

# Emergency department-reported injuries associated with mechanical home exercise equipment in the USA

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Received 26 March 2013

Revised 10 June 2013

Accepted 17 August 2013

## ABSTRACT

The goal of this study was to generate national estimates of injuries associated with mechanical home exercise equipment, and to describe these injuries across all ages. Emergency department (ED)-treated injuries associated with mechanical home exercise equipment were identified from 2007 to 2011 from the National Electronic Injury Surveillance System. Text narratives provided exercise equipment type (treadmill, elliptical, stationary bicycle, unspecified/other exercise machine). Approximately 70 302 (95% CI 59 086 to 81 519) mechanical exercise equipment-related injuries presented to US EDs nationally during 2007–2011, of which 66% were attributed to treadmills. Most injuries among children ( $\leq 4$  years) were lacerations (34%) or soft tissue injuries (48%); among adults ( $\geq 25$  years) injuries were often sprains/strains (30%). Injured older adults ( $\geq 65$  years) had greater odds of being admitted, held for observation, or transferred to another hospital, compared with younger ages (OR: 2.58; 95% CI 1.45 to 4.60). Mechanical exercise equipment is a common cause of injury across ages. Injury awareness and prevention are important complements to active lifestyles.

## INTRODUCTION

A minimum of 30 min of exercise most days is recommended for healthy adults.<sup>1</sup> Many people use mechanical home exercise equipment, preferring the convenience of exercising at home. Although prior studies have examined paediatric injuries from mechanical exercise equipment,<sup>2–10</sup> none have described injuries across the age spectrum associated with home mechanical exercise equipment. We sought to generate national estimates of injuries associated with mechanical home exercise equipment in the USA and describe these injuries to identify opportunities for injury prevention.

## METHODS

### Data source

The National Electronic Injury Surveillance System (NEISS) is a database of consumer product and sports activity-related injuries treated in a national probability sample of US emergency departments (ED). Narrative text provides additional details on each injury.<sup>11</sup> We examined exercise equipment-related injury cases (product code 3277) occurring at home that required ED care in 2007–2011. Text-search algorithms in Microsoft Excel categorised equipment injuries as: treadmill, elliptical, stationary bicycle, and unspecified/other exercise machine.<sup>12</sup> Misspellings

and synonyms were also searched. The unspecified/other exercise machine category included narratives that did not identify a machine type (unspecified, eg, exercise machine) or identified a machine type that was infrequently referenced (other, eg, Nordic ski trainer, stair climber). Narratives referring to non-mechanical equipment, such as exercise balls, jump ropes and pull-up bars were identified and excluded. Narratives were reviewed by one coauthor (KRI) to evaluate the performance of the text-search algorithms. Cohen's kappa statistic was calculated to test inter-rater reliability.

Diagnoses were categorised as laceration (including punctures, avulsions and amputations), soft tissue injury (including contusion/abrasion, crushing injury and haematoma), fracture, sprain/strain, concussion/closed head injury (including concussion, internal organ injury to the head and skull fractures<sup>13</sup>), burns, non-injury and other. Text narratives for all cases categorised by NEISS as 'Other/Not Stated' were manually reviewed: cases with apparent non-injury diagnoses (eg, chest pain) were categorised as non-injury. The following NEISS diagnoses were grouped into one 'other' injury category: dislocation, foreign body, dental injury, nerve damage, internal organ injury (non-head), haemorrhage, poisoning, anoxia, ingestion of a foreign object, or dermatitis/conjunctivitis. ED discharge disposition was categorised as treated and released, transferred to another hospital, admitted, held for observation, or fatality, or left without being seen. Injury reports were grouped by age as follows: 0–4, 5–9, 10–14, 15–24, 25–44, 45–64 and 65 years and older.

Previous studies cite mechanical home exercise equipment as sources of severe hand and finger injuries among children, specifically friction burns, amputations and avulsions, so we evaluated these types of injuries separately.<sup>3–7</sup> Friction burn injuries were defined as diagnoses of burns to fingers or hands.

