



POLICY STATEMENT

Trampoline Safety in Childhood and Adolescence

abstract

FREE

Despite previous recommendations from the American Academy of Pediatrics discouraging home use of trampolines, recreational use of trampolines in the home setting continues to be a popular activity among children and adolescents. This policy statement is an update to previous statements, reflecting the current literature on prevalence, patterns, and mechanisms of trampoline-related injuries. Most trampoline injuries occur with multiple simultaneous users on the mat. Cervical spine injuries often occur with falls off the trampoline or with attempts at somersaults or flips. Studies on the efficacy of trampoline safety measures are reviewed, and although there is a paucity of data, current implementation of safety measures have not appeared to mitigate risk substantially. Therefore, the home use of trampolines is strongly discouraged. The role of trampoline as a competitive sport and in structured training settings is reviewed, and recommendations for enhancing safety in these environments are made. *Pediatrics* 2012;130:774–779

George Nissen, a competitive gymnast, patented the modern trampoline as a “tumbling device” in 1945. Nissen initially designed the trampoline as a training tool for acrobats and gymnasts and subsequently promoted it for military aviator training. Recreational use of trampolines is a more recent phenomenon, driven primarily by the increased availability of relatively inexpensive trampolines marketed for home use.

The evolving pattern of trampoline use and injury resulted in a series of published policy statements from the American Academy of Pediatrics (AAP) in 1977, 1981, and 1999.^{1–3} The American Academy of Orthopedic Surgeons issued trampoline safety position statements in 2005 and 2010.⁴ The Canadian Pediatric Society and the Canadian Academy of Sports Medicine issued a joint statement on trampoline use in 2007.⁵ These statements all discouraged recreational and playground use of trampolines and urged caution with and further study of trampoline use in supervised training and physical education settings.

The recent growth of trampoline as a competitive sport, the emergence of commercial indoor trampoline parks, research on the efficacy of safety measures, and more recently recognized patterns of catastrophic injury with recreational trampoline use have prompted a review of the current literature and an update of previous AAP policy statements regarding trampolines.

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KEY WORDS

trampoline, injury, sports medicine, safety, cervical spine injury

ABBREVIATIONS

AAP—American Academy of Pediatrics

NEISS—National Electronic Injury Surveillance System

USCPSC—US Consumer Product Safety Commission

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EPIDEMIOLOGY

Over the past several decades, national estimates of trampoline injury numbers have been generated annually by using the US Consumer Product Safety Commission's (USCPSC) National Electronic Injury Surveillance System (NEISS).⁶ Trampoline injuries increased throughout the 1990s, with case numbers more than doubling between 1991 and 1996 (from approx 39 000 to >83 000 injuries per year). Injury rates and trampoline sales both peaked in 2004 and have been decreasing since then (Table 1).^{6,7} As home trampoline use appears to be waning, commercial trampoline parks and other trampoline installations have been emerging over the past several years. Although indoor commercial parks typically consist of multiple contiguous trampoline mats with padded borders, other setups are highly variable. Any effect of these facilities on trampoline injury trends should be monitored but is not yet evident.

A comparison of trampoline injury prevalence with those from other sports and recreational activities provides a sense of the societal burden of injury; however, it does not reflect the true risk of trampoline use by an individual. Risk takes into account the exposure or frequency of a given activity, and unfortunately, exposure data for many recreational activities, including trampoline use, are difficult to define and measure. Trampoline injury rates for 2009 were 70 per 100 000 for

0- to 4-year-olds⁶ and increased to 160 per 100 000 for 5- to 14-year-olds. Injury rates attributable to bicycling and use of playground equipment were higher in these age groups, but population exposure was likely significantly greater in these 2 activities as well.

In children younger than 14 years, rates of swimming injuries were similar to those for trampoline.⁶ Once again, exposure comparisons are difficult, but home swimming pools and home trampolines do share some features in terms of injury risk. Home trampolines and home swimming pools are both considered by many insurance companies to be "attractive nuisances" capable of enticing children into potentially dangerous situations. As such, many homeowner insurance policies have trampoline exclusions or mandate that trampolines are within enclosed areas with restricted access, similar to rules for swimming pools and spas. A key difference between swimming pools and trampolines is that evidence-based safety recommendations for home swimming pools (ie, 4-sided fencing that completely isolates the pool from the house and yard) are a broadly publicized focus for many groups concerned with public safety, but trampoline safety information has not been as well studied or as widely disseminated. Many parents and supervising adults do not appear to be aware of key components of trampoline safety, such as limiting the

trampoline to 1 user at a time, and this may contribute significantly to current injury rates.⁸

