ORIGINAL RESEARCH

Sailing Injury and Illness: Results of an Online Survey

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Objective.—The purpose of this study was to describe the relative frequency, patterns, and mechanisms of sailing-related injuries in dinghies and keelboats. Data were also collected on risky and risk-averse behaviors of sailors, as well as on sailing-related illnesses.

Methods.—A web-based, logic-driven, multiple-choice survey was developed and links were posted on sailing-related websites. Data were collected from March through November 2006 on any injuries or illnesses sailors sustained over the prior 12 months.

Results.—From 1188 respondents, a total of 1715 injuries and 559 illnesses was reported. The top 3 injuries for keel boats were leg contusions (11%), hand lacerations (8%), and arm contusions (6%), and in dinghies they were leg contusions (13%), knee contusions (6%), and leg lacerations (6%). The most common mechanisms of injury were “trip/fall,” “hit by object,” and “caught in lines.” Tacking, heavy weather, and jibing were the most common factors contributing to injury. The rates of injury and severe injury in this internet-based survey were 4.6 and 0.57 per 1000 days of sailing, respectively. Of the 70 severe injuries, 25% were fractures, 16% were torn tendons or cartilage, 14% were concussions, and 8% were dislocations. The median rate of lifejacket use was 30%, and median rate of sunscreen use was 80%. Sixteen percent of sailors reported sunburn over the prior 12 months. Seven percent of sailors reported use of alcohol within the 2 hours preceding injury.

Conclusions.—The most common injuries in both keel boats and dinghies are soft-tissue injuries to the extremities. Severe injuries and illnesses in sailing are uncommon in this study population.

Key words: sailing, injury, illness, injury prevention

Though sailing is an ancient means of transportation and has been a recreational and competitive endeavor for hundreds of years, relatively little is known about the injuries associated with this sport. Most studies regarding the nature and cause of sailing injuries have been limited by small data-sets, and are restricted to a specific geographic location, regatta, or class of sailboat.^{1–3} Much of the sailing-related sports medicine literature concentrates on the physiologic demands of the sport.^{4–6} A better understanding of the most common types of sailing-related injuries and the mechanisms by which they occur can facilitate the development of evidence-based injury prevention strategies. Injury prevention aboard a vessel is particularly important due to the fact that definitive

medical care is often hours or days away, and medical supplies are limited.

The sport of sailing encompasses a wide spectrum of activities from recreational day sailing on a lake, to around-the-world ocean racing. Sailboats range in size and complexity from the single-handed 2.4-m, 35-kg Optimist dinghy to 24-m, 25 000-kg America’s Cup boats with a crew of 16. Depending on the type of craft, the crew position, and the environmental conditions encountered, the physical demands required of the sailor can vary widely. A useful distinction endorsed by the literature is to divide sailing craft into 2 major categories: dinghies, which are small boats with crews of 1 or 2 that are dependent on crew weight for ballast; and keelboats, which are larger, generally sailed with crews of 3 or more, and depend on a weighted keel for stability.⁷ In dinghies, the sailor expends a significant amount of energy leveraging his or her body over the side of the boat (“hiking”) to keep it from capsizing, whereas on keel boats the most physically demanding activity is turning

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("grinding") winches, which are used to gain a mechanical advantage over lines under high tension.^{8,9} Sailors are at risk of acute injuries from direct impact, which can result in lacerations, contusions, and fractures, as well as chronic injuries from repetitive activities such as hiking, grinding winches, and steering.¹⁰ Injuries may result from actions that are sudden and sporadic and are often performed in awkward positions due to unpredictable movements of the vessel and poor ergonomics.⁷

The aim of this surveillance study was to gather a large database of sailing-related injuries and illnesses with a focus on the patterns of injury and mechanisms by which they occur. We were also interested in learning more about the most severe injuries and how they arise. Another aspect of this study was to examine risky and risk-averse behaviors of sailors. In particular we wanted to learn more about use of lifejackets, sunscreen, and alcohol among this study population. We hope that identifying the causes of the most common and most serious injuries will lead to further understanding of the scope and nature of sailing injuries and allow further development of safety recommendations.

