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Too Many Pediatric Trampoline Injuries

Ronald A. Furnival, MD*‡; Kellee A. Street, MD‡; and Jeff E. Schunk, MD*‡

ABSTRACT. *Background.* Recent reports note a dramatic increase in the number of pediatric trampoline injuries (PTI) during the past several years. In 1996, the US Consumer Product Safety Commission estimates that 83 000 patients received treatment for trampoline injuries in US hospital emergency departments (EDs), and that ~75% of these patients were <15 years of age. We sought to review our experience with PTI since our previous report (*Pediatrics* 1992;89:849), and to determine if the American Academy of Pediatrics' current (*Pediatrics* 1981;67:438) safety recommendations are adequate.

Methods. Retrospective medical record review of all PTI patients presenting to the pediatric ED from November 1990 through November 1997.

Results. A total of 727 PTI patients were included; medical records were unavailable for 3 patients. The annual number of PTI nearly tripled during the study period, from 51 in 1991 to a peak of 148 in 1996. PTI patients were 53% female, with a median age of 7 years; 37% were <6 years of age. Privately owned trampolines accounted for 99% of PTI. Most injuries (66%) occurred on the trampoline, 28% resulted from falls off, and 4% from imaginative mechanisms. One hundred eleven patients (15%) suffered severe injury (1990 Abbreviated Injury Scale value ≥ 3), usually of an extremity (89 out of 111). Fractures occurred in 324 patients (45%). Spinal injuries were common (12%), including 7 patients with cervical or thoracic fractures, and 1 with C7 paraplegia. Fractures were more frequently associated with falls off the trampoline, whereas spinal injuries more frequently occurred on the trampoline. Eighty patients (11%) required prehospital medical transport to our ED, 584 (80%) had ED radiographs, and 382 (53%) required pediatric surgical subspecialty involvement. Seventeen percent of PTI patients (125 out of 727) were admitted to the hospital, including 9 to the pediatric intensive care unit; 99 (14%) required one or more operations. Mean hospital stay was 2 days (range, 1–63 days); 24 stays (19%) were for ≥ 3 days. We estimate that the hospital charges for the acute medical care of PTI study patients at our institution totaled ~\$700 000.

Conclusions. PTI are dramatically increasing in number, and result in considerable childhood morbidity. Most PTI occur on privately owned trampolines. Few, if any, safety recommendations for the trampoline are followed. We support recommendations for a ban on the recreational, school, and competitive pediatric use of trampolines. *Pediatrics* 1999;103(5). URL: <http://www.pediatrics.org/cgi/content/full/103/5/e57>; *trampoline, injuries, injury prevention, recreation.*

ABBREVIATIONS. AAP, American Academy of Pediatrics; ED, emergency department; PTI, pediatric trampoline injuries; PCMC, Primary Children's Medical Center; AIS, Abbreviated Injury Scale; ISS, Injury Severity Score; RR, relative risk; CI, confidence interval; CPSC, United States Consumer Product Safety Commission.

In response to a number of devastating cervical spine injuries, the American Academy of Pediatrics (AAP)¹ issued a policy statement in 1977 recommending "that trampolines be banned from use as part of the physical education programs in grammar schools, high schools, and colleges, and also be abolished as a competitive sport." Throughout the next 4 years, trampoline-related injuries dramatically decreased, as schools faced increased insurance costs and legal liability, and the trampoline was dropped from physical education programs.² In 1981, the AAP³ softened the previously recommended ban with a second policy statement, "Trampolines II," which did not directly endorse trampoline use, but called for a "revision of the Academy's position to allow for a trial period of limited and controlled use" of the trampoline by schools. "Trampolines II" also called for an ongoing "careful assessment of the incidence and severity of injury" during this trial period, and included seven safety recommendations, including a ban on home and recreational use of trampolines.³ Unfortunately, the increase in closely supervised school and athletic trampoline use sought by "Trampolines II" did not occur, and the number of children injured on privately-owned trampolines increased.

