Skateboarding:
More Dangerous than Roller Skating or Inline Skating

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Published in the
Archives of Pediatrics & Adolescent Medicine
Volume 152, October 1998 (pg. 985-991)

Abbreviations: National Pediatric Trauma Registry (NPTR); Injury Severity Score (ISS); National Electronic Injury Surveillance System (NEISS)

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And you thought skating on thin ice was dangerous!

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Abstract

Objective.-- To describe circumstances, severity, and outcomes of skating-related injuries among children admitted to trauma centers.

Design.-- Cross-sectional comparison of roller skaters (N = 154), inline skaters (N = 190), and skateboarders (N = 254) age 5 to 19 who were hospitalized for their injuries.

Setting.-- 79 hospitals and pediatric trauma centers participating in the National Pediatric Trauma Registry between 1988 and April, 1996.

Results.-- Three-quarters of the study sample were male (75.8%), nearly half (47.8%) were injured on roads, and over one third (37.1%) had head injuries. Among skateboarders 50.8% had head injuries, compared to 33.7% of inline skaters, and 18.8% of roller skaters ($P < .001$). According to the Injury Severity Score, injuries to skateboarders were eight times more likely to be severe or critical compared to roller skaters' injuries, and skateboarder's injuries were more than twice as likely to be severe or critical compared to inline skaters' injuries. Mean hospital length of stay was 6.0 days for skateboarders, 3.4 for inline skaters, and 2.4 for roller skaters ($P < 001$). Skateboarders were more likely to be male and they were more likely to be injured on roads than inline skaters or roller skaters.

Conclusions.-- Skateboarding-related injuries are more severe and have more serious consequences than roller skating or inline skating injuries. Research is needed to identify ergonomic and behavioral factors responsible for higher head injury risk to skateboarders, and interventions are needed to reduce the risk.

Introduction

Waking after a long sleep, a modern day Rip Van Winkle would be amazed at the skaters and skateboarders whizzing by on streets, sidewalks, and bicycle paths. This is a new kind of traffic -- often barely in control, faster than a pedestrian, but slower than a bicycle or motor vehicle. Skating has become a major recreational activity and is emerging as a new mode of urban transportation. [1] Injuries associated with roller skates, inline skates and skateboards have skyrocketed accordingly. [2,3]

Most studies of skating injuries are based on National Electronic Injury Surveillance System (NEISS) data, which is maintained by the Consumer Product Safety Commission. [4] According to this national database, about 160,000 roller skaters, skateboarders, and inline skaters were treated in hospital emergency departments between July 1992 and June 1993. The male-to-female ratios were very different for the three types of injured skaters. [5] Nearly all skateboarders were male, as were the majority of inline skaters, however the majority of roller skaters were female. The median age was 12 years for roller skaters, 13 for skateboarders, and 15 for inline skaters.

The vast majority of inline skating injuries are due to forward falls on outstretched arms, without vehicle, bicycle, or other-skater involvement. [6] It follows that articles describing skating injuries often focus on wrist and upper extremity injuries. [7,8] However, lower extremity injuries[5,9] and head injuries also occur and can be quite serious. [5]

Research on skateboard-related injuries suggests that head injuries are more common among younger children and extremity injuries are more common among older children.[10,11] However, because older skateboarders tend to skate faster and on "streets and highways," when they sustain head injuries, they are more severe.[10] This illustrates the complexity of research in this area: different types of skating appeal to males and females of different ages. Inline skating tends to attract the broadest age range; skateboarding is done primarily by males age 11 to 14; and the majority of roller skaters are younger females. In addition, type of skate appears to be related to skating location (skate park versus city street) and to use of protective gear. In turn, skating location and use of protective gear influence type and severity of injuries. [3,7]

One trend is clear. Without major changes in skating safety behavior, skating-related injuries and deaths are expected to rise. [7,12] A high proportion of injuries occur to novice skaters[3] and skateboarders, [13,14] suggesting that many skating-related falls are preventable if skaters take the time to learn the basics while skating on flat smooth, dry, surfaces. [6,9,15] Moreover, when falls do occur, injuries can be prevented or minimized by wearing appropriate protective gear. [3,7,16]

Most research on skating injuries has examined the early acute phase--what happens in the doctor's office or emergency department. Follow-up treatment and services and hospital care have rarely been studied. To gain a more accurate picture of skating-related injuries, we examine the acute hospital stay of children admitted for roller skate, skateboard, and inline skate injuries.

