

Child Development and Pediatric Sport and Recreational Injuries by Age

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Context: In 2010, 8.6 million children were treated for unintentional injuries in American emergency departments. Child engagement in sports and recreation offers many health benefits but also exposure to injury risks. In this analysis, we consider possible developmental risk factors in a review of age, sex, and incidence of 39 sport and recreational injuries.

Objective: To assess (1) how the incidence of 39 sport and recreational injuries changed through each year of child and adolescent development, ages 1 to 18 years, and (2) sex differences.

Design: Descriptive epidemiology study.

Setting: Emergency department visits across the United States, as reported in the 2001–2008 National Electronic Injury Surveillance System database.

Patients or Other Participants: Data represent population-wide emergency department visits in the United States.

Main Outcome Measure(s): Pediatric sport- and recreation-related injuries requiring treatment in hospital emergency departments.

Results: Almost 37 pediatric sport or recreational injuries are treated hourly in the United States. The incidence of sport- and recreation-related injuries peaks at widely different ages. Team-sport injuries tend to peak in the middle teen years,

playground injuries peak in the early elementary ages and then drop off slowly, and bicycling injuries peak in the preteen years but are a common cause of injury throughout childhood and adolescence. Bowling injuries peaked at the earliest age (4 years), and injuries linked to camping and personal watercraft peaked at the oldest age (18 years). The 5 most common causes of sport and recreational injuries across development, in order, were basketball, football, bicycling, playgrounds, and soccer. Sex disparities were common in the incidence of pediatric sport and recreational injuries.

Conclusions: Both biological and sociocultural factors likely influence the developmental aspects of pediatric sport and recreational injury risk. Biologically, changes in perception, cognition, and motor control might influence injury risk. Socioculturally, decisions must be made about which sport and recreational activities to engage in and how much risk taking occurs while engaging in those activities. Understanding the developmental aspects of injury data trends allows preventionists to target education at specific groups.

Key Words: athletes, youth, adolescents, athletic injuries, safety

Key Points

- Pediatric sport and recreational injuries are a significant public health concern in the United States.
- The injury risk varies across child development for particular types of sport and recreational injuries.
- Sex disparities were common in the incidence of pediatric sport and recreational injuries.

The magnitude of fatal and nonfatal, unintentional, pediatric injuries represents an increasingly recognized public health problem in the United States and around the world. Statistics from the Centers for Disease Control and Prevention indicate that 7712 US children died of unintentional injuries in 2009, or more than 21 children per day.¹ Furthermore, more than 8.6 million children were treated for injuries in emergency departments (EDs) in 2010, representing 23 596 children treated per day, 983 per hour, and 16 per minute.¹ Cost estimates resulting from injuries to American children, age 0 to 14 years, in 2000, exceeded \$50 billion.²

Traditionally, injury researchers use 5-year age spans (eg, ages 0–4, 5–9, 10–14) to examine injury incidence during childhood. However, such a broad analysis of age groups lacks the precision that might be needed to understand fully how child and adolescent development interacts with the process of injury events and, subsequently, to design age-

appropriate injury-prevention strategies. Agran et al³ illustrated this problem using data from the 1997 California Office of Statewide Health Planning and Development database. Analyzing injury hospitalization and death data, they showed an elevated poisoning risk among 1-year-olds (rate = 83 per 100 000) that was not well represented by the 0 to 4-year age range and that was far higher than the rate among 4-year-olds (rate = 14 per 100 000).³ This pattern was attributed to 1-year-olds being newly mobile and developmentally prone to explore, discover, and ingest potentially poisonous household items when unsupervised. By age 4, children may have developed the cognitive skills to avoid potentially poisonous household items.