In 1992, we reported 114 pediatric trampoline injuries treated in our pediatric emergency department (ED).⁴ Nearly all the injuries took place on privately-owned equipment, usually while few of the suggested safety guidelines were being observed; furthermore, a detailed review of the literature provided no evidence that the guidelines of "Trampolines II" would adequately prevent injury. Based on these findings, we called for "a ban on the use of recreational trampolines for the pediatric population."⁴ Although the authors of some recent studies have also called for such a ban on private trampoline use,^{5–7} no recent formal policy addressing trampoline use has been issued from any pediatric advocacy organization.

We sought to look further at the PTI patients presenting to our ED, to analyze the factors contributing to PTI occurrence (type of jump, number of participants on the mat, etc), the type of trampoline injuries treated at our institution, the nature of the medical care required, and to estimate overall hospital

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charges for the treatment of these children (a full-sized trampoline can be purchased locally for under \$250). In addition, we will address the efficacy of safety guidelines as outlined by the AAP in "Trampolines II," as well as other recommendations from the medical literature.

METHODS

All PTI patients, who were treated in the ED at Primary Children's Medical Center (PCMC), from November 1, 1990 (when enrollment in our previous study ended) through October 31, 1997, were included for review. Patients were identified from the ED trauma log, (which is maintained daily, and includes a brief description of the injury mechanism, diagnoses, and outcome for all trauma patients evaluated in the ED), and their medical records were retrospectively reviewed. Children whose medical records were incomplete, who were admitted to the hospital but not evaluated in the ED or who were readmitted for subsequent therapy, were not tracked and were excluded. Data gathered for review included patient demographics, mechanism of injury, type of injury, trampoline ownership, hospitalization versus outpatient treatment, and subspecialty referral. In addition, all injuries were characterized for each patient using the Glasgow Coma Scale,⁸ the 1990 Abbreviated Injury Scale (AIS-90),⁹ and a calculated Injury Severity Score (ISS).^{10,11}

An estimate of the overall hospital charges for PTI acute medical care at our institution was calculated using computerized PCMC Patient Account Services data. For PTI ED outpatient charges, accounting data from 76% (93 out of 122) of the 1997 patients was used to estimate overall charges for outpatients from the previous years. For PTI inpatient charges, accounting data from 64% (16 out of 25) of hospitalized patients from 1996 and 1997 was used to estimate overall charges for inpatients from the previous years. Accounting data from 78% (7 out of 9) of the PTI patients initially admitted to the pediatric intensive care unit (PICU), was used to estimate the overall critical care charges. Medical charges for physician services, prehospital transport, and outpatient follow-up visits all use separate billing services, and were not included, nor were charges for patients requiring hospital readmission.

Patient data were initially analyzed with descriptive statistics concerning demographic characteristics of the PTI population (age, sex, mechanism of injury, etc). In addition, we analyzed the type of injuries treated in the ED, as well as the treatment measures required (prehospital medical transport, hospitalization and length of stay, surgical consultation or operation, PICU admission and length of stay, etc). Categorical variables were analyzed using χ^2 analysis; nonnormally distributed continuous variables were compared using Mann-Whitney *U* analysis. Comparisons were considered statistically significant if $P < .05$. Relative risk (RR) with a 95% confidence interval (CI) was also calculated. Statistical calculations were performed with StatView 5 for Macintosh (SAS Institute Inc, Cary, NC).

To preserve patient confidentiality, no names or medical record numbers were included in the data, in any presentation, or in publication, nor were patients or family members contacted in the course of this study. This study was reviewed and approved by the PCMC Research and Human Subjects Institutional Review Board.