Methods

The data for this study were extracted from the National Pediatric Trauma Registry (NPTR). [17] The NPTR is a voluntary multi-institutional database with information on many aspects of pediatric trauma. At the time of the study, there were 79 children's hospitals or pediatric trauma centers contributing data to the NPTR.

A trained trauma nurse coordinator at the participating institution completes a data collection form for each trauma patient, according to instructions developed by the NPTR and explained in an operational definitions manual. [18] To guarantee uniformity across institutions, coding for natural and external causes of injury, severity scoring, data management, analyses, and reporting are performed centrally by the staff at the NPTR.

The NPTR includes children and adolescents aged 0 to 19 years who are admitted to the hospital for an acute injury, including patients who are dead on arrival, or die in the emergency department. All injuries are included except burning, poisoning, and near drowning. From October 1988 to April 1997 there were 62,190 cases recorded in the registry.

Sample

After selecting sports-related injury as the mechanism of injury, relevant NPTR cases were detected via a word search of the injury description. The search identified children injured while skating and skateboarding, and then we excluded ice skaters and skaters of unspecified type. In addition, due to the rarity of skating injuries in very young children, six children under five years of age were excluded.

The final sample included 598 cases involving roller skates, inline skates, and skateboards, consecutively recorded in the NPTR between October 1988 and April 1997. This included eight children who died, four of whom were skateboarders. Each child was admitted to the hospital between October 1988 and January 1997.

Based on findings in the entire sample, we then analyzed two subsamples. The sample of 598 children was first restricted to male inline skaters and skateboarders who were injured in falls, regardless of place of occurrence (N = 284) and then to the smaller subset of males injured in falls on the road (N = 140). Vehicle-related events were excluded from the two subsets to allow us to examine the specific injuries associated with each type of skate. Roller skaters were excluded because their demographic profile was different and they tended to skate in different locations.

Variables

We analyzed the type of skate by year of injury, gender, age, injury setting, causes of injury, number of diagnoses, anatomical region of injury, injury severity, functional status, and acute hospital length of stay. Severity of injury was measured by the Injury Severity Score (ISS). [19] In our analysis, we grouped ISS values into the following categories: trivial = 0 to 3 (including ISS = zero, no injury), minor = 4 to 8, moderate = 9 to 15, severe = 16 to 24, and critical = 25 to 75. Functional status was assessed at discharge by rating the child's ability in nine functional domains: vision, hearing, speech, self-feeding, bathing, dressing, walking, cognition, and behavior. The child's performance in these functional areas was rated by a clinician as being "age appropriate," "impaired," or "unable," and we combined the last two categories.

Crosstabulations with chi squares and difference of means tests were calculated using Statistical Package for the Social Sciences (SPSS for Windows 1994). [20] Graphs were made using Quattro Pro for Windows (1993). [21]

Results

Figure 1 shows that the type of skater in our sample changed drastically from 1989 to 1996. No inline skaters were even reported to the registry in the first two years, but by 1996 they accounted for 55 percent of all skating-related injuries in the NPTR sample. On the other hand, skateboarders made up about three-quarters (76%) of the cases in 1989, but dropped to one quarter (25%) by 1996.

See Figure 1 at End of Text

Table 1 shows a breakdown of key variables by type of skate -- roller (N = 154), inline (N = 190), and board (N = 254). There were some fundamental differences in the demographic profiles of children using these three types of skates, the settings in which they were injured, and the causes and severity of their injuries. In fact, all variables were significantly related to type of skate ($p < .001$).

See Table 1 at End of Figures

Among skateboarders in the series, 93.3% were male, versus 82.6% among inline skaters, and only 38.3% among roller skaters. Skateboarders were the oldest, followed by inline skaters, and roller skaters.

Table 1 shows quite clearly that, in this sample, children injured on skateboards had more serious injuries than the other two types of skaters. Based on the Injury Severity Score (ISS), only 2.0% of the children injured while roller skating had severe or critical injuries, compared to 7.4% for inline skaters and 16.5% for skateboarders. The average number of diagnoses was 1.3, 2.0, and 2.3, respectively. Similarly, mean hospital length of stay was 2.4 days for roller skaters, 3.4 days for inline skaters, and 6.0 days for skateboarders, or a total of 2,531 acute hospital days.

Only 14.9% of roller skaters sustained their injuries on the road, compared to 54.7% of inline skaters, and 62.6% of skateboarders ($P < .001$). Similarly, only 2.6% of roller skaters were hit by vehicles, compared to 22.1% of inline skaters, and 24.8% of skateboarders (Table 1).