Methods

This was an observational retrospective survey of self-reported sailing-related injuries and illness. An internet-based, multiple-choice logic-driven survey was developed with DatStat software (Illume v2.2). A prototype of the on-line survey was piloted to 30 volunteers with sailing experience, and comments were solicited. A final version of the survey instrument was derived and links to this survey were posted on the English language sailing-related websites: sailinganarchy.com, ussailing.org, and sailingscuttlebutt.com. Data were collected from March 2006 to November 2006.

The survey, which can be viewed at <http://www.rhodeislandhospital.org/rih/services/ipc/Research/past/sailing.htm>, was divided into a demographics section (8 questions), an injury description section (15 questions), and an illness description section (3 questions). Respondents were asked about any sailing-related injuries or illnesses that they had sustained during the preceding 12 months, and branch-points directed only those with injuries and/or illnesses to the appropriate sections of the survey. A repeat sequence of questions for the sailing injuries section was generated for those subjects who had more than 1 injury to report. In order to simplify data analysis, and limit the length of the survey, a maximum of 2 injuries and 2 illnesses could be reported by a single respondent.

In the demographics section data were collected regarding the subject's age, gender, level of experience,

"home port," approximate number of days spent sailing in the prior 12 months, and percentage of time using sunscreen and wearing a lifejacket when sailing. The injury section included questions pertaining to injury type, anatomic location, type of sailboat, location on-board when the injury occurred, and whether the respondent was racing, in sight of land, or had consumed alcohol in the 2 hours preceding injury. More than 1 answer could be selected for body part injured. Respondents were asked 5 questions pertaining to how, where, and why each injury took place. One question asked for the mechanism of injury, another for factors contributing to the injury, the third what part of the boat contributed to the injury, the fourth asked what activity the sailor was doing, and the last where on the boat the injury occurred. More than 1 answer could be selected as factors contributing to injury. Injury severity was classified by the non-exclusive categories "No treatment," "First-aid on boat," "Sought medical care after injury," "Evacuated from boat," and "Hospitalized for injury." A similar scale was used for sailing-related illness. Illnesses or injuries requiring evacuation or hospitalization were categorized as "severe." The question "type of sailboat" included the categories keelboat, dinghy, catamaran, and windsurfer. Because of the small percentage of sailors reporting injuries on catamarans (4%) and windsurfers (<1%), many of the injury analyses in this study were limited to "keelboat" or "dinghy" categories, and for these, catamaran and windsurfing injuries were excluded.

In the illness section there were questions pertaining to type and severity of illness. Free text boxes at the end of the injury and the illness section of the survey allowed respondents to elaborate on the specifics of an injury or illness. Many multiple-choice check-box questions had the option of marking "other" as an answer, and respondents could free-text a response to that specific question in an adjacent free-text box. Each section required that all questions be answered before a respondent could proceed to the next section. Only free-text fields, and the question regarding alcohol consumption, could be left unanswered before proceeding.

All of the questions in which "other" was a possible response were independently reviewed by 2 study investigators. For example, for the question "What part of your body was injured?" 1 of the 18 choices was "hand." Some respondents selected "other" and wrote in the adjacent free-text box: finger, or thumb, or fingers. If both investigators independently reclassified "finger" as a "hand" injury, then that response was re-coded as a hand injury for ease of analysis. If the investigators did not agree, then the response was left as "other." A total of 68 responses were re-categorized in this manner.

Table 1. Skill level and safety behaviors of respondents, N = 1860

Variable	Percent
Self-rated ability	
Beginner	2.3%
Intermediate/Experienced	73.9%
Professional/Pro Equivalent	23.8%
Life jacket use	Median 30%
0–25% of time	48%
26%–50% of time	16%
51%–75% of time	6%
76%–100% of time	30%
Sunscreen use	Median 80%
0–25% of time	19%
26%–50% of time	14%
51%–75% of time	14%
76%–100% of time	53%
Alcohol within 2 hours of injury ^a	7%

^a n = 1715.