RESULTS

The trauma log identified 730 patients who received medical treatment in our ED for trampoline injuries from November 1, 1990 through October 31, 1997. A total of 727 PTI patients were included for review; 3 ED outpatients with incomplete medical records were excluded. Twelve PTI patients (1.7%) were readmitted to the hospital, primarily for follow-up operations of orthopedic injuries, and 12 patients returned to the ED for reevaluation of their injuries, but were not admitted; only the initial ED visits were included for both groups. PTI occurred throughout the year, with the majority in the warm

weather months of spring and summer (Fig 1). The annual number of PTI patients presenting to our ED dramatically increased during the course of the study, from 51 in 1991, to a peak of 148 in 1996, with a slight decrease in 1997 (Fig 2). The number of hospital admissions also rose each year from 9 in 1991, to 23 in 1994, and then remained fairly constant through 1997 (Fig 2).

The median age of PTI patients was 7 years (range, 3 months to 17 years); 388 (53.3%) were female (Fig 3). Thirty-seven percent of PTI patients (266 out of 727) were <6 years of age. Ownership of the trampoline on which the PTI occurred could be determined for 87.6% (637 out of 727) of patients. Eight patients (1.3%) were injured in a school or gym, the remaining 629 PTI (98.7%) occurred on privately-owned (family's, relative's, neighbor's, or friend's) equipment.

The mechanism of injury was noted for 716 of the 727 (98.5%) PTI patients (Table 1). The majority of PTI (65.9%) occurred on the body of the trampoline, including falls onto the mat, falls onto the springs, collisions with other trampolinists, and flips or complex maneuvers on the mat. A minority of PTI (28.2%) occurred from falls off of the trampoline, or from imaginative mechanisms (4.4%). The number of trampolinists on the mat at the time of injury was documented for 26% (187 out of 727) of PTI patients. Two or more people were on the trampoline in 83% (156 out of 187) of these cases, with as many as 6 trampolinists noted at the time of injury.

All PTI were characterized by AIS-90 scoring, summarized by body region in Table 2. Fifteen percent of all PTI patients (111 out of 727), and 71% of the hospitalized PTI patients (89 out of 125) suffered a severe injury (defined as an AIS-90 value ≥ 3), usually of an extremity (Table 2). For all PTI patients, the median ISS was 4 (range, 1-25), with a median of 9 for those requiring hospitalization. Fractures were common, occurring in 45% (324 out of 727) of PTI patients. Eighty-six patients (12%) had a spinal injury, most with minor strains, but included 7 patients with cervical or thoracic fractures, 6 with spinal cord injury without radiographic abnormality syndrome, and 1 patient with a permanent C7 paraplegia. Closed head injury with an associated altered level of consciousness (Glasgow Coma Scale <15) was noted

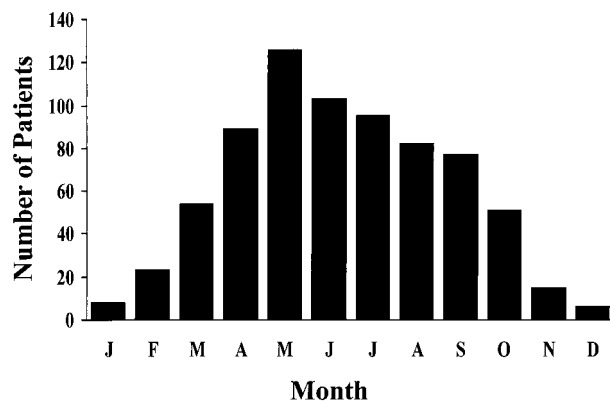


Fig 1. Number of pediatric trampoline injury patients by month of year.

