playground of this size (these estimates are based on competitive bids for playground resurfacing materials in Omaha, Neb, 1992).

Play is the work of children. While adult work site safety is regulated by the Occupational Safety and Health Administration, there is little regulation of the work sites of America's urban children and youth. State and local health departments should work closely with city and county departments of parks, recreation, and public works and with school systems to minimize the risk and lessen the severity of playground injuries through injury prevention outreach, periodic playground surveillance, and rigorous park maintenance. Just as local service organizations in many cities have adopted roads and highways for beautification and litter control, community-based organizations and local businesses can sponsor safe parks for children in America's cities. □

Acknowledgments

This paper was presented in part at the Prevention 89 Meeting, April 1989, Atlanta, Ga, and at the 117th Annual Meeting of the American Public Health Association, October 1989, Chicago, Ill.

We wish to thank Carolyn Sue Stallings for assistance with the playground study, including data collection. We also thank Dr. Michael Weitzman for his general contributions as Director of Parent and Child Services for the Boston Department of Health and Hospitals. The Massachusetts Statewide Comprehensive Injury Prevention Program provided the baseline playground checklist. William Chavey assisted with data management. Joan Rostermundt, Betty Bogard, and Trysha Ahern assisted with manuscript preparation.

References

1. Chalmers DJ, Langley JD. Epidemiology of playground equipment injuries resulting in hospitalization. *J Paediatr Child Health.* 1990;26:329–334.
2. Langley JD, Chalmers D, Collins B. Unintentional injuries to students at school. *J Paediatr Child Health.* 1990;26:323–328.
3. Reichelderfer TE, Overbach A, Greensher J. Unsafe playgrounds. *Pediatrics.* 1979; 64:962–963.
4. Centers for Disease Control. Playground-related injuries in preschool-aged children—United States, 1983–1987. *MMWR.* 1988; 37:629–632.
5. Oliver TI, McFarlane JP, Haigh JC, Cant GM, Bodie AM, Lawson JS. Playground equipment and accidents. *Aust Paediatr J.* 1981;17:100–103.
6. Illingworth C, Breenan P, Jay A, Al-Rawi F, Collick M. 200 injuries caused by playground equipment. *Br Med J.* 1975;4:332–334.
7. Sacks JJ, Smith JD, Kaplan KM, Lambert DA, Sattin RW, Sikes RK. The epidemiology of injuries in Atlanta day-care centers. *JAMA.* 1989;262:1641–1645.
8. Ridenour MV. Elementary school playgrounds: safe play areas or inherent dangers. *Percept Motor Skills.* 1987;64:447–451.
9. Sacks JJ, Holt KW, Holmgreen P, Colwell LS, Brown JM. Playground hazards in Atlanta child care centers. *Am J Public Health.* 1990;80:986–988.
10. Coppens NM, Gentry LK. Video analysis of playground injury-risk situations. *Res Nurs Health.* 1991;14:129–136.
11. Ramsey LF, Preston JD. *Impact Attenuation Performance of Playground Surfacing Materials.* Washington, DC: Consumer Product Safety Commission; March 1990.

Surface-Specific Fall Injury Rates on Utah School Playgrounds

Daniel M. Sosin, MD, MPH, Patricia Keller, RN, BSN, Jeffrey J. Sacks, MD, MPH, Marcie-jo Kresnow, MS, and Peter C. van Dyck, MD, MPH

ABSTRACT

The purpose of this study was to estimate surface-specific rates of fall injuries on school playgrounds. Playground injuries related to falls from climbing equipment and the surfaces involved were identified from injury reports for 1988 to 1990 from 157 Utah elementary schools. Enrollment data and playground inspections were used to estimate student-years spent over each surface. The fall injury rates per 10 000 student-years were asphalt, 44; grass, 12; mats, 16; gravel, 15; and sand, 7. These data did not show that impact-absorbing surfaces reduce fall injuries on playgrounds better than grass. Improved field studies are needed to guide policy decisions for playground surfacing. (*Am J Public Health.* 1993;83:733–735)

