Snell's response to *CSA Child Helmet Standard*

The CSA amendment for children's bicycle helmets may be unnecessary and burdensome to the industry and the public. Unless compelling evidence can be assembled in its support, the amendment should not be implemented.

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The amendment to CAN/CSA-D113.2, Cycling Helmets, introduces substantial changes to the ways children's bicycle helmets have been previously evaluated. The scope of these changes is so great that the amendment amounts to a rejection of most all currently available children's helmets and a call to industry to manufacture new and radically different children's bicycle headgear.

Current bicycle helmets originated as protection from serious injuries that cause death or long term disability. Epidemiological data indicate they have served that purpose well. However, proponents of the amendment suggest the following: first, concussion should be considered a serious form of injury that threatens long term disability; second, current children's bicycle helmets fail to protect bicyclists from concussion and third, the amendment specifies helmets that will be effective protection against concussion as well as other serious injury.

If this chain of contentions can be demonstrated, it will be ample justification for implementing the amendment. However, supporting evidence has not been produced. Without such evidence, experience and reason indicate that the changes proposed in the amendment may result in increased instances of serious head injury and that the rejection of current headgear will most certainly disrupt the helmet industry and undermine the public's faith in headgear.

The remainder of this development will be devoted to describing the extent of the changes posed in the amendment and the consequences for the bicycling public and for the industry.

How Helmets Protect

The critical issue for bicycle helmets is impact protection. When a helmeted bicyclist is struck on the head, the helmet must manage all the severity of the impact and limit the shock transmitted through the helmet to the cyclist. There are two major considerations: the impact severity which is proportional to the height from which the cyclist fell, and the shock which is proportional to the forces applied to the head.

Technically, shock might be thought of as an acceleration time history that describes a short, violent transition from one velocity to another. In this case, shock describes the transition from the falling velocity just before impact to the rebound velocity just afterwards.

The most widely accepted model relating shock to serious head injury states simply that if the peak acceleration of the shock does not exceed a certain value, there will be no serious injury. This is a threshold model. Any peak acceleration below the injury threshold is no more threatening than any other peak below this threshold. Any peak above this threshold is unacceptable.

Helmets attenuate rather than eliminate shock. They have a limited capacity to reduce and control the peak acceleration. Helmets manage impact by deforming, that is, by being crushed between the cyclist's head and whatever he is falling against. As the head crushes the helmet, it is gently slowed until one of two things happens. Either the head comes to a stop or the helmet is crushed to its minimum thickness.

If the head slows to a stop before the helmet is crushed to its minimum thickness, the peak acceleration to the head is determined by the helmet properties and by the mass of the human head. If the helmet is well made and has been designed to a good helmet standard, there will be no death or permanent injury.

If, instead, the head is still in motion when the helmet reaches its minimum thickness, the helmet properties are no longer relevant. The peak acceleration will be determined by the properties of the head and of the impacted surface, and will soar well above levels that anyone might consider tolerable.

The amount of crush in a given helmet increases with the severity of the impact. Therefore, for any particular helmet, there is an ultimate protective capacity, that is, an impact severity which just sufficient to crush the helmet to the limit of its minimum thickness.

Thus, in order for a helmet to protect in a given accident, two conditions must be satisfied. First, the helmet's ultimate protective capacity must be greater than the impact severity. Then, the helmet properties must be such that peak acceleration does not exceed the level of the wearer's tolerance. Of course, there are many other considerations that will complicate this simplified presentation but the essence of helmet function is summarized by two parameters, ultimate protective capacity and peak acceleration.

These two parameters depend on physical helmet properties. The peak acceleration varies with the helmet's stiffness. Stiffer helmets resist crushing and impart higher peak accelerations. The ultimate protective capacity depends on both the stiffness and the wall thickness. Stiffer helmets, by resisting crushing, manage greater impact severities than softer helmets of the same thickness. Thicker helmets allow more crush and therefore manage greater impact severities than thinner helmets of the same stiffness.

How Standards Work

Helmet standards set lower limits on impact protection by prescribing impact tests. These tests evaluate helmet stiffness and ultimate protective capacity simultaneously. In the tests, a helmet sample is placed on a metal headform of a given mass and dropped onto a steel anvil with an impact of a prescribed severity. The peak acceleration of the headform must not exceed a prescribed criterion.

If the peak acceleration of the headform exceeds the criterion, it's usually for one of two reasons. Either the helmet was too stiff causing the peak acceleration to exceed the criterion even though some crush capacity may have remained at the end of the impact, or the helmet was too soft and too thin and was crushed to its minimum thickness before the impact was over. Thus, the impact test replicates the essentials of head impact. If the test set-up, the prescribed severity and the peak acceleration criterion are well chosen, effective headgear will meet the requirements and questionable headgear will not.