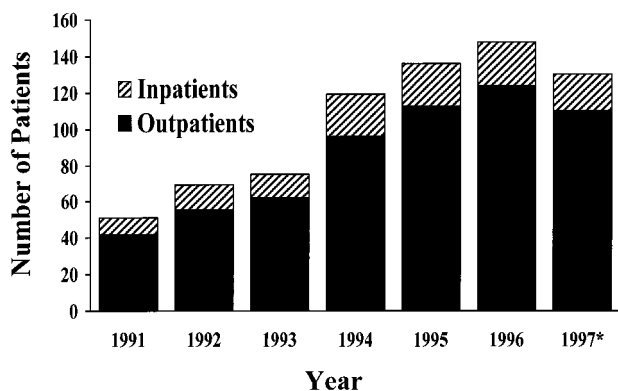


Fig 2. Annual number of pediatric trampoline injury patients, divided by inpatient versus outpatient therapy. (*The 1997 total does not include the months of November and December, when 1 PTI patient was treated in the ED, and was excluded from study.)

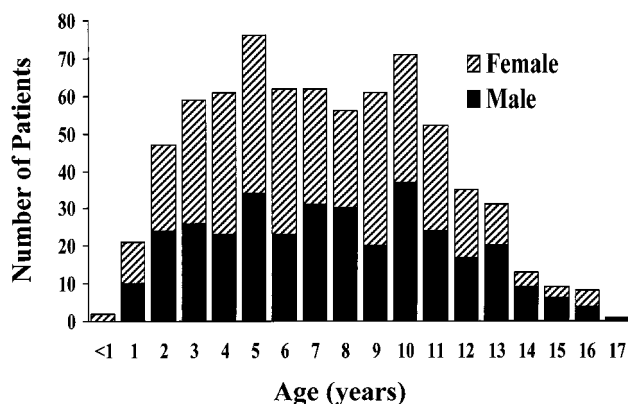


Fig 3. Number of pediatric trampoline injury patients by age and gender.

TABLE 1. Mechanism of Trampoline Injury for 727 Pediatric Patients

Mechanism	Number of Patients (%)
Injury on trampoline	479 (65.9)
Fall on mat	284
Fall on springs	81
Collision	66
Flip/complex	48
Fall off trampoline	205 (28.2)
Imaginative	32 (4.4)
Known mechanism	716 (98.5)
Unknown mechanism	11 (1.5)

in 15 PTI patients (2%), including 2 patients with epidural hematomas. Three patients suffered liver or splenic lacerations requiring nonoperative inpatient treatment.

Eighty PTI patients (11%) were brought to our ED by prehospital medical transport, including 12 by air transport services. In the ED, 80% of patients (584 out of 727) had radiographic imaging studies performed, including 35 computed tomography scans. Consultation from pediatric surgical subspecialty services (orthopedic surgery, general surgery, neurosurgery, etc) was obtained for 382 PTI patients (53%). One or more operations were required for 14% (99 out of 727) of PTI patients, most frequently for fracture reduction of the supracondylar humerus ($n = 31$),

TABLE 2. Number of Pediatric Trampoline Injuries Assigned Each 1990 Abbreviated Injury Severity Score (AIS-90) Value*

Body Region	Number of Injuries Assigned to Each AIS-90 Value				
	1	2	3	4	5
Head	10	72	2	2	0
Face/neck	157	3	12	0	1
Chest	26	3	1	1	0
Abdomen	15	5	3	0	0
Extremity	154	232	89	0	0
Skin	0	3	0	0	0

* AIS-90 grades each injury by severity, from 1 (least severe) to 5 (survival uncertain) within six body regions.

radius and/or ulna ($n = 28$), tibia and/or fibula ($n = 16$), and femur ($n = 11$). Seventeen percent of patients (125 out of 727) required hospital admission, including 9 who were initially admitted to the PICU. The mean hospital length of stay was 2.4 days (range, 1–63 days); 19% (24 out of 125) of all hospitalizations were for 3 or more days. None of the 727 PTI study patients died as a result of their injuries.