Our analysis was conducted using data from the National Electronic Injury Surveillance System (NEISS),⁴ a database of injuries treated at hospital EDs across the United States. We considered all sport and recreational injuries reported during an 8-year time span (2001–2008) among children

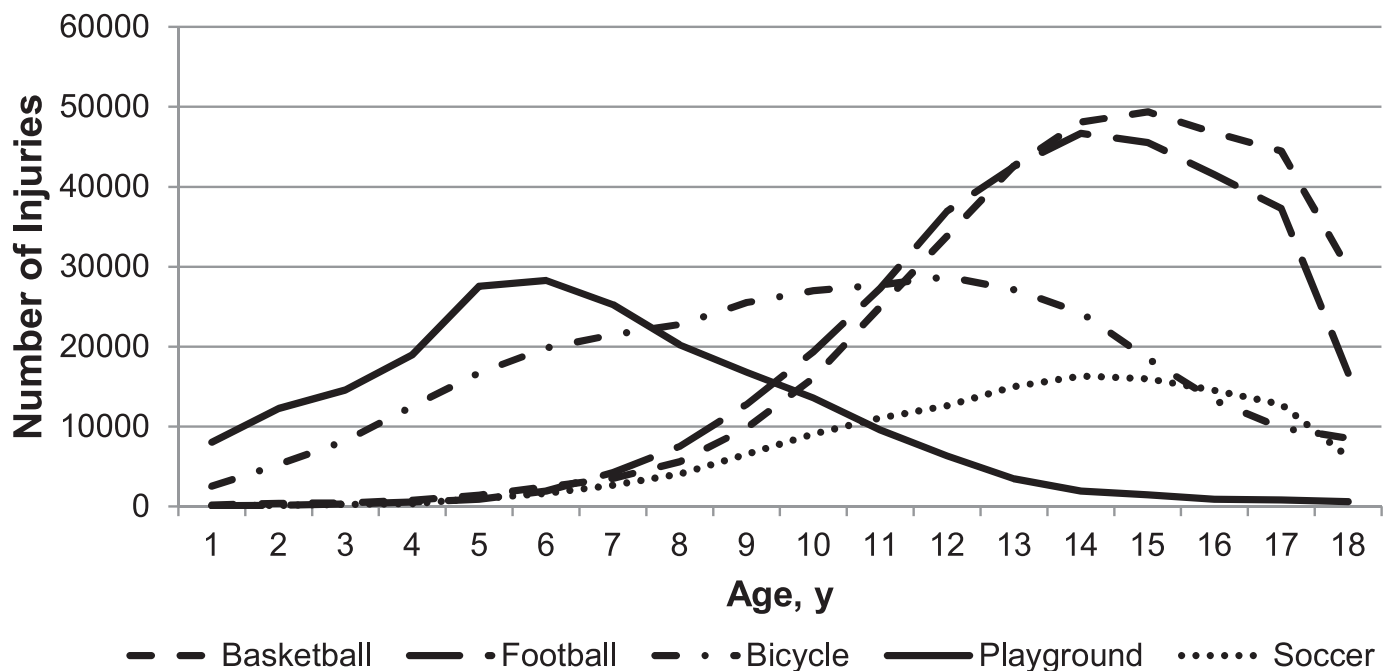


Figure. Trajectory in the number of injuries treated in emergency departments, by age, for the 5 leading causes of sport and recreational injuries to children in the United States, 2001–2008.

ages 1 to 18 years. Our analysis was descriptive and focused on changes in injury incidence through child and adolescent development. Sex differences were considered as a secondary topic of interest.

METHODS

Data Source

Data for this study were taken from the 2001–2008 NEISS data sets, which are collected by the United States Consumer Product Safety Commission and the National Center for Injury Prevention and Control from a sample of hospital EDs across the United States. Specifically, the NEISS data were collected from about 100 hospitals, ranging from small to large, and including children’s hospitals. Patients treated at the sampled hospitals are representative of national injury patterns involving consumer products.^{4,5} Data are collected daily, 365 d/y, by hospital staff, using a standardized coding manual. Only initial hospital visits by patients are included in the data set. As detailed elsewhere,^{4,5} numerous safeguards flag and correct invalid coding or data entries. Secondary data analysis was approved by the institutional review board at the University of Alabama at Birmingham.

