

Sailing Injuries: A Review of the Literature

ANDREW NATHANSON, MD, FACEP, FAWM

ABSTRACT

Sailors are at risk for acute injuries, overuse injuries, environmental injuries, and sailing-related illnesses. Sailing-related injury rates vary from 0.29 to 5.7 per 1,000 hours which is lower than many other land-based sports. However, the fatality rate of 1.19 per million sailing-days is relatively high. The most common injuries are contusions and lacerations predominantly to the upper and lower extremities. Falls and impacts from various parts of the sailboat are the most common mechanisms of traumatic injury. High winds, operator inexperience, and operator inattention are the most common contributing factors for injury. Among Olympic-class sailors, overuse injuries to the back (29–45%) and knees (13–22%) are commonly reported. As many as seventy-three percent of sailing-related deaths are due to drowning as a result of falls overboard (39–44%) or capsizing the vessel (20–40%). Eighty-two percent of sailing-related drowning victims in US waters were not wearing a lifejacket. Leading contributing factors to fatal sailing accidents are high winds (12–27%), alcohol use (10–15%), and operator inexperience (8%).

KEYWORDS: sailing, injury, illness, fatalities

INTRODUCTION

By far the largest wilderness areas on earth are oceans and lakes which cover over 71% of the planet's surface. For over 5,000 years, humans have used sailing craft as an efficient means of traversing these waterways in order to fish, transport goods, and explore distant lands. Although the invention of steam engines in the late 18th century gradually made commercial sailing obsolete, sailing soon transitioned into a recreational pastime, first in Europe, then in the United States. Sailboat racing was first formalized in 1851, when the schooner *America* defeated 14 British entries in a race around the Isle of Wight in what has since become the America's Cup, considered the oldest international sporting event in the world.¹

Present-day sailing encompasses a broad spectrum of activities from day-sailing on a lake, to around-the-world racing.

Sailboats range in size and complexity from single-handed 2.4 m Optimist training dinghies, to 30 m "maxi" racing boats sailed by a crew of 22, and capable of speeds in excess of 30 mph. In 2011 the US Coast Guard (USCG) estimated that 3.7% of all US households owned a sailboat, and that there were 154 million sailing person-hours in US waters.²

The physical demands of sailing vary greatly depending on the type of vessel, the windspeed, whether cruising or racing, as well as the crew member's position on the boat. In dinghies, the sailor spends significant energy levering his or her body "hiking" over the side of the boat to keep it from capsizing. In keelboats the most demanding activity is turning winches to pull in lines under tension.

Sailors are at risk of injury and illness from a variety of causes. Environmental risks include solar exposure, hypothermia, immersion injuries, and motion sickness. Acute injuries are often caused by falls, direct impact from various parts of the boat, and from lines under tension. Finally, overuse injuries can be sustained by repetitive activities such as "grinding" winches, steering the vessel, and hiking.

Medical care for injury or illness aboard a sailboat presents some unique "wilderness" challenges, particularly when far offshore. Definitive medical care may be days away, supplies are limited, space below-deck is often cramped and poorly lit, and the motion of the vessel can be violent and unpredictable. Evacuation at sea is often dangerous and not always an option. Compounding these challenges is the fact that injuries are most likely to occur during stormy weather when crew members are fully engaged in sailing the boat and may be fatigued or seasick.

Injury rates, mechanisms of injury and types of injury have been found to vary significantly according to the type of sailboat and type of sailing. For ease of study, the medical literature and the US Coast Guard generally categorize sailboats into two groups; vessels greater than 6m in length equipped with a weighted keel for stability and usually motorized, known as keelboats, and smaller, non-motorized dinghies and catamarans which are dependent on crew weight for stability and are easily overturned. Most studies focus on a particular class of sailboat or regatta, so findings may not be generalizable, and comparisons of injury-rates between studies is difficult due to differing definitions of injury and methodologies.

METHODS

A search was preformed using PubMed with the terms ‘sail’, ‘sailing’, ‘yacht’, ‘yachting’, and ‘injury’, ‘injuries’, or ‘medical’. Studies were limited to the English language literature between 1990 and 2018. A total of 27 articles were retrieved, from which 14 were selected. Public access USGC Data-bases were also reviewed.