### Data analysis

Data were analysed using Stata/SE V11.2.<sup>14</sup> National estimates of injuries and 95% CIs were calculated using NEISS sample weights and the survey (svy) commands in Stata. Incidence rates were calculated using national injury estimates and US census population data for 2007–2011.<sup>15</sup> We evaluated bivariate associations between age groups, body part injured, diagnosis, discharge disposition and machine type using Fisher's exact or  $\chi^2$  tests. Mean ages were compared across

**To cite:** Graves JM, Iyer KR, Willis MM, et al. *Inj Prev* Published Online First: [please include Day Month Year] doi:10.1136/injuryprev-2013-040833

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diagnoses and body parts individually in a pairwise manner using an adjusted Wald test with Bonferroni correction. We employed multivariate logistic regression to evaluate associations between age group and discharge disposition or machine type, adjusting for sex, body part injured, diagnosis and machine type in the discharge disposition regression.

The University of Washington Human Subjects Division considered this research exempt from ethics review, because it used publicly available, deidentified data.

## RESULTS

In the NEISS sample, we identified 1782 injury cases attributable to mechanical home exercise equipment (872 cases were excluded as non-mechanical equipment). A manual narrative review of all 1782 cases found that the text-search algorithm correctly classified 96.9% (95% CI 0.94 to 0.96) of narratives into the appropriate exercise equipment group or unspecified/other category ( $\kappa$ : 0.95). Misclassified narratives were manually recoded based upon information from narrative text ( $n=55$ ).

An estimated 70 302 (95% CI 59 086 to 81 519) ED-treated injuries were attributed to mechanical home exercise equipment, from 2007 to 2011, in the USA. Most injuries were associated with treadmills, followed by stationary bicycle and unspecified/other exercise machines (table 1). The age distribution appeared bimodal and was confirmed using a kernel density estimation plot. The majority of injuries were to children (0–9 years) (35.2%, 95% CI 30.0 to 40.3), and adults ( $\geq 25$  years) (52.8%, 95% CI 47.9 to 57.8). The national incidence over the 5-year period was 4.58 per 100 000 individuals (all ages), with the

highest incidence among children (0–4 and 5–9 years) and lowest for adolescents and young adults (15–24 years) (table 1).

## Injury characteristics

Across all age groups, injuries most commonly occurred to the lower extremities (37%, 95% CI 33 to 41). However, body part varied by age ( $p<0.01$ ) (table 2). For children 0–4 years, most injuries occurred to the upper extremities (46%, 95% CI 40 to 53), followed by the head/neck (37%, 95% CI 31 to 44). For adults  $\geq 45$  years, 24% of injuries occurred to the trunk (95% CI 20 to 29). Mean age of individuals with head/neck or upper extremity injuries (24.5 years, 95% CI 20.9 to 28.0) was significantly lower than those with lower extremity (36.5 years, 95% CI 33.6 to 39.3), trunk (50.4 years, 95% CI 47.6 to 53.2) or other injuries (47.3 years, 95% CI 35.1 to 59.4) ( $p<0.01$ ).

Injury diagnosis also varied by age ( $p<0.01$ ) (table 2). Children (0–9 years) often sustained soft tissue injuries (47%, 95% CI 42 to 53) or lacerations (34%, 95% CI 30 to 39); these were less common among all older ages. The mean age for soft tissue injuries was 22.2 years (95% CI 18.4 to 25.9) and 21.9 years (95% CI 18.1 to 25.7) for lacerations. Individuals who sustained a fracture or sprain/strain were significantly older than individuals with other injury diagnoses: 41.0 years for fractures (95% CI 37.2 to 44.8) and 43.9 years for sprains/strains (95% CI 41.1 to 46.7) ( $p<0.01$ ).

Discharge disposition remained relatively constant across age groups (table 2), with the exception that 11% (95% CI 6 to 16) of older adults (age 65 years and older) were transferred, admitted, held for observation, or died. After adjusting for sex, body part injured, diagnosis and machine type, older adults were

**Table 1** Demographics for the study sample and national estimates of mechanical home exercise equipment-related injuries treated in US emergency departments, 2007–2011

