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Bicycle helmets – To wear or not to wear? A meta-analyses of the effects of bicycle helmets on injuries

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Highlights

- Meta-analysis includes 55 studies of the effects of bicycle helmets on injuries.
- Bicycle helmets reduce head injury by 48% and serious head injury by 60%.
- Bicycle helmets reduce face injury by 23% and do not increase cervical spine injury.
- Bicycle helmet effects are larger in single bicycle crashes than in collisions.

Abstract

A meta-analysis has been conducted of the effects of bicycle helmets on serious head injury and other injuries among crash involved cyclists. 179 effect estimates from 55 studies from 1989–2017 are included in the meta-analysis. The use of bicycle helmets was found to reduce head injury by 48%, serious head injury by 60%, traumatic brain injury by 53%, face injury by 23%, and the total number of killed or seriously injured cyclists by 34%. Bicycle helmets were not found to have any statistically significant effect on cervical spine injury. There is no indication that the results from bicycle helmet studies are affected by a lack of control for confounding variables, time trend bias or publication bias. The results do not indicate that bicycle helmet effects are different between adult cyclists and children. Bicycle helmet effects may be somewhat larger when bicycle helmet wearing is mandatory than otherwise; however, helmet wearing rates were not found to be related to bicycle helmet effectiveness. It is also likely that bicycle helmets have larger effects among drunk cyclists than among sober cyclists, and larger effects in single bicycle crashes than in collisions with motor vehicles. In summary, the results suggest that wearing a helmet while cycling is highly recommendable, especially in situations with an increased risk of single bicycle crashes, such as on slippery or icy roads.

Introduction

Head injuries, and specifically traumatic brain injury (TBI) are among the most typical injuries among fatally injured cyclists (Joseph et al., 2017; Ekström and Linder, 2017). In-depth analysis of 71 fatal bicycle crashes in Norway in 2005–2012 in which a cyclist was killed, showed that 54% of unhelmeted cyclists (65% of cyclists had been unhelmeted) most likely would have survived the crash if they had worn a helmet (Statens vegvesen, 2014).

The effects of bicycle helmets on head injury have previously been investigated in several meta-analyses (in chronological order): Thompson et al. (1999), Attewell et al. (2001); Elvik, 2011, Elvik, 2013; Olivier and Creighton (2016). The two oldest meta-analyses found large reductions of head and brain injury among helmeted cyclists (about 60% or more). Elvik (2013) concluded that the results by Attewell et al. (2001) are affected by publication. In a re-analysis of the studies included in the meta-analysis by Attewell et al. (2001), Elvik (2013) found somewhat smaller effects of bicycle helmets when more recent studies were included in meta-analysis (−50% head injuries) than when only older studies were included (−57% head injuries). The meta-analysis by Olivier and Creighton (2016) is the most comprehensive one. It is based on 40 studies from 1989 to 2016 and concludes that bicycle helmets reduce head injury by 51%, serious head injury by 69% and fatal head injury by 65%. With the help of meta-regression analysis, Olivier and Creighton (2016) show that the effects of bicycle helmets differ by type of injury, but that none of the following factors are likely to have affected the results: Setting for data collection, pro- vs. retrospective data collection, mandatory helmet legislation (yes vs. no), age category (adults vs. children), proportion of males, proportion of bicycle-motor vehicle collisions, time trend bias (publication year), and publication bias either.

The aim of the present study is to replicate the results from Olivier and Creighton (2016), based on a larger number of studies, and to investigate the effects of some additional potential confounding variables. The present meta-analysis includes 15 studies in addition to the 40 studies included in the meta-analysis by Olivier and Creighton (2016). In addition to most of the potential confounding variables investigated by Olivier and Creighton (2016), it investigates the effects of controlling for potential confounding variables in the individual studies, differences between hospital vs. emergency department (ED) or police reported data, and effects of the choice of comparison group on the estimated effects of bicycle helmets on cervical spine injuries. Publication bias has been tested by inspecting funnel plot diagrams for each type of injury, and by using the trim-and-fill (T&F) method developed by Duval and Tweedie (2000).

Statistical control for confounding variables in the individual studies is potentially relevant moderator variable in meta-analysis. A number of factors are related to both helmet use and crash involvement or crash severity. For example, unhelmeted cyclists are more often under the influence of alcohol, they cycle more often without light in the dark, and they are more often involved in single bicycle crashes (Høye and Hesjevoll, 2016). If such factors are not controlled for in an individual study, the results may be biased. Such biases, if present, should be taken into account when calculating summary effects.

