

Is Your Child's Seating System HAZARDOUS?

Wheelchair lap belts, trunk supports and positioning straps need to be installed and used safely.

By Peter W. Axelson, Denise Chesney, and Jamie Noon

A young girl with athetoid cerebral palsy had a seating system equipped with a lap belt and butterfly chest support — simple devices to position her in her wheelchair. One day, she was left unattended for a short while. During this time, her hips slipped underneath her lap belt, she slid down in her wheelchair and was asphyxiated by her butterfly chest support.

There have been several incidents in which children — and adults — with limited awareness of safety issues involving their wheelchair seating systems have been asphyxiated by a trunk support or positioning belt. While the number of reported incidents is relatively small, the situations have resulted in serious injury or death.

Potential Hazards of Your Child's Seating System

Wheelchair lap belts, trunk supports (for example, butterfly and H-harnesses), and positioning straps are commonly used to position children in their wheelchairs. These devices appear relatively easy to install and use. They are often "cute" and colorful, and look quite simple and harmless. They are intended to make your child's system better by providing support to the pelvis (hips) and torso.

However, improper use of these positioning devices can be hazardous and in some cases fatal to children and adults.

If your child slides down in the wheelchair and slips underneath the lap belt, his/her neck could get caught on the trunk support or lap belt. This could lead to injury, strangulation, or even death.

In another reported case, a child with spastic diplegic cerebral palsy slipped down in his wheelchair and was asphyxiated by his H-harness. His seating system did not have any type of pelvic positioning device.

If a trunk support is used and positioning of the pelvis/hips is not maintained properly with a lap belt or other device, the risk of injury increases.

Importance of Proper Pelvic Positioning

The effectiveness of the entire seating system often relies upon proper positioning of the pelvis, because this provides a stable base of support. An appropriate pelvic positioning device helps to achieve this. The lap belt is one of the most commonly used devices for this; therefore, careful attention must be paid to its selection, installation and use.

As a parent, it is important to understand how a lap belt should be installed so that you can determine if your child's seating system has been set up properly. It is also important to understand how to use a lap belt properly so that you, or anyone else who might position your child in his or her wheelchair, does not put your child at risk of injury.

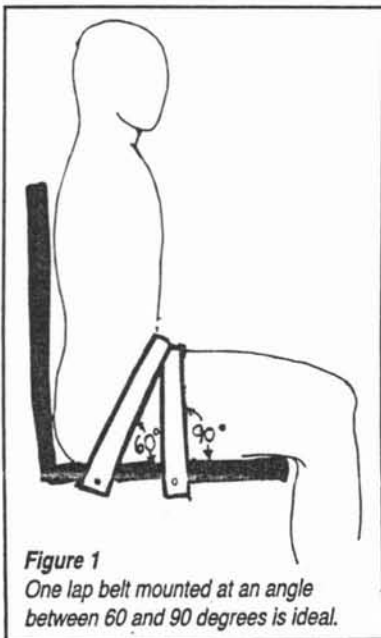


Figure 1
One lap belt mounted at an angle between 60 and 90 degrees is ideal.

Installation and Use of Lap Belts

A wheelchair lap belt should be snug across the user's pelvis or upper thighs. It should not be easily loosened through casual contact or normal activities. Once cinched to the correct tightness, the belt length should not be easily adjustable. In addition, the lap belt release mechanism should be easy to identify so that the child can be removed from the wheelchair when desired or in the event of an emergency.

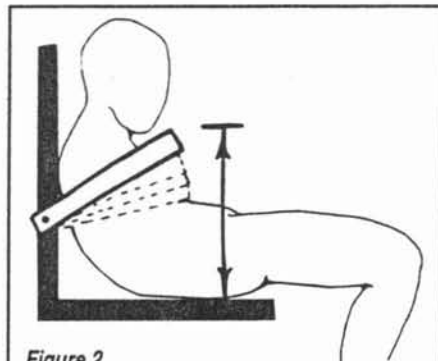


Figure 2
Using a lap belt that is mounted at zero degrees to the seat surface can be dangerous. If it pivots upward, it creates a space underneath the lap belt which can allow the user's pelvis to slide forward in the seat.