Figure 2 shows that skateboarders were more likely to have head injuries (50.8%) than inline skaters (33.7%) or roller skaters (18.8%). Roller and inline skaters were significantly more likely to have upper extremity injuries compared to skateboarders. The proportion with lower extremity injuries was similar for all three types of skaters, and the differences were not statistically significant.

See Figure 2 at End of Text

Table 2 shows injury-related impairments at discharge from the hospital. Fortunately, vision, hearing, speech, behavior, and cognition impairments were rare, as these types of impairments can be very serious and long-lasting. In contrast, self-feeding, walking, dressing, and bathing impairments were quite common; fortunately, these impairments are not usually as serious or long-lasting.

See Table 2 at End of Figures

To understand the impact of injured body region, next we looked at children with injuries to only one body region: head (N=185), upper extremity (N=206), or lower extremity (N=129). Based on the Injury Severity Score, children with upper and lower extremity injuries had less severe injuries compared to children with head injuries ($p < .001$). Looking at the same groups of children, the mean acute hospital length of stay was 1.8 for children with upper extremity injuries, compared to 4.4 for children with head injuries, and 5.8 for children with lower extremity injuries. When looking at the sum of acute hospital days in the three groups, upper extremity injuries account for far fewer acute hospital days (19%) than either head injuries (42%) or injuries to the lower extremities (39%).

Finally, in the full sample (N = 598), crosstabulations of gender by ISS (in five categories) show that males had more severe injuries than females ($p < .01$). Males were more likely to be injured on the road than females (66% versus 30%, $p < .001$) and 42% of males had head injuries versus only 23% of females ($p < .001$).

Subsample #1. Male inline skaters and skateboarders injured in falls

The inquiry now turns to exploring the differences between inline skaters and skateboarders injured in falls. To remove potential confounding variables (gender and cause of injury), we restricted these analyses to males injured in falls on skateboards or inline skates. In other words, we excluded females, roller skaters, and children who were hit by vehicles.

In this subsample, large differences remained between the 174 male skateboarders and 110 male inline skaters injured in falls. For instance, skateboarders were still significantly older than injured inline skaters (mean age = 12.8 versus 11.7, $p < .01$) and they tended to have more severe injuries ($p < .05$). Figure 3 shows the anatomical regions of injury for the two groups. Compared to inline skaters, skateboarders were significantly more likely to have lower extremity injuries (21.8% versus 10.9%) and head injuries (46.0% versus 19.1%), and significantly less likely to have upper extremity injuries (32.8% versus 63.6%).

See Figure 3 at End of Text

Even though children hit by vehicles were excluded, place of injury may remain a confounding variable; 66.9% of this subsample of skateboarders were injured on roads compared to 54.0% of inline skaters ($p = .06$). Consequently, the sample was further restricted to only skaters injured in falls that occurred on roads.

Subsample #2. Those in subsample #1 who were injured on roads
After restricting to males injured in falls on roads, 140 cases remain. Inline skaters still tended to be younger (mean age 11.9 years) than skateboarders (13.0 years, $p < .05$) and to have less severe injuries ($p < .05$). Previous differences between inline skaters and skateboarders in percentages with lower extremity injuries disappeared. However, the two remaining differences were highly significant; 49.5% of the skateboarders had head injuries versus only 23.4% of the inline skaters, and 31.2% of skateboarders had upper extremity injuries versus 51.1% of inline skaters (Figure 4).

See Figure 4 at End of Text

Comment

Three major findings emerge from this study.

1) Skateboarders have more serious injuries and are more likely to have head injuries than inline skaters or roller skaters.
2) Males are both more likely to be injured skating than females and to have more serious injuries.
3) Upper extremity injuries are most salient in emergency department-based studies of skaters, but in our hospital-based sample, head and lower extremity injuries appear more prominent.

Injury Severity and Type of Skater

In our sample, skateboarders had more serious injuries than inline skaters, and roller skaters had the least severe injuries. This contrasts sharply with the findings of Schieber, Branche-Dorsey, and Ryan, [5] who report 52% of inline skaters are in the "more severe" category compared to 46% of roller skaters, and only 36% of skateboarders.

These two studies differ in three very fundamental ways, so we did not expect concurrence. First, the sample studied by Schieber and colleagues was emergency department-based and ours was based on hospital admissions. In fact, only 27% of the children in our sample were treated in an emergency department before arriving at the hospital. Second, Schieber and colleagues used their own severity measure, which was calibrated differently than the Injury Severity Score, which we used. For example, a child whose only injury is a concussion with brief loss of consciousness is considered "more severe" on their measure but has only a "minor" injury according to our ISS categories. Third, NEISS only records the most serious injury diagnosis and as many as fifteen diagnoses are recorded in the NPTR.

