

COLLECTIVE REVIEW

Injuries Associated With Whitewater Rafting and Kayaking

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Whitewater rafting and kayaking are growing exponentially in popularity, with almost 10 million rafters and 2 to 3 million kayakers, yet little has been published concerning the safety or hazards of these activities. This article reviews the demographics of such injuries and the types of injuries commonly encountered. Fortunately, fatalities are uncommon in these activities, with rafting and kayaking fatalities occurring at a rate of 0.55 and 2.9 per 100 000 user days, respectively. Injury rates for kayaking and rafting are 3 to 6 and 0.26 to 2.1 per 100 000 boating days, respectively. Acute injuries in kayaking are usually due to the transferred force of the water on the upper extremity, most often the shoulder, or the impact on an object while “swimming.” Acute rafting injuries are more often due to contact with another rafter’s paddle or other equipment; the next most common injury is the rafter hitting an object while “swimming.” Chronic injuries are very uncommon in rafting but account for 25% to 40% of all kayaking injuries and are most often either shoulder or wrist complaints.

Key words: injury, sports, wilderness, kayak, raft

Introduction

Whitewater kayaking, rafting, and canoeing are fast becoming some of the most popular new “adventure sports,” with images of kayaking and rafting used in advertising for everything from soft drinks to automobiles. As the popularity of whitewater boating continues to increase, physicians may expect to see more patients who are injured by this activity. Although, to my knowledge, no prospective studies of whitewater boaters have been performed to assess true injury rates, there have been a number of retrospective studies as well as case reports of fatalities that allow us to develop an understanding of some of the risks involved in whitewater boating.

Background and demographics

The difficulty of a whitewater rapid is graded on a scale from I to VI, with class I water being the easiest (essentially moving flatwater) and class VI the most difficult (which is rarely, if ever, run, and then only with a

high risk of death) (Table 1). There is a move afloat, however, to create an “open-ended” class IV (ie, class 5.x), as in rock climbing. As boat, especially kayak, construction has advanced, previously unrunnable rivers and rapids are increasingly challenged and successfully run. Additionally, kayak construction has evolved along with the new sport of “play” or “rodeo” boating, in which participants intentionally go into a hydraulic (hole) and perform both vertical and horizontal maneuvers. In 2002, the Teva Tour hosted 14 National Whitewater Rodeo Competitions, in addition to countless local competitions.

Rafting participants far outnumber kayakers, but this is largely because participants in commercial rafting trips go no more than once or twice a year, thus exposing more people to rafting. Recent estimates place the number of rafting participants at 9.8 million, with more than 3 million participants considered “enthusiasts” (ie, those who have rafted more than twice in the past year).¹ According to the Outdoor Industry Association, in 2000, there were 6.5 million kayakers, with the number of kayakers growing “explosively.” Of the 6.5 million kayakers, between 1.4 and 2.8 million are whitewater kayakers, with a growth of almost 15% annually.^{1,2} Kayakers are almost 70% male, whereas the male:female ratio of rafters is somewhat more reflective of the US

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Table 1. River difficulty rating

River class	Explanation
Class I	Easy—waves small; passages clear; no serious obstacles
Class II	Medium—rapids of moderate difficulty with passages clear
Class III	Difficult—rapids are longer and rougher than those of class II. Many larger, irregular waves with rock and other features that require maneuvering. Scouting recommended
Class IV	Very difficult—rapids are generally longer, steeper, and more heavily obstructed than class III rapids. Powerful and irregular waves, requiring precise maneuvering. Scouting required if the rapid is not known
Class V	Extremely difficult—long, difficult, and violent rapids; often multiple rapids with very little interruption. Extremely congested and obstructed river with large drops and steep or congested routes. Scouting mandatory but difficult. Risk of death is significant
Class VI	Extreme and expedition—often considered “unrunnable.” Extremely dangerous and difficult. For groups of extremely skilled boaters only. Once such a rapid has been repeatedly run, it is usually reclassified as a Class 5.x. Risk to swimmers and boaters is extremely high.

population at 55% male and 45% female. Participants in both sports are overwhelmingly white (90% or more). The demographics of injured kayakers and rafters reflect the population that participates in these sports.

