# Children presenting to a Canadian hospital with trampoline-related cervical spine injuries

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**BACKGROUND:** Trampoline-related injuries are preventable by avoidance. There are few published reports focusing on cervical spine injuries from trampolines in the paediatric population.

**METHODS:** Patients younger than 18 years of age who presented to Stollery Children's Hospital (Edmonton, Alberta) between 1995 and 2006, with a cervical spine injury or death from trampoline use were identified via a medical records database search. Data were collected retrospectively from the hospital charts, and were presented using descriptive statistics.

**RESULTS:** There were seven cases of cervical spine injury secondary to trampoline use. Four patients had lasting neurological deficits at discharge from hospital, and another patient died at the scene due to refractory cardiac arrest. Injuries were sustained both on (n=5) and off (n=2) the trampoline mat from mechanisms that included attempted somersaults on the trampoline and falls from the trampoline. All the trampolines were privately owned home trampolines. An ambulance was called for five patients, intravenous fluids were administered to two patients with hypotension and spinal shock, and cardiopulmonary resuscitation was performed on one patient. All six patients surviving the initial injury were admitted to hospital for a mean ± SD of 9.5±9.0 days. These six patients underwent imaging including x-rays, computed tomography and magnetic resonance imaging, and three patients required surgery for spinal stabilization.

**CONCLUSION:** Cervical spine injuries from trampolines lead to severe neurological sequelae, death, hospitalization and significant resource use. The authors agree with the Canadian Paediatric Society's statement that trampolines should not be used for recreational purposes at home, and they support a ban on all paediatric use of trampolines.

**Key Words:** *Cervical; Children; Injury; Spine; Trampoline*

## Les enfants qui consultent à un hôpital canadien en raison d'un traumatisme de la colonne cervicale découlant de l'utilisation du trampoline

**HISTORIQUE :** Les traumatismes reliés au trampoline sont évitables si on n'utilise pas cet engin de gymnastique. Peu de rapports sont publiés sur les traumatismes à la colonne cervicale attribuables au trampoline au sein de la population pédiatrique.

**MÉTHODOLOGIE :** Les auteurs ont repéré, au moyen d'une recherche dans une base de données de dossiers médicaux, les patients de moins de 18 ans qui avaient consulté au *Stollery Children's Hospital* (d'Edmonton, en Alberta) entre 1995 et 2006, en raison d'un traumatisme de la colonne cervicale ou d'un décès découlant de l'utilisation d'un trampoline. Ils ont colligé les données rétrospectives dans les dossiers hospitaliers et les ont présentées au moyen de statistiques descriptives.

**RÉSULTATS :** Les auteurs ont recensé sept cas de traumatisme de la colonne cervicale secondaire à l'usage du trampoline. Quatre patients présentaient un déficit neurologique permanent au congé de l'hôpital, et un autre est mort sur les lieux de l'accident en raison d'un arrêt cardiaque réfractaire. Les patients ont subi des traumatismes à la fois sur le matelas du trampoline (n=5) et à l'extérieur de ce matelas (n=2) à cause de tentatives de sauts périlleux et de chutes. Tous les trampolines appartenaient à des familles. Cinq patients ont été déplacés en ambulance, deux ont reçu des liquides par voie intraveineuse en raison d'hypotension et de choc spinal, et un a subi une réanimation cardiorespiratoire. Les six patients ayant survécu au traumatisme initial ont été hospitalisés pendant une période moyenne ± ÉT de 9,5±9,0 jours. Ces six patients ont eu une imagerie, y compris des radiographies, une tomodensitométrie et une imagerie par résonance magnétique, et trois patients ont dû être opérés pour stabiliser leur colonne vertébrale.

**CONCLUSION :** Les traumatismes de la colonne cervicale causés par le trampoline s'associent à de graves séquelles neurologiques, à un décès, à une hospitalisation et à une mobilisation importante de ressources. Les auteurs souscrivent au document de principes de la Société canadienne de pédiatrie, selon lequel les trampolines ne devraient pas être utilisés pour un usage récréatif à domicile, et ils appuient l'interdiction de tout usage pédiatrique des trampolines.

