

Articles

Acute Injuries From Mountain Biking

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We questioned members of 2 southern California off-road bicycling organizations about injuries associated with the use of all-terrain bicycles. Cyclists were asked about riding and safety habits, the kind(s) of injury sustained with their most recent accident and whether they sought medical treatment, and the circumstances of the accident. Of 459 mailed surveys, 268 (58.4%) were returned. Respondents (82.8% of whom were male) ranged in age from 14 to 68 years. Of these, 225 (84%) had been injured while riding all-terrain bicycles, 51% in the past year. Although most injuries were characterized as minor, 26% required professional medical care, and 4.4% of those injured were admitted to hospital. Extremity injuries—abrasions, lacerations, contusions—occurred in 201 (90%) cyclists with 27 (12%) sustaining a fracture or dislocation. High levels of helmet use (88%) may explain the low occurrence of head and neck trauma (12%). Frequent riding and riding on paved terrain were associated with increased severity of injury, although most accidents—197 (87.6%)—occurred off paved roads. These results suggest that, compared with regular bicyclists, all-terrain cyclists have more, but not necessarily more severe, injuries. Clinicians and emergency medical personnel should be aware that the increasing popularity of off-road cycling may change the frequency and nature of bicycling injuries.

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As recreational bicycling changes, we can expect to see a change in injuries to cyclists. According to industry statistics, the most widely sold bicycle is now the all-terrain bicycle (ATB) or "mountain bike," accounting for an estimated 67% of sales in 1990.¹ An ATB is a 10- to 21-speed bicycle with a heavy-duty frame, relatively upright riding geometry, special brakes and components, and "fat" tires designed to allow the rider to travel on various types of terrain, including dirt roads, gravel, and "single-track" paths. We describe the frequency, type, and severity of injuries sustained in mountain bike accidents and try to clarify the circumstances and risk factors leading to their occurrence.

Previous studies of bicycling injuries have focused on children,^{2,3} urban settings,^{4,5} head injuries,^{3,6-8} and helmet use.⁹⁻¹¹ Most have looked at injuries from the standpoint of riders who required medical attention,^{5,7,12,13} autopsies,^{6,14} or both, limiting discussion to only the most seriously injured and neglecting the rest of those who participate in the sport. We know of no reports that detail the injuries sustained in the comparatively new pastime of mountain biking. Thus we chose to investigate retrospectively mountain bicyclists who generally ride off road, concentrating on acute injuries whether or not they received medical treatment.

Methods

We mailed an anonymous two-page questionnaire to each of the 252 members of a Los Angeles bicycling club

and to the 207 members of a similar San Diego club. Both clubs specifically encourage off-road recreational cycling. As an incentive to respond, we included an offer to win, by lottery, one of four gift certificates from a bicycle shop. At one-month intervals for two months, we sent reminders to those who did not respond.

After requesting demographic information, the questionnaire contained multiple-choice questions about riders' experience, equipment use, and bicycle maintenance habits. Cyclists who had ever been injured were asked about their most recent injury. We defined an injury as "the presence of pain, discomfort, or disability," rated as mild if no treatment was needed or if it was self-treated, moderate if medical care was sought, and severe if admission to a hospital was required. We requested details of the accident leading to the injury, including the nature of the ride; the type and grade of the terrain, weather characteristics, whether a collision occurred; if equipment had failed; helmet use at the time of accident; alcohol or drug use; and contributing factors such as excessive speed, inattentiveness, unfamiliarity with terrain, and poor riding ability.

We used the computer programs EXCEL and STATVIEW to organize and tabulate the data. All riders who reported injuries were divided into two groups—those who sought professional medical attention (moderate and severe injuries) and those who did not (mild). We then compared the details of the accidents between these two groups to identify risk factors for serious injuries. The

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TABLE 1.—*Demographics and Mountain Bike Use Among 268 Off-road Riders, Southern California, 1990*

Demographics	Value
Age, yr (SD)	
Mean.....	36.2 (±9.4)
Median.....	36
Range.....	14 to 68
Sex, No. (%)	
Male.....	222 (82.8)
Female.....	46 (17.2)
Years riding, No. (SD)	
Mean.....	4.2 (±2.3)
Range.....	0.33 to 15
Frequency of riding/× wk, %	
<1.....	10.1
1-2.....	44.4
3-5.....	41.4
≥6.....	4.1
Total hr/wk (SD)	
Mean.....	6.6 (±3.9)
Range.....	0.5 to 28
Off-road hr/wk (SD)	
Mean.....	5.0 (±3.1)
Range.....	0 to 20

Student's *t* test was used and χ^2 analysis with Yates's correction applied where appropriate for 2 × 2 contingency tables.*

Results

Of the 459 surveys sent, 268 were returned, yielding a response rate of 58.4%—59.5% from Los Angeles, 57.0% from San Diego. Those who returned the questionnaire will be referred to as "riders." The demographic results are shown in Table 1. The age of the riders ranged from 14 to 68. Most riders were male (82.8%), which corresponds to the proportion of males and females in the study population (club members), estimated from the original mailing lists. The mean number of years' experi-

*Deborah Wingard, PhD, assisted with the development of the survey and with statistical analysis. David Asada collected data and helped organize it.

ence on a mountain bike was 4.2 (SD 2.3) with responses ranging from 4 months to 15 years. On average, riders indicated a mean of riding 6.6 hours total on their mountain bikes each week, and of this, 5 hours per week (76%) were spent riding off road. Thus, this group fulfilled the criteria of being predominantly off-road riders.

