Are seat belt restraints as effective in school age children as in adults? A prospective crash study

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Abstract

Objective To study effectiveness of seat belts for protecting school age children in road vehicle crashes.
Design Crash examinations by trained investigators.
Setting Ten Canadian university based crash investigation centres.
Subjects 470 children aged 4-14 years, with 168 selected for detailed analysis, and 1301 adults.
Main outcomes measures Use of seat belts by vehicle occupants; severity of injury adjusted for age and crash severity.
Results Overall, 40% (189/470) of children were unbelted. Of the 335 children in cars driven by belted adults, 73 (22%) were unbelted. The odds of sustaining fatal or moderately severe injury (injury severity score ⩾4) for children in the front passenger seat was more than nine times higher for unbelted children than for belted ones (odds ratio 9.8 (95% confidence interval 2.4 to 39.4)) and for those in the rear left seat was more than two times higher for unbelted than for belted children (2.6 (1.1 to 5.9)). The protection afforded by seat belts compared favourably with the results for adults in the same seat positions (odds ratios for unbelted *v* belted adults of 2.4 and 2.7 for front and rear seat passengers respectively).
Conclusions Seat belts helped to protect school age children from injury in road vehicle crashes. However, 40% of children were unbelted. Despite standard seat belts being designed for adults, school age children were at least as well protected as adults.

Introduction

Road vehicle crashes are a leading cause of death in North America and the United Kingdom in children aged 4-14 years.[1 2] In most developed countries traffic safety legislation mandates specific restraints for toddlers and infants, but there are no seat belts designed specifically for older children. School age children have to use the standard seat belts designed for adults.

Standard lap belts are designed to restrain an adult just below the centre of gravity at the pelvis.[3] However, the immature anatomy of a child's pelvis cannot provide anchor points for the belt until the child is at least 10 years of age.[4] Deceleration forces on children in the event of a crash may produce injuries in the abdomen and mid-lumbar spine.[5 6] The addition of the torso sash to the lap belt may place children at increased risk of cervical spine injuries.[7]

The purpose of our study was to determine whether seat belts are as effective for school age children as they are for adults.

Methods

Selection of subjects

The Road Safety and Motor Vehicle Regulation Directorate of Transport Canada funded a national network of 10 university based research teams, called the Passenger Car Study, to conduct in depth investigations of car crashes from 1984 to 1992. Each team in the Passenger Car Study investigated a sample of car crashes resulting in injury or death that occurred within a prescribed geographical area adjacent to the team's location.[8 9] Seat belt use was determined primarily by examination of the interiors of the cars, including loading of the seat belt locking mechanism and seat belt fraying.

We studied individual occupants identified in the Passenger Car Study who were aged 4-14 years; where, if seat belts were worn, they were worn correctly; and for whom complete data on their seat position and injury severity score were available. Fewer than 1% of the sample had used a booster seat or were involved in a crash where an airbag was deployed, and we therefore excluded these subjects.

Outcome measures

Collision investigators calculated the change in velocity experienced in the passenger compartment using the barrier equivalent velocity algorithm.[10–12] Barrier equivalent velocity was available only in the later years of the study and, because of limited resources, was performed on only a single vehicle in each crash.

We obtained abbreviated injury scores from hospital and coroner documentation and used them to derive the Injury severity scores.[13 14] We decided a priori that a difference in mean injury severity score of >1 was clinically important. We also evaluated the score as a binary outcome response (score ⩾4) indicating at least moderately severe injury.[2]

Statistical analysis

In crashes with more than one child occupant, we randomly selected one school age child for analyses in order to preserve the independence of the observations. Firstly, we performed a matched pair analysis comparing injury severity in adult drivers and child passengers. Secondly, we compared injury severity of adults with children in the front passenger seat to evaluate the effect of the lap-torso belt and in the rear left seat (behind the driver) to evaluate the effect of the lap belt.