Trampoline-related injuries have been reported in the literature for decades; in more recent years, they have created international concern with calls for the implementation of guidelines and safety measures in an attempt to decrease the number and severity of injuries (1-23). While cervical spine injuries are not the most common injury sustained, they are the major cause of neurological sequelae and death associated with trampoline injury. In the paediatric population, however, there are still relatively few published reports focusing on these specific types of trampoline-related injuries. More data are needed about the incidence, mechanism and circumstances of these potentially catastrophic injuries. The goal of the present study is to provide Canadian-specific data on these injuries by reporting cases of children who presented to the Stollery Children's Hospital in Edmonton, Alberta, between 1995 and 2006, with trampoline-related cervical spine injuries.

## METHODS

All patients younger than 18 years of age who presented to the Stollery Children's Hospital between 1995 and 2006, with a cervical spine injury or death related to trampoline use were identified via a medical records database search. The search was performed by a medical records specialist using the following codes. Emergency room patients were admitted with a sport activity code U99.062 (trampoline) and cervical spine injuries. Inpatients were admitted with a

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**TABLE 1**
**Anatomical injuries and neurological sequelae of seven case reports**

| Case | EMS called | Initial resusciation | Imaging | Anatomical injury | Initial neurological symptoms | Surgery | Hospital days | Symptoms at discharge |
|---|---|---|---|---|---|---|---|---|
| 1 | Yes | None | XR C-spine<br>CT C-spine | C6 facet fracture | Midline neck pain | No | 1 | Philadelphia collar for 2 weeks; no deficits |
| 2 | Yes | IV fluid bolus | XR C-spine<br>XR T-spine<br>CT C-spine<br>MRI C-spine<br>XR chest | C1-2 cord contusion*; fracture right 8 and 9 ribs | Right hemiplegia; Horner's syndrome | Yes† | 23 | Persistent weakness in the right upper greater than in the right lower extremity |
| 3 | Yes | CPR, intubation, adrenaline, AED 2 shocks | None | High cervical spine injury‡ | Vital signs absent | No | 0 | Death |
| 4 | No | None | CT head<br>CTA head<br>MRA head | Right vertebral artery dissection; right thalamic infarct | Right hemiplegia | No | 5 | Persistent weakness and mild sensory deficit on the right side |
| 5 | No | None | XR C-spine | C1-2 subluxation* | Occipital and neck pain | Yes§ | 8 | Halo fixation for 6 weeks, followed by Philadelphia collar for 3 weeks |
| 6 | Yes | IV fluid bolus, inotropes, steroids | XR C-spine | C4-5 facet dislocation | C5 quadriplegia | Yes† | 18 | Quadriplegia with 3/5 strength biceps, 1/5 strength triceps |
| 7 | Yes | None | XR C-spine<br>XR T-spine<br>CT head<br>MRI C-spine | SCIWORA | Decreased power right arm | No | 2 | Weakness of the right hand |

**Found to have congenital cervical spine anomaly – os odontoideum; †C4-5 posterior cervical instrumentation and fusion; ‡Medical examiner report documented this as cause of death, but no autopsy was performed; §C1-2 arthrodesis with bone graft. AED Automated external defibrillator; C-spine Cervical spine; CPR Cardiopulmonary resuscitation; CT Computed tomography; CTA Computed tomographic angiogram; EMS Emergency medical services; IV Intravenous; MRA Magnetic resonance angiogram; MRI Magnetic resonance imaging; SCIWORA Spinal cord injury without radiological abnormality; T-spine Thoracic spine; XR X-ray*

code for cervical spine injury – the International Classification of Diseases, Ninth Revision 805.00-805.18 (18 codes) for fracture of vertebral column without mention of spinal cord injury, cervical; 806.00-806.19 (20 codes) for fracture of vertebral column with spinal cord injury, cervical; and 952.00-952.09 (10 codes) for spinal cord injury without evidence of spinal bone injury, cervical; and the International Classification of Diseases, Tenth Revision S12 (14 codes) for fracture of neck; and S14 (17 codes) for injury of nerves and spinal cord at neck level. These reports were reviewed manually to eliminate those injuries due to other mechanisms such as traffic, playground equipment, snowboarding, etc. The remaining 30 records were hand searched (search of the physical chart by medical records) to see if a trampoline was the associated mechanism of the injury.