PTI patients who fell off the trampoline were more likely to have a fracture ($P = .0007$; RR = 1.34; 95% CI, 1.14–1.58), or require an operation ($P = .04$; RR = 1.51; 95% CI, 1.04–2.19), than those injured on the body of the trampoline. In contrast, spinal injuries were more likely to occur on the body of the trampoline ($P = .0002$; RR = 2.98; 95% CI, 1.57–5.64), with a strong association with flip/complex mechanisms of injury ($P < .0001$; RR = 6.03; 95% CI, 4.25–8.56). PTI patients requiring hospital admission were younger ($P = .02$ by Mann-Whitney U), had higher ISS values ($P < .0001$ by Mann-Whitney U) and were more frequently brought by prehospital transport ($P = .0005$; RR = 2.95; 95% CI, 2.17–3.99), than patients who were discharged from the ED.

An estimate of the hospital charges for the acute care of PTI patients was performed using 1996 and 1997 computerized PCMC Patient Account Services data. This subset of PTI patients was not significantly different from the other PTI patients for mechanism of injury, type of injury, ISS, ED evaluation using radiography or surgical consultation, hospital admission, PICU admission, operation, or hospital length of stay. The hospital charges for outpatient PTI medical care was estimated using patient account data from 76% (93 out of 122) of the patients who were discharged from the ED in 1997. The average hospital charge for these patients was \$340.27 (range, \$29.52 to \$2708.42). An estimate of the total PTI outpatient charges, with application of the average charge to all 602 outpatients during the study period, exceeds \$205 000. Patient account data were available for 64% (16 out of 25) of the 1996 and 1997 hospitalized PTI patients. The average charge for these inpatients was \$2700.97 (range, \$619.46 to \$5484.96). The estimate of total PTI inpatient charges, with application of the average inpatient charge to the 116 non-PICU patients, was ~\$310 000. Accounting data were available for 78% (7 out of 9) of the PTI patients who were initially admitted to the PICU. The average charge for these critical care patients was \$20 843.68 (range, \$3264.18 to \$110 337.65). The total inpatient

charges for the 9 PICU patients, using the above average charge, was an estimated \$185 000. Therefore, the total hospital charges for acute medical care at our institution for PTI patients during the 7-year study period was ~\$700 000.

DISCUSSION

The 7 years since our previous report have seen a steady increase in the annual number of PTI patients presenting to our facility. With 727 PTI patients in this study, 114 patients from our previous series,⁴ and 7 patients in a report from the PCMC Department of Pediatric Medical Imaging,¹² our institutional experience with trampoline injuries is the most extensive in the medical literature. Unfortunately, the trampoline continues to be one of the most common causes of childhood injury among our ED patients. Although a number of authors have made recommendations to improve the safety of trampoline use, our experience, and a review of the medical literature, would indicate that these measures are at best, ignored in the recreational setting, and are probably ineffective.

With a median age of 7 years, our PTI patients were younger than those in two large epidemiologic studies, both of which noted a median age of 10 years.^{6,7} In addition, 37% of our patients were younger than 6 years of age, a higher proportion than noted in several recent trampoline injury studies, including our previous report.^{4-7,13-15} The young age of our PTI patients may simply reflect the referral patterns in our area, but a dramatic increase in PTI among children younger than 5 years of age was also noted in Smith's⁶ analysis of nationwide data from the United States Consumer Product Safety Commission (CPSC). Despite previous recommendations that the trampoline be limited to older, and presumably more capable children, it is apparent that very young children are increasingly suffering from trampoline injury.