The survey was limited to those 18 years or older, and data from those reporting their age to be less than 18 were deleted. Data were collected on DatStat survey software, Illume v. 3.1 (Seattle, WA), and analyzed on S.A.S. v. 9.1 (Cary, NC). The Pearson chi-square test was used to investigate associations between study factors.

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Results

SURVEY RESPONSE

A total of 1881 respondents completed the demographic section; 21 surveys were excluded because the respondents were <18 years of age. At least 1 sailing injury in the prior 12 months was reported by 1468 (79%) respondents. Of those with an injury, 1353 (92%) went on to

provided complete data on 1 injury, and 362 provided complete data about a second injury, giving us data on a total of 1715 injuries. Data were also collected on 559 sailing-related illnesses.

DEMOGRAPHICS AND SAFETY BEHAVIORS

The average age of the study population was 40.1 (SD 13.2; range 18–80) years, and most were North American (97%) males (83%). A large majority of respondents (74%) rated themselves as “intermediate/experienced amateur,” and on average, respondents sailed an estimated 65 days (SD 50) over the previous 12 months. The median rate of lifejacket use was 30%, and the median rate of sunscreen use was 80%. Sailors under the age of 30 reported significantly less frequent sunscreen use than those over 30 (χ^2 (1) = 42.29; P < .0001), with 45% of those young sailors using sunscreen less than half the time they sailed. However, sailors under the age of 30 reported more than median use of lifejackets than those over 30 (χ^2 (1) = 9.72; P < .01) (Table 1). Seven percent of respondents admitted to the consumption of alcohol within the 2 hours preceding injury.

INJURIES

Of the 1715 reported injuries, 1226 (71%) occurred in keel boats, 397 (23%) in dinghies, 65 (4%) in catamarans, 4 (<1%) in windsurfers, and 23 (1%) of respondents selected “not applicable” for boat type. The majority of the injuries in this study population took place while racing (79%) and in sight of land (94%).

Type and anatomic location of injuries on dinghies and keel boats

Patterns of injury reported in keel boats and dinghies were quite similar (Tables 2 and 3). The most common types of injuries on both keel boats and dinghies were contusions, lacerations, and sprains. The most commonly injured regions of the body on keelboats were upper extremity (40%), lower extremity (38%), and trunk

Table 2. Type and location of sailing injuries for keelboats, n = 1226

Injury location	Contusion	Laceration	Sprain/strain	Fracture	Concussion	Dislocation	Other ^a	Total
Head/neck	3%	2.6%	0.6%	0.6%	2.5%	0.1%	1.3%	10.7%
Trunk	5%	0.6%	2.9%	1.6%	0.0%	0.0%	0.8%	10.9%
Upper extremity	13.7%	12.7%	7.3%	1.8%	0.0%	1.0%	3.5%	40.0%
Lower extremity	18.4%	10.3%	5.9%	1.7%	0.0%	0.5%	1.6%	38.4%
Total	40%	26.2%	16.7%	5.7%	2.5%	1.6%	7.2%	100.0%

^a Other = thermal burn, rope burn, blisters, tendon rupture.

Table 3. Type and location of sailing injuries for dinghies, n = 397

<i>Injury location</i>	<i>Contusion</i>	<i>Laceration</i>	<i>Sprain/strain</i>	<i>Fracture</i>	<i>Concussion</i>	<i>Dislocation</i>	<i>Other^a</i>	<i>Total</i>
Head/neck	3.9%	4.9%	0.4%	0.3%	2.3%	0%	0.3%	12.1%
Trunk	1.6%	0.4%	3%	0.3%	0%	0%	0.1%	5.4%
Upper extremity	13%	13.6%	6.4%	1%	0%	1.8%	2.6%	38.4%
Lower extremity	22.5%	12.2%	6.1%	0.8%	0%	0.3%	2.2%	44.1%
Total	41%	31.1%	15.9%	2.4%	2.3%	2.1%	5.2%	100%

^a Other = rope burn, blisters, tendon rupture.