	Study sample n	National estimates*		National incidence per 100 000	
		Estimate	95% CI	Estimate	95% CI
Total	1782	70 302	(59 086 to 81 519)	4.58	(3.85 to 5.32)
Age, years					
0–4	456	14 276	(11 742 to 16 811)	13.86	(11.40 to 16.32)
5–9	290	10 444	(8692 to 12 196)	10.39	(8.64 to 12.13)
10–14	130	4937	(3971 to 5904)	4.80	(3.86 to 5.74)
15–24	85	3491	(2456 to 4525)	1.61	(1.13 to 2.09)
25–44	252	10 705	(8814 to 12 596)	2.59	(2.13 to 3.04)
45–64	311	14 087	(12 139 to 16 035)	3.53	(3.05 to 4.02)
65+	258	12 362	(10 364 to 14 360)	6.25	(5.24 to 7.26)
Sex					
Male	849	32 150	(29 710 to 34 590)	4.26	(3.93 to 4.58)
Female	933	38 152	(35 712 to 40 592)	4.90	(4.59 to 5.21)
Type of equipment†					
Treadmill	1184	46 049	(43 913 to 48 185)		
Elliptical	89	3589	(2505 to 4674)		
Stationary bicycle	272	11 759	(9959 to 13 560)		
Unspecified/other exercise machine	237	8905	(7354 to 10 455)		
Discharge disposition					
Treated and released	1687	66 978	(65 780 to 68 175)		
Transferred, admitted, held for observation, or fatality	91	3199	(2050 to 4347)		
Left without being seen	4	126	(–18 to 270)		

Source: NEISS, 2007–2011.

\*National estimates are calculated with statistical weights as advised by experts at the Consumer Product Safety Commission to account for the inverse probability of selection for each injury episode.

†Determined from narrative review.

ED, emergency department; NEISS, National Electronic Injury Surveillance System.

**Table 2** Characteristics of injuries attributed to mechanical home exercise equipment (all types) treated in US emergency departments, 2007–2011, weighted to reflect national estimates

	0–4 years (n=14 276) % (95% CI)	5–9 years (n=10 444) % (95% CI)	10–14 years (n=4937) % (95% CI)	15–24 years (n=3491) % (95% CI)	25–44 years (n=10 705) % (95% CI)	45–64 years (n= 14 087) % (95% CI)	≥65 years (n=12 362) % (95% CI)	All ages (n=70 302) % (95% CI)
<b>Body part injured</b>								
Head/neck*	38 (31 to 44)	25 (19 to 32)	20 (11 to 28)	10 (3 to 16)	13 (8 to 18)	16 (11 to 20)	14 (11 to 18)	21 (18 to 23)
Upper extremities	46 (40 to 53)	33 (25 to 42)	27 (19 to 36)	11 (1 to 20)	16 (12 to 19)	17 (12 to 22)	21 (15 to 27)	26 (23 to 30)
Lower extremities	13 (8 to 18)	35 (27 to 43)	53 (44 to 61)	60 (48 to 73)	52 (45 to 58)	40 (33 to 47)	38 (32 to 43)	37 (33 to 41)
Trunk	2 (0 to 3)	6 (2 to 9)	0 (0 to 1)	14 (5 to 23)	19 (14 to 24)	25 (19 to 31)	23 (17 to 30)	14 (12 to 16)
Other†	1 (0 to 2)	1 (–1 to 3)	0 (0 to 1)	5 (–1 to 11)	1 (0 to 2)	3 (0 to 5)	4 (2 to 6)	2 (1 to 3)
<b>Diagnosis</b>								
Laceration	34 (28 to 40)	35 (28 to 43)	33 (22 to 44)	10 (3 to 18)	10 (6 to 13)	13 (8 to 17)	13 (8 to 18)	21 (18 to 24)
Soft tissue injury‡	48 (41 to 55)	47 (38 to 55)	35 (24 to 45)	20 (6 to 33)	18 (12 to 24)	16 (10 to 22)	20 (14 to 26)	30 (26 to 33)
Fracture§	5 (3 to 8)	9 (5 to 13)	13 (7 to 20)	14 (3 to 24)	14 (8 to 19)	16 (10 to 22)	15 (10 to 21)	12 (10 to 14)
Sprain/strain	1 (0 to 3)	4 (2 to 7)	14 (7 to 21)	40 (26 to 54)	39 (31 to 46)	30 (22 to 39)	21 (16 to 27)	20 (16 to 24)
Concussion/closed-head injury¶	8 (5 to 11)	2 (0 to 3)	2 (–1 to 6)	4 (0 to 8)	3 (0 to 5)	3 (1 to 6)	2 (0 to 4)	4 (3 to 5)
Burns	2 (1 to 4)	1 (0 to 3)	–	–	–	–	–	1 (0 to 1)
Non-injury**	–	–	0 (0)	7 (0 to 14)	6 (3 to 9)	11 (6 to 17)	10 (5 to 15)	5 (4 to 7)
Other††	2 (0 to 4)	2 (0 to 4)	2 (0 to 5)	6 (0 to 11)	11 (6 to 17)	10 (6 to 14)	18 (11 to 25)	8 (5 to 11)
<b>Discharge disposition</b>								
Treated and released	97 (95 to 99)	99 (99 to 100)	99 (98 to 100)	99 (98 to 100)	97 (95 to 100)	92 (88 to 96)	89 (84 to 94)	95 (94 to 97)
Transferred, admitted, held for observation, or fatality	2 (1 to 4)	0 (0 to 1)	0 (0 to 1)	1 (0 to 2)	3 (0 to 5)	8 (4 to 12)	11 (6 to 16)	5 (3 to 6)
Left without being seen	0 (0 to 1)	0 (0)	1 (–1 to 2)	–	–	–	0 (0)	0 (0)
<b>Equipment type</b>								
Treadmill	69 (63 to 76)	58 (51 to 65)	63 (53 to 74)	75 (64 to 86)	66 (59 to 73)	68 (62 to 74)	62 (56 to 69)	66 (62 to 69)
Stationary bicycle	10 (6 to 14)	27 (20 to 34)	10 (1 to 19)	8 (–2 to 14)	11 (6 to 16)	16 (12 to 21)	26 (20 to 33)	17 (14 to 19)
Elliptical	6 (2 to 9)	5 (2 to 9)	9 (3 to 14)	6 (2 to 14)	6 (3 to 9)	6 (2 to 10)	1 (–1 to 2)	5 (4 to 7)
Unspecified/other exercise machine	15 (10 to 20)	10 (6 to 14)	18 (10 to 26)	11 (4 to 17)	16 (12 to 21)	10 (6 to 13)	11 (6 to 15)	13 (10 to 15)