Injuries

Of the 268 riders, 225 (84%) reported sustaining at least one injury while all-terrain bicycling (Table 2). Of all riders, 137 (51.1%) were injured in the past year. We cannot estimate the actual incidence of injury because cyclists may have been involved in more than one accident in the preceding year. Almost 90% of the injured riders (*n* = 201) damaged extremities. In all, 37% (*n* = 84) sustained an injury or injuries to the trunk, and head and neck trauma occurred in 12% (*n* = 27) of victims. Most injuries were mild, requiring no treatment (21.8%), or were self-treated (48%). A quarter (26%) of the victims saw physicians either in an emergency department (14.6%) or in the office. Ten cyclists (4.4%) were admitted to hospital, generally for less than a week, but one was an inpatient for 30 days.

Circumstances of Accidents

Leading to Injury

Most injury-causing accidents occurred during the months of June and July and the fewest in the winter months. Injuries happened predominantly during the middle of the day (63.1%) in clear weather (89.3%) while the victim was riding primarily for recreation (86.7%). Injuries were more likely to occur off road (87.6%) than on paved terrain (Table 3), and most happened while descending a grade (74.2%). Most of the injured fell without a preceding collision. In 23 collisions leading to injury, 13 were with stationary objects. The other 10 collisions were with a moving object, either another bicycle or a motor vehicle. Of the five incidents involving a motor vehicle, four occurred on paved terrain, with all five sustaining injuries severe enough to cause the riders to miss school or work; all but one required professional medical attention.

TABLE 2.—*Characteristics of Injuries Among 225 Off-road Victims in Their Most Recent Mishap, Southern California, 1990*

Anatomic Location	Injury	Victims, No.*	Percentage of All Victims, <i>n</i> =225†
Extremities	Laceration, abrasion	167	74.2
	Contusion	76	33.8
	Sprain, strain	30	13.3
	Fracture, dislocation	27	12.0
Trunk.....	Laceration, abrasion	49	21.8
	Contusion	41	18.2
	Internal injury	13	5.8
Head, neck.....	Laceration, abrasion	25	11.1
	Contusion	8	3.6
	Fracture	1	0.4

*225 victims sustained 437 injuries.
†The sum of totals equals more than 100% because each victim may have had more than 1 injury for each anatomic location.

TABLE 3.—Characteristics of the Most Recent Ride in Which Injury Occurred Among 225 Off-road Victims, Southern California, 1990

Characteristic	Injury Victims, n=225	
	No.*	%
Type of terrain		
Paved.....	28	12.4
Dirt.....	96	42.7
Rocks.....	29	12.9
Sand.....	4	1.8
Combination of dirt, rocks, sand.....	60	26.7
Other.....	8	3.6
Grade		
Steep uphill.....	8	3.6
Moderate uphill.....	12	5.3
Flat.....	34	15.1
Moderate downhill.....	90	40.0
Steep downhill.....	77	34.2

*Totals do not equal 225 for all characteristics because not all responded.

Of those injured, 80 (36%) thought excessive speed contributed to their mishap; 78 (34.7%) attributed it to riding unfamiliar terrain. Other factors included inattentiveness (22.7%) and riding beyond their ability (19.6%). Six of the injured (2.6%) reported that they were using either alcohol or marijuana at the time of the accident. Many (20%) could not continue with their intended ride after the accident mainly because their injuries were too severe. Among those, 17 said they walked away from the injury site, but 10 of them needed to be carried from the scene, 1 by helicopter.

Safety Practices and Equipment Failure

Of the 268 riders, more than half (55%) provided maintenance for their bikes six times a year or more. Most (86%) wore helmets routinely; only 2.2% stated they never used a helmet. At the time of their accident 88% (n = 198) were wearing a helmet. Equipment failure caused 7% of the accidents. The most common items that failed were the brakes and tires. Other equipment lapses involved the front fork, handle bar, and headset.

Risk Factors for Severe Injuries

We compared those who sustained injury requiring professional medical attention with those who had had accidents but received only mild injuries. The two groups did not differ significantly in age, sex, and years of experience on an all-terrain bicycle. The more seriously injured group tended to ride more total hours each week (7.8 versus 6.3, $P < .01$) and more off-road hours each week (5.7 versus 4.8, $P < .05$). When the circumstances of their accident were compared, the group that required a physician's evaluation were more likely to have had their mishap while riding on paved terrain than off road ($P < .01$).