To adjust for selective sampling, the NEISS data set assigns sample weights to data points, so the data set estimates annual, population-based ED visits nationwide. Because we analyzed data across 8 years of the survey, sample weights were divided by 8 for analytic purposes, preserving the pattern of estimated, annual ED visits nationwide for our analyses. Therefore, frequencies reported in this article use sample weights and represent the number of annual ED visits by the US population during the 8-year period of 2001–2008.⁴

Variables

Patient age and sex were culled from medical records. Injury data from all sport- and recreation-related injuries in the NEISS data set incurred by children ages 1 to 18 years were included in the analysis. We omitted injuries to infants younger than 12 months because such infants are typically nonmobile, and injuries typically result from supervisor behavior and decisions rather than child behavior or decisions. We were interested in pediatric injuries only and, therefore, omitted injuries to individuals older than 18 years. Injury cases were classified into mutually exclusive categories of sport or recreational activities based on a combination of the consumer products involved (eg, scooter, skateboard, snow skis) and the medical description of the incident.

Analytic Plan

Our data analysis was descriptive. We first prepared a descriptive table displaying injuries across the 39 sport and recreation activities and the 18 years of age. Next, we examined the 5 most common causes of sport and recreational injuries for each year of age development. Last, we assessed the percentage of boys’ and girls’ injuries for each of the 39 sport and recreational injury types.

RESULTS

During the years 2001–2008, an estimated 2 566 178 children, ages 1 to 18 years, were seen in US EDs for sport or recreation injuries. That divides into about 320 722 injuries per year or about 37 pediatric sport and recreational injuries treated per hour in the United States.

The estimated national annual injuries by sport and recreational activity and by age are displayed in Table 1. The table is organized by frequency of injury, with the most

Table 1. Estimated Number of Annual Injuries in the United States by Sport or Recreational Activity and Age Extended on Next Page

Activity ^a	No. of Injuries by Age, y												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Basketball	181	397	450	764	1396	2437	3504	5603	9812	16077	24988	33817	42611
Football	91	138	304	550	918	1919	4237	7509	12757	19374	27298	36953	42543
Bicycles ^b	2517	5270	8212	12522	16719	19816	21505	22777	25492	26997	27719	28733	27126
Playgrounds ^c	8051	12246	14585	18990	27561	28279	25254	20216	16777	13606	9573	6346	3453
Soccer	93	127	248	347	974	1637	2661	4051	6561	9061	11075	12616	15007
Baseball	419	803	1507	2075	2827	3548	5040	5937	8224	10708	11627	11909	11405
Skateboards	110	307	608	628	1037	1287	1864	2997	3515	5121	7415	11400	13351
Trampolines	1131	2790	4103	4569	5694	6492	6613	7513	7600	7390	7375	7040	6032
Exercise ^d	1921	2585	2184	2212	2218	2068	2327	2400	2990	3333	3720	4622	5002
Gymnastics and cheerleading	360	462	745	691	1149	1673	1701	2721	3573	5076	4870	5905	6589
Lacrosse and rugby ^e	348	636	825	646	1039	1293	2149	3193	4579	6049	6365	5907	5888
Swimming	1240	1997	2866	3153	3905	4203	3923	3912	4319	4403	4347	4544	3822
All-terrain vehicles	411	541	608	889	1222	1459	1705	2022	2465	2819	3604	4182	5178
Scoters	509	1114	2187	2560	4047	4348	4379	5342	5872	5889	5943	4218	2886
Snow skiing	0	50	29	114	376	417	818	1144	1859	2564	3999	5699	7271
Combative	5	86	74	117	315	556	661	1206	1416	1486	1949	3999	4692
Softball	34	67	74	79	191	245	494	675	1709	2195	3495	4373	6049
Hockey	22	66	95	239	242	403	683	734	875	1710	2817	3924	5295
Mopeds and minibikes ^f	15	137	85	161	293	471	910	1080	1614	1830	2595	3288	3853
Roller skating ^g	48	133	140	363	745	1536	2111	3308	4095	4929	4519	4014	2896
Volleyball	3	3	6	30	58	55	164	407	679	876	1574	2920	4046
Inline skating	16	9	43	74	346	685	1078	2210	3031	3853	3674	3478	2390
Horseback riding	46	295	319	350	489	491	564	1161	1305	1476	1849	2309	2368
Tobogganing and sledding ^h	45	175	474	719	965	1190	1417	1586	1944	2138	2374	2151	1708
Fishing	236	423	484	771	820	936	929	1136	1225	1492	1650	1853	1682
Golf	183	612	847	1083	1213	1286	1508	1461	1105	1050	944	876	993
Track and field	1	1	0	3	17	8	82	102	188	329	781	1276	2074
Amusement ⁱ	423	662	893	808	1036	1122	983	968	1275	1279	965	1028	831
Ice skating	2	21	81	217	479	677	1309	1018	1323	1611	1388	1303	1402
Go-carts	61	188	236	188	287	407	695	549	711	957	1040	1242	1117
Water skiing ^j	0	20	28	37	49	96	114	224	338	413	647	697	971
Racquet sports	21	86	71	72	115	171	223	362	364	380	464	668	713
Bowling	43	358	511	722	557	436	436	344	210	271	278	183	279
Snowmobiles	29	28	45	46	31	33	60	92	112	55	125	103	276
Nonpowder guns	31	67	121	25	16	37	69	6	140	187	173	242	213
Billiards	74	94	81	152	98	63	115	53	119	124	86	161	160
Watercraft ^k	1	18	3	15	33	30	24	43	23	60	70	59	128
Camping	88	104	103	71	56	121	116	121	116	94	115	92	12
Other sports	508	642	593	630	582	744	877	1516	1777	2279	3382	3433	3598
Total	3584	6052	7819	10132	13653	15820	17537	19680	23084	27126	30850	34876	37100