In our study, much of the difference in severity across skater types appears to be related to differences in age, sex, skating locations and motor vehicle involvement. Skateboarders appear to have more serious injuries than inline skaters partly because they tend to be older (adolescent) males who skate on roads and are hit by vehicles. However, even after restricting the sample to males injured in non-vehicular falls on the road, there were some major differences between skateboarders and inline skaters. Skateboarders were still older, they had higher Injury Severity Scores, they were twice as likely to have head injuries, and much less likely to have upper extremity injuries (Figure 4).

The finding that skateboarders' injuries were more serious than those of roller skaters is consistent with findings of Baker and colleagues. [2] Their analysis looked at children treated in emergency departments after being injured in a wide variety of recreational activities (on playgrounds, roller skates, skateboards, or riding on children's vehicles). Interestingly, skateboarding was the mechanism of injury most likely to result in a hospital admission; almost 13% of children seen in the Emergency Department for skateboarding injuries were admitted to the hospital.

The preponderance of head injuries among skateboarders merits further examination. Future research on roller and inline skaters and skateboarders is needed to explore differences in skating safety behavior and ergonomics. Are skateboarders in this sample more prone to head injuries because they:

- engaged in different kinds of skating (e.g., aggressive stunt skating);
- skated at dangerous locations (e.g., on streets);
- had different types of falls (e.g., backward versus forward)
- had less control over their skateboards; or
- because they were less likely to wear helmets?

Female versus Male Skaters

This sample was disproportionately male, and males had more serious injuries than females. Previous research shows that males are at highest risk of skating-related injuries because they do more outdoor skating, they skate in more dangerous locations, and they wear less protective gear than females. [1,22] Roller skaters are different, however. In our sample, over sixty percent of roller skaters were female and they were significantly younger than the other types of skaters. In addition, two thirds of their injuries occurred at home or in recreation areas, where speeds are slower and encounters with vehicles are rare.

These age and sex distributions are similar to emergency department-based data of the National Electronic Injury Surveillance System. [4] In the NEISS data, however, roller skaters are grouped with ice skaters and other unspecified types of skaters. Although this makes comparison difficult, roller skaters still appear to be disproportionately female and younger than other types of skaters.

Anatomical Region of Injury

The percentage of children having upper extremity injuries in this sample is much lower than the percentages reported by other researchers for inline skaters, [5,7,8,9] roller skaters, [23,24] and skateboarders (Table 3). [5] One reason is that the other studies are based on emergency department data and our study is based on hospital data. By themselves, most upper extremity injuries are not severe enough to require inpatient hospitalization.

See Table 3 at End of Figures

Among children in the NPTR sample, body region of injury had a profound impact on severity and outcomes. Children with head injuries and injuries to the lower extremities had more severe injuries (based on the ISS) and they spent significantly more days in

the hospital than children with upper extremity injuries.

All together, these 520 children accounted for 1,928 days in the hospital. Of those days, children with head injuries accounted for 42%, children with lower extremity injuries 39% and children with upper extremity injuries only 19%.

Injury Prevention

Comparing skateboarders to roller skaters and inline skaters provides both a context for understanding skateboarding, and two alternatives. Based on these results, would-be skaters should be encouraged to take up roller skating or inline skating, rather than skateboarding.

Only 7% of skateboarders were female, compared to 62% female among our sample of roller skaters. It follows that different prevention strategies may be needed for skateboarders and roller skaters, just as they are for inline skaters and roller skaters. [25] For instance, given the preponderance of males being injured on skateboards, clinicians and health educators may want to target males for prevention efforts.

The high percentage of inline skaters wearing wrist guards [1,26,27] suggests that inline skaters are aware of the danger of wrist and forearm injuries. While some emphasis should remain on upper extremity injury, more attention should now be paid to preventing skating-related head and lower extremity injuries. Even though head and lower extremity injuries are less common than upper extremity injuries, they deserve more attention because they are generally more serious and require a longer hospitalization period.

Many of the head injuries in our sample would have been prevented if the children had been wearing helmets. Along with knee pads, the best way to prevent lower extremity injuries is to avoid the crash altogether. Better training and skating at safer locations can help skaters avoid bad falls and it can reduce chances of getting hit by a vehicle.