Although the prevalence of trampoline injuries is decreasing, concern persists regarding the severity of injuries sustained on the trampoline. Studies over the past decade in other countries revealed hospitalization rates between 3% and 14%.^{8,9} Hospitalization rates in the United States have been approximately 3% from 2005 to 2009.⁶

TRAMPOLINE SAFETY CONCERNS

Unfortunately, the very forces that make trampoline use fun for many children also lead to unique injury mechanisms and patterns of injury. The trampoline industry has attempted to address the safety concerns with implementation of voluntary safety standards. In response to the 1999 AAP policy statement recommendation against consumer trampoline use, the USCPSC, the International Trampoline Industry Association, and the American Society of Testing and Materials Trampoline Subcommittee issued a revision of performance and safety standards. Equipment recommendations included the following: (1) extending padding to the frame and springs; (2) improving the quality of the padding; and (3) prohibiting inclusion of ladders in the packaging to help prevent young children from accessing the trampoline. Printed warnings were included with new trampoline equipment that recommended avoiding somersaulting, restricting multiple jumpers, and limiting trampoline use to children 6 years or older. Concerns have been raised as to whether these recommendations, in addition to other measures proposed in previous policy statements, have substantially affected the rate or severity of injuries.^{9,10}

Another area of concern included reports of decreased quality of recreational trampoline equipment sold over the

TABLE 1 Trampoline-Related Injuries

Year	Actual Number of Cases ^a	Estimated Number of Injuries ^b	Rate of Injury per 100 000	Estimated Number of Hospitalizations/DOA
2004	3277	111 851	38.1	—
2005	3330	108 029	36.4	3537
2006	3277	109 522	36.6	4793
2007	3226	107 435	35.6	3188
2008	3130	104 752	34.5	2843
2009	3041	97 908	31.9	3164

DOA, deaths on arrival.

^a From the USCPSC, NEISS, which gives a probability sample. Each injury case has a statistical weight.

^b Calculated national estimate of trampoline injuries treated in US emergency departments.

past several decades. According to the International Trampoline Industry Association, trampolines sold in 1989 had an expected life of 10 years; the expectation for trampolines sold in 2004 was only 5 years.¹⁰ Warranty coverage has also decreased since 2004, but the warranty for the frame and mat is consistently found to be greater than for the padding and enclosure nets. This reflects the manufacturers' expectation that the padding and enclosure net will need replacement during the lifetime of the trampoline.¹⁰

MECHANISMS OF TRAMPOLINE-RELATED INJURY AND THE EFFICACY OF CURRENT SAFETY MEASURES

Multiple Simultaneous Users

Several studies have revealed that approximately three-quarters of injuries occurred when multiple people were using the trampoline at the same time.^{11–13} The smallest participants were up to 14 times more likely to sustain injury relative to their heavier playmates.¹⁴ Heavier users create more recoil of the mat and springs and greater upward impaction forces than smaller users can generate on their own. These forces must be absorbed by the falling body and can be larger than landing on solid ground.¹⁵ The risk associated with weight differences in the participants, in combination with less developed motor skills, likely contributes to the increased risk of fractures and dislocations in younger children.

Falls From the Trampoline

The most obvious risk of trampoline use is the ability to propel oneself to greater heights off a trampoline than from a jump on the ground. Falls from the trampoline can be severe and accounted for 27% to 39% of all trampoline-associated injuries.^{10,16,17} Risk of falling is increased by the "off-balance" bounce that occurs when

the trampoline is placed on an uneven surface, and children who fall off the mat are more likely to be injured if they make contact with nearby trees or other ground obstacles.

Netting and other perimeter enclosures to prevent falls from the trampoline were first commercially available in 1997, and the American Society for Testing and Materials produced a safety standard for enclosures in 2003. There is a paucity of literature on the effects of netting and other safety measures on injury risk. However, current evidence suggests that the availability of enclosures on the market has not significantly affected the proportions of injuries attributable to falls off the trampoline,¹⁰ and there does not appear to be an inverse correlation between presence of safety equipment and rates of injury.⁸ Proposed reasons for lack of efficacy of safety enclosures include positioning of enclosures on the outside of the frame⁸ and inappropriate installation and maintenance.¹⁰ Children are often tempted to climb or grasp the netting, which may be an additional source of injury.

Impact With Trampoline Frame and Springs

Approximately 20% of trampoline injuries have been attributable to direct contact with the springs and frame. However, similar to concerns regarding enclosure use, current literature on the effects of padding use on injury is sparse. Available data suggest that the availability and use of padding does not seem to correlate with decreased rates of injury.^{8,10} Rapid deterioration of padding has been cited as 1 potential reason for the lack of safety efficacy.^{8,10}

Trampoline Shape

No data exist regarding the difference in injury rates between rectangular

and round trampolines. However, rectangular trampoline mats have a larger "sweet spot" that may provide a straighter and more consistent bounce across a broader area of the mat. This may translate into lower injury risk with rectangular trampolines as compared with round.

