Cycling-related crash risk and the role of cannabis and alcohol: a case-crossover study

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ABSTRACT

Objective. To examine whether alcohol and cannabis consumption increase crash risk among non-fatally injured bicyclists (N = 393) seen in three Canadian emergency departments, between April 2009 and July 2011.

Method. Employing a case-crossover design, cannabis and alcohol were identified through blood sample or by self-report. All cyclists involved in a crash and exposure status (cannabis and alcohol) were compared between case period (current crash) and two control periods: prior to the last time the victim cycled around the same time of day; and the typical use prior to bicycling. Crash risk was assessed through conditional fixed effects logistic regression models.

Results. Approximately 15% of cyclists reported using cannabis just prior to the crash, and 14.5% reported using alcohol. Cannabis use identified by blood testing or self-report in the case period and by self-report in the control period yielded a crash risk of 2.38 (1.04–5.43); however, when self-report was used for both the case and control periods the estimate was 0.40 (0.12–1.27). Alcohol use, as measure either in blood or self-report, was associated with an odds ratio of 4.00 (95% CI: 1.64–9.78); results were similar when alcohol was measured by self-report only.

Conclusion. Cannabis and alcohol use each appear to increase the risk of a non-fatal injury-related crash among bicyclists, and point to the need for improved efforts to deter substance use prior to cycling, with the help of regulation, increased education, and greater public awareness. However, cannabis results should be interpreted with caution, as the observed association with crash risk was contingent on how consumption was measured.

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Introduction

Psychoactive substance use poses considerable risk to cyclists (Martínez-Ruiz et al., 2013). In particular, alcohol and cannabis impair the cognitive and psychomotor skills necessary for safe cycling behavior (Crocker et al., 2010; Li et al., 2001). Alcohol has been detected in a high percentage of cyclists involved in crashes leading to injury or death (Crocker et al., 2010; Li et al., 1996, 2001). Moreover, although evidence is limited, alcohol consumption among cyclists has been shown to increase the risk of an injury or fatal crash (Li et al., 2001; Martínez-Ruiz et al., 2013; Olkkonen and Honkanen, 1990) with a clear dose–response relationship starting at blood alcohol concentrations (BACs) of 0.02 g/dL,

lower than the legal limit for driving a motor vehicle in most jurisdictions worldwide.

No studies have examined cannabis prevalence in cyclists involved in crashes, nor whether acute cannabis consumption increases bicycle crash risk. We know from data in Canada, the United States, and Europe that cannabis is the second most common substance, after alcohol, found in motor vehicle drivers injured or killed in crashes (Dussault et al., 2002; Mura et al., 2003). THC (Δ9 tetrahydrocannabinol) is the main psychoactive component in cannabis which typically produces euphoria, relaxation, as well as changes in perception, deficits in attention span and memory, and psychomotor function (Hall and Degenhardt, 2009; Kalant, 2004). Experimental and simulator studies confirm that THC produces impairment in the skills necessary for safe driving, which include unsafe driving speed, poor lane control, and increased decision and response times (Berghaus et al., 1995).

There is also strong evidence that acute cannabis use increases motor vehicle crash risk (Bogstrand et al., 2012; Laumon et al., 2005;

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Ramaekers et al., 2004), including two recent meta-analysis that note a doubling in the risk of crashes leading to serious injury or death (Asbridge et al., 2012; Li et al., 2012). Using data from a case-crossover study of injured cyclists presenting to emergency departments after a crash, we assess both the prevalence of alcohol and cannabis use in bicyclists involved in crashes, and determine whether acute alcohol and cannabis consumption increases the risk of a crash involving injury. This study is timely given recent legislative changes in Canada (expanding medical marijuana) and individual U.S. states, such as Colorado and Washington State (legalizing possession of small quantities of cannabis), that point to a likely increase in the prevalence of cannabis use in the general population.

Methods

Participants

Participants were non-fatally injured cyclists presenting to an emergency department after being involved in a traffic crash. Between April 2009 and June 2011, injured cyclists were recruited from three Canadian hospitals, capturing diverse patient populations (rural, urban, suburban, multi-ethnic, differing income and social class). The Queen Elizabeth II Health Sciences Centre in Halifax, Nova Scotia, is the largest adult tertiary care hospital in Atlantic Canada and the only adult tertiary care center in Nova Scotia. St. Michael's Hospital in Toronto is an inner-city trauma center with a high proportion of crashes involving major traumas. Humber River Regional Hospital in north-central Toronto is a large, acute-care hospital, with a crash patient population who largely suffer from less severe injuries. Participants were 16 years of age and older in Halifax, 18 years of age and older in Toronto, and must have presented to hospital within 24 h of their crash. Participants were recruited using a probability time sampling strategy, with different four-hour time slots randomly selected, and with the probability of selection based on occurrence density (i.e. times with higher risk for occurrence of crashes had a greater chance of being selected) (Asbridge et al., 2014; Borges et al., 2006).