^a Activities are listed in decreasing order of injury incidence. Bold text is used for the age of development with the highest number of injuries.

^b Bicycles and accessories.

^c Playgrounds and playground equipment.

^d Exercise and exercise equipment.

^e Lacrosse, rugby, and other miscellaneous ball games.

^f Mopeds, minibikes, other off-road vehicles.

^g Skating other than ice skating and inline skating, including roller skating.

^h Toboggans, sleds, snow discs, snowtubes.

ⁱ Amusement attractions.

^j Water skiing, tubing, surfing.

^k Personal watercraft.

frequent causes appearing first. Peak age of injury incidence for each activity is marked in bold. Bowling caused the most injuries to children at the youngest age (4 years), and camping and personal watercraft, the oldest (18 years). The years with the most peaks of sport and recreational activity injuries were the middle teenage years, with 6 activities peaking in frequency at age 14 years and 9 activities peaking at age 15 years.

Total injuries varied widely across years of age. In general, younger children incurred the fewest sport and recreational injuries, and injury counts increased steadily

into the early teen years, with the overall peak occurring at 14 years. The decline in the later teen years was modest until age 18 years, when the rate plummeted to a rate comparable with age 6 years. Total injuries also varied widely across sport and recreational activities. Billiards, camping, and personal watercraft use all resulted in fewer than 200 injuries per year nationally, whereas basketball, football (American style), and bicycling each caused more than 300 000 injuries.

The 5 leading sport- and recreation-related injury causes at each age of development are shown in Table 2. In