Results

The Passenger Car Study investigated 7853 crashes involving 13 421 vehicles with 21 629 occupants, of whom 796 were children age 4-14 years with known seat belt status. Of the 796 children, 646 were in vehicles where occupants had correctly worn seat belts and had complete data for injury severity scores. We randomly selected one child from each car, yielding 470 children. Overall, 40% of children and 29% of adults were unbelted. Among adult drivers who were belted, 22% of the children in the same vehicle were unbelted (P=0.0001). Compared with unbelted adults,

Table 1 Comparison of injuries sustained by child and adult passengers involved in road vehicle crashes by seat belt status: front seat occupants

	Mean (95% CI) injury severity score*	Odds ratio (95% CI) of moderately severe injury†
Children (n=83):		
Belted (n=56)	0.8 (0.5 to 1.2)	1.0
Unbelted (n=27)	3.4 (2.0 to 6.3)	9.8 (2.4 to 39.4)
Adults (n=1144):		
Belted (n=787)	1.7 (1.5 to 1.8)	1.0
Unbelted (n=357)	3.0 (2.6 to 3.6)	2.4 (1.8 to 3.2)

*Adjusted for age and barrier equivalent velocity. †Injury severity score ≥4.

Table 2 Comparison of injuries sustained by child and adult passengers involved in road vehicle crashes by seat belt status: rear seat occupants

	Mean (95% CI) injury severity score*	Odds ratio (95% CI) of moderately severe injury†
Children (n=85):		
Belted (n=52)	1.0 (0.6 to 1.6)	1.0
Unbelted (n=53)	2.1 (1.2 to 3.6)	2.6 (1.1 to 5.9)
Adults (n=157):		
Belted (n=53)	1.1 (0.6 to 1.7)	1.0
Unbelted (n=104)	2.2 (1.6 to 3.0)	2.7 (1.2 to 6.2)

*Adjusted for age and barrier equivalent velocity. †Injury severity score ≥4.

the odds ratio of moderately severe injury for unbelted children was 0.76 (95% confidence interval 0.36 to 1.6), for belted adults 0.21 (0.06 to 0.77), and for belted children 0.12 (0.01 to 0.95).

From the 470 children, we selected 168 children (83 front seat and 85 rear seat) from later study years with complete information on barrier equivalent velocity for subsequent analyses. We compared these 168 children with 1301 adults (1144 front seat and 157 rear seat) with known seat belt status and complete injury severity scores. These analyses were stratified by front passenger seat and left rear seat. Among the 83 children in the front passenger seat, 10 (37%) of the 27 unbelted children were killed and 13 (48%) sustained at least moderately severe injury (injury severity score ≥4), compared with four (7%) and nine (16%) respectively of the 56 belted children (table 1). Among the 85 children in the rear left seat, five (15%) of the 33 unbelted children were killed and 14 (42%) were at least moderately severely injured, compared with six (12%) and 13 (25%) respectively of the 52 belted children (table 2). When these results are compared with those for 1144 adults in the front passenger seat (table 1) and 157 adults in the rear left seat (table 2), they show that seat belts were of similar or better effectiveness for the school age children.

Discussion

Our results consistently show that school age children involved in motor vehicle crashes were less severely injured if they were wearing a seat belt. Previous research has provided mixed results on the effectiveness of seat belts for school age children, and in some jurisdictions children are still allowed to travel unbelted in the back seats of road vehicles.[8] Although a standard lap belt may cause abdominal and spinal injuries in some children, the so called lap belt syndrome is rare (reported in one study to occur in only 1.4% of all child passengers injured in motor vehicle crashes[6]). The slight possibility of this injury should not be misinterpreted by parents or clinicians to suggest that school age children should travel without a seat belt. Our study confirms the results of Corneli et al[15] that school age children were at least as well protected as adults by standard seat belts. Therefore, the most critical issue identified in this study is the need to urge parents and guardians to "buckle up" their children.

Our findings do not answer the question about whether the degree of protection afforded by standard seat belts is sufficient. A child aged 5-14 years in a standard lap-torso belt may have a risk of injury 70% higher than does a child aged 0-4 years in a child car seat.[16] Thus, although we found seat belts to be at least as effective for school age children as they were for adults, infants and toddlers may be even better protected in their respective restraints.

