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Risk factors for cycling accident related injury: The UK Cycling for Health Survey

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A B S T R A C T

Cycling has become increasingly common in the United Kingdom (UK) but so too have injuries related to cycling accidents. There is presently little data on the health of people cycling in the UK. Data were collected using an online questionnaire from 4961 cyclists (mean age 47.9 yrs, 79.2% men) contacted through large UK cycling organisation networks. The questionnaire collected information on participant demographics, self-reported cycling behaviour and cycling accident-related injury. Main outcome was suffering an injury related to a cycling accident in last five years. 54.3% of the sample reported a cycling accident resulting in injury. In multivariate adjusted models, accidents were associated with age (over 60's had lowest risk; OR: 0.61, 95% CI, 0.47–0.78), gender (women lower risk than men; 0.86, 0.75–1.00), weekly cycling distance in a dose-dependent manner (> 160 km/wk; 2.44, 2.02–2.94), cycling experience (curvilinear association), commuting (1.33, 1.17–1.51), use of various safety equipment, always stopping at red signals (0.86, 0.73–0.99), and regular use of minor roads as oppose to major roads (0.80, 0.68–0.94). There were 842 reported head injuries, 15% of which required an overnight stay in hospital. Helmet use was associated with lower odds of being admitted overnight (0.59, 0.40–0.86). Our results represent the largest health survey of UK cyclists to date and reflect the experience of many UK cyclists regarding accident related-injury.

1. Introduction

Since 1993, there are 600 million more miles rode by bicycle per year in the United Kingdom (UK) (Department of Transport Statistics, 1949). The capital city average cycling distances have increased by 63% since 1995/97, 3 times the national average (Department of Transport, 2012). The increasing popularity of cycling in the UK has been attributed to recent successes in British professional cycling and incentives such as the 'cycle to work' scheme. This is a welcome change in attitudes to physical activity in Britain where the prevalence of obesity in the UK population exceeds 25% (Joint Health Surveys Unit, 2010). Furthermore, in 2008, just 6% of English men and 4% of women who took part in the Health Survey for England met physical activity guidelines (Joint Health Surveys Unit, 2010). Cycling is accessible to most of the population and offers a potentially low cost solution to increase physical activity levels since it can be incorporated into people's daily lives as means of transport (Kahlmeier et al., 2011).

Despite this welcome increase in cycling rates in Britain, increasing amounts of cycling have been paralleled by increasing number deaths and serious injuries amongst cyclists in recent years. In 2012, 3340 cyclists were killed or seriously injured compared to 2528 in 2002 (Keep, 2013). Cyclists are twice as likely to be fatally injured per person per mile compared to car occupants (Beck et al., 2007). Safety is the commonest reason given for not cycling (Mindell et al., 2011). Efforts have been made to study environmental factors and helmet use in bicycle injuries. Traffic volume, land use, path and roadway designs have all been posited as important factors in bicycle accidents (Romanow et al., 2012; Schepers et al., 2014; de Geus et al., 2012). While the use of helmets have been shown to prevent a proportion of head injuries (Thompson et al., 2000; Elvik, 2011; Amoros et al., 2012). Indeed, the impact of legislation enforcing helmet use has been shown to reduce head injury at a population level (Walters et al., 2011), however this finding has been refuted in different parts of the world (Dennis et al., 2013). Helmet legislation has been an ongoing debate since some studies show that cycling rates fall, and it is argued

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that the risks are far outweighed by reduced mortality from the health benefits of cycling (Watkins and Mindell, 2013). The mixed findings on helmet use and accidents may be explained by other factors, for example, helmet users may be more likely to use collision prevention measures (lights, high visibility clothing) in conditions of reduced visibility (McGuire and Smith, 2000), and are less likely to have consumed alcohol (Orsi et al., 2014). Also, violation of red traffic signals by cyclists has been highlighted as a road safety issue (Road Network Performance and Research Team, 2008). Consequently, the means by which cycling safety can be improved is contentious and has provoked a fierce debate in the mass media between representatives of motor vehicle drivers and cyclists.

However, limited studies have examined the relationship between self-reported cycling behaviour and cycling accidents among cyclists from the UK. In a small study of 293 cyclists presenting as a result of a cycling accident (Davidson, 2005), the most commonly injured were men in isolated bicycle accidents on roads without cycle paths during daylight hours; only 20.8% of patients wore helmets and the majority of those injured at night (62.5%) had consumed alcohol. We present results regarding cycling behaviour and cycling accident-related injuries from a UK nationwide survey of cyclists.