Discussion

Mountain biking resulted in injuries to 84% of the members of two southern California ATB cycling clubs who responded to our survey. Although most were minor extremity injuries requiring only self-care, a quarter required medical attention and 5% admission to hospital. Given the growing popularity of ATB ownership, which soared from 200,000 in 1983 to 11 million in 1989,¹⁵ it is apparent that accidents from mountain biking are common. By describing these injuries and the circumstances in which they occurred, we have tried to clarify risk factors and to aid in accident prevention and treatment.

Most ATB riders in this study injured themselves while cycling off road downhill. Important contributing factors included excessive speed, unfamiliar terrain, and inattentive riding. Equipment failure played a role, but less often than the 10% to 15% found among road riding accidents.^{16,17}

We are confident that the respondents are representative of the entire study group, first, because our response rate compares favorably with rates in other mailed surveys, and, second, because those who replied have demographic characteristics similar to those members who did not reply.

Nevertheless, we urge caution in interpreting the results for several reasons. Injured club members may be more motivated to respond, although as other retrospective studies have the same weakness, comparisons are valid. We obviously missed any deceased riders and possibly any who stopped mountain bike riding because of severe injuries. In both situations, the results may underestimate the true risk. Respondent recall could also lead to biased results, particularly when a subjective judgment is called for. This seems less of a problem for objective detail such as injury type, severity, anatomic location, and treatment method.

Other studies using similar methods have found that road conditions contribute to as much as 52% of bicycle accidents.¹⁶ Because most off-road mountain biking occurs on irregular terrain, accidents would be expected to be common. In fact, nearly 83% of mountain bike racers in Mammoth Mountain had had accidents, resulting in an average of 8.5 accidents per person (T.K.C., unpublished data, September 1989).

We compared our results with three other survey-based studies of bicycling injuries (Table 4). Kruse and McBeath randomly surveyed 539 college student cyclists in Wisconsin: 29% had been in an accident within the previous three years; a third of those required professional medical attention.¹⁶ Sgaglione and colleagues polled 93 urban cyclists at Manhattan bicycle meets.⁴ Half had had at least one accident leading to injury, 37% of which required medical care. An investigation similar to ours was done on 492 members of two Kansas City bicycling clubs who were principally recreational riders on paved terrain. Nearly half (46.3%) had had an accident leading to trauma.¹⁷ Of those injured, 34.8% needed medical attention or were admitted to hospital. Thus, although

TABLE 4.—Review of Retrospective Surveys of Biking Injuries

Study and Location	Cyclists, No.	Mean Age, yr	Cyclists Reporting Injuries, %	Injured Victims Seeking Medical Care, %	Injured Victims Admitted to Hospital, %
Kruse and McBeath, 1980 ¹⁶ Madison, Wisconsin	539	23	18.0*	32.0	1
Sgaglione et al, 1982 ⁴ Manhattan, New York	93	25	50.4†	31.0	6
Kiburz et al, 1986 ¹⁷ Kansas City, Missouri	492	34	46.3	23.8	11
This study, 1990 Southern California	268	36	84.0	26.0	4.4

*29% of the bicyclists had an accident in the previous 3 years, of which 62% were injured.
†54.8% of the bicyclists had an accident of which 92% were injured.

our results suggest that the incidence of injuries from mountain biking is higher than that from road cycling, the proportion of injuries requiring a physician's evaluation is comparable.

In contrast to other studies, we found a low occurrence of head injuries and a high use of safety helmets (90%). This offers further support to Thompson and co-workers, who demonstrated the effectiveness of helmets in preventing serious head injury.¹⁰ Although it is known that children wear helmets infrequently^{3,9,11} and that their use increases with age,^{9,10} the best documented compliance rate for all ages is still no better than 57%.⁸ What accounts for the apparent willingness of the ATB riders we studied to wear helmets? Because they are older they may not only be more aware of studies advocating their use¹⁸ and more able to afford them, but may also be less likely than younger cyclists to think that helmets are "uncool."²³ Rules of the National Off-Road Cycling Association requiring helmet use in all their racing events may influence those members of the club who ride competitively. Last, mountain bikers may know that they run a high risk of injury. This would support data from University of New Mexico (Albuquerque) students suggesting that perceived risk is an important factor in the use of safety helmets.¹⁹

With this information, health care professionals can better educate ATB riders about injuries typical of the sport and their risk factors. Clinicians should reinforce helmet use and equipment maintenance and encourage cyclists who ride on paved roads to be particularly aware of motor vehicles and follow traffic regulations. Advising frequent riders that they run a higher risk of injury might increase their level of caution. For ATB riders who ride off road, appropriate speed—particularly downhill—is critical. Learning the terrain they plan to travel, per-

haps with someone familiar with the area, might also be helpful.

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