Fatalities

Death is obviously the most feared consequence of a whitewater mishap. Fortunately, deaths are relatively rare in these sports. A report from *American Whitewater* in 2000 by Laura Wittmann,³ based on data from 30 managed rivers from 1994 to 1998, calculated the fatality rate of all whitewater participants (rafters, canoeists, and kayakers) at 0.87 per 100 000 user days. Data from West Virginia from 1984 to 1999 showed only 11 fatalities in approximately 2 million commercial rafters, for a fatality rate of 0.55 per 100 000 rafter days.⁴ Examining only whitewater kayakers and using a very conservative estimate of the total number of whitewater kayakers in 1998 (700 000), Wittmann³ calculated the fatality rate per 100 000 participants to be 2.9. The fa-

Table 2. Fatality rates

Activity	Fatality rate per million participant days	Reference
Kayaking	8.7–2.2	3
Rafting	4.5–8.7	3,4
Trekking	5–15	26
Skydiving	8.7	27
Scuba diving	3.1	28
Alpine skiing	0.57	28
Driving*	152	29

*Assumes 1 day of driving is 100 miles.

tality rates of other outdoor sports are listed in Table 2 for comparison.

Charlie Walbridge has examined whitewater fatalities as far back as the early 1970s and, along with J. Tinsley, has published 5 anthologies on the topic.^{5–9} His reports focus on individual events as a way of helping others avoid similar situations. He notes that the number of whitewater fatalities has increased in recent years, but this may merely reflect the growth that these sports are experiencing. He also documents and comments on the fact that there are 2 distinct types of whitewater fatalities. The first, which has been an issue for many years, is the inexperienced rafter, canoeist, and, less frequently, kayaker who gets caught in a situation above his or her capability. The second most common type of whitewater fatality involves highly accomplished boaters, usually kayakers, attempting extremely dangerous whitewater. Unfortunately, it appears that the latter type of fatality has been on the rise for the past few years.

Typical of this type of fatality, as detailed in the following discussion, is the case of Witt Mills, an accomplished kayaker from Oregon. While visiting family and friends in North Carolina, he joined a strong group of kayakers on the class V “Narrows” section of the Green River. According to a description published by Mr Walbridge in *American Whitewater*, Mr Mills missed a key left-to-right “boof” (flat jump off a small drop) and pinned his boat vertically. Despite courageous and well-coordinated rescue attempts, he was not rescued and, in fact, the would-be rescuers could not retrieve the body until after the dam-controlled release of water to the river was completed (see <http://www.americanwhitewater.org/safety/archive/id/669/>).

Drownings such as these are particularly troubling for several reasons. First, they almost always involve a young, healthy, active individual whose life is suddenly

cut short. The personal and family tragedy is obviously overwhelming. Second, as in the Mills case, there is often not an easily identifiable and correctable “error.” Rock and mountain climbers have long accepted the notion of “inherent risk” in their sports. Perhaps whitewater boaters also accept the inherent risk of their sport, but it is unclear whether this concept is accepted by the American population at large (as witnessed by wilderness and adventure activity liability lawsuits and attempts to limit access on the basis of risk).

Injuries

Whitewater injuries generally fall into 4 main categories on the basis of the etiology of injury: 1) trauma from striking an object—in the river or on another participant’s equipment; 2) traumatic stress from the interaction of the paddler’s positioning and equipment and the force of the water; 3) overuse injuries; and 4) submersion and environmental injuries.^{10–13}

The analysis and comparison of studies on whitewater injuries are somewhat limited by the different methodologies of the studies. Although all the studies located were retrospective, they varied on the definition of injuries, method of data collection, and type of boating involved.

Kayak injuries

INJURY RATES

As mentioned, because of the retrospective nature of the previously cited studies, it is not possible to calculate true injury rates. However, a general sense of injury frequencies can be obtained by looking at the studies by Fiore and Houston¹⁰ and Schoen and Stano.¹¹ For example, Schoen and Stano reported 4.5 injuries per 1000 kayaking days, with 1.9 injuries per 1000 days when medical intervention was sought. Fiore found there were between 3.6 and 5.9 injuries per 1000 kayaking days, with half of the injured kayakers seeking medical care (D.C.F., unpublished data, 2001). A New Zealand study of accidents in the adventure tourism industry had a much lower injury rate of 14 per “million participation hours.”¹⁴ If each kayaking day is assumed to be 8 hours, then the corresponding rate of injuries is only 0.1 per 1000 kayaking days. However, this study did not separate flatwater (lake and sea) kayaking from whitewater kayaking.