Introduction

Playgrounds account for almost 200 000 injuries treated in emergency departments annually in the United States.[1] Falls from climbing equipment account for nearly one quarter of injuries on public playgrounds.[2] Climbing equipment is associated with a disproportionate number and severity of injuries relative to its prevalence on playgrounds.[1,3] Impact-absorbing surfaces have been recommended below climbing equipment to prevent fall injuries.[1–5] The merit of this recommendation is based on laboratory tests. The impact-attenuating qualities of synthetic mats and loose-fill materials (pea gravel, sand, wood chips, etc.) are extremely varied and depend on depth of the material, size of particles, drop height, and environmental conditions (e.g., moisture and temperature).[6–8] In actual use, loose-fill surfaces are rarely maintained at recommended depths[3,9,10] and require regular maintenance to loosen compacted material.[6–8] Also, children may be less cautious when playing over resilient surfaces (risk compensation), leading to an increase in frequency and height of falls over these surfaces. Because of the considerable potential differences between laboratory and field conditions and because of variations

Daniel M. Sosin is with the Division of Field Epidemiology, Epidemiology Program Office, and Jeffrey J. Sacks and Marcie-jo Kresnow are with the National Center for Injury Prevention and Control, all at the Centers for Disease Control and Prevention, Atlanta, Ga. Patricia Keller and Peter C. van Dyck are with the Division of Family Health Services, Department of Health, State of Utah, Salt Lake City, Utah.

Requests for reprints should be sent to Daniel M. Sosin, MD, MPH, Epidemiology Program Office (C-08), Centers for Disease Control and Prevention, 1600 Clifton Rd NE, Atlanta, GA 30333.

This paper was accepted January 15, 1993.

Editor's Note. See related editorial by Runyan (p 637) in this issue.

TABLE 1—Distribution of Playground Climbing Equipment, by Surface and Height, 157 Utah Schools, School Years 1988/89 and 1989/90

Height	No. Pieces of Equipment (Column %)					
	Mats	Gravel	Sand	Grass	Asphalt	Total
<4 ft	36 (14)	231 (26)	26 (14)	40 (34)	21 (88)	354 (24)
4–6 ft	81 (30)	203 (23)	81 (44)	29 (25)	3 (13)	397 (27)
>6 ft	149 (56)	451 (51)	76 (42)	49 (42)	0 (0)	725 (49)
Total (row %)	266 (18)	885 (60)	183 (12)	118 (8)	24 (2)	1476

TABLE 2—Incidence of Fall Injury Reports, by Surface and Severity, 157 Utah Schools, School Years 1988/89 and 1989/90

	Surface				
	Sand	Mats	Gravel	Grass	Asphalt
Student-years	33 822	35 525	112 538	16 174	3396
Injury reports	24	56	167	20	15
Incidence, total[a]	7.1	15.8	14.8	12.4	44.2
Rate ratio	1.0 (reference)	2.2	2.1	1.7	6.2
Severe injuries	14	30	71	10	10
Incidence, severe[b]	4.1	8.4	6.3	6.2	29.4
Rate ratio	1.0 (reference)	2.0	1.5	1.5	7.1

[a]Fall injury reports per 10 000 student-years.
[b]Fractures and concussions per 10 000 student-years; note that one injury report may contribute more than one severe injury.

in the costs of surfaces, it is important to evaluate the effectiveness of different surfaces under conditions of actual use.[11]

We addressed the effectiveness of different surfaces below playground climbing equipment by calculating surface-specific fall-injury incidence rates in Utah elementary schools.