2. Methods

2.1. Study design and participants

The study design was adapted from The National Runners Health Survey (Williams, 1997) which recruited participants via subscriptions to Runner's World® magazine in the United States. In the present study we designed an online survey that was distributed nationwide to members, subscribers and followers of UK cycling organisations, including the CTC®, British Cycling®, Sky Ride®, Cycling Weekly® and Cycling Fitness® magazine via Twitter®, email newsletters, websites and print publications. The aim was to capture participants from a variety of cycling backgrounds ranging from commuters to amateur racing cyclists. The study gained ethical approval from the University College London Graduate School Ethics committee. By completing the questionnaire participants implied their consent to take part in the study.

2.2. Survey measures

The survey was designed to identify different cycling behaviours (use of safety equipment, helmet use, road usage, traffic light violation), cycling accident history (number of accidents sustained in past 5 years, number of injuries suffered in past 5 years), details of specific injuries (site of injury, type of injury, concurrent helmet usages, subsequent medical attention and treatment) in addition to cycling history (years spent cycling, total weekly cycling distances).

2.3. Statistical analysis

We used multiple logistic regression to compute odds ratios (OR) with accompanying 95% confidence intervals (CI) for the risk of injury related to cycling accidents. The main independent variables entered into models included age (categorised into 10 year age bands), gender, weekly cycling distance and years of cycling (each categorised into 4 equal groups), use of helmet, lights, high visibility clothing, headphones, commuting (yes/no), and specific cycling behaviours including stopping at red lights and road usage (major roads, minor roads, trails/paths closed to traffic or off-road). The independent variables were first analysed in a univariate model and then a multivariate model that was mutually adjusted for all included variables. We also employed logistic regression to examine the association between use of a helmet and being admitted to hospital overnight in cyclists presenting with head and spinal injuries. All analyses were conducted using SPSS version 21.

3. Results

Surveys from 4961 participants were analysed. The descriptive characteristics of the sample are displayed in Table 1. The majority of the sample was male, and 70% were aged 40 and above. The sample displayed a wide range of cycling experience and cycling specific behaviours in relation to road usage, use of safety equipment, and obeying the highway code.

Table 1
Descriptive characteristics ($N=4961$).

Variable	Mean (or %)	Range
Age	47.9	16–88
Men (%)	79.2	
Distance cycled (km/wk)	113.1	1–650
Cycling experience (yrs)	21.6	0–78
Commuters (%)	52.2	
Always stop at red lights (%)	80.6	
Use headphones whilst cycling (%)	6.1	
Use of safety equipment (%)		
Helmet	86.2	
Lights	87.2	
High visibility clothing	69.6	
Road usage (%)		
Mainly major roads	19.4	
Minor roads	69.0	
Trails/paths/off-road	11.6	
Injury related cycling accident last 5 yrs		
None	45.7	
One or two	41.8	
More than two	12.5	

Table 2
Risk factors for cycling accident-related injury (N=4961).

Variable	N	Univariate OR (95% CI)	Multivariate[a] OR (95% CI)
Age category			
16–30	535	Ref	Ref
31–40	935	0.94 (0.76, 1.16)	0.85 (0.68, 1.08)
41–50	1411	0.80 (0.65, 0.98)	0.80 (0.64, 1.00)
51–60	1137	0.72 (0.58, 0.89)	0.76 (0.60, 0.95)
> 60	943	0.50 (0.40, 0.62)	0.61 (0.47, 0.78)
Sex			
Male	3930	Ref	Ref
female	1031	0.80 (0.70, 0.92)	0.86 (0.75, 1.00)
Weekly cycling distance (km)			
< 60	1324	Ref	Ref
60–96	1200	1.39 (1.19, 1.63)	1.32 (1.12, 1.55)
96–160	1544	1.99 (1.71, 2.31)	1.81 (1.55, 2.12)
> 160	886	2.72 (2.28, 3.35)	2.44 (2.02, 2.94)
Cycling experience (years)			
< 5	1413	Ref	Ref
6–17	1055	2.02 (1.71, 2.37)	2.03 (1.71, 2.41)
18–35	1267	1.40 (1.20, 1.63)	1.45 (1.23, 1.71)
> 35	1197	1.11 (0.85, 1.16)	1.32 (1.10, 1.59)
Commuter			
No	2369	Ref	Ref
Yes	2592	1.74 (1.56, 1.95)	1.33 (1.17, 1.51)
Use of safety equipment[b]			
Helmet	4275	1.47 (1.25, 1.73)	1.42 (1.19, 1.70)
High visibility clothing	3454	1.05 (0.93, 1.19)	0.94 (0.82, 1.07)
Lights	4326	1.90 (1.60, 2.25)	1.63 (1.35, 1.96)
Use of headphones whilst riding			
No	4657	Ref	Ref
Yes	304	1.39 (1.10, 1.76)	1.16 (0.90, 1.50)
Skipping red lights			
Sometimes/always	929	Ref	Ref
Always stop	3998	0.77 (0.68, 0.89)	0.86 (0.73, 0.99)
Road usage			
Mainly main roads	964	Ref	Ref
Minor roads	3423	0.