The Stollery Children's Hospital is the only children's hospital for Northern Alberta, and has a referral base of 1.7 million people. Data collected retrospectively from the charts were entered into a case report form created for the present study. These data included demographic information, circumstances surrounding the injury event, mechanism of injury, medical care received, and neurological status at time of presentation and at discharge. Paramedic charting, emergency room charts and hospital ward charts were reviewed for these data. The study was approved by the health research ethics board of the University of Alberta (Edmonton, Alberta), and the need for patient consent for chart review was waived. As far as the authors are aware, there have been no regulations in Alberta regarding trampoline use and management.

**TABLE 2**
**Mechanism of injury in seven trampoline spinal injuries**

| Mechanism | n |
|---|---|
| Injury on trampoline mat | 4 |
| Forward somersault | 3 |
| Handstand | 1 |
| Fall off of trampoline mat | 2 |
| Landing on head | 2 |
| Playing under trampoline | 1 |
| Jumped on head | 1 |

## RESULTS

Seven cases of trampoline injury that met the study inclusion criteria were identified, and the charts reviewed. There were five boys and two girls, with a mean ± SD age of 11.6±2.0 years (median 11.5 years; range nine to 14 years). All seven patients suffered an injury to the cervical spine (Table 1). Four patients had lasting neurological deficits at the time of discharge from hospital, and one other patient died of refractory cardiac arrest (Table 1). The injuries were sustained both on (n=5) and off (n=2) the trampoline mat from mechanisms that included attempted stunts on the trampoline (ie, somersaults) and falls from the trampoline. One case was found that involved injury secondary to playing under the trampoline while another participant was jumping on it (Table 2). All the trampolines were privately

owned home trampolines. The experience of the injured children could not be determined, although it seems that most of them were not well experienced on the trampoline. The authors were also unable to determine whether there were spotters or instructors present, because this information was not recorded in the chart.

Information on the health care received both at the scene by paramedics (when applicable) and in hospital is shown in Table 1. An ambulance was called for five of the seven cases, intravenous fluids were administered to two patients presenting with hypotension and spinal shock, and cardiopulmonary resuscitation was performed on one patient presenting with cardiopulmonary arrest. All six patients surviving the initial injury were admitted to hospital with an average stay of 9.5±9.0 days. These six patients underwent various imaging studies including x-rays, computed tomographic scans and magnetic resonance imaging; three required surgery for spinal stabilization (Table 1).

**Case 1**
A child attempting a handstand on a home trampoline fell forward on the trampoline mat, resulting in hyperflexion of the neck. The child complained of instant midline neck pain, but no neurological symptoms. An undisplaced C6 facet fracture was diagnosed and treated with a Philadelphia collar for two weeks. There were no neurological sequelae at the time of discharge.

**Case 2**
A child attempting a forward somersault on a relative's backyard trampoline landed on the head on the trampoline mat with hyperflexion injury. The child developed sudden absent sensation in all limbs and quadriplegia for 5 min, followed by a slow return of movement on the left side. The child presented with right-sided hemiplegia and hypotension requiring intravenous fluid boluses. A C1-2 cord contusion and presence of os odontoideum (a congenital bony abnormality of the cervical spine) were diagnosed and treated with C1-2 arthrodesis and bone graft. At the time of discharge to the rehabilitation hospital, some function had returned to the right side, but weakness was still present; the child was able to walk with one person's assistance.

**Case 3**
A child fell off a friend's backyard trampoline, landing on the head. The child complained of instant neck pain and, while holding the neck, laid down on the ground. The child rapidly had a cardiopulmonary arrest, and resuscitation attempts were unsuccessful. Cause of death was a presumed high cervical spine injury.

**Case 4**
A child playing under a backyard trampoline was injured when another child jumping on the trampoline landed on the child's head. Over a 24 h period, the child developed headache, vomiting, dizziness, ataxia, and weakness and decreased sensation to the right upper and lower extremities. The child was diagnosed with complete right vertebral artery dissection with occlusion of the right posterior inferior cerebellar artery and distal left posterior cerebral artery, and thalamic infarction. Weakness and sensory deficit on the right side and poor coordination were still present at the time of discharge. With the deficit on the right side, and injury to the vertebral artery along its course in the transverse processes of the cervical vertebrae, the injury was considered to be a spinal injury.

**Case 5**
A child fell on a neighbour's backyard trampoline mat landing on the back of the head. The child complained of neck pain but no neurological symptoms. C1-2 subluxation and os odontoideum were diagnosed and treated with C1-2 arthrodesis and bone graft. No neurological sequelae remained at the time of discharge.