Clinician's role

Increasingly, athletes are using inline skates for cross-training. [6,7] Thus, along with "garden variety" recreational skaters, clinicians are likely to encounter growing numbers of young athletes, as well as student and work commuters. [9,12,13]

Clinicians can help prevent skating-related injuries in a number of ways:

- by communicating the injury risk to children and parents (especially risks associated with skateboarding);
- by advising their patients who skate to wear protective gear (helmets, knee and elbow pads, and wrist guards);
- by advocating for safe skating areas (e.g. skate parks, multi-purpose paths, skate-friendly pedestrian ramps);
- by strongly recommending skaters take lessons;
- by doing post-injury counseling about proper skating safety behavior; or
- by championing effective approaches for reducing skating injuries, including legislation.

Future Research

We went one step beyond previous research that examined emergency department cases. [6,7,9,12] We examined circumstances, severity, and outcomes in the subset of children with serious skating-related injuries requiring hospital admission. Only 27% of the children in our hospital-based sample even went to an emergency department prior to their hospital admission. In other words, there is not much overlap between our hospital-based sample and previous samples of emergency department cases. An important next step is to collect data on the even smaller subset of skaters who are discharged from the hospital with functional limitations. We expect this would lend further support to our emphasis on less common but more serious injuries to the head and lower extremities.

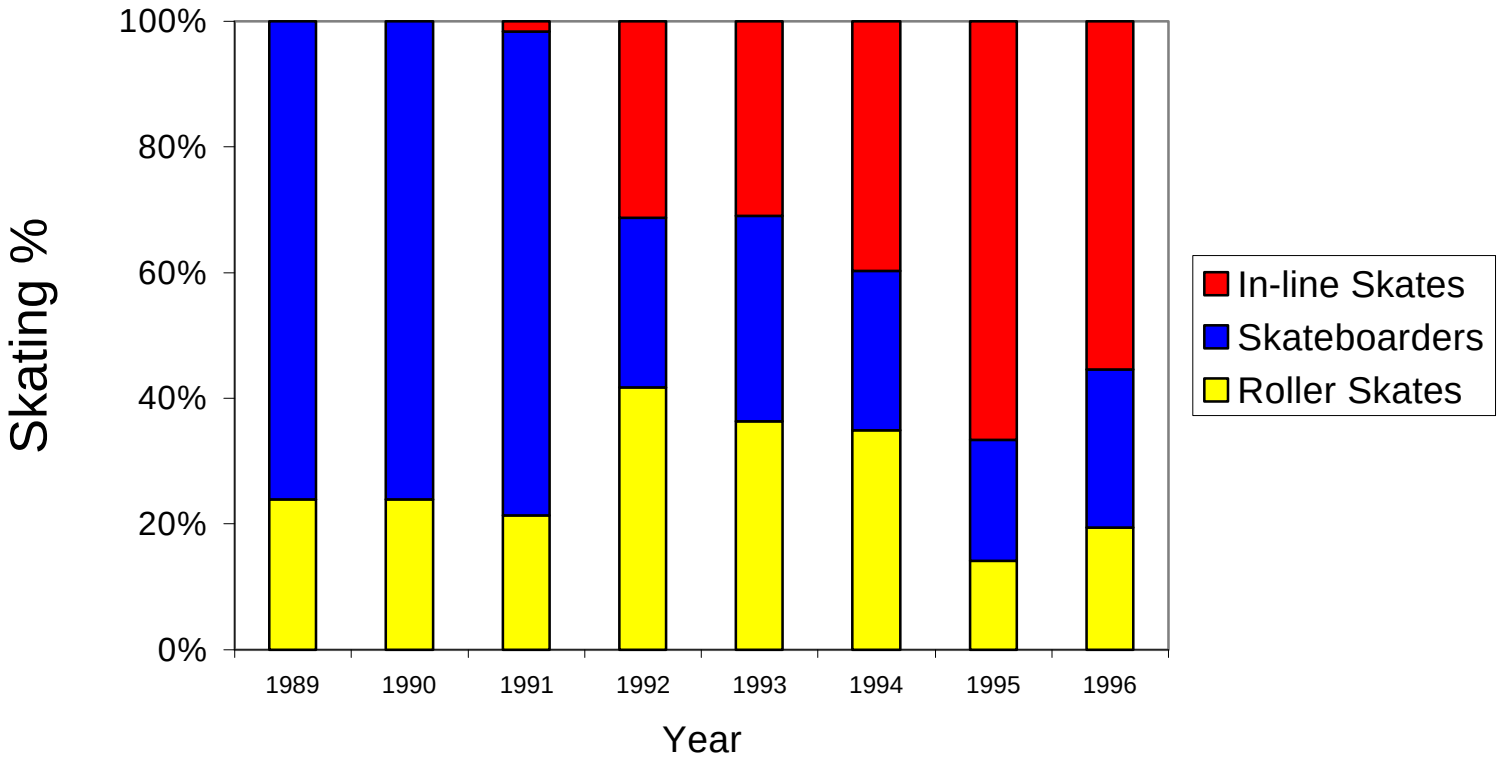
The Injury Severity Score can serve as a common denominator allowing clearer comparisons of skaters in different samples. On Table 1, we show the injury severity scores of children in this sample. Whether examining skaters in emergency departments, hospitals, or looking at the subset of those discharged from hospitals with impairments, future researchers are encouraged to collect and display similar ISS data.