The lap belt angle between the seating surface and the belt, ideally should be between 60 and 90 degrees (Figure 1). Any angle less than 45 degrees from the seat surface could be dangerous. To understand why, let's examine the two extremes: a zero-degree and a 90-degree lap belt angle.

A zero-degree lap belt would be attached to the back posts and would be horizontal when fastened around the user. This belt can pivot about its attachment point. If it pivots upward, it creates vertical clearance under the belt which can allow the user's hips to slide underneath (Figure 2). This is called submarining. ➡

The lap belt then loses contact with the user's bony structures and becomes positioned over the softer abdominal area, no longer supporting the user in the proper sitting position.

In contrast, a lap belt mounted at 90 degrees is perpendicular to the seating surface. As this belt pivots about its attachment point, the vertical clearance under the belt decreases (Figure 3), making it difficult for the user to slide underneath.

A lap belt between 60 and 90 degrees creates a downward pull or force across the user's upper thigh and prevents the pelvis from sliding forward.

The point of attachment dictates the angle of the lap belt to the seat surface. As the attachment point moves forward along the seat rail, the angle between the belt and the seat surface approaches 90 degrees.

Conversely, as the attachment point moves rearward, the belt angle decreases. This results in a greater probability of the user sliding under the lap belt.

A lap belt that is attached behind the seat-back junction will almost always result in an angle that is less than 45 degrees.

Wheelchair users who have poor safety awareness and tend to move their legs and feet, are at a higher risk of sliding under

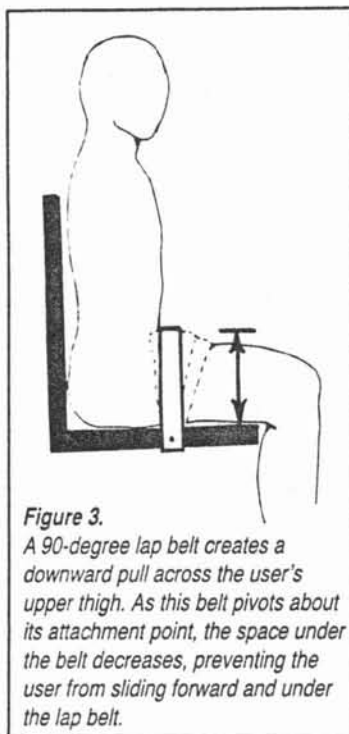


Figure 3.
A 90-degree lap belt creates a downward pull across the user's upper thigh. As this belt pivots about its attachment point, the space under the belt decreases, preventing the user from sliding forward and under the lap belt.

the lap belt if their lower extremities are not properly supported and positioned.

While in a seated position, raising one's legs flexes the hips which promotes backward tilting of the pelvis. This facilitates sliding under the lap belt. Under these circumstances, the legs should be securely positioned.

Lap Belt vs. Motor Vehicle Seat Belt

It is critical to understand that wheelchair lap belts do not typically provide the same protection as motor vehicle seat belts. In fact, use of a wheelchair lap belt as a motor vehicle seat belt can contribute to serious

injury in a crash.

Wheelchair postural lap belts and their associated anchorages are not designed or intended to withstand high static or impact loads. A new standard, SAEJ2249-Wheelchair Tiedowns and Occupant Restraint Systems for Use in Motor Vehicles, provides guidance for the proper installation and use of wheelchair and occupant restraint systems. (See "Additional Information" on page 28.)