However, standards do more than merely identify good helmets, they become the template for future helmet models. Manufacturers will design and build to the standard so that helmets will provide no less than what is required but they will not provide very much more. The standard will effectively define the future of headgear and the headgear industry.

Standards also have legal significance. Manufacturers of safety equipment must be prepared to demonstrate in court that they have exercised due diligence in every aspect of product design, production, and distribution. Part of this demonstration must include proof that their products meet the newest applicable standards. If, for any reason, products in distribution fail in some significant manner to meet current standards, manufacturers must demonstrate due diligence in recalling the affected units.

Standards bear directly in the public's selection and use of headgear, on the evolution of the helmet industry and on the legal responsibilities of manufacturers. Good standards are essential to the success of good helmets and the development of better helmets. Sound choices for impact test severity levels and shock attenuation are the essence of good standards.

The test severities and peak acceleration criteria for most of the current bicycle helmet standards are based on work begun by Dr. George Snively shortly after an auto racing tragedy in the 1950's.

Pete Snell's Accident

William "Pete" Snell died in 1956 because his then state of the art helmet lacked the protective capacity to see him through what was termed a survivable accident. Pete Snell's helmet represented an intuitive solution for impact protection. After Snell's death, Dr. George Snively demonstrated that human intuition is not a reliable guide to understanding crash impact, particularly in the millisecond time domains in which crash impact occurs.

Snively discovered that most injuries of helmeted people occurred because the liner had reached full compression, that is, the helmet had used up all its protective capacity, before the impact was over. Helmets were too thin and far too soft.

Snively studied auto racing accidents and compared injury versus helmet compression in real world impacts to peak acceleration versus helmet compression in laboratory tests. He concluded that young healthy men could expect to withstand head impacts corresponding to lab tests incurring from 400 to 600 G's. Since tolerances vary among people and are likely to vary with age, Snively set Snell test criteria at about 300 G's.

Snively then set up the first of the Snell helmet standards selecting an impact test severity so high that only a very few of the most effective auto racing helmets could meet it. Over the years, Snively redrafted the Standard pushing the test severity higher and higher guiding the helmet industry toward the development of better, more effective head protection.

As the years passed, Snell Standards were expanded from auto racing helmets to other headgear. In 1972, a special addendum to the standards was prepared for bicycle helmets. In 1984 the Foundation promulgated a separate bicycle standard which was followed by newer standards in 1990 and 1995.

Today, there is skepticism about Snively's methods and about the use of his findings. Snively's pioneering studies considered a necessarily small number of incidents among a limited population and used death and serious injury as a discriminant. Building on Snively's earlier work, better studies would include greater numbers of observations across broader populations. These studies might include other considerations in addition to death and permanent disability such as short term problems and perhaps subtle sequelae such as cognitive and learning dysfunctions.

Unfortunately, those studies have not yet taken place. We can only guess at what they might reveal. However, any attempt to base standards and helmets on such guesswork would be premature, perhaps disastrously premature.

The Amendment versus Current Snell & ASTM Standards

The major differences between the amendment and current standards is in the test headform masses, the prescribed impact severities and the acceleration criteria. The total effect of these changes requires some calculation but, for the smallest helmets, boils down to this: the peak shock permitted is no more that 40% of that currently allowed but the ultimate protective capacity has been halved.

The new helmet must be much softer than current requirements demand but could conceivably be of about the same thickness. Such a helmet would transmit half the shock for minor crashes but it would not protect at all for more serious impacts. New helmets complying fully with the amendment could still transmit lethal shocks to the children wearing them in impacts half as severe as those managed by current helmets.

Thus, the CSA amendment imposes a sweeping realignment of shock attenuation versus ultimate protective capacity. The new shock attenuation requirement effectively eliminates most all current children's helmets from the market.

The only possible justification for changes of this magnitude is that current helmets have failed to prevent injuries. It is unlikely that current categories of serious injury have been grossly under-reported. However, proponents of the amendment insist that concussion be re-evaluated as a serious injury and propose the lower peak acceleration criterion as a means of concussion protection.

Concussion

Virtually every epidemiological study has demonstrated that bicycle helmets provide highly effective protection from serious injuries. Death and permanent injury seem to occur only when the impact is so severe that the helmet is overwhelmed, or when the impact falls below the helmet's edge. If cases of extremely severe crash impacts are excluded, the worst outcome seems to be concussion.

