diving	88.9% (0.33)	0% (0.84)	0% (0.61)	11.1% (0.01)*
Diving board	91% (0.05)*	1.3% (0.25)	3.9% (0.54)	3.8% (0.03)*
Pool	94.6% (0.05)*	0.4% (0.65)	3.8% (0.01)*	1.2% (0.97)
Water tubing	96.1% (0.82)	0% (0.62)	0% (0.22)	3.9% (0.08)

All values reported as frequency (%), *p* value

AMA against medical advice

*Although *p* < 0.05, an applied Bonferroni correction led to a non-significant value

on age group, as younger persons appear the most commonly active within water recreational activities overall [3].

Lacerations were the most common type of injury resulting from water-based sports and activities overall. This was consistent with a study reporting pediatric injuries from water sports [18]. Similarly, lacerations were the most common injury in surfing-, water skiing-, water tubing-, diving board-, and pool-related activities. This was consistent with other documented surfing injuries [11, 12] and water skiing injuries [7]. Previous studies examining water tubing found fractures, sprains, and strains to be the most common type of injury sustained [8, 9], though this was not localized to the maxillofacial region. In regard to scuba diving, the data in this study showed the most common injury type to be contusions and abrasions. A previous study showed lacerations were the most common scuba diving-related injury, although, again this was not specific to the maxillofacial region [16]. These differences highlight the importance of investigating injury localization as it relates to various specialists, as anatomical location may predispose varying impacts of injury and thus injury types.

When water activity was analyzed alongside disposition following ED presentation, patients in all activities were more likely to be treated and released directly from the ED rather than being admitted or transferred. Interestingly, one study documented that 30% of all surfing-related injuries required

surgery and the average hospital length for a patient admitted for a surfing injury was 5.8 days [14], perhaps suggesting that maxillofacial surfing injuries are less severe than other body regions. Patients presenting to the ED with scuba diving injuries had the highest rate of signing out AMA. This may be a limitation of sample size, or suggest higher precautions amongst healthcare providers given the acuity and awareness of decompression illness.[16]

Maxillofacial location was correlated with injury type in order to assess at-risk anatomical locations. The facial region, scalp, and oral region most commonly suffered lacerations. The orbital/eye region and auricular region most commonly suffered contusions/abrasions. The head and face have been cited as the most commonly injured region from water tubing [8] and surfing [12, 14]. When analyzing orofacial injuries suffered during pool-related activities, lip and tooth injuries were most common [4], likely in part due to concrete surroundings predisposing these injuries.

In terms of age group, young adults were the most commonly injured overall. Young adults were significantly more likely to sustain injuries from activities involving water skiing, a diving board, pool, and water tubing. Middle-aged adults most commonly sustained injuries from scuba diving, perhaps related to these age groups' greater rates of participation in scuba diving. In the

Table 4 Anatomical location and injury type

Anatomical location	Injury type			
	Dental	Contusion/abrasion	Laceration	Fracture
Facial	0% (< 0.001)	20.7% (< 0.001)	63.2% (< 0.001)	16.1% (< 0.001)
Scalp	0% (0.01)*	31.3% (0.54)	65.1% (0.01)*	3.6% (< 0.001)
Orbital/eye	0% (0.14)	96% (< 0.001)	3.2% (< 0.001)	0.8% (< 0.001)
Oral	18.4% (< 0.001)	4.4% (< 0.001)	77.2% (< 0.001)	0% (< 0.001)
Auricular	0% (0.42)	52.5% (< 0.001)	47.5% (0.14)	0% (0.04)*

All values reported as frequency (%), *p* value

*Although *p* < 0.05, an applied Bonferroni correction led to a non-significant value

Table 5 Activity and age

Activity	Age (y)		
	19–34	35–64	> 64
Surfing	52.6% (0.23)	44.5% (<0.001)	2.9% (<0.001)
Water skiing	77.5% (<0.001)	21.6% (<0.001)	0.9% (0.01)*
Scuba diving	33.3% (0.18)	66.7% (0.07)	0% (0.4)
Diving board	71.8% (<0.001)	26.9% (0.05)*	1.3% (0.04)*
Pool	50.9% (<0.001)	38.3% (0.31)	10.8% (<0.001)
Water tubing	82.4% (<0.001)	17.6% (<0.001)	0% (0.04)*

All values reported as frequency (%), *p* value

y years

*Although $p < 0.05$, an applied Bonferroni correction led to a non-significant value

elderly population, pool injuries were significantly higher than the other water sports and activities, but were still the least common group for all maxillofacial injuries. This may be due to a propensity for falls in conjunction with a hazardous area and potentially a propensity to participate in pool activities over other water-based activities.

Heightened awareness of the types of maxillofacial injuries in the healthcare community can allow for increased efficiency and improved outcomes in regard to diagnosing, treating, and educating patients on the injuries related to water-based sports and activities. Additionally, legislative action may be undertaken to regulate participation in ways that mitigate risk, such as requiring more extensive training on proper utilization of various modalities used for water sports, thus preventing common errors. Young adult males who actively participate in water sports and activities should be educated on the related injuries, as they are the most affected group. Similarly, it may be that elderly adults should be supervised around pool-based activities given their rates of injury. Further potential measures include certifications required by surfers and water skiers on how to manage large lacerations in a boat or on the beach while waiting for emergency medical services to arrive.

Our study is met with several limitations. The NEISS collects data from ED visits, meaning injuries managed in the outpatient setting or at home are not captured. We also used disposition to help categorize severity, but it is unknown which centers are captured within the NEISS database and how many are equipped to handle burns, which can create flaws in using transfers as a prognosis indicator. Furthermore, data is collected and filed in a heterogeneous manner, creating potential documentation inconsistencies. Despite these, the NEISS provides a nationwide sample size with strong variety and large volumes, allowing for studies with significant power.

Conclusion

There appears to be a distinct pattern profile for individuals who sustain maxillofacial trauma while participating in water sports. In particular, young males should be educated on the potential injuries that they can incur while participating in these leisure activities. Additionally, specific activities may be associated with varying injury types. The results of this study may increase interest in legislature and patient counseling when seeking such activities.

Compliance with ethical standards

Conflict of interest There authors declare that they have no conflict of interest.

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