Skating is a very public activity, yet systematic data on this emerging sport are not yet available. Observational data are needed describing skating safety behavior and groups at risk for sustaining outdoor skating injuries. Physicians and other health care professionals are urged to pay more attention to patients with skating-related injuries. Clinical participation is needed in studies that document the types of injuries, treatments and services provided, and outcomes attained.

Acknowledgements:

This work was supported by the National Institute on Disability and Rehabilitation Research (H133B50006), US Department of Education, Washington, D.C. and by the National Center for Injury Prevention and Control (R491CCR302486), Centers for Disease Control and Prevention, Atlanta, Georgia. Many thanks to the physicians and trauma registry coordinators at the NPTR participating hospitals. In addition, we wish to thank Dr. Sarah C. Stiles for reading and commenting on several versions of the manuscript.

Figure 1: Type of skater, by year



(N = 598 injured skaters)

Figure 2: Type of skater, by anatomical region of injury (n=598)

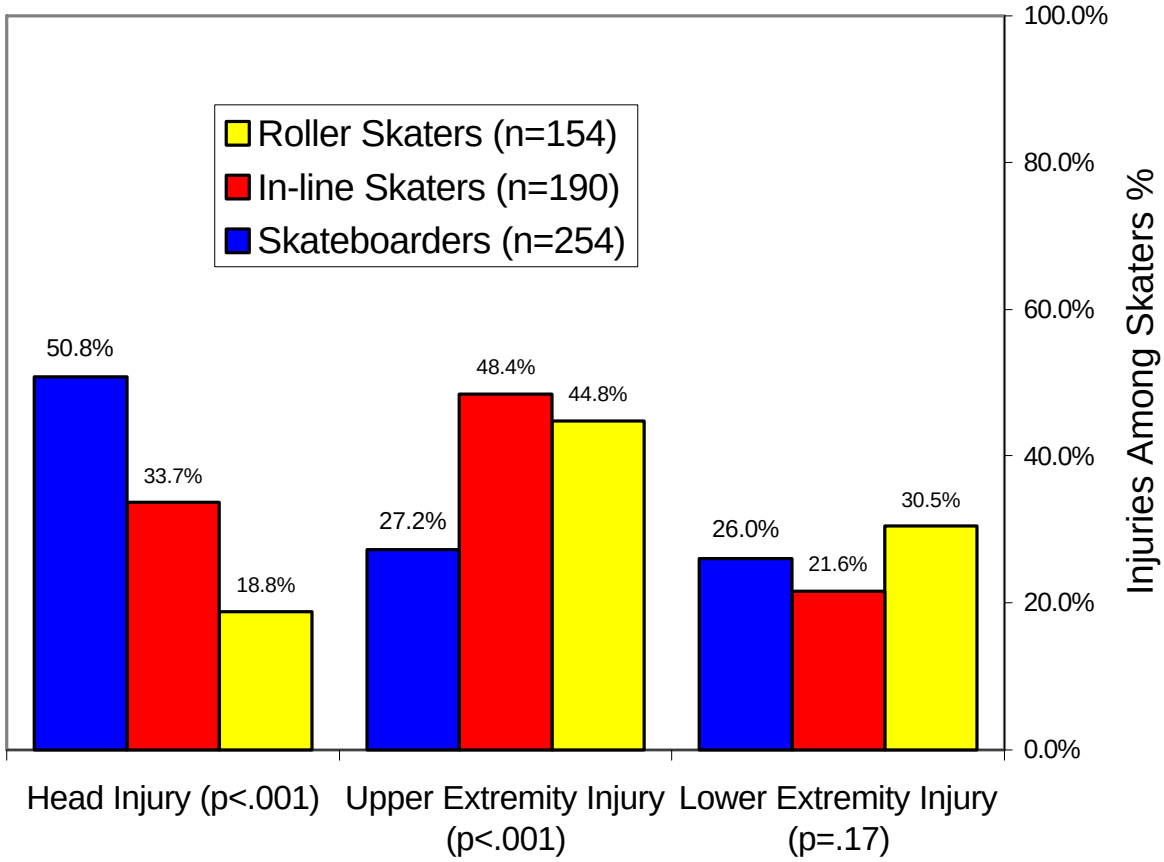


Figure 3: Type of skater, by anatomical region of injury, based on a subsample of males injured in falls (n=284)