Methods

Injuries were ascertained from student injury reports from elementary schools (kindergarten through grade 6) in Utah during the 2 school years from fall 1988 to summer 1990. Student injury reports are completed by school personnel and submitted to the state. Although school participation is voluntary, the computerized database included 83% to 85% of the elementary schools in Utah and 89% to 92% of the elementary students for the years reviewed. Reportable injuries were those severe enough to cause school absence of at least half a day or to warrant medical attention and treatment. Eligible reports were those with the following codes: location, "athletic field" or "playground"; injury activity, "climbing" or "playing on bars"; equipment involved, "yes"; and contributing factor, "fall." Surfaces on which falls occurred included asphalt, concrete, grass, dirt, synthetic (rubber-like) mats, sand, and gravel. Because of the extremely limited use of concrete under climbing equipment and the similar impact-attenuating characteristics of the two materials,[6] injuries on concrete were included with injuries on asphalt. Because of assumed similar characteristics and the potential for variability in labeling of grass vs dirt, an a priori decision was made to group grass and dirt together as "grass."

A one-time inspection was conducted of all school playgrounds in 1988 and 1989 by local health departments to count equipment, determine the maximum height from which a child could fall, and identify the surface below equipment. Because the specific piece of equipment involved in an injury was not identified on the injury report, characteristics of equipment and surfaces (e.g., maximum fall height) could not be linked directly to injury events. A relative height score was calculated for each surface type by multiplying the percentage of equipment in the lowest height category (<4 ft) by zero, that in the middle category (4 to 6 ft) by one, and that in the highest category (>6 ft) by two.

A student-year reflects the playground exposure of a single student during a single school year. For this study, we assumed that each piece of climbing equipment at a given school had equal use by students there. The incidence of fall injury reports was calculated for each surface as follows:

$$I_x = \frac{\sum N_{xi}}{\sum (2E_i \cdot (P_{xi}/P_i))} \cdot 10\,000,$$

where I_x = the incidence of fall injury reports per 10 000 student-years for surface x (summed for 157 schools); N_{xi} = number of injury reports at school$_i$ on surface x; E_i = school$_i$ enrollment as of September 1989; P_{xi} = pieces of climbing equipment at school$_i$ over surface x; and P_i = total pieces of climbing equipment at school$_i$. E_i was multiplied by 2 because the study covered 2 years. We chose not to calculate confidence intervals for the surface-specific injury rate ratios because of the unusual degree of uncertainty in the assumptions used for calculating incidence rates (e.g., equal use of equipment on a playground) and the limited adjustment for important confounders.

Results

A total of 448 injuries, including 108 fractures and 27 possible concussions, were recorded on the 282 reports that met the selection criteria. The overall incidence of playground fall injury reports (events) was 14 per 10 000 student-years, and rates were comparable for girls and boys (15 and 13, respectively). The incidence varied by grade and was lowest in kindergarten (3 per 10 000 student years) and highest in first grade (19), with rates of 16 in second and third grades, 15 in fourth grade, 16 in fifth grade, and 10 in sixth grade.

Sixty percent of the 1476 pieces of climbing equipment were sited over gravel (Table 1). Most of the equipment over mats and gravel was more than 6 feet high; only 13% of the equipment over asphalt was more than 4 feet high. The relative height scores were 142 for mats, 128 for sand, 125 for gravel, 109 for grass, and 13 for asphalt.

The incidence of fall injury reports was lowest for sand (Table 2). The injury rate for asphalt was six times that for sand. Mats and gravel had rates twice that of sand; however, the rate difference was between 7 and 9 injuries per 10 000 student-years. Incidence rate ratios for severe injuries (fractures and possible concussions) were similar to the overall rate ratios (Table 2).