**Case 6**
A child attempting a forward somersault on a relative's home trampoline landed on the head on the trampoline mat with hyperflexion injury. The child had instant quadriplegia and presented in spinal shock. Bilateral C4-5 facet dislocation was diagnosed and treated with C4-5 arthrodesis. At the time of discharge, the child had recovered minimal function in the upper extremities, but none in the lower extremities.

**Case 7**
A child attempting a forward somersault on a backyard trampoline landed on the head on the trampoline mat with hyperflexion injury. The child complained of weakness and paresthesias to the right arm. The child was diagnosed with spinal cord abnormality without radiological abnormality based on normal imaging, but clinically decreased strength in the right extremity that persisted at the time of discharge.

## DISCUSSION

Our search revealed seven cases of cervical spine injury secondary to trampoline use; four with long-term sequelae and one death. Our data search was over an 11-year time period and included patients presenting to our emergency department, which serves a catchment area of 1.7 million people. Moreover, due to winter weather, outdoor trampolines in Northern Alberta can only be used for less than six months of the year.

Since the introduction of the trampoline in 1936, there have been numerous trampoline-related injuries reported in the literature. In response to a number of devastating cervical spine injuries, the American Academy of Pediatrics (AAP) issued a policy statement in 1977 that recommended "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 (1)". A decline was seen in the number of trampoline-related injuries in the early 1980s, which was likely related to this AAP statement (24).

In 1981, the AAP softened its position when it released a second position paper 'Trampolines II,' which stated that "the Academy does not endorse trampoline use, but a revision of the Academy's position to allow for a trial period of limited and controlled use by schools seems appropriate (2)". The paper outlined seven precautions – trampolines should not be a part of routine physical education classes, should have no role in competitive sports, should not be used in the home or in recreational settings, must be used with trained personnel present, must be secured when not in use and kept well maintained, should only be used in schools or sports activities complying with these recommendations, and stunts such as somersaults must only be attempted by skilled jumpers. An upward trend in the incidence of trampoline-related injuries has been noted since that time, with the number of children treated in emergency departments in the United States doubling from 1990 to 1995 (3). Several studies (4-8) have found similar results. Since the debut of trampolining as an Olympic sport in 2000, it is expected that the popularity of this sport will continue to increase.

There are some Canadian data on trampoline injuries. A search of the Canadian Hospitals Injury Reporting and Prevention Program showed an increase in trampoline-related injuries of 374% from 1990 to 1998, presenting to participating hospital emergency rooms (8). More recently, the Canadian Hospitals Injury Reporting and Prevention Program reported that comparing the period between 1997 to 2001 and 1990 to 1996, the OR for trampoline-related hospital admissions was 1.85 (95% CI 1.56 to 2.20), and there was a significant increase in all trampoline-related emergency room cases between 1999 and 2006 ($P<0.001$) (25). The trampoline injuries occurred at the patient's own (44%) or someone else's (45%) residence, usually during the summer months (77% from May to September). The median age was 10.1 years (range 13 months to 53.7 years; interquartile range seven to 12.8 years), with boys accounting for 51.6% of injuries. Injuries occurred on the trampoline mat in 52.4% of children, on the ground surface in 28.9% and with another person in 14.3%. Of all cases, 12.4% were admitted to hospital (compared with 5.3% of all children with sports and recreation injuries being admitted to hospital). Of the 2705 cases between 1999 and 2003, 19 (0.7%) involved the spine and cord, including fracture (n=10), dislocation (n=4), nerve injury (n=1) and others (n=4). Another 137 (5.1%) involved the neck, including sprain or strain (n=88), soft tissue, bruise or abrasion (n=42), and muscle or tendon (n=7) (25). These data suggest that the epidemic of trampoline injuries occurring in the United States (14) is also occurring in Canada (25).