ACUTE INJURIES: MECHANISM AND TYPE

To my knowledge, 3 survey studies on whitewater kayaking injuries have been published, the first in 1987 and

the other 2 in 2001 and 2002. Blisters were the most common minor injury, reported by 30% of respondents in the 1987 study by Kizer¹² and reported by more than 90% in the 2002 study by Schoen and Stano.¹¹ Other than blisters, acute injuries were most commonly due to striking an object in the river or the force of the water on the kayaker’s equipment (as in an overextended paddle brace). All 3 studies found the upper extremity, especially the shoulder, to be the most commonly injured part of the body.^{10–12} Shoulder dislocations, occurring in 5% to 15% of injured kayakers, accounted for the vast majority of all dislocations and were the most significant injury to the upper extremity.^{10–12} Shoulder injuries are so common—and feared—among kayakers that the American Whitewater safety card (a plastic card meant to be carried in the boat) includes information on how to treat a shoulder dislocation while on the river. The primary cause for this injury in kayaking is improper technique. Paddlers often abduct and externally rotate at the shoulder while paddling downriver or while playing. Maneuvers that are particularly risky include high-bracing (preventing themselves from capsizing by sculling [pushing/sliding] their paddle on the water), “eskimo rolling,” and many rodeo moves. In an effort to prevent shoulder dislocations, most instructors emphasize the importance of limiting shoulder exposure by keeping the arms tucked in close to the body. To my knowledge, no studies have yet been performed to examine the effectiveness of these efforts.

The face, head, and neck region are the next most frequently injured areas of the body. Unfortunately, these studies did not separate injuries to the face vs the head or neck. Obviously, closed head injuries would be a major concern because of the likelihood of drowning. Because these studies used retrospective surveys, it is unlikely that any significant closed head injuries were sustained by responders. In the author’s experience, however, facial trauma is fairly common, and some kayakers have begun wearing face guards on their helmets.

CHRONIC KAYAK INJURIES

Chronic injuries, typically of the upper extremity, are fairly common in kayakers, accounting for 25% to 40% of all injuries.^{10,11} The overwhelming majority of these injuries are to the upper extremity, most often the shoulder or wrist. The shoulder is vulnerable to overuse injuries due to improper technique, especially while surfing or playing in hydraulics or “holes.” Kayakers may also develop a de Quervain tenosynovitis, related to the constant wrist flexion and extension as the paddler alternates the blade in the water.^{15,16} Newer paddles with reduced blade offset and bent-shaft paddles have been

developed to alleviate this strain, but no studies have been performed to document improvement. Another fairly common complaint among kayakers is low back strain.^{11,16} Schoen and Stano¹¹ noted that back injuries accounted for slightly less than 15% of injuries. They also noted that the new style of “play boating” may account for an increase in chronic back strain.

INJURY SEVERITY

Fortunately, very few kayaking-related injuries are severe. Fiore and Houston¹⁰ found that although 51% of the injured kayakers sought medical attention, less than 5% reported less than a good recovery. Schoen and Stano¹¹ had similar findings, with 47% of acutely injured kayakers and 36% of chronically injured kayakers seeking medical care. Chronic injuries were associated with the most prolonged symptoms in both of these studies.^{10,11} Obviously, because of the retrospective nature of these studies, serious injuries that led to the participant no longer kayaking were missed.

Rafting injuries

INJURY RATES

The best data on injury risks in whitewater rafting come from the West Virginia data compiled by Whisman and Hollenhorst¹⁷ and Whisman,¹⁸ in which they found injury rates of 0.26 to 0.44 per 1000 rafter days. Unfortunately, as Whisman mentions, “The accuracy of injury incidence rates in commercial rafting is questionable because of suspected over-reporting of minor injuries that may not meet the reporting criteria, and by verification complexities that preclude the determination of how many possibly reportable injuries go unreported.”¹⁸ The New Zealand adventure tourism study calculated an injury rate of 537 per million participant hours.¹⁴ If we again assume that an average day on a river is 8 hours, this translates into an injury rate slightly less than 1 per 1000 days, which is on par with the injury rate for white-water kayaking as noted above.