Table 1. Extended From Previous Page

No. of Injuries by Age, y					
14	15	16	17	18	Total
48 090	49 394	46 783	44 452	29 781	360 537
46 680	45 554	41 527	37 286	16 676	34 2314
24 261	18 494	13 291	9 846	8 543	319 840
1 946	1 446	916	813	591	210 648
16 326	15 961	14 537	12 777	6 186	130 245
10 785	10 516	8 552	7 125	5 371	118 380
13 527	11 902	8 483	6 805	5 449	95 808
4 022	3 245	2 021	1 405	1 222	86 257
6 839	6 973	7 379	6 331	6 723	71 827
7 916	8 169	7 456	5 730	3 375	68 160
5 278	5 663	4 997	4 452	3 916	63 223
3 622	3 266	3 092	2 709	2 160	61 483
6 284	7 167	5 277	5 230	5 408	56 470
2 023	1 378	731	569	394	54 390
6 343	8 162	5 953	4 508	4 807	54 114
6 817	6 991	6 630	6 838	4 210	48 047
6 390	7 307	5 363	4 248	3 168	46 155
5 724	6 251	6 506	5 088	2 922	43 597
4 962	5 068	4 018	3 266	3 334	36 981
2 113	1 490	1 101	729	642	34 914
5 392	5 451	5 018	4 115	2 417	33 215
1 791	1 290	1 064	839	806	26 677
2 177	2 206	1 864	1 756	1 537	22 564
1 372	1 294	1 189	836	888	22 463
1 257	1 324	907	924	845	18 895
1 120	836	672	474	407	16 671
2 759	2 585	2 516	2 011	967	15 701
684	589	601	605	505	15 257
1 005	838	663	499	457	14 293
975	680	726	623	496	11 179
832	1 051	1 460	989	1 231	9 195
862	1 231	1 029	975	928	8 734
318	407	316	364	399	6 433
253	373	381	430	365	2 837
307	265	191	269	234	2 593
98	78	75	80	107	1 817
169	133	325	276	391	1 797
134	40	79	67	136	1 667
3 699	3 541	3 036	2 889	2 079	35 805
37 333	35 138	29 872	25 277	15 809	390 742

general, playground and bicycle injuries were the most common in the earlier ages of development, whereas team sports—especially basketball, football, and soccer—emerged as activities causing more injuries in later childhood and adolescent years.

The 5 leading sport- and recreation-related injury causes overall, throughout development—basketball, football, bicycling, playgrounds, and soccer are presented in the Figure. The 3 team sports—basketball, football, and soccer—showed a relatively similar trajectory: few injuries in early childhood, followed by a sharp increase in injuries around age 8 or 9 years, peaking in the middle teenage years, and then falling off rather sharply at 17 to 18 years. Basketball and football followed remarkably parallel trajectories, whereas soccer had a more muted peak. The 2 other most common causes of pediatric injury—playgrounds and bicycling—possessed very different pathways across development. Playground injuries peaked in the early elementary school years and then showed a slow but consistent drop-off into very low numbers during the teenage years. Bicycling injuries peaked in the preteen

years but were fairly common throughout most of childhood.

Information on the secondary question of interest, sex disparities in sport and recreational injuries, is offered in Table 3. Wide disparities emerged, with boys incurring more than 85% of baseball, football, moped, and non-powder gun injuries, and girls incurring more than 85% of gymnastics, cheerleading, and softball injuries. Sex disparities were absent in just a few sport and recreational activities: amusement attractions, ice skating, playgrounds and playground equipment, racket sports, soccer, track and field, and trampoline each had an injury incidence no greater than 55% for 1 sex.

DISCUSSION

Sport and recreational activities are generally safe, enjoyable, and healthy. Millions of youth in the United States and worldwide engage in sports and recreation daily without injury. Injuries, however, do occur and can dramatically affect physical and mental health. One critical aspect of preventing pediatric sport and recreational injuries is understanding how the injury risk varies across child and adolescent development. Such an understanding will help aid injury-prevention efforts by allowing experts to focus on specific causes and age groups.

Our results begin to address that need. We report the number of injuries incurred in the United States during an 8-year period, across 18 years of age, and for 39 sport and recreational activities. Examining just 1 year of age or just 1 type of sport or recreational activity offers substantial information. Rather than arduously reviewing the detailed information available in our tables, we discuss some of the more surprising data patterns and then address factors that may explain these findings.