Recommendation for Adult Supervision

Trampoline safety recommendations have consistently advised adult supervision when children are on the trampoline. However, multiple studies reveal that approximately one-third to one-half of injuries^{8,12,17–19} occurred despite reported adult supervision. These authors have raised concerns regarding supervision complacency, particularly when safety measures are in place, as well as lack of adult knowledge and intervention regarding risk behavior with trampoline use.

PATTERNS OF INJURY WITH TRAMPOLINE USE

Most trampoline injuries are manifestations of routine musculoskeletal injury mechanisms, but several unique patterns of injury are attributed to trampoline use and may warrant additional attention. Although the most common trampoline-related injury is an ankle sprain,¹² more serious injuries are not uncommon.

By Age

Patterns of injury vary by patient age. In retrospective reviews, individuals younger than 6 years accounted for 22% to 37% of individuals with a trampoline-related injury presenting to emergency departments for evaluation.^{8,16} Although most trampoline injuries are sprains, strains, contusions, or other soft tissue injury, younger children seem to be more prone to bony injury.^{11,18} According to an analysis of data from the NEISS,

29% of injuries in the 6- to 17-year age group resulted in fractures or dislocations, as compared with 48% in children 5 years and younger.¹⁸ Data from the Canadian Hospitals Injury Reporting and Prevention Program revealed higher rates of hospitalization for trampoline injuries in children younger than 4 years as compared with their older counterparts.⁹

Extremity Injuries

The lower extremity is the most common site of trampoline injury, accounting for 34% to 50% of injuries.^{11,20} Of these injuries, 1 study revealed that >60% involved the ankle,²⁰ and approximately three-quarters of ankle injuries were sprains.⁶ The upper extremities were injured in 24% to 36% of cases. Of these, approximately 60% were fractures.^{3,11} Upper extremity injuries were more common in participants who fell off the trampoline.¹²

Head and Neck Injuries

Although rates of extremity injuries are high, often the most frightening and alarming trampoline injuries are those to the head and neck. Many reports have revealed that head and/or neck injuries accounted for 10% to 17% of all trampoline-related injuries,^{3,11,12,20} and 0.5% of all trampoline injuries resulted in permanent neurologic damage.²¹ Head injuries occurred most commonly with falls from the trampoline.²⁰ Cervical spine injuries can happen with falls but also commonly occur on the trampoline mat when failed somersaults or flips cause hyperflexion or hyperextension of the cervical spine. These injuries can be the most catastrophic of all trampoline injuries suffered.

UNIQUE INJURIES ATTRIBUTED TO TRAMPOLINE USE

Proximal Tibial Fractures

Trampoline-related fractures of the proximal tibia have been described in

children 6 years and younger.^{15,22} These injuries have included transverse fractures as well as more subtle torus-types injuries. These injuries occurred when young children were sharing the trampoline with larger individuals, resulting in greater impact forces, as discussed previously.

Manubriosternal Dislocations/Sternal Injuries

Sternal injuries have traditionally been described as a result of major trauma. However, several case reports²³ have been published of children between 10 and 11 years old suffering from isolated trampoline-related sternal fracture or manubriosternal dislocation. These occur after thoracic hyperflexion injuries on the trampoline.^{23,24} They typically heal uneventfully; however, surgical stabilization may be necessary if pain persists.²⁴

Vertebral Artery Dissection

Several cases of vertebral artery dissection presenting 12 to 24 hours after a neck injury on the trampoline have been reported. Vertebral artery dissections are the result of abrupt cervical hyperextension and rotation. Trauma to the artery may result in an intramural thrombus, which can cause a subsequent dissection of the vessel and possible intracranial emboli. These are often devastating injuries and may produce lasting neurologic complications.^{25,26} Any neck pain associated with trampoline use requires prompt medical evaluation and diagnostic assessment.

Atlanto-axial Subluxation

Although patients with known atlanto-axial instability are often advised against the use of trampolines, there have been 2 reported cases of trampoline-related atlanto-axial subluxation in previously normal children.²⁷ Torticollis or neck pain after a trampo-

line-related neck injury warrants prompt medical evaluation and diagnostic assessment.