Injury mechanisms associated with trampoline use have long been debated in the medical literature. Unfortunately, Smith's recent nationwide epidemiologic report⁶ using CPSC data did not include information about injury mechanism. In a report from a nationwide database in New Zealand, with 2098 hospital admissions throughout a 10-year period, Chalmers and coworkers⁷ found that 80% of trampoline injuries occurred from falls off, whereas we found that the majority (65.9%) of our PTI patients were injured on the body of the trampoline, as other reports have also documented.^{4,5,12,16-32} Although falls from the trampoline were significantly associated with fractures in our study, we did not find an association between falls from the trampoline and hospital admission. Comparison of our patients and those requiring hospitalization in the New Zealand study is difficult, but in both populations, fractures were the predominant injury. Most of our 324 PTI patients with fractures were treated as ED outpatients, with reductions performed, when necessary, under a conscious sedation and regional anesthesia protocol by our pediatric orthopedic surgery service.³³ Seventy-one percent of our hospitalized PTI patients suffered

a severe injury (AIS ≥ 3), as compared with an estimated 12% of the New Zealand inpatients, suggesting that differences in admission practices may account for the dissimilar rates of injury mechanisms, with the more severe trampoline injuries occurring on the body of the trampoline.^{7,15} Nearly 16% of our PTI patients were injured while performing flips or other complex maneuvers, or in collisions with other trampolinists. In addition, 4.4% of our PTI patients in the current study, a similar proportion to other reports, were injured during imaginative activities (eg, jumping off of a roof onto the trampoline, jumping with a snowboard on the trampoline, jumping while other children are underneath the trampoline, etc), emphasizing the hazards of unsupervised pediatric trampoline use.^{4,14} Unfortunately, injury on the trampoline may occur even with adult supervision. Smith and Shields⁵ noted in a recent report that 73% of PTI patients <6 years of age were injured on the trampoline while under direct adult supervision. Furthermore, a parental survey found that 55% of PTI patients continued to play on the trampoline even after suffering an injury, demonstrating that measures to increase safety awareness as a means to reduce trampoline injuries are unlikely to be very effective.⁵

Fractures and spinal injuries were more common among our PTI patients (45% and 12%, respectively) than other recent studies.^{5,6,13-15} Seventeen percent of our PTI patients required hospitalization, the highest rate reported since our previous series,^{4-6,13-15} and 14% of our PTI patients required an operation, a rate also higher than previously reported.^{5,6,13} Finally, by objective injury severity measures, (a median ISS of 4 for all patients, a median ISS of 9 among hospitalized patients, an AIS ≥ 3 for 15% of all patients, and an AIS ≥ 3 for 71% of hospitalized patients) our PTI patients were more severely injured than noted in two previous reports.^{5,7} Given this level of injury severity among our PTI patients, the trampoline cannot be considered a simple backyard toy.

The very nature of the trampoline safety debate has changed considerably since "Trampolines II."³ The first AAP statement on trampoline safety, so-called "Trampolines I," facilitated the elimination of trampolines from schools and athletic organizations.^{1,2,4,6,13} "Trampolines II" was intended to support a "trial period of limited and controlled use by schools" with an ongoing "careful assessment of the incidence and severity of injury" and has been unsuccessful on two levels. First, no return of the trampoline to physical education classes in schools has occurred, nor is likely to occur, because of the hostile legal environment generated by these and similar statements.^{2,13} In addition, such "limited and controlled use" was exactly what initially led to the stronger stance of "Trampolines I"; trampoline injuries were occurring in schools and athletics, including devastating spinal injuries, despite use by trampolinists of collegiate and Olympic-caliber skill levels,^{2,16,20,24-26,29-32} despite closely monitored use under the supervision of trained instructors and coaches,^{17,18,20,22-26,29,30,32} and despite the use of spotters along the sides of the trampoline.^{17,23,29,30} Second, although "Trampolines II" stated that "the trampoline