Several individual sport and recreational activities showed injury patterns that surprised us. We did not anticipate, for example, that the largest number of bowling injuries might be incurred by young children—those 4 and 5 years old. We also did not expect so many—several hundred—toddlers (1–3 years old) to be injured by activities designed primarily for adolescents and adults, such as all-terrain vehicles, snowmobiles, fishing, and mopeds and minibikes. Also surprising was that exercising and exercise equipment was among the top 5 causes of injuries for 3 age categories: 1-year-olds, 2-year-olds, and 18-year-olds and that bicycle injuries persisted throughout all of child and adolescent development, placing it among the top 5 causes of sport and recreational injuries from ages 1 to 18 years.

Other results were expected. Playground and trampoline injuries were most prominent throughout early and middle childhood but were then replaced in prominence by team sports, with baseball as a top 5 injury cause at 7 years and team sports accounting for 4 of the top 5 causes of sport and recreational injuries from ages 11 to 18 years (baseball, basketball, football, and soccer). Interestingly, despite US football's reputation as a physical contact sport, basketball caused more injuries to US youth than did football, which may be partly due to exposure issues. Very few girls play competitive football in the United States, but both boys and girls play basketball, both competitively and recreationally. More youth may also be engaged in recreational (playground,

Table 2. Top 5 Sport and Recreational Injury Causes by Age Extended on Next Page

Rank	Activity by Age, y								
	1	2	3	4	5	6	7	8	9
1	Playgrounds ^a	Playgrounds ^a	Playgrounds ^a	Playgrounds ^a	Playgrounds ^a	Playgrounds ^a	Playgrounds ^a	Bicycles ^b	Bicycles ^b
2	Bicycles ^b	Bicycles ^b	Bicycles ^b	Bicycles ^b	Bicycles ^b	Bicycles ^b	Bicycles ^b	Playgrounds ^a	Playgrounds ^a
3	Exercise ^c	Trampolines	Trampolines	Trampolines	Trampolines	Trampolines	Trampolines	Trampolines	Football
4	Swimming	Exercise ^c	Swimming	Swimming	Scoters	Scoters	Baseball	Football	Basketball
5	Trampolines	Swimming	Scoters	Scoters	Swimming	Swimming	Scoters	Baseball	Baseball

^a Playgrounds and playground equipment.

^b Bicycles and accessories.

^c Exercise and exercise equipment.

Table 3. Percentage of Injuries Incurred by Each Sex Across Sport and Recreational Activities

Activity	%	
	Males	Females
Football	95	5
Combative	89	11
Skateboards	89	11
Mopeds and minibikes ^a	88	12
Baseball	86	14
Nonpowder guns	86	14
Fishing	83	17
Hockey	78	22
Snowmobiles	77	23
Water skiing ^b	75	25
Basketball	73	27
Bicycles ^c	73	27
Go-carts	72	28
Snow skiing	71	29
All-terrain vehicles	70	30
Golf	68	32
Lacrosse/rugby ^d	67	33
Billiards	65	35
Camping	64	36
Scoters	61	39
Tobogganing and sledding ^e	61	39
Exercise ^f	59	41
Bowling	58	42
Swimming	58	42
Inline skating	56	44
Personal watercraft	56	44
Playgrounds ^g	55	45
Racquet sports	53	47
Soccer	53	47
Trampolines	53	47
Amusement ^h	49	51
Track and field	47	53
Ice skating	45	55
Roller skating ⁱ	41	59
Volleyball	26	74
Horseback riding	25	75
Gymnastics and cheerleading	14	86
Softball	12	88
Other sports	59	41

^a Mopeds, minibikes, and other off-road vehicles.

^b Water skiing, tubing, surfing.

^c Bicycles and accessories.

^d Lacrosse, rugby, and other miscellaneous ball games.

^e Toboggans, sleds, snow discs, snowtubes.

^f Exercise and exercise equipment.

^g Playgrounds and playground equipment.

^h Amusement attractions.

ⁱ Skating other than ice skating and inline skating, including roller skating.

driveway, or “pick-up”) basketball nationwide than in football.