Use of Trunk Supports

An anterior trunk support, such as a butterfly, sternal support or H-harness,

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Recommended Practices

- Make sure the pelvis is properly positioned.
- Always follow the recommended practices specified by the manufacturer.
- The length of the lap belt should not be too easily adjustable; once adjusted, it should maintain its adjustment during normal use.
- The lap belt angle should be 60 to 90 degrees from the seating surface.
- Keep the point of attachment of the lap belt as close to the seating surface as possible.
- Keep the lower extremities properly positioned and supported.
- Always use a snug lap belt or other pelvic positioning device when an anterior trunk support is used.
- Always use approved vehicle safety equipment that is attached to the vehicle when traveling in a motor vehicle. A postural (pelvic) lap belt alone is unsafe.
- The positioning and adjustment of the trunk support should not be too easily adjustable. It should not be possible to disconnect or remove the trunk support and attach it in an incorrect orientation. ■

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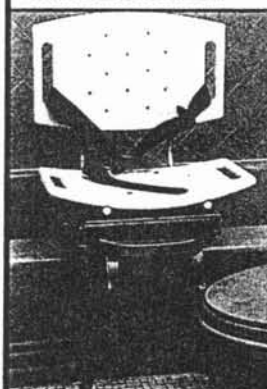
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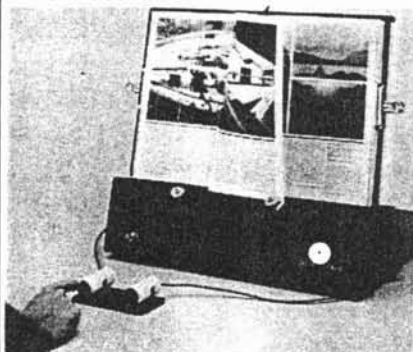
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Seating System

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when used correctly can provide needed postural support. It is imperative to understand that proper positioning of the pelvis must be maintained at all times to avoid the risk of asphyxiation by the trunk support.

The trunk support should be designed such that it is not possible for the user or attendant to adjust it through casual contact or normal activities. It should also be easy to disconnect or remove when desired. If it is possible to disconnect or remove a trunk support and attach it in a reversed or upside down orientation, differences in strap length could position the trunk support closer to the child's neck area, putting the child at a greater risk of injury. Thus, the trunk support should be set up or designed to prevent it from being attached upside down or sideways.

Assessing Your Child's Current Seating System

You might think that the person or persons who provided your child's seating system set it up the "right way." Unfortunately, not everyone who recommends, sells or installs seating and positioning equipment is aware of the issues presented in this article.

If you think that your child's seating system is not set up properly, contact your local rehabilitation center or medical facility as soon as possible to determine if a seating assessment is necessary and what to do in the meantime.

If you suspect a hazard, be sure your child does not use the wheelchair unsupervised until it has been reassessed.

A seating assessment should be conducted by a team of people of which a member is a RESNA-certified Assistive Technology Provider (ATP), Assistive Technology Supplier (ATS) or NRRTS Certified Rehabilitation Technology Supplier (CRTS).

Educate others

If your child uses a lap belt, trunk support and/or positioning straps, it is important to educate anyone who might adjust these components or take your child in and out of the wheelchair. This could include family members, caregivers, babysitters, teachers, drivers and social workers. Continue to educate new people as staff can change frequently.

Who is responsible for the appropriate set up of the wheelchair lap belt as well as the combination of other positioning

devices that might be used? Is it the lap belt manufacturer, the store owner who sold it to you, or the physician who prescribed the components? Or is it the rehabilitation technology supplier, therapist, clinician, or assistive technology provider who recommended or set up the seating system?

Could responsibility fall on anyone who uses, positions, or adjusts the components, including teachers, health care workers, volunteers, social workers, and parents?

Is anyone responsible, or are these just unfortunate circumstances? The creation of seating standards that establish a standard of practice could reduce the number of these tragic incidents. It is important to understand that it is not just an issue of how the system is set up, but also of how the equipment is being used on a day-to-day basis. If a worker in a residential facility removes a lap belt, that person needs to understand the implications of doing so, and the potential risks involved with the different types of positioning equipment.