(11%). The corresponding statistics for dinghies were lower extremity (44%), upper extremity (38%), and head/neck (12%). Examining the data in more detail, the top 3 injuries for keel boats were leg contusions (11%), hand lacerations (8%) and arm contusions (6%), and in dinghies they were leg contusions (13%), knee contusions (6%) and leg lacerations (6%). Head, face, and eye injuries constituted 11% of dinghy injuries and 9% of keelboat injuries, and the vast majority of those were from being hit by the boom or spinnaker pole often while tacking or jibing in heavy weather.

Head lacerations were relatively more frequent on dinghies (4.8%) than on keelboats (2.5%), and fractures were relatively more frequent among keelboat sailors (5.7%) than dinghy sailors (2.4%). The mechanisms and patterns of head injuries and hand injuries reported on both keel boats and dinghies are described in Table 4.

Table 4. Common patterns of hand and head injuries for all types of sailboats combined

	<i>Hand injuries, n = 398</i>	<i>Head injuries, n = 190</i>
Type of injury	Laceration = 54% Contusion = 18% Sprain/strain = 10% Other = 10%	Contusion = 34% Laceration = 29% Concussion = 24% Fracture = 4%
Mechanism	Other = 38% Caught in lines = 28% Trip/fall = 19% Hit by object = 17%	Hit by object = 65% Trip/fall = 19% Other = 10% Caught in lines = 3%
Part of boat	Rope/line = 28% Deck = 16% Winch = 7% Cleat = 5%	Boom = 46% Spinnaker pole = 12% Other = 12% Hatch = 8%
Contributing factors	Heavy weather = 23% Tack = 16% Sail change = 13% Jibe = 12%	Jibe = 26% Heavy weather = 17% Tack = 14% Sail change = 12%

Mechanisms of injury and contributing factors for dinghies and keelboats

Figures 1 and 2 illustrate which parts of the boat contributed to keelboat and dinghy injuries.

The most common mechanisms of injury were “trip/fall,” “hit by object,” and “caught in lines” (Table 5). The “objects” most frequently cited as resulting in injury were the boom, spinnaker pole, sail clew (bottom rear corner), and collisions with fellow crew members. Tacking or jibing maneuvers played a role in 36% of injuries on dinghies, and 30% of injuries on keelboats. “Heavy weather” was often cited as a contributing factor to injury, as were fatigue and equipment failure. Failed equipment most often cited as causing injury included blocks, cleats, winches, and standing rigging.

When queried as to what activity they were engaged in immediately preceding injury the most common responses were “crossing from one side of the boat to the other” during a tack, “changing sails,” operating a winch, and steering (Table 5).

Most injuries on keel boats (63%) and dinghies (46%) occurred in the cockpit. The next most common location onboard for injuries to arise was on the foredeck for keelboats (25%) and midship for dinghies (11%).

Figure 1. Part of keelboat associated with injury, n = 1226.

Figure 2. Part of dinghy associated with injury, n = 397.

Severity of injury and injury rate

A large proportion of the injuries reported (47%) were minor in nature and “required no treatment,” and 4% were classified as severe injuries because they required “evacuation” from the vessel and/or “hospitalization.” Twenty-six percent of respondents received “first-aid onboard,” and 33% “sought medical care after injury.” These groups were not mutually exclusive.

Of the 4% (70) of injuries classified as severe, 25% were fractures, 16% were torn tendons or cartilage, 14% were concussions, and 8% were dislocations. The majority of severe injuries were to the head (24%), knee (15%), leg (10%), and arm (9%). Among these severe injuries several injury patterns could be identified: planned and unplanned jibes in high winds where the sailor was struck by the boom, mainsheet, or spinnaker pole; collisions with other boats; catastrophic rig failure; and falls through open hatches or companionways resulting in extremity fractures and head lacerations. Knee cartilage injury attributed to prolonged hiking in dinghies and small keelboats often required surgical repair. Three eye injuries resulted in permanent loss of vision: 1 from being struck by the boom; another from a hydraulic ram handle; and the last from a spinnaker pole during a jibe.