Our findings concerning the sex of injured children were largely as expected. Boys tended to have more injuries than girls in most categories, as has been reported in the broader child-injury literature.¹ The sports that had the higher numbers of female injuries were those that are more prototypically engaged in by US girls—softball, gymnastics and cheerleading, horseback riding, and volleyball.

How might the findings be explained? Caution must be exercised in interpreting causality from our descriptive data analysis, but biological development likely plays some role. Perceptual, cognitive, and motor skills develop throughout childhood and may affect how youth engage in activities that require balance, coordination, decision-making, and other developmental skills. Misjudgments, missteps, and miscalculations—often developmentally driven—can result in injury.⁶

Sociocultural factors are also likely relevant. To state the obvious, children are more likely to be injured in the sport and recreational activities in which they engage. We were unable to adjust our analysis for exposure,^{7,8} but one would expect more pediatric basketball injuries than pediatric bowling injuries based on the assumption that US children spend more time playing basketball than they do bowling. Sociocultural factors also may play more subtle roles. Increased independence from supervision and a developmental tendency toward impulsive risk taking could contribute to the high rate of injuries in “adventure” activities such as tobogganing and sledding, scooters, skateboards, and skates in the early and middle adolescent years.

The role of sociocultural factors may be increasingly important if national calls to increase physical activity among youth are successful.^{9,10} That is, we might expect increased sports and recreational injuries as youth are increasingly exposed to risk. That risk may vary through child development, and identifying data trends will assist with injury-prevention efforts.

Like all research using large, archival data sets, such as the NEISS, this study has strengths and limitations. Strengths include the size and scope of the data set and its ability to address a wide range of injuries across ages and sport and recreational activities. However, we also cite several limitations. First, we were unable to control for exposure to sport or recreational activities or injury situations. Second, we lacked detail about specific injury events, including antecedents and consequences of individual injury events, the particular types of injuries caused by each sport or recreational activity, or the severity of individual injuries. For example, exercise equipment

Table 2. Extended From Previous Page

Activity by Age, y									
10	11	12	13	14	15	16	17	18	Total
Bicycles ^b	Bicycles ^b	Football	Basketball	Basketball	Basketball	Basketball	Basketball	Basketball	Basketball
Football	Football	Basketball	Football	Football	Football	Football	Football	Football	Football
Basketball	Basketball	Bicycles ^b	Bicycles ^b	Bicycles ^b	Bicycles ^b	Soccer	Soccer	Bicycles ^b	Bicycles ^b
Playgrounds ^a	Baseball	Soccer	Soccer	Soccer	Soccer	Bicycles ^b	Bicycles ^b	Exercise ^c	Playgrounds ^a
Baseball	Soccer	Baseball	Skateboards	Skateboards	Skateboards	Baseball	Baseball	Soccer	Soccer

injuries to young children were likely caused by toddlers catching their fingers in equipment that adults were using, rather than being injured while using the equipment themselves.^{11,12} Third, an understanding of the severity of injuries would be particularly helpful to future researchers. Swimming injuries may range, for example, from allergic rashes to life-altering spinal-cord injuries. Although there were slightly more basketball than football injuries overall, football injuries may be more severe (eg, head injuries, fractures) than basketball injuries (eg, sprains). Fourth, we relied on injury reports from EDs only and did not include injuries that still affected children and their parents but were treated in urgent care settings, primary caregiver offices, school athletic trainer or nurse offices, or elsewhere. Fifth, we lacked information about the geographic location where the injury occurred or where the patients lived. Future investigators might consider differences between sport and recreational injury incidence among rural, urban, and suburban patients.

In conclusion, we found that almost 37 children experienced a medically treated sport or recreational injury in the United States every hour. Team sports (eg, basketball, football, soccer), plus bicycling and playgrounds, were the most common causes of pediatric sport and recreational injuries, but injuries were caused by a range of activities. Injury incidences varied across child and adolescent development, with different activities peaking in incidence at different ages.

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