Discussion

Consistent with laboratory tests showing excessive deceleration at drop heights over asphalt of only 2 inches,[6] the risk of equipment-related fall injuries appeared greater over asphalt despite considerably lower equipment heights over asphalt. Given the heterogeneity of other surfaces (e.g., in depth, size, environmental conditions) and the data limitations discussed below, our data do not enable us to identify one impact-absorbing surface as clearly superior. In fact, there are no findings from this study, or others known to us, to validate superior performance of any impact-absorbing surface in actual use when compared with grass and dirt. Even when relatively minor injuries were included, the absolute risk of injury on grass appeared to be low (12 injury events per 10 000 student-years). Thus, the priority of modifying playground surfaces other than asphalt seems legitimately debatable.[11]

To open debate and promote scientific inquiry is, perhaps, as far as these data can take us. The data limitations were considerable, beginning with our inability to directly measure play time over each surface (exposure) and our reliance on an assumption of equal play on each piece of equipment at a school. In all likelihood, children have definite preferences for equipment and those preferences could have been associated with the type of surface. For example, if multiplatform, integrated climbing structures are more popular or accommodate more children and are more likely to be sited over impact-absorbing surfaces because they are newer, then assuming equal exposure would underestimate the true exposure and thereby overestimate the rate of injuries on impact-absorbing surfaces.

Some factors may confound the relationship between surface type and fall injury. Factors potentially affecting the risk of a fall, independent of their association with surface type, include student age, supervision, and equipment design. Similarly, student age, other equipment features (such as height), and surface hazards (such as contaminants and protrusions) may affect the risk of an injury when a fall occurs. Potential bias, such as differential reporting of injuries by schools with more or less impact-absorbing material, must also be considered. The ability of future studies to address these factors will be important for understanding the mechanisms through which the field effectiveness of impact-absorbing surfaces appears to be diminished. Because playground equipment injuries are relatively uncommon, resourceful case-control designs and exposure measurement techniques are likely to be necessary. Just as there is an imperative in curative medicine to consider technologic advances in terms of health outcomes, preventive strategies such as using impact-absorbing surfaces for the prevention of playground injuries should be assessed with health measures of performance, not just their intuitive appeal or results of laboratory tests. □

Acknowledgments

This study was partially funded by grant R49/CCR803285-03 from the Centers for Disease Control and Prevention.

The authors wish to thank the following: Don Mudget, Calvert Cazier, Patricia Cox, and Ron Steele, Division of Family Health Services, Department of Health, Utah, for coordination of data collection, entry, and programming; the environmental health inspectors of Utah local health departments for conducting the playground inspections; and Barbara Houston, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, for programming and data editing.

References

1. Centers for Disease Control. Playground-related injuries in preschool-aged children—United States, 1983–1987. *MMWR*. 1988;37:629–632.
2. Tinsworth DK, Kramer JT. *Playground Equipment-Related Injuries and Deaths.* Washington, DC: US Consumer Product Safety Commission; April 1990.
3. Boyce WT, Sobolewski S, Sprunger LW, Schaefer C. Playground equipment injuries in a large, urban school district. *Am J Public Health*. 1984;74:984–986.
4. Reichelderfer TE, Overbach A, Greensher J. Unsafe playgrounds. *Pediatrics.* 1979; 64:962–963.
5. *Handbook for Public Playground Safety.* Washington, DC: US Consumer Product Safety Commission; 1991.
6. Preston JD, Ramsey LF. *Impact Attenuation Performance of Playground Surfacing Materials.* Washington, DC: US Consumer Product Safety Commission; March 1990.
7. Mahajan BM, Beine WB. *Impact Attenuation Performance of Surfaces Installed Under Playground Equipment.* Washington, DC: National Bureau of Standards; 1979. US Dept of Commerce Publication NBSIR 79-1707.
8. *Playground Surfacing: Technical Information Guide.* Washington, DC: US Consumer Product Safety Commission; 1990.
9. Sacks JJ, Holt KW, Holmgreen P, Colwell LS Jr, Brown JM Jr. Playground hazards in Atlanta child care centers. *Am J Public Health*. 1990;80:986–988.
10. Langley J, Crosado B. School playground climbing equipment—safe or unsafe? *NZ Med J.* 1982;95:540–542.
11. Ball DJ, King KL. Playground injuries: A scientific appraisal of popular concerns. *J Royal Soc Health*. 1991;111:134–137.