should never be used in home or recreational settings", private and recreational trampoline injuries have reached epidemic proportions.⁶ Ninety-nine percent of our PTI patients, in both the current and previous report, were injured on private equipment.⁴ Similarly high rates of private trampoline ownership were noted in the US CPSC data analysis (93%), in an Australian report (84%), and in the national database from New Zealand (71%).^{6,7,14} From a follow-up phone survey of their trampoline injury patients in nearby Logan, Utah, Larson and Davis¹³ found that 96% had access to an average of three privately-owned trampolines. Virtually all the authors addressing trampoline safety before these recent reports were concerned about trampoline use in schools and athletics, and uniformly deplored trampoline use in the private recreational setting.^{3,16,20,21,23,30,34} Recommendations in several recent reports regarding recreational trampoline use have included increased supervision, increased use of spotters, placing the trampoline at ground level, placing padding around the outside of the trampoline, enclosing the trampoline within a fence, and the avoidance of complex maneuvers.^{7,13-15} However, a review of the literature clearly indicates that similar measures failed to make trampolines safe enough for the "limited and controlled use" in schools and athletics. These measures are very likely to fail again in the unlimited and uncontrolled use now occurring in the private, backyard setting.

We estimated that the hospital charges for acute care of the 727 PTI patients treated at our facility was ~\$700 000. Because physician services, prehospital transport, outpatient follow-up visits, and hospital readmissions were not included, this value represents an underestimate of the true charges. In addition, because our PTI patient population was more severely injured than noted in recent reports,^{5-7,13-15} comparisons of hospital charges to other centers may be problematic. A more comprehensive overall estimate of the costs associated with PTI, including medical, legal, insurance, and disability costs, appears in a position statement from the American Academy of Orthopaedic Surgeons, "Trampolines and Trampoline Safety."³⁵ For the 52 103 ED visits of PTI patients <15 years of age in 1995, the estimate totals a staggering \$272.6 million.³⁵

Our report is subject to several limitations. First, as a retrospective study, we used only information available from the medical record, and thus depended on nonstandardized documentation for our data. However, because of our previous report, our physicians and nursing staff are more aware of certain risk factors and injury mechanisms associated with trampoline use, and provided more detailed documentation as a result. We were able to determine trampoline ownership for 87.6% and mechanism of injury for 98.5% of PTI patients, directly from patient records, both very high percentages for a retrospective review. Second, although 727 of 730 of the PTI patients who were treated in our ED were included in this review, patients admitted to our facility bypassing the ED, extremely uncommon at our institution, are not included. Third, our estimates

of the hospital charges for acute PTI care are derived from 1996 and 1997 dollar amounts, and may not accurately reflect charges from previous years, although the current medical management climate has generally resulted in shorter hospital stays, and more outpatient care than in years past. Finally, our PTI patients may be more likely to require subspecialty care, surgery, or hospitalization than reported elsewhere, because of our unique regional referral patterns. For 1997, our rate of hospital admissions was 15%, quite similar to the 17% rate among PTI patients.

When the AAP recommended a ban on infant walkers in the US in 1995, the CPSC estimated that 25 000 children were injured each year, and 11 deaths were attributed to walkers in the preceding 5 years.³⁶ The CPSC estimates that in 1996, US hospital EDs treated 83 000 patients for trampoline injuries, ~75% of whom were <15 years of age, with 6 deaths reported since 1990.³⁷ Pediatric trampoline injuries have clearly reached epidemic levels, and we must join other authors in once again calling for a ban on the private recreational trampoline use by children.^{4-7,16,19,21,23,29,30,34} Furthermore, our review of the literature indicates that before "Trampolines I," severe trampoline injuries occurred despite advanced skill, trained supervision, and standard safety measures. We must therefore also call for an end to the "trial period of limited and controlled use by schools," and recommend a return to the unequivocal and stronger stance of "Trampolines I."^{1,3} Trampolines have no place in children's homes, schools, or competitive sports.

SUMMARY

We report on 727 children with trampoline injuries, treated in our Pediatric ED during a 6-year period. Our experience, and a review of the medical literature, indicates that trampolines cannot be made safe enough for private pediatric recreational use, and that a trial period of limited and controlled use by schools is unlikely to occur. Pediatricians should be aware of the hazardous nature of trampoline use, and support a return to the unequivocal 1977 AAP stand of "Trampolines I." The trampoline has no place in the home, school, or competitive setting for children.

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