Many researchers have demonstrated that trampoline use can cause injuries of the cervical spine (1-23). While cervical spine injuries are not the most common injury sustained, they are the major cause of neurological sequelae and death associated with trampoline injury. Furnival et al (14) reported that 12% of trampoline injuries presenting to their emergency department in Salt Lake City, Utah (USA), had cervical spinal injuries. The United States Consumer Product Safety Commission (19) reports that since 1990, they have received 11 reports of deaths related to trampoline use, six of whom were teenagers. We can put our data in perspective using local information. On average, each year between 1998 and 2003, there were 12 child or teen major trauma patients with a spinal cord injury (n=59) in Alberta, giving a range of one to two cases per 100,000 per year (26). Cervical spine injuries accounted for 25 of 59 (42%) of these spinal cord injuries over this five-year period (26). In the three-year period (between 2003 and 2005), the hospital admission rate for spinal cord injury in Alberta was lower than 0.5 per 100,000 children younger than four years of age (two admissions), and lower than 1.5 per 100,000 children four to 14 years of age (16 admissions) (27). Therefore, we estimate that our seven cases of trampoline-related cervical spine injuries over 11 years may account for at least 13% (seven of estimated 55 cases) of cervical spine injuries in children in Alberta. This is likely a conservative estimate because we did not include any patients who may have presented to the other children's hospital in Alberta.

Despite previous widespread assumptions that trampoline injuries can be prevented with the use of good quality safety mats and the presence of both trained instructors and spotters, many studies (7,10,11,14,15) have documented that trampoline-related cervical spine injuries have occurred despite the implementation of these safety measures. Frequently, cervical spine injuries have resulted from a fall on the trampoline mat and not from a fall off of it (10,11,14,15), supporting arguments that the use of improved equipment standards and safety enclosures are not enough to prevent these injuries. Similarly, these injuries have occurred in the presence of spotters and have been independent of the jumper's experience (7,10,11,14,15). In our case series, four of the seven patients were injured on the trampoline mat and one while playing underneath it. We are in agreement that no amount of 'safety precautions' can prevent these injuries.

In 1999, the AAP reaffirmed its policy statement on trampoline use, recommending that trampolines not be used in the home environment, as a part of routine physical education classes in schools or in outdoor playgrounds (18). They made specific design and behavioural recommendations for the limited use of trampolines in supervised training programs. In 2007, the Canadian Paediatric Society published a joint statement with the Canadian Academy of Sport Medicine, recommending that "trampolines should not be used for recreational purposes at home (including cottages and temporary summer residences) by children or adolescents (28)". The statement encourages professionals to advise parents of the dangers and recommends that professionals advocate for legislation requiring product labels to have warnings of the dangers. In our study, at least four of the injuries did not occur on the family's own trampoline, but rather on a neighbour's, relative's or friend's trampoline. Parents need to be aware of this danger when their children visit other homes. The statement did not discuss the use of

trampolines in settings such as schools and training programs, stating that more research needs to be done to assess the risk of injury in these settings. One limitation of our study is that all injuries occurred on privately owned trampolines and did not demonstrate the dangers of usage in gymnastic classes or schools. There have been many authors, however, who believe that the use of trampolines in physical education programs should also be discouraged (7,9-12,14,15,21,23). Many have called for a complete ban on trampoline use in the paediatric population (7,10,11,14,15,21), stating that this is the only solution to prevent trampoline injuries.

There are several limitations of our study. First, this is a small case series from a single centre. Also, it could be argued that case 4 was not a cervical spine injury; however, we believe the clinical findings suggested cord as well as thalamic/cerebellar injury with the vertebral artery dissection. We could not determine some variables we had hoped to obtain, such as the degree of experience of the child, and the amount of supervision provided. Nevertheless, we have provided Canadian-specific data about the dangers of trampoline use. We also believe that other investigators have shown that experience and supervision are not adequate to prevent the most severe trampoline injuries. Trampolines are widely sold and used in Canada, and the present report should emphasize the need for public health attention to this mechanism of injury. The limitations of the present study, we believe, do not change the main conclusion that home use of trampolines has resulted in devastating cervical spine injuries in children, and accounts for an estimated significant proportion of cervical spine injuries in children (greater than 13%).

Cervical spine injuries are not the most common injury sustained from trampoline use but, as we have shown, they can be catastrophic when they do occur. We agree with the Canadian Paediatric Society's statement that trampolines should not be used for recreational purposes at home and that warnings of the potential dangers should be put on product labels. Although our data do not address trampoline use in other settings, based on the data of others, we support a stronger position recommending the elimination of trampolines in schools and training programs as well. The literature has shown that the most severe injuries are not preventable by the implementation of safety measures, and we join other authors in supporting a ban on all paediatric use of trampolines.

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