ACUTE INJURY: MECHANISM AND TYPE

Rafters share the same risk of submersion and “swimming” hazards as kayakers, but because of differences in equipment, rafters have unique injury risks. Whisman and Hollenhorst¹⁷ analyzed injury reports from commercial rafters on 4 West Virginia rivers from 1995 to 1997. They found that slightly more than half (51%) of the injuries occurred while the boater was in the raft, often the result of being struck by a paddle or other

rafting equipment. The second most common cause of injury was the rafter being thrown from the raft and striking an object while “swimming” in the river (40%); next most common were injuries onshore, accounting for 8% of all injuries. Similar injury profiles were reported by the Arkansas Headwaters Recreation Area in 1997.¹⁹ Compared to kayaking, many more raft injuries were to the face (33%) and to the knee (15%), with the shoulder trailing at only 6%.¹⁹ Lacerations are also more common among rafters, occurring in one third of injured rafters in the West Virginia rivers study.¹⁷

CHRONIC INJURIES

Chronic injuries appear to be much less common in rafters than in kayakers. Only 13% of rafting injuries have been found to be chronic, compared to 25% to 40% of kayaking injuries (D.C.F., unpublished data, 2001). The most obvious explanation for this is that there are many more occasional, commercial rafters than there are kayakers. Unfortunately, the only study addressing the injuries suffered by whitewater raft guides was a case report of an outbreak of staphylococcal skin infections.²⁰

INJURY SEVERITY

There are very few data available to determine the severity of rafting injuries. Of the injured rafters reported in the West Virginia study, 60% were able to continue their trip down the river on the raft.¹⁷

MISCELLANEOUS RISKS

Kayakers and rafters are at risk for infectious diseases such as giardiasis, reported in as many as 14% of participants.^{13,17} Other, less common illnesses may relate to the locale of the whitewater trip, with cases of schistosomiasis, leptospirosis, and hemlock poisoning having been reported on rafting trips.^{21–23} Other well-recognized risks run from the mundane but frequent sunburn to potentially fatal hypothermia due to cold water immersion.^{13,24}

Conclusion

Whitewater rafting and kayaking are exciting sports that are currently undergoing phenomenal growth. Although risk is inherent in all “adventure” sports, the fatality risk of whitewater boating (29 per million kayaking days, 5.5–8.7 per million rafting days) is on par with other “adventure” sports (Table 2).^{25–28} Deaths from these sports are always tragic and premature, and the death rate in kayaking may be climbing, especially at the “ex-

treme" edge of the sport. For comparison, however, in 2001, the highway fatality rate in the United States was 1.52 per million miles traveled.²⁹ If we very conservatively estimate that the average distance traveled to kayak or raft is 50 miles (100 miles round-trip), that would mean the average whitewater boater has a fatality risk of dying on the highway of 152 per million trips, significantly higher than the risk of dying on the river!

Because of different methods of tabulating injuries, comparisons of injury rates between sports are problematic. Injury rates in kayaking and rafting, in the range of 2 to 6 per 1000 activity days, are similar to those in mountain bike racing (4 per 1000 starts).

The injuries that do occur in rafting and kayaking appear to result from different mechanisms, with most raft injuries suffered by contact with equipment on the raft but most kayaking injuries suffered because of 1) contact with objects in the river, or 2) the stress of the river on the kayaker's equipment (and transmitted to his or her body). Likewise, we found different injury types in the 2 sports, with facial injuries, especially lacerations, much more prevalent in rafting and shoulder injuries more common in kayaking.

Efforts to reduce the number of injuries in whitewater rafting and kayaking will likely need to focus on different approaches. Because the overwhelming majority of rafter days are by commercial rafters and because many states and localities regulate commercial rafting, requiring outfitters to limit the number of rafters in each boat and requiring rafters to wear helmets, possibly with face masks, may be 2 feasible approaches.

Because kayaking, on the other hand, is a much more individualistic sport, it would be futile to attempt to legislate approaches to limit injuries. Rather, injury prevention in kayaking will probably have to focus more on equipment changes and education. Some potential equipment modifications that may reduce injuries include bent-shaft and reduced blade offset paddles and the use of face masks. Educational efforts will need to be tailored to the skill level of the boaters being targeted. For the large number of occasional boaters, education about river safety may be effective. The skilled "extreme" kayaker, however, is unlikely to need, or respond to, general river safety education. Educational efforts to limit injuries and death in these athletes will likely need to build on a better understanding of risk-taking behavior in elite athletes.

Future directions of study include assessments of initiatives to lower injury and fatality rates. These studies would most likely need to take a variety of formats involving disparate fields. For example, studies of equipment changes could incorporate bioengineering data as well as ongoing outcomes data, while efforts to educate

the public about risks would need to incorporate assistance from the public health and safety fields. Lastly, efforts to alter risk-taking behaviors would likely benefit from collaboration with colleagues in psychology.

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