Values indicate percentages and 95% CIs in parentheses.

Source: NEISS, 2007–2011.

Cells with ‘–’ indicate instances with no (n=0) observations for which estimation was not possible. Equipment type based on narrative reviews.

\*Head/neck category includes ear, eye, face, neck, and mouth.

†Includes internal injuries, injuries to 25–50% or all the body, or body part not recorded.

‡Includes contusions, abrasions, crushing injuries, and haematomas.

§Non-head.

¶Includes concussion or the following injuries to the head body part: fracture, internal organ injury.

\*\*Based on narrative review of cases categorised by NEISS as missing/not stated.

††Includes dislocation, foreign body, dental injury, nerve damage, internal organ injury (non-head), haemorrhage, poisoning, anoxia, ingestion of a foreign object, or dermatitis/conjunctivitis.

NEISS, National Electronic Injury Surveillance System.

more likely to require more medical care compared with persons of younger ages (OR: 2.58; 95% CI 1.45 to 4.60).

### Machine type

Older adults (aged 65 years and older) were more commonly injured on stationary bicycles relative to younger ages (table 2) ( $p<0.01$ ). Adjusting for sex, body part injured and diagnosis, injuries among older adults had greater odds of being attributed to stationary bicycles than unspecified/other machines, compared with younger individuals (<65 years) (OR: 2.01, 95% CI 1.32 to 3.06).

The proportion of injuries attributed to specific mechanical home exercise equipment varied across types of injuries and diagnoses (table 3). Lower extremity injuries were common for treadmills, stationary bicycles and elliptical machines (36–48% of all injuries). Many injuries attributed to treadmills were also upper extremity injuries (31%; 95% CI 26 to 35); these injuries were not common with stationary bicycles (16%, 95% CI 11 to 21) or elliptical machines (18%, 95% CI 10 to 25).

### Friction burns

Nationally, approximately 309 (95% CI 75 to 543) hand or finger friction burn injuries occurred from 2007 to 2011 and only among children (0–9 years), representing only 1.2% (95% CI 0.3 to 2.2) of injuries in this age group. Most friction burn injuries involved treadmills (79.9%; 95% CI 43.6 to 100); the remainder involved stationary bicycles.