So be aware of the potential hazards, educate others on the proper use of your child's seating system components, and provide feedback to the professionals who prescribe and provide your child's equipment. ■

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Additional Information

Potential Hazards of Wheelchair Lap Belts.

By Peter W. Axelson, and Denise A. Chesney. Proceedings of the RESNA 1995 Annual Conference. RENESA Press, Arlington, VA.

A Seat Belt Is a Seat Belt Is a...
By A.F. Bergen. Assistive Technology, Vol. 1, No. 1, 1989.

Wheelchair Tiedowns and Occupant Restraint Systems for Use in Motor Vehicles. SAEJ2249. Published by the Society of Automotive Engineers, Warrendale, PA.

RESNA

1700 N. Moore St., Suite 15, Arlington, VA 22209 tel: (703) 524-6686, www.resna.org

NRRTS

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SAE Society of Automotive Engineers
400 Commonwealth Drive, Warrendale, PA 15096-0001, tel: (412) 776-4841 ■

POTENTIAL HAZARDS OF WHEELCHAIR LAP BELTS

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ABSTRACT

Wheelchair lap belts are commonly used to maintain the appropriate pelvic position of a wheelchair user. Through our research and consulting experience we have found that accidents and incidents have occurred as a result of misapplication, and/or misuse of wheelchair lap belts. There appears to be a lack of awareness of the hazardous situations that could potentially occur when a wheelchair lap belt is not selected, mounted and used properly. A lap belt mounted to the wheelchair at the wrong location will create an inappropriate lap belt angle. Excessive vertical movement of the lap belt and clearance underneath the lap belt would then facilitate sliding in the seating system. With careful selection and use, a wheelchair lap belt may serve as an effective device for pelvic positioning without putting the user at risk of strangulation, suffocation or other injurious situations.

BACKGROUND

It is widely known that when seating an individual, a stable base of support is essential. A wheelchair lap belt is one of the simplest and most common devices used to achieve pelvic stabilization. Since the success of the entire seating system often relies upon proper pelvic positioning, careful attention must be paid to the selection and use of the lap belt (1). The rehabilitation industry has essentially accepted a lap belt angle of 45 to 90 degrees to the seating surface as a standard; although written standards do not exist.

OBJECTIVE

The objective of our work was to analyze two seating systems involved in wheelchair incidents to determine the appropriateness and the level of safety provided by all positioning devices, particularly wheelchair lap belts. The selection, method and location of attachment, and the effectiveness of all positioning devices used on the seating systems were examined. Existing knowledge and industry standards were also taken into consideration during the analysis.

METHOD/APPROACH

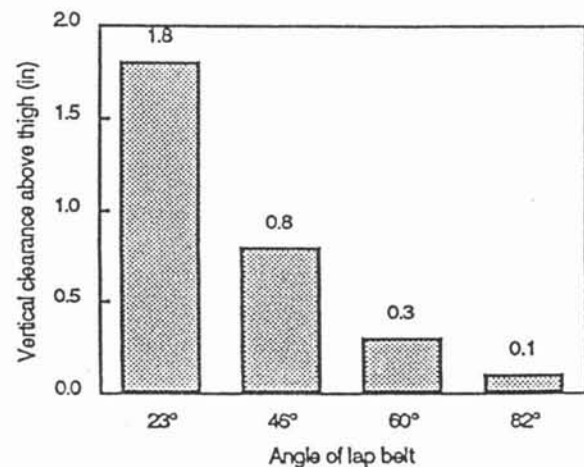
Evaluation of the two different seating systems (Cases A and B) began with detailed documentation and measurements of the seating components. ANSI/RESNA wheelchair standards measurement methods (2) were used. The wheelchair lap belts were evaluated to determine if they met the following criteria for

safety and function:

1. When properly positioned, the wheelchair lap belt: stabilized the pelvis; maintained proper pelvic positioning, and allowed pelvic movement, if appropriate.
2. The angle of the lap belt was at a minimum of 45 degrees from the seating surface (with 90 degrees being a vertical lap belt).
3. The point of attachment of the lap belt was as close to the seating surface plane as possible.
4. The length of the lap belt was adjustable and, once adjusted, the belt remained fixed in length.
5. The lap belt was not used as a seat belt in a motor vehicle.
6. Lower extremities were properly positioned.