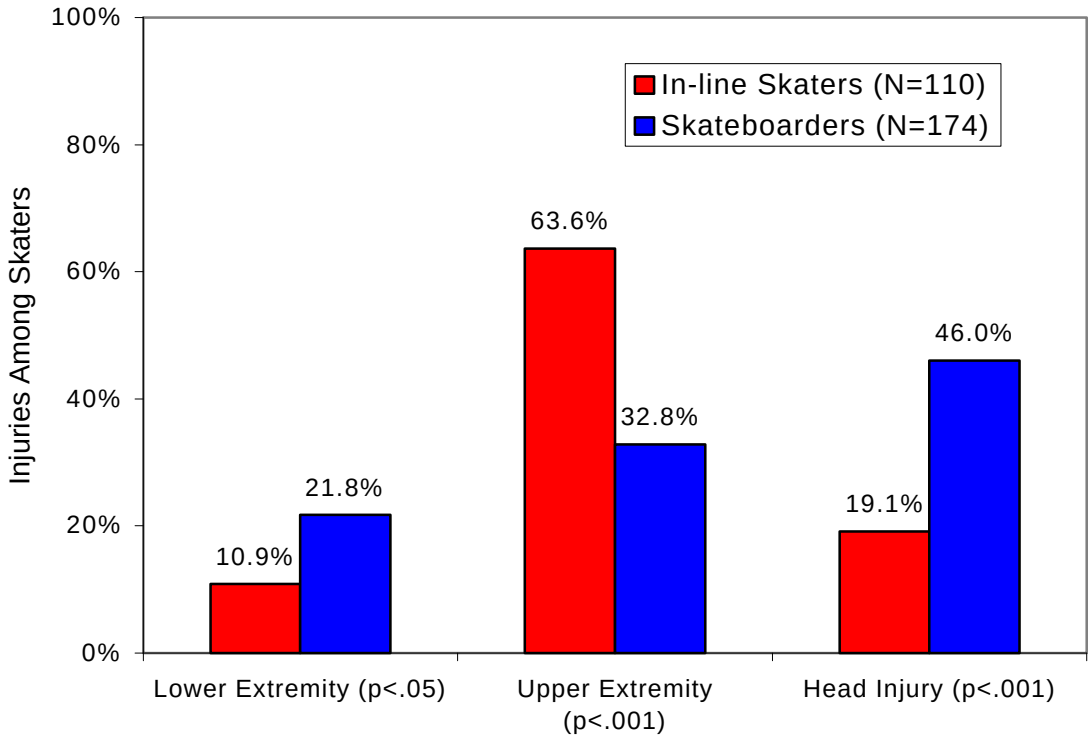


Figure 4: Type of skater, by anatomical region of injury, based on a subsample of males injured in falls on the road (n=140)