In 36% of these severe injuries “heavy weather” was considered a contributing factor. Crew inexperience and lack of communication among crew mates were also often cited as contributing factors.

The overall rate of injuries requiring medical care among this population of sailors responding to a web-based survey was 4.6 per 1000 days of sailing, while the rate of severe injury was 0.56 per 1000 days.

SAILING-RELATED ILLNESSES

There were 559 sailing-related illnesses described by respondents as having occurred in the previous 12 months. Over half (53%) were sunburn, many of which were reported to have arisen on cloudy days, or because

Table 5. Mechanism, activity, contributing factors, and on-board location for injuries on keelboats (n = 1226) and dinghies (n = 397)

Factor	Factor level	Keelboat	Dinghy
Mechanism of injury	Trip/fall	30%	19%
	Caught in lines	22%	12%
	Hit by object	21%	21%
	Winch	8%	0%
	Fall overboard	2%	4%
	Not applicable	7%	6%
	Other ^a	10%	38%
Activity	Sail change	18%	3%
	Crossing centerline during tack	17%	14%
	Tailing	10%	<1%
	Grinding	9%	0%
	Walking	8%	1%
	Steering	8%	20%
	Hiking	5%	21%
	Climbing mast	1%	<1%
	Trapeze	0%	8%
	Not applicable	5%	5%
	Other ^b	18%	24%
Contributing factors	Heavy weather	23%	19%
	Tack	17%	19%
	Sail change	12%	2%
	Planned jibe	8%	10%
	Unplanned jibe	5%	7%
	Fatigue	5%	7%
	Capsize	<1%	13%
	Broach	4%	3%
	Equipment failure	4%	2%
	Docking	2%	1%
	Grounding	1%	<1%
	Collision	1%	1%
	Not applicable	2%	2%
	Other ^c	14%	12%
Location on board	Cockpit	46%	63%
	Foredeck	25%	5%
	Amidships	22%	11%
	Below deck	3%	1%
	Off boat	1%	4%
	Not applicable	1%	10%
	Other	2%	6%

^a Overuse, repetitive motion, capsize.

^b Boat maintenance, rigging boat, launching, righting boat.

^c Crew error, slippery deck.

sunscreen had not been applied. Not surprisingly, sea sickness (31%) was the next largest category, followed by dehydration (7%), and hypothermia (2%). There were only 4 medical illnesses classified as severe: 2 cases of hypothermia among dinghy sailors who capsized in cold water; and 2 cases of sea sickness that resulted in dehydration.

Discussion

This study is 1 order of magnitude larger than prior studies of sailing injuries, and attempted to look at the specific causes of injury, and patterns of injury in more detail. We used a web-based format to rapidly disseminate our survey tool to a widely scattered population of sailors, and collect responses in a digital format, at a reasonable cost. This method of data collection has been validated in the medical literature, with results that are very similar to those found on traditional paper-based surveys.^{11,12}

IMPORTANT FINDINGS

We found an injury rate of 4.6 per 1000 days of sailing. A study of America's Cup racing¹ found an injury rate of 2.2 injuries per 1000 *hours* of sailing, and another study found the rate among novice dinghy sailors 0.29 injuries per 1000 *hours* of sailing¹³; however, direct comparison to injury rates in other studies is difficult as definitions of injury, study populations, and data collection methods vary between studies. We found the most common injuries in keel boats were leg contusions, hand lacerations, and arm contusions, and that in dinghies they were leg contusion, knee contusions, and leg lacerations. Head contusions, lacerations, and concussions comprised roughly 10% of injuries on both dinghies and keelboats and the majority of these were caused by impact from the boom and spinnaker pole. While other studies have found that contusions and lacerations are the most common types of injuries,^{13,14} prior studies have not linked the type of injury to anatomic location for all injuries.