### Avulsions and amputations

Between 2007 and 2011, an estimated 895 amputations and avulsions (95% CI 447 to 1342) of fingers and hands were attributed to mechanical home exercise equipment. Among these, 81.5% (95% CI 60.8 to 100) occurred among children (0–9 years) and 73.1% (95% CI 51.1 to 95.0) were attributed to treadmills.

### DISCUSSION

Mechanical home exercise equipment-related injuries are common, and affect people of all ages. Treadmill machines comprise 66% of injuries, but constitute approximately only 1/4 of the market share of such equipment.<sup>16</sup> Mechanical belt-driven

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**Table 3** Characteristics of injuries attributed to mechanical home exercise equipment (by type) treated in US emergency departments, 2007–2011, weighted to reflect national estimates

	Treadmill (n=46 049) % (95% CI)	Stationary bicycle (n=11 759) % (95% CI)	Elliptical (n=3589) % (95% CI)	Unspecified/other exercise machine (n=8905) % (95% CI)
Body part injured				
Head/neck*	19 (17 to 22)	15 (10 to 20)	23 (14 to 33)	35 (30 to 41)
Upper extremities	31 (26 to 35)	16 (11 to 21)	18 (10 to 25)	21 (14 to 27)
Lower extremities	36 (32 to 39)	48 (39 to 57)	44 (31 to 57)	28 (21 to 34)
Trunk	12 (10 to 14)	20 (14 to 26)	14 (4 to 23)	16 (10 to 22)
Other†	2 (1 to 3)	2 (0 to 3)	1 (–1 to 3)	1 (–1 to 3)
Diagnosis				
Laceration	18 (15 to 22)	23 (17 to 29)	28 (18 to 38)	30 (24 to 37)
Soft tissue injury‡	33 (29 to 37)	25 (18 to 32)	15 (7 to 22)	24 (18 to 29)
Fracture	10 (8 to 12)	18 (13 to 23)	8 (2 to 14)	17 (12 to 23)
Sprain/strain	21 (16 to 26)	18 (12 to 24)	25 (13 to 37)	13 (7 to 19)
Concussion/closed-head injury§	3 (2 to 4)	2 (0 to 3)	3 (–2 to 7)	7 (3 to 12)
Burns	1 (0 to 2)	1 (–1 to 2)	–	–
Non-injury¶	5 (4 to 7)	7 (3 to 11)	10 (3 to 17)	2 (0 to 4)
Other**	8 (6 to 11)	7 (3 to 11)	11 (2 to 21)	7 (1 to 12)
Discharge disposition				
Treated and released	96 (95 to 97)	92 (88 to 96)	92 (86 to 99)	97 (94 to 100)
Transferred, admitted, held for observation, or fatality	4 (2 to 5)	8 (4 to 12)	8 (1 to 14)	3 (0 to 6)
Left without being seen	0 (0 to 1)	0 (0)	–	–

Values indicate percentages and 95% CIs in parentheses.

Source: NEISS, 2007–2011.

Cells with “–” indicate instances with no (N=0) observations for which estimation was not possible. Equipment-type based on narrative reviews.

\*Head/neck category includes ear, eye, face, neck, and mouth.

†Includes internal injuries, injuries to 25–50% or all the body, or body part not recorded.

‡Includes contusions, abrasions, crushing injuries, and haematomas.

§Includes concussion or the following injuries to the head body part: fracture or internal organ injury.

¶Based on narrative review of cases categorised by NEISS as missing/not stated.

\*\*Includes dislocation, foreign body, dental injury, nerve damage, internal organ injury (non-head), haemorrhage, poisoning, anoxia, ingestion of a foreign object, or dermatitis/conjunctivitis.

NEISS, National Electronic Injury Surveillance System.

equipment may present disproportionate injury risk in mechanical home exercise equipment. While we do not have data on the use of these machines, our study suggests the need to consider the hazards associated with in-home mechanical exercise equipment in the context of exercise recommendations.