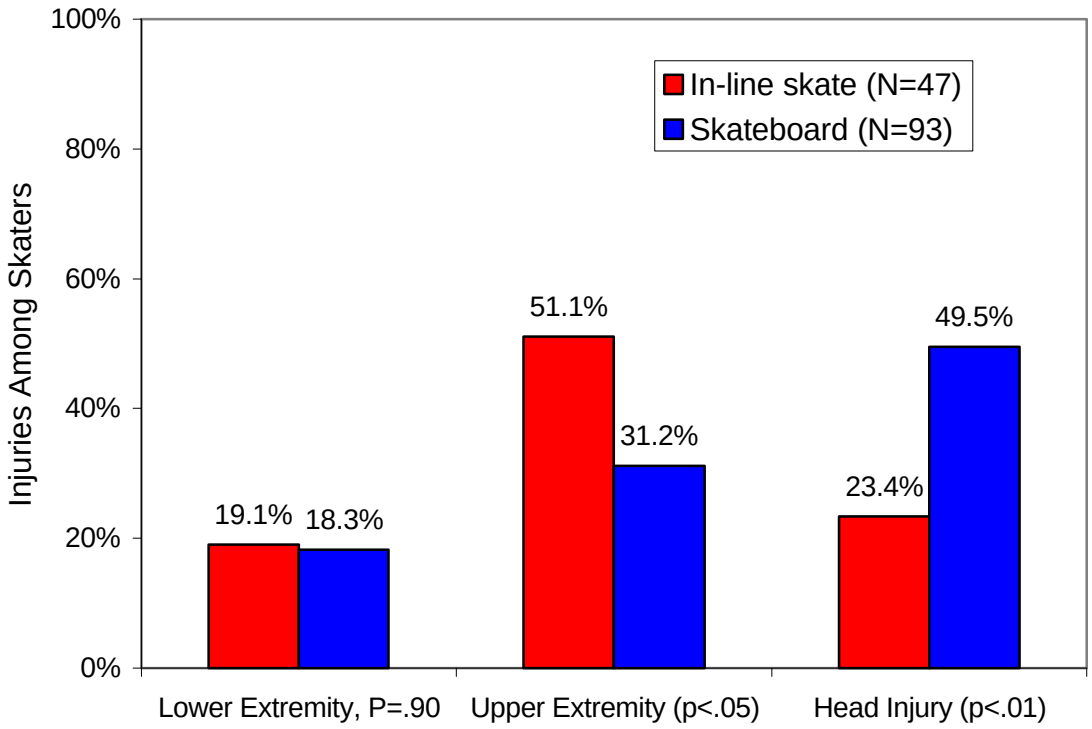


Table 1

Type of Skate by Selected Variables

*** p < .001	Roller Skate (N=154)	Inline Skate (N=190)	Skate Board (N=254)	Total (N=598)
Gender* **				
Male	38.3	82.6	93.3	75.8%
Female	61.7	17.4	6.7	24.2%
	100.0%	100.0%	100.0%	100.0%
Age* **				
5 to 9	44.2	25.9	18.5	27.5%
10 to 14	50.6	64.0	57.9	58.0%
15 to 19	5.2	10.2	23.6	14.6%
	100.0%	100.1%	100.0%	100.1%
Injury Setting* **				
Home	22.1	16.8	15.0	17.4%
Recreation	42.9	12.6	5.9	17.6%
Road	14.9	54.7	62.6	47.8%
Other	20.1	15.8	16.5	17.2%
	100.0%	100.0%	99.9%	100.0%
Injury Mechanism* **				
Fall	92.2	72.6	73.6	78.1%
Hit by Motor Vehicle	2.6	22.1	24.8	18.2%
Other	5.2	5.3	1.6	3.7%
	100.0%	100.0%	100.0%	100.0%
Injury Severity Score* **				
Trivial (0-3)	7.8	7.9	5.5	6.9%
Minor (4-8)	68.0	45.5	44.5	50.8%
Moderate (9-15)	22.2	39.2	33.5	32.4%
Severe (16-24)	2.0	3.7	10.2	6.0%
Critical (25-75)	0.0	3.7	6.3	3.9%
	100.0%	100.0%	100.0%	100.0%
Mean # Diagnoses* **	1.3	2.0	2.3	2.0
Mean Hospital LOS* **	2.4	3.4	6.0	4.2

Table 2

Number and Percent of Impairments at Discharge among Children without Pre-Existing Impairments

	Number	Percent
Vision	3	0.5
Hearing	6	1.0
Speech	11	1.9
Behavior	10	1.7
Cognition	17	2.9
Self-feeding	107	18.2
Walking	166	28.3
Dressing	307	52.3
Bathing	322	54.9

N of cases ranges from 583 to 587 because children who had pre-existing impairments were excluded.

Percentages add to more than 100.0% because many children had multiple impairments.

Table 3

Percentages Having Upper Extremity Injuries by Type of Skate in Different Studies

Author	Roller Skate	Inline Skate	Skate Board	Sample	Age Range
This study	42.9 (154)	46.8 (190)	24.4 (254)	Hospital-NPTR	5 - 19
Schieber et al., 1994	62.0 (92,963)	61.0 (30,863)	40.0 (34,938)	EDs - NEISS	5 - 71
Callé & Eaton, 1993	…	58.5 (444)	…	EDs - NEISS	See note #2
Callé & Eaton, 1993	…	77.2 (57)	…	EDs - local	6 - 55
Malanga & Stuart, 1995	…	78.0 (32)	…	ED - local	6 - 46
Ellis et al., 1995	…	88.7 (194)	…	EDs - Canada	3 - 19
Ferkel et al., 1981	72.0 (186)	…	…	Student Health or ED	7 - 58
Inkelis, 1988	74.0 (78)	…	…	ED - local	4 - 15

Data are given as percentage (number). NPTR indicates National Pediatric Trauma Registry: ED, emergency department; NEISS; National Electronic Injury Surveillance System; and ellipses not studied.

#2 The precise age range is not given in the study by Callé and Eaton (1993), but the authors state that the group is younger than the local sample that they also studied, which had an age range of 6 to 55 years.

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The End