Study design

A case-crossover design was employed, which is well-suited for studies of transient effects on the risk of rare acute events (Dussault et al., 2002; Mura et al., 2003), and has previously been employed to study factors influencing crash risk (Redelmeier and Tibshirani, 1997; Soderstrom et al., 1995). With this design each subject serves as their own control, the strengths of which are a reduction in the impact of confounding from known and unknown sources and the elimination of control-selection bias (Maclure and Mittleman, 2000; Rothman and Greenland, 1998).

For the case period, cannabis and alcohol were assessed (through blood sample or self-report) within the six hours before the crash. For cyclists who consented to provide a blood sample, we defined acute cannabis and alcohol use as any THC level (>0.2 ng/ml) or any ethanol level (>2.0 mmol/L). Our primary assessment of risk factor exposure was based on blood sample results, if present, and self-report results otherwise, and measured dichotomously.

The control condition necessary to quantify risk is established by asking cases about their past exposure. Two different control periods were used to determine past exposure (Dussault et al., 2002). For the first control condition, cannabis use and alcohol use were assessed retrospectively for the same time interval (i.e. six hours) during the last time the cyclist rode their bicycle around the same time of day. The second control condition was the self-reported usual frequency of cycling under the influence of cannabis and alcohol over the preceding six months (Yu et al., 2013). Unfortunately, a limitation of this study is that the case period draws on either biologic or self-report data, while the control period measures exposure only through self-report.

Interview

The interview drew on questions from the WHO Collaborative Study on Alcohol and Injuries (Borges et al., 2006), and assessed: 1) a socio-demographic driver/cyclist profile (age, gender, country of birth, education, employment status) and injury history; 2) events surrounding the crash (cannabis and alcohol use, time of crash, crash location, reason for crash, injury type, severity, and history); 3) cannabis use, alcohol use, and general driving information for the control period; and 4) usual patterns of substance use over the past six months,

including problem use measured through the CUDIT and AUDIT scales (Mercer and Jeffery, 1995). Blood samples were collected via an informed consent procedure and all blood analysis was completed at the laboratory at the Centre for Addiction and Mental Health in Toronto, Canada. All consenting cyclists received $50 for participating in the study, irrespective of whether they completed the interview. Additional details on the study protocol can be found elsewhere (Asbridge et al., 2014).

Control for confounding

In addition to the within-person design, we addressed potential confounding of other drugs with the inclusion of measured screening for the presence of benzodiazepines and cocaine, two drugs often found in studies of impaired cyclists.

Statistical analyses

We estimated conditional fixed effects logistic regression models to account for the within-person structure of the case-crossover approach (Maclure and Mittleman, 2000; Marshall and Jackson, 1993). Our main models measure cannabis impairment alone and alcohol impairment alone, identified either in blood or through self-report, if no sample was present. This was achieved by removing all cyclists who had used alcohol, benzodiazepines, or cocaine, to isolate the effect of cannabis on crash risk, and removing cyclists who had used cannabis, benzodiazepines, and cocaine, when looking at alcohol use and crash risk. We ran additional models looking at blood sample results only, self-report results only, and among all cyclists regardless of what combinations of cannabis, alcohol and other drugs were used. For the above analyses we employed our first control condition, substance use during the "last time driving". We also analyzed our main models, measuring cannabis and alcohol alone, with a second control condition — "usual frequency".

Ethical approval for this research study was obtained from all participating hospitals, universities, and centers, and all human participants gave written informed consent to participate.

Results

In total, 393 cyclists who presented to emergency departments in Halifax and Toronto due to a crash were included in the study. Ineligibility was due to young age, poor mental or physical competency, death, discharge or leaving without treatment, language barrier, or having a crash that occurred outside the study window, leaving us with a response rate of 73%. Of those eligible, 153 (39% of those consenting) agreed to provide a blood sample. Among all cyclists, 58 (14.8%; CI: 11.2–18.3) reported using cannabis prior to the crash and 57 (14.5%; CI: 11.0–18.0) reported pre-crash alcohol use; when restricted to the 153 cyclists who provided a blood sample, more than one in four (28.8%; CI: 21.5–35.6) had positive levels of THC and slightly higher than one in five (21.6%; CI: 15.0–28.1) had a positive blood alcohol level (Table 1).

Relative to substance-free cyclists, those who used cannabis prior to the crash were, on average, younger (none over 65 years of age), more likely to be male (98%), Canadian-born (90%), had a high school education or less, and were more likely to be unemployed. Cyclists using alcohol prior to the crash were similar to those using cannabis, with the exception of being slightly older, on average, with a higher proportion foreign born, and with a higher rate of unemployment relative to those using cannabis. Cyclists who used cannabis prior to the crash had elevated rates of alcohol dependence (20.7%) and cannabis dependence (25.9%) relative to substance-free cyclists, while those who used alcohol pre-crash had elevated rates of alcohol dependence (22.8%) and, to a lesser extent, cannabis dependence (10.5%).

Cannabis and alcohol related cycling crashes were more likely to occur in the evening and at night (Table 1). No differences were observed between crashes involving alcohol or cannabis and those that did not, with respect to injury severity or crash location. Cyclists who used cannabis pre-crash were more likely to indicate being distracted or to have lost control of their bicycle as the reason for the crash; those who used alcohol pre-crash also cited distraction more often,