TRAMPOLINE USE IN A STRUCTURED TRAINING PROGRAM

Trampoline was accepted as an Olympic sport in 2000. In addition, trampolines are part of structured training programs in sports such as gymnastics, diving, figure skating, and freestyle skiing. USA Gymnastics and US Trampoline and Tumbling Association both administer competitive training and development programs in the sport of trampoline. USA Gymnastics oversees Olympic competition in single trampoline. The US Trampoline and Tumbling Association sponsors competition in single trampoline, synchronized trampoline, and double mini-trampoline. Some competitions accept athletes as young as 3 years old, although the majority of competitors are older than 8 years.

Competitive trampoline programs use a rectangular trampoline that is significantly different in size, quality, and cost than a recreational trampoline. Competition-style trampolines have center mats that are 7 ft by 14 ft. They are surrounded by a rim of padding over the springs and the 10-ft by 17-ft frame. These trampolines are raised off the ground and have 6 ft of end-deck padding. They do not have enclosure netting present. Within the competition setting, these trampolines have an additional 5- to 6-ft radius of padding present on the floor. In the training setting, competitive trampolines may be either raised off the ground, or "pit" trampolines, which are located at ground level. Either a bungee system or a rope and pulley system with a harness is used as athletes master tumbling skills.

No research documents the injury patterns or rates that occur specifically

in the structured training environment or with competitive trampoline events. Given the significant differences between the recreational and the structured training settings, extrapolation of data from the recreational setting to a formal training program is not appropriate. This is an area in which more research is warranted.

CONCLUSIONS

1. Although trampoline injury rates have been decreasing since 2004, the potential for severe injury remains relatively high. More prospective data are needed on this topic.
2. Enclosures and padding are not expected to prevent the large numbers of injuries that occur on the trampoline mat itself and may provide a false sense of security.
3. Many injuries occur even with reported adult supervision.
4. Multiple jumpers increase injury risk, particularly to the smallest participants.
5. Current trampoline equipment has shorter warranties than in the past, and protective equipment may require earlier replacement.
6. Individuals 5 years and younger appear to be at increased risk of fractures and dislocations from trampoline-related injuries.
7. Somersaulting, flipping, and falls put jumpers at increased risk of head and cervical spine injury with potentially permanent and devastating consequences.
8. Equipment, safety measures, and supervision within structured training programs are significantly different than those used in the recreational environment.

RECOMMENDATIONS FOR TRAMPOLINE USE

1. Pediatricians should counsel their patients and families against

recreational trampoline use and explain that current data indicate safety measures have not significantly reduced injury rates and that catastrophic injuries do occur. For families who persist in home trampoline use despite this recommendation, pediatricians should advise parents and their children on the following guidelines until better information becomes available:

- a. Homeowners should verify that their insurance policies cover trampoline-related claims. Coverage is highly variable and a rider may need to be obtained.
- b. Trampoline use should be restricted to a single jumper on the mat at any given time.
- c. Trampolines should have adequate protective padding that is in good condition and appropriately placed.
- d. Trampolines should be set at ground level whenever possible or on a level surface and in an area cleared of any surrounding hazards.
- e. Frequent inspection and appropriate replacement of protective padding, net enclosure, and any other damaged parts should occur.
- f. Trampolines should be discarded if replacement parts are unavailable and the product is worn or damaged.
- g. Somersaults and flips are among the most common causes of permanent and devastating cervical spine injuries and should not be performed in the recreational setting.
- h. Active supervision by adults familiar with the above recommendations should occur at all times. Supervising adults should be willing and able to enforce these guidelines. Mere

presence of an adult is not sufficient.

- i. Parents should confirm that these guidelines are in place anytime their child is likely to use a trampoline.
2. Data are insufficient regarding the safety of trampoline parks and similar installations. Until further safety information is available, the cautions outlined here regarding home trampolines are also applicable to recreational trampoline use in any setting.
 - a. Pediatricians should advocate for all commercial jump parks to inform jumpers of the risk associated with trampoline use and the AAP guidelines for use.
 - b. Parents should be aware that the rules and regulations of jump parks may not be consistent with the AAP guidelines for trampoline use and that the jumpers may be at increased risk for suffering an injury, potentially catastrophic.
 - c. Injury rates at these facilities should be monitored.
 3. The trampoline was designed as a piece of specialized training equipment for specific sports. Pediatricians should only endorse use of trampolines as part of a structured training program with appropriate coaching, supervision, and safety measures in place. In addition to the aforementioned recommendations, the following apply to trampolines used in the training setting:
 - a. Any attempts at new skills, particularly somersaults or flips, should only follow an appropriate skill progression and include appropriate coaching and spotting measures.
 - b. Use of safety belts/harnesses is encouraged when skill development is being taught.

LEAD AUTHORS

Susannah Briskin, MD
Michele LaBota, MD

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CONSULTANTS

Paul Stricker, MD
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Anjie Emanuel, MPH

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