SAILING INJURIES

Injury Rates, Types of Injury and Mechanisms of Injury

Dinghies

In a study of the 2016 Olympic summer games (raced in 10 classes of smaller boats), 21 out of 360 sailors (5.5%) suffered an injury; only two of those injuries resulted in time-loss from sports participation.³ This compares favorably to an average injury rate of 9.5% for all Olympic athletes, ranking sailing 26th out of 40 sports regarding risk of injury. Injury rates at an international 2014 Olympic-class regatta, and among elite dinghy sailors in New Zealand, and novice dinghy sailors in Germany have been reported as 0.59 per 1,000 hours, 0.2 injuries per year and 0.29 per 1,000 hours, respectively.^{4,5,6} (See **Table 1**.) The newer, faster, and less stable Olympic-class boats, the 49er and Nacra 17, have higher rates of acute injuries than the other classes.⁴

The most frequent (but least severe) acute injuries aboard dinghies sailed by elite as well as novice sailors are contusions (9–55%) which are often caused by falls and contact with various parts of the boat (**Figure 1**) during rapid turning maneuvers in confined quarters.^{4,6} Hand injuries (6–31%) including lacerations, fractures, finger dislocations and rope burns from handling lines, the tiller or the center-board are also common.^{4,6} Head injuries, which appear to be more common among intermediate (11%)⁷ than more advanced (3%)⁴ sailors, are often caused by impact from the low-hanging boom and are among the most severe. Boom-related trauma can cause scalp or facial lacerations, contusions, fractures, and concussions.⁶ Capsizing (13– 52%)^{6,8} and collisions with other boats or objects (3–23%)^{7,8} are other common mechanisms of injury.

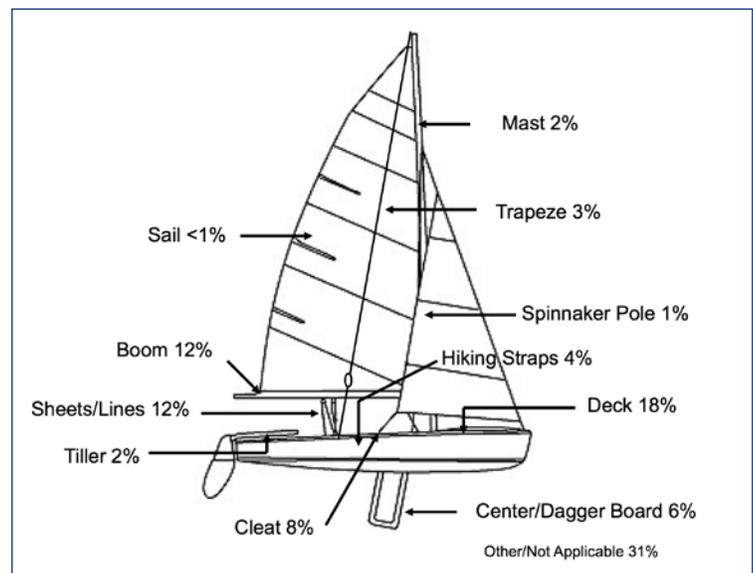
Overuse injuries, particularly among elite competitive racers, are very common and, in some studies, outnumber acute injuries.⁴ Hiking in a straight leg position places high static and dynamic loads on the extensor mechanism of the leg, particular the knees, as well as the back. Low back pain (29–45%) and knee pain (13–22%) are consistently the most common chronic conditions reported by dinghy racers.^{4,5}

Table 1. Summary of Dinghy Sailing Injury Studies

Study	Soligard ³	Schaefer ⁶	Tan ⁴	Nathanson ⁷
Population (Study Design)	2016 Olympic Games (Prospective)	Novice sailors (Survey)	Elite Dinghy Racing (Survey)	Dinghies mixed population (Internet Survey)
Average Age (SD)			24 (6)	40 (13)
Male Gender	57%		57%	83%
# Injuries	21	238	341	397
Injury Rate	5.5% of sailors/ Olympics	0.29/1,000 hours	0.59/1,000 hours#	4.6/1,000 days
Type of injury				
Laceration/Abrasion	29%	33%	5%	31%
Fracture	5%	1%	8%	2%
Sprain/Strain	29%	1%	45%	16%
Contusion	14%	55%	9%	41%
Dislocation			4%	2%
Concussion		4%	1%	2%
Burns		4%		
Other	9%	2%	8%	
Chronic/overuse	14%		19%	
Body Part Injured				
Head/Neck	0	32%	6%	12%
Back/trunk	33%	2%	33%	5%
Upper extremity	24%	39%	28%	39%
Lower extremity	38%	27%	34%	44%
Other/unknown	5%			

Injury rate for sailing and land-based training

Figure 1. Part of dinghy associated with injury, n = 397



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Keelboats

A study of the 2003 America's Cup reported an injury rate of 2.2 per 1,000 hours of sailing, while the injury rate for land-based conditioning was 8.6 per 1,000 hours. Bowmen and grinders had the highest rates of injury while sailing, and helmsmen the lowest.⁹ A study of an amateur around-the-world race, and an Internet-based survey of intermediate/advanced sailors found injury rates of 9 and 4.6 per 1,000 sailing *days*, respectively.^{10,7} (See **Table 2.**) By comparison, in studies using similar definitions of injury, recreational alpine skiing was found to have an injury rate of 4 per 1,000 hours, and men's collegiate soccer 17 per 1,000 hours.^{11,12}