Compared with adults, children experienced proportionally more injuries from mechanical home exercise equipment. Because young children do not typically use equipment for exercise, these injuries are likely to have resulted from unsupervised access to home machines intended for adult use.<sup>17</sup> A large proportion of children experienced lacerations and soft tissue injuries to the head and upper extremities. Although relatively uncommon, severe injuries to the hands and fingers may result in disability. Treadmills were primary sources of these severe hand and finger injuries, consistent with previous studies of friction burns,<sup>3–6</sup> while amputations and avulsions have been attributed to stationary exercise bicycles.<sup>7</sup> These paediatric injuries suggest design modifications, parental education, and reduced accessibility for children may be warranted to improve the safety of mechanical home exercise equipment.

Older adults (aged 65 years and older) were more likely to sustain injury requiring hospitalisation. Older adults were more likely to be injured on stationary bicycles, potentially due to differential exposure. We speculate that older adults may prefer to exercise on a fixed piece of equipment to minimise hazards from balance problems. Confounding factors may include

medication, balance or frailty.<sup>18</sup> Regular exercise, balance and strength training reduce the risk of falls in older adults.<sup>19</sup> Our findings underscore the importance of reviewing health benefits and the possibility of injury when exercising at home with mechanical equipment.

Manufacturers, retailers, owners, users and healthcare providers can help prevent injuries from mechanical home exercise equipment. Manufacturers could modify equipment design to improve safety for users and children in the household.<sup>7 10 20–22</sup> Retailers can educate buyers about safety features, hazards and proper use of machines at the time of purchase.<sup>3</sup> Positioning the machine to face the doorway, or using a mirror could improve visibility if there are children in the household, as recommended in a previous study on paediatric treadmill injuries.<sup>17</sup> Users should be aware of safety features, and should be vigilant about their surroundings to prevent injury to others. Healthcare providers may review risks and benefits with patients who wish to begin an exercise programme.<sup>5</sup>

This study has limitations. Specific equipment type was not routinely recorded in narratives, and misclassification may have occurred. Reliable measures of exposure to mechanical home exercise equipment were not available. These data only captured injuries reported in EDs, and injury information is limited in detail (eg, injury mechanism is not coded in NEISS). Also, non-injury diagnoses, although reported here, are not systematically collected by NEISS and, therefore, should not be considered a

representative estimate of non-injury diagnoses associated with mechanical home exercise equipment. Finally, the pattern of injuries observed in this study may be specific to the USA. However, studies in other countries have similarly described paediatric injuries from treadmills and exercise bicycles.<sup>6 8 9 17</sup> Preventing injuries from mechanical home exercise equipment is relevant to countries where exercising at home may also be common. Further practice-based research investigating effective injury prevention approaches may be warranted.

Despite these limitations, this is the first study to generate national estimates for mechanical home exercise equipment-related injury across the age spectrum. As Americans seek to attain healthier lifestyles, we may see continued use of mechanical home exercise equipment. It is critical that manufacturers, retailers, owners, users and healthcare providers prioritise safety as a component of a healthy lifestyle.

### What is already known on this subject

- Recommendations suggest 30 min a day of vigorous physical activity.
- Use of mechanical home exercise equipment associated with child injury risk.

### What this study adds

- Mechanical home exercise equipment is associated with emergency department injuries across the age spectrum.
- Older individuals were at risk of hospitalisation following in-home exercise-related injuries.
- Treadmill machines comprise 66% of injuries, but constitute approximately only 1/4 of the market share of such equipment.
- Compared with adults, children were at much greater risk for injuries from mechanical home exercise equipment.

**Contributors** MSV, JMG and BEE conceived of the study. JMG and MSV designed the study. JMG and KRI acquired the data. All authors contributed substantially to data interpretation and critical manuscript revisions. All authors gave final approval of the version to be published.

**Funding** Dr Graves receives fellowship support from National Institute of Child Health and Human Development (PI: Rivara, T32 HD057822-01A2). This work was

also supported by the Harborview Injury Prevention & Research Center, University of Washington.

**Competing interests** None.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data sharing statement** Data used in this study are free and publicly available from the Consumer Product Safety Commission.

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*Inj Prev* published online September 23, 2013

doi: 10.1136/injuryprev-2013-040833

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<http://injuryprevention.bmj.com/content/early/2013/09/09/injuryprev-2013-040833.full.html>

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*These include:*

### References

This article cites 17 articles, 2 of which can be accessed free at:  
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