To objectively evaluate specific configurations of the lap belt in Case B (described on next page), computer drawings were created using AutoCAD. Measurements of a small subject group were made to determine the approximate maximum percentage of compression of the thigh and of the torso that could be applied without pain or injury. Different lap belt attachment points and angles were simulated on the computer. Measurements were made to determine the effects of these various seating configurations on the amount of vertical clearance that could occur under the lap belt, assuming that the torso would be compressed 28% against the lap belt in a sliding situation.

Effects of the Lap Belt Attachment Point and Angle on the Amount of Vertical Clearance Above the Thigh



The results of the computer simulations of different lap belt configurations are shown in the bar graph. As the lap belt attachment point was moved forward along the seat rail, the angle between the lap belt and seating surface increased and the amount of vertical clearance that could occur under the belt decreased.

If the lap belt is attached such that the angle is greater than 60 degrees, when the lap belt pivots there is only a small increase in the amount of clearance under the lap belt. For example, in Case B assuming that the torso can compress 28%, a lap belt mounted at 45 degrees can pivot to create a vertical clearance that is over 250% more than the vertical clearance for a lap belt mounted at 60 degrees.

In addition, a literature search was conducted to identify the current knowledge within the seating industry. Electronic databases were searched for incidents and accidents involving lap belts and other positioning devices.

RESULTS

In addition to the two seating systems that instigated the investigations (A,B), four other incidents involving significant injury to the wheelchair user were identified: one by a colleague (C), and three through DEN Reports (Device Electronic Network) (D,E,F).

CASE	DESCRIPTION OF INCIDENT
A	A child with spastic diplegic cerebral palsy was riding on a bus on his way to school when he slipped down in his wheelchair and was asphyxiated by his H-harness.
B	A child with athetoid cerebral palsy slid down in her wheelchair and was asphyxiated by her butterfly chest support.
C	An elderly woman slid down in her wheelchair and was asphyxiated by her torso restraint.
D	Patient was found sitting on footrest of wheelchair with seatbelt around her neck.
E	Patient was found dead, half out of wheelchair with the belt up around throat.
F	Patient was left unattended in wheelchair with the wheelchair belt on. The patient was found to have slipped down in the wheelchair with arms extended above the head and belt around patient's chest.

Analysis of the two seating systems involved in Cases A and B revealed the following:

Case A:

The seating system contained an H-harness, but not a lap belt.

Case B:

The seating system contained a lap belt and a butterfly chest support.

When fastened, the angle between the lap belt and the seating surface was less than 45 degrees.

The lap belt was attached to the seat rail behind the seat-back junction.

The lap belt did not contain a mechanism for maintaining the proper length and thus could be easily lengthened/loosened.

The foot/ankle restraint straps were too long and the Velcro closure was not secure, thus the position of the lower extremities was not properly maintained.

DISCUSSION

The results of these wheelchair incident investigations indicate that careful attention to the following issues must be made in order to ensure a safe seating system.

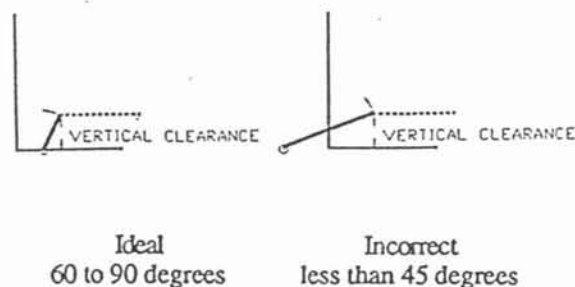
Use of Chest Supports

When using an anterior chest support, proper positioning of the pelvis must be maintained at all times. Although this seems like common sense, it is sometimes overlooked or neglected.