As with dinghy sailing, contusions are common among keel-boat sailors (12–40%), as are lacerations (5–26%).^{9,7} Many of these injuries are the results of falls (30%) which can be attributed to walking on a wet, lurching, and steeply angled deck, often cluttered with lines, winches, and hatches.⁷ Impact from rigging, flogging sails and other crewmembers is another cause of injury. (**Figure 2**) In a study of a mixed population of keelboat sailors, leg contusions (11%) and hand lacerations (8%) were most common.⁷ In the 635-nautical mile Newport to Bermuda race, 47% of injuries were found to be to the hand/fingers, mostly from operating winches and handling lines under high tension.¹³ Probably due to the heavier forces involved, fractures have been found to be more common on keelboats (5.7%) as compared to dinghies (2.4%).⁷ Burns from hot liquids, foods and the engine have also been widely reported in off-shore sailing.^{10,13} During the 2001–02 Volvo around-the-world race, one-third of injuries occurred below-decks likely due to the forceful and erratic movements of those yachts in heavy weather.¹⁴

In offshore racing, helmsmen/women can develop carpal tunnel syndrome from gripping the wheel for prolonged periods of time. Chronic/overuse injuries to the shoulder, elbow, and back are common among grinders in both near and offshore sailing.¹⁴

Risk Factors for Injury and Severe/Fatal injuries

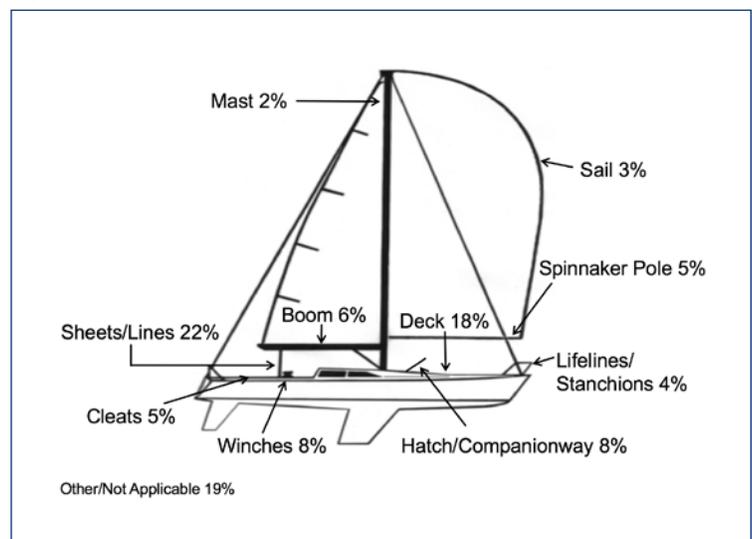
Studies of recreational and competitive dinghy and keelboat sailing have consistently identified high winds as a leading contributing factor for injury.^{4,6,7,13} Not only do stronger winds place exponentially higher loads on rigging, and increase risk of capsize, they can also create large and hazardous seas. Turning maneuvers (i.e. tacks, jibes) have also been identified as contributing factors for injury in sailing craft of all sizes, likely because the boom crosses the boat overhead, and sails and lines must be released on one side of the boat and pulled in on the other.^{6,7}

Table 2. Summary of Keelboat Sailing Injury Studies

Study	Neville ⁹	Nathanson ⁷	Price ¹⁰
Population (Study Design)	America's cup keelboats (Prospective)	Keelboats (Internet Survey)	Amateur Around-the-world race (Prospective)
Average Age (SD)	33 (5)	40 (13)	21-60 (range)
Male Gender	100%	83%	78%
# Injuries	220	1,226	299
Injury Rate	5.7/1,000 hours#	4.6/1,000 days	9/1,000 days at sea
Type of injury			
Laceration/Abrasion	5%	26%	12%
Fracture	2%	6%	12%
Sprain/Strain	68% ^	17%	10%
Contusion	12%	40%	36%
Dislocation		2%	1%
Concussion		3%	7% *
Burns		2%	16%
Other	13%	5%	6%
Chronic/overuse			
Body Part Injured			
Head/Neck	14%	11%	12%
Back/trunk	20%	11%	21%
Upper extremity	40%	40%	22%
Lower extremity	25%	38%	17%
Other/unknown			27%

Injury rate includes land-based training, ^ Including chronic/overuse injuries, * "Head injuries No LOC"