Limitations of study

The sampling for this study was not random, and the results may apply only to more severe crashes. Furthermore, this study, like all studies of injury, is subject to selection bias[17 18] because subjects will be identified to police, ambulances, insurance companies, or tow truck drivers because of crash severity or injury. However, selection bias tends to reduce the estimated benefit of interventions, such as child restraint, because those who are protected are less likely to be identified. Thus, any such bias would lead to our underestimating the true protective effect of seat belts.

Another potential limitation of our study was that the reporting of seat belt use relied in part on occupants' self reports. However, a strength of this study was that, in contrast to prior studies, the assessment of seat belt use was based primarily on vehicle inspections by experienced collision investigators, including assessment of belt loading and fraying. Furthermore, any information from car occupants was obtained by an independent third party and in a confidential manner to maximise honest responses.

Our information on seat belt use was from 1984 to 1992, but a study in the mid-1990s reported similarly low rates of seat belt use.[15] Finally, seat position and seat belt type were highly associated, making any inferences about their respective safety impossible.

What is already known on this topic

Although child restraints protect young children in road vehicle crashes, it is not known whether standard seat belts used by school age children work as well

School age children are often unbelted in cars

What this study adds

Data from detailed crash assessments indicate that seat belts protected children at least as well as adults

Adults were more likely than children to be belted, and 22% of children travelling with belted drivers were unbelted

Conclusion

School age children (4-14 years old) restrained with a seat belt were 2-10 times as safe as unbelted children in car crashes and were at least as well protected as adults wearing seat belts. Despite these benefits, 40% of children in our study were unbelted. Urgent efforts should therefore be made to increase the use of seat belts by school age children. However, it is not clear if the degree of protection afforded by such belts could be improved. Given the impact of childhood injury on potential life lost, further research and development of highly effective restraints designed for school age children is warranted.

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Driver sleepiness and risk of serious injury to car occupants: population based case control study

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Abstract

Objectives To estimate the contribution of driver sleepiness to the causes of car crash injuries.

Design Population based case control study.

Setting Auckland region of New Zealand, April 1998 to July 1999.

Participants 571 car drivers involved in crashes where at least one occupant was admitted to hospital or killed ("injury crash"); 588 car drivers recruited while driving on public roads (controls), representative of all time spent driving in the study region during the study period.

Main outcome measures Relative risk for injury crash associated with driver characteristics related to sleep, and the population attributable risk for driver sleepiness.

Results There was a strong association between measures of acute sleepiness and the risk of an injury crash. After adjustment for major confounders significantly increased risk was associated with drivers who identified themselves as sleepy (Stanford sleepiness score 4-7 *v* 1-3; odds ratio 8.2, 95% confidence interval 3.4 to 19.7); with drivers who reported five hours or less of sleep in the previous 24 hours compared with more than five hours (2.7, 1.4 to 5.4); and with driving between 2 am and 5 am compared with other times of day (5.6, 1.4 to 22.7). No increase in risk was associated with measures of chronic sleepiness. The population attributable risk for driving with one or more of the acute sleepiness risk factors was 19% (15% to 25%).

Conclusions Acute sleepiness in car drivers significantly increases the risk of a crash in which a car occupant is injured or killed. Reductions in road traffic injuries may be achieved if fewer people drive when they are sleepy or have been deprived of sleep or drive between 2 am and 5 am.

Introduction

Published estimates of the proportion of crashes attributable to sleepiness vary more than tenfold, from 1-3% for the United States[1] to 10% in France[2] and 33% in Australia.[3] This variation reflects the quality of the data available as these figures are derived from descriptive information about crashes.

Measures of acute and chronic sleepiness, sleep restriction, sleep disorders, and work patterns that interfere with normal sleep have been associated with decreased performance in psychomotor tests and driving simulators[4–8] and with increased rates of crashes in selected populations.[9] We examined the association of these sleep related characteristics with the risk of