Angle of Lap Belt

The angle of the wheelchair lap belt should ideally be between 60 and 90 degrees from the seating surface. This angle creates a downward pull across the thigh/abdominal intersection. As the lap belt pivots about its attachment point, its rotation results in less vertical movement than for a lap belt mounted at a lesser angle. The resistance provided by the lap belt prevents the pelvis from sliding under the lap belt and thus makes it very difficult for a user's pelvis to slide forward.

Effects of Different Lap Belt Angles Attachment Points



Point of Attachment of Lap Belt

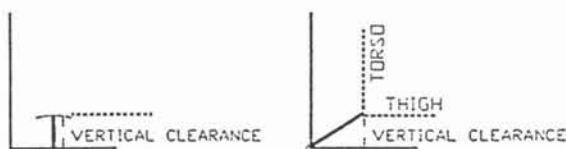
A lap belt attached behind the seat to back junction (for instance on the seat rail behind the user) will almost always result in a lap belt angle less than 45

degrees. When the lap belt pivots upward, there is an increase in the amount of clearance under the lap belt. The probability of sliding under the restraint is thereby increased.

If the lap belt is attached such that the angle is 90 degrees when the lap belt pivots, the amount of vertical clearance under the lap belt can only decrease. When looking at a 90 degree lap belt, it is not obvious how a vertically oriented lap belt would prevent sliding. However, since the vertical clearance in the belt cannot increase, the user cannot slide underneath the belt and thus can not slide forward.

If the lap belt is mounted at the seat to back junction, the angle will almost always be less than 45 degrees because the torso is almost always thicker than the legs.

Effects of Different Lap Belt Attachment Points



90 degree lap
belt mount

Mounting at seat to
back junction is
less than 45 degrees

Other Lap Belt Issues

It is critical that the length of the lap belt is maintained during use. Once cinched to the proper tightness, it should not be possible for the user to loosen the lap belt through casual contact or during normal daily activities.

When in a seated position, flexing at the hips by raising one's legs facilitates posterior tilting of the pelvis. Therefore, if the user tends to move his/her legs or feet and the lower extremities are not properly restrained, the user might slide under the lap belt.

Wheelchair lap belts are designed to be used as postural supports, not as pelvic restraints in a motor vehicle. They are not designed to withstand high static or impact loads. Use of a wheelchair lap belt as motor vehicle seat belt may lead to serious injury or death in the event of a collision, evasive maneuver, or even under normal driving conditions. When traveling in a motor vehicle, a proper seat belt and shoulder harness attached to the vehicle and meeting SAE safety standards must be used.

CONCLUSION

A wheelchair lap belt should be attached forward of the seat-back junction and as close in height as possible to the seating surface. When the lap belt is attached in this location, it usually creates the desired 45 to 90 degree angle. By minimizing the length of the lap belt, the amount of clearance that can occur under the lap belt is also decreased.

Should there be seating standards to ensure that wheelchair users are provided with safe seating systems?

Standards exist for automobile and aircraft seating. The expertise in the wheeled mobility and seating industry has progressed. The expertise is now available to develop seating standards that address basic seating needs. Therefore, we feel that the time has come for the development of wheelchair seating standards that address basic seating needs. Improper seating systems have caused several fatalities. Many users are currently at risk. If standards for wheelchair seating were implemented, incidents and accidents could be prevented and would provide wheelchair users with safer seating systems.

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- (1) Bergen A.F., "A Seat Belt Is a Seat Belt Is a ...". *Assistive Technology* 1989; 1(1):7-9.
- (2) ANSI/RESNA WC/07 Wheelchairs - Determination of Seating and Wheel Dimensions, 1991.

ACKNOWLEDGMENTS

Our thoughts are with the families and friends involved in the cases mentioned in this article.