Most injuries were caused by falls, being struck with an object, and from overuse, with heavy weather, as well as tacking and jibing maneuvers often cited as contributing factors. Other investigators have also found a relationship between heavy weather and incidence of injury,^{2,13,15} and have described overuse injuries from hiking,^{16,17} but have not shown the association between part of boat and injury with as much detail.

SAFETY RECOMMENDATIONS

Falls could likely be reduced by improved footwear, better antiskid deck surfaces, less cluttered, more ergo-

nomic deck layouts, and adherence to the sailing maxim "one hand for the boat, and one hand for yourself." Protective head gear, padded spars, and higher boom clearance have the potential to reduce impact injuries, especially severe head and facial injuries. Overuse knee injuries among dinghy sailors from prolonged hiking were found to be fairly common, and it has been suggested that some of these injuries could be prevented by strength training and improved technique.^{17,18} Any efforts on large keelboats aimed at improving teamwork and communication between crew members (especially between cockpit and foredeck) are likely to pay dividends in terms of reducing preventable injuries.

The average lifejacket use rate in our study was only 30%, in line with a 1999–2007 observational study sponsored by the US Coast Guard (USCG), which found lifejacket use rates on sailboats of approximately 25%. By comparison, the USCG study found wear rates among adults in canoes was 23%, in kayaks was 80%, and in powered inflatables was 15%.¹⁹ According to USCG statistics, two thirds of recreational boating deaths are caused by drowning, and 80% of sailors who drowned in US waters between 2003 and 2007 were not wearing a lifejacket.²⁰ Lifejacket use rates can be increased not only by education but also by improving the aesthetics and comfort of jackets, and by enforcing use at regattas and sailing schools.

We found that 16% of those surveyed reported having suffered from sunburn while sailing in the preceding 12 months, and that sunscreen utilization was low, particularly in sailors less than 30 years old. Participants in water sports have been shown to be at increased risk for developing skin cancer because of prolonged exposure to solar radiation,²¹ and sunburns are known to increase an individual's risk of melanoma, and basal cell carcinoma.²² Focused educational interventions aiming to reduce the incidence of skin cancer should be targeted towards sailors, particularly those in younger age groups.

Sea sickness is a common malady among sailors and is most common during heavy weather when the workload and risk for injury aboard a sailing vessel is highest. Those stricken by sea sickness are often despondent, weak, and may have impaired cognitive function, which can place a short-handed crew and sailing vessel in danger.²³

Seven percent of injured sailors reported the consumption of alcohol within 2 hours of injury. A USCG study found that alcohol was the leading contributing factor in 21% of all boating fatalities.²⁰ While the effects of alcohol are dose-dependent, even low levels of alcohol use while boating is a potential problem.²⁴

STUDY LIMITATIONS AND FUTURE DIRECTIONS

Respondents to the survey were generally experienced adult sailors (only 2% self-rated beginners), who spent a lot of time sailing (an average of 65 days per year), and thus are not representative of the sailing population as a whole. This is probably due to the fact that experienced and professional sailors are more likely to be browsing sailing-oriented websites where the survey was advertised than are beginners. There are a number of biases in this web-based survey including responder bias and recall bias. Reliance on self-described injuries by non-medical personnel may lead to erroneous reporting, and would not allow for inclusion of fatal injuries. Lastly, the survey allowed a maximum 2 injuries and 2 illnesses occurring within the prior 12 months to be reported.

Prospective studies of sailing-related injuries using data collected by medical personnel are needed to better establish the true incidence of specific injury diagnoses rather than relying only on self-report. Ideally these studies would be targeted towards well-defined cohorts of sailors such as Olympic-class racers, keelboat racers, recreational day sailors, and offshore sailors.

Conclusions

Leg contusions and hand lacerations were the most common injuries on keelboats, and leg contusions and knee contusions were the most common among dinghy sailors. Severe sailing injuries requiring evacuation or hospitalization are uncommon, with a rate of 0.56 per 1000 days of sailing in this web-based survey. Younger sailors use sunscreen less frequently than older sailors and 16% of respondents suffered from sunburn while sailing in the last 12 months. Average lifejacket use was only 30%.

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