The type of data source is another potentially relevant study-level moderator in meta-analysis. It has been argued that the selection of injured cyclists reduces the validity of the results because helmeted cyclists are underrepresented (Olivier and Radun, 2017). In the present study, the relevance of this argument is investigated both in a hypothetical example and by comparing results from empirical studies that are based on different types of data sources.

The choice of comparison group when investigating the effects of bicycle helmets on neck injuries may affect the results from individual studies and is therefore also a potentially relevant study-level moderator variable in meta-analysis. When bicycle helmets reduce head injury, head injuries are inappropriate as a comparison group because a decrease of the number of head injuries will necessarily increase the proportion of other types of injuries among injured cyclists.

Other moderator variables that were investigated in the present study are the cyclists age (adults vs. children), helmet usage rates/helmet laws, and crash type. Helmet effects may differ between children and adult cyclists, amongst other things because of differences in crash dynamics (children are smaller, have lower bicycles, and cycle probably slower than most adults) and crash types (children cycle less in mixed traffic than adults and have therefore probably fewer collisions with motor vehicles). Proportions of head injuries may also differ between children and adults, but the results are inconsistent between different studies (for example, the proportion of head injuries is far higher among unhelmeted children than among adults (both helmeted and unhelmeted) in the study by Høye (2017), but lower among children than among adults in the study by Ji et al. (2006).

Helmet usage rates and helmet laws may affect the effects of bicycle helmets on injuries because of general differences between cyclists who use helmets voluntarily (without helmet laws) or involuntarily (with helmet laws), regarding both crash and injury risk and misuse of helmets (for example not fastening the helmet among involuntary users) (Robinson, 2006).

Crash type may also be a relevant moderator variable for helmet effectiveness. According to theoretical considerations and crash investigations, bicycle helmets have a larger injury reducing potential in single bicycle crashes than in bicycle-motor vehicles collisions (Hynd et al., 2011). In bicycle-motor vehicle collisions there is a much higher risk of serious non-head injury (Park et al., 2017), and bicycle helmets have only limited potential to protect from serious head injury in high energy impacts or when a cyclist is overrun by a motor vehicle.

In contrast to Olivier and Creighton (2016) who conducted a meta-regression analysis and tested for each potential confounding variable whether it improves model fit, the present study compares summary effects between subgroups of studies in order to investigate the effects of potential confounding variables. This is a less rigorous but more descriptive approach. It provides more information and a sounder basis for drawing conclusions about methodological and other factors that may affect bicycle helmet effects and results from bicycle helmet studies. With the subgroup analysis approach, it is possible to draw conclusions that are based on more than statistical significance alone, such as the size of effect estimates or differences between effect estimates, and the consistency of results between different types of injury. P-values or statistical significance alone do not say anything about the size or theoretical or practical relevance of an effect (Wasserstein and Lazar, 2016). Moreover, the subgroup analyses can compare summary effects between more than two levels of a potential moderator variable (such as helmet legislation which in some studies is present for a part of all cyclists and not either present or absent in all studies as assumed in the meta-analysis by Olivier and Creighton, 2016).

Section snippets

Meta-analysis

Estimated effects of bicycle helmet use on numbers of injured cyclists from different published studies were summarized using the log-odds method of meta-analysis. Estimates of effect were calculated as odds ratios (ORs) for different types of injuries. An estimated effect of bicycle helmets is expressed as the odds of a helmeted cyclist sustaining a specific type of injury (vs. not sustaining that type of injury or sustaining a specific other type of injury) compared to the odds of an …

Results

All available effect estimates that refer to head injury are shown in a forest plot in Fig. 1 in chronological order. All available effect estimates that refer to any injury, facial injury, or cervical spine injury, are shown in Fig. 2. The dotted lines in the diagrams are linear trend lines fitted to the data in the figures and cannot be interpreted as functions describing the relationships between age and bicycle helmet effect (from some years, more than one effect estimate is available while …

Discussion

The results from the present meta-analysis show that bicycle helmets reduce ***head injury*** by 48%, serious head injury (KSI) by 60%, fatal head injury by 71%, and TBI by 53%. All of these results are statistically significant. The summary effect for serious head injury is somewhat smaller than in the meta-analysis by Olivier and Creighton (2016), but otherwise the results are similar, despite a larger number of studies and the selection of effect estimates with statistical control for potentially …

Conclusions

Bicycle helmets have consistently been found to reduce head injury, specifically serious and fatal head injury. The results from different meta-analyses are remarkably consistent, despite methodological differences. The results from the present meta-analysis indicate that the effects of bicycle helmets are larger in single bicycle crashes than in collisions with motor vehicles. Bicycle helmets were found to be somewhat more effective in reducing head injury when bicycle helmet use is mandatory …

Acknowledgments

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