The mechanisms and even the diagnosis of concussion are only poorly understood. It is known that current bicycle helmets reduce the instance of concussion but there may be mechanisms of concussion that are not responsive to helmet properties.

Even more uncertain is whether concussion merits the same attention as the deadly and permanently disabling injuries helmets were originally intended to address. Proponents of the amendment suggest that concussion may be associated with learning disabilities and cognitive dysfunctions but, at this time, any connection is pure speculation.

Concussion must not be trivialized but it is generally considered recoverable. The multiple concussion syndrome observed in boxers and football players, is not a concern for bicyclists, motorcyclists or race car drivers. If concussion were all there were to worry about, none of these would wear helmets. It would be unconscionable to reduce levels of protection against death and serious injury in order to provide another sort of protection that might be altogether unnecessary.

Children's Needs

But what of the needs of children? Children are not the same as adults. They are smaller, lighter, much less muscular and, because they are still developing, perhaps much more susceptible to permanent injury. Should concussion among children be dismissed as quickly as concussion among adults?

Good questions, yes, but policy must be based on answers. The best information available is that current helmets protect children as well as adults. What little is known of children in terms of anatomy, physiology and impact tolerance resonates with this proven observation.

1. Children's tissues are more resilient than those of adults. Their veins are much less likely to rupture so that hematomas and gross tissue damage frequently observed in adults are much less likely in children.

2. Children's heads are smaller. These smaller dimensions translate into lower internal shear and tension stresses during impact acceleration.

3. Children's skulls are more flexible. Without a helmet, a child's head could be expected to deform much more than an adult's in a comparable impact. The child's skull might not fracture, but the greater deformation might exceed the strain limits even of the child's more resilient tissues.

4. Children, especially young children, fall much more often than adults. When children fall, their falls are much, much more likely to result in direct head impact. Adults virtually always manage to protect their heads, frequently at the expense of other injuries. Young children almost never do.

If children's lighter heads amplify the shock they receive in today's helmets, points one and two seem to compensate. Point three goes beyond compensation, if total skull deformation is an injury mechanism, then stiffer helmets would limit this deformation. Point four is a teleological observation. In childhood, we are subject to head impact almost routinely. It has been reported that the majority of falls among young children result in direct head impact but that falling adults almost always manage to avoid head strikes. As children, we seem to have been granted some additional measure of head impact tolerance at least until we have had a chance to learn head protection.

Risks and Benefits

The benefits offered by the amendment are, at best, uncertain but as the amendment's proponents have pointed out, there is little to fear from lower peak accelerations. However, there should be real concern about the lower ultimate protective capacity. The 60% reduction in peak acceleration is matched by a 50% reduction in protective capacity. Epidemiology and analysis of accident involved helmets suggest that very few accidents exceed the protective capacity of current children's helmets but no one knows how many accidents might exceed half that value.

What is known is that when an accident exceeds the protective capacity of the helmet, the peak acceleration suddenly increases until the head begins to deform. The remaining impact energy produces tissue rather than helmet damage.

The hazards created by the sweeping reduction in protective capacity are, for now, a matter of speculation. Even so, they should carry more weight than the benefits supposed for the reduction in peak acceleration. However, even if these changes are injury neutral, they will have definite and adverse repercussions for the public and for the bicycle helmet industry.

The public immediately loses access to the current helmet models which are proven head protection. The public also must replace current headgear. Finally the public loses faith in the industry that produced and sold headgear now pronounced ineffective.

The industry loses their investment in current product lines and loses some or all of the value of their trademarks. They also must recall product from their retailers and distributors. The most responsible may also want to recall directly from consumers. To survive, manufacturers must bear all these losses and still be able to develop and bring to market new lines of children's helmets.

The only possible justification for such turmoil would be conclusive evidence that current helmets impose an unacceptable risk of injury that can only be ameliorated by the sweeping changes imposed in the amendment. No such evidence has been produced. Without such evidence, these changes must not be imposed.

Conclusion

What continues to be certain is that, by the most objective measures, today's helmets protect children. Until more protective headgear is available, and is proven so in epidemiological studies, we must not put children at risk by outlawing the most effective helmets yet produced. Further, unless new objective evidence raises serious questions about the protective capabilities of current helmets, we must hesitate even to tinker with the standards to which these helmets were made.

We have not seen the end of helmet or standards developments. These will come although, for many, not soon enough. However, since Snell's death, the achievements of Dr. George Snively and others like him have meant and continue to mean life and health for many, many more. We must act as guardians for these achievements and see that they are passed down to future generations, with improvements possibly but most certainly without dilution or defect. We must not allow even the most selfless motivation to distract us from our responsibility.

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