Figure 2. Part of keelboat associated with injury, n = 1,226



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While the majority of sailing injuries in most studies are of relatively minor, severe injuries do occur and sailing-related fatalities are more common than in most land-based sports. In a study of 841 sailing injuries reported to the USCG requiring more than first aid, operator inattention (22%) and inexperience (11%) were identified as the leading preventable factors.⁸

An analysis of 70 severe injuries requiring evacuation or hospitalization, found that high winds were a contributing factor in 35% of cases, and that 25% of these injuries were fractures, 16% soft tissue injuries, and 14% concussions.⁷ Injury patterns for severe injuries included: planned and accidental jibes where the sailor was struck by the boom, or mainsheet; collisions with other boats; dismastings; and falls through open hatches or companionways.

A study of annual USCG Boating Accident Reports from 2000–11 found that there were 271 sailing-related fatalities in US waters during the time period, as compared to 197 football-related deaths.^{8,15} Drowning was found to be the most common cause of death (73%) followed by trauma (10%), and hypothermia (4%). Falls overboard (41%), capsizing (29%), sinking (7%), and collisions (5%) were leading accident mechanisms.⁸ Among those who drown, 82% were not wearing a lifejacket. Using exposure data from the 2011 USCG National Recreational Boating Survey (a large-scale, population-based, weighted survey), a fatality rate of 1.19 deaths per million sailing person-days was calculated, which is similar to a calculated rate of 1.06 deaths per million skiing/snowboarding-days.^{2,8}

The leading operator-preventable contributing factors for fatal sailing accidents were alcohol use (keelboats 15%, dinghies 10%), operator inexperience (8%), and improper look-out/inattention (keelboats 10%, dinghies 5%). The leading non-preventable contributing factors were high winds (keelboats 12%, dinghies 27%), hazardous waters (keelboats 9%, dinghies 10%), and equipment failure (keelboats 4%, dinghies 6%).⁸

SAILING-RELATED ILLNESSES/ ENVIRONMENTAL INJURIES

Although any illness which occurs on land may also occur at sea, prolonged exposure to the elements, confined living quarters, poor hygiene, and the motion of the vessel predispose sailors to a number of disorders. Seasickness is the most common illness directly attributable to sailing (8%–15% of all illnesses) and is directly correlated to stormy conditions.^{10,13} Though almost never fatal, it is often incapacitating which can result in safety concerns among short-handed crews in heavy weather. Seasickness usually resolves after 3 days of a constant sea-state and its symptoms can be moderated or prevented by the use of medications which are most effective when taken before embarkation or at the very first onset of symptoms. Scopolamine, the most effective medication,

has strong anticholinergic side effects and can cause urinary retention, psychosis, blurred vision, and dry mouth.

Among 360 novice, round-the-world sailors, dermatologic conditions accounted for 21% of medical cases. Sunburn, boils to the buttocks (from sitting on deck), cellulitis, and tinea infections featured prominently.¹⁰ Upper respiratory infections were reported to cause 18% of illnesses, and gastroenteritis, including a cluster of cases on one boat, caused 15% of illnesses.

CONCLUSIONS

Although the majority of sailing injuries are minor and injury rates are low, the risk of death, predominantly from drowning, is higher than that of many land-based competitive sports. While many sailing-related injuries are soft tissue injuries that require nothing more than first aid, some are more severe. Among this latter group, some injuries could be prevented by more ergonomic sailboat design, use of gloves, and use of helmets.

Fatal sailing accidents often occur when sailors unexpectedly find themselves in the water after falling overboard or capsizing. Falls overboard on keelboats can largely be prevented by wearing tethers which should be worn on-deck in stormy conditions, or whenever sailing at night. Dinghy sailors should be cautious when sailing in high winds, and wear insulating clothing in cold water with the expectation that they will capsize. Lifejackets should be worn when sailing, as there is compelling evidence that lifejackets save lives. A before-and-after study in Australia showed a significant decrease (U-26; $p = .04$) in boating-related drownings once lifejackets were mandated by law.¹⁶ Alcohol use, though likely underreported in many studies, has been found to be a contributing factor to drowning, sailing injuries, and sailing fatalities. Though current RI laws prohibit a boat operator to be intoxicated, the law should be broadened to include passengers, as they are just as likely to fall overboard and drown as is the skipper.¹⁷

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Author

Andrew Nathanson, MD, FACEP, FAWM, Clinical Professor of Emergency Medicine, Department of Emergency Medicine, Alpert Medical School of Brown University.

Correspondence

Andrew Nathanson, MD
Rhode Island Hospital
593 Eddy St., Claverick 2
Providence, RI 02903
401-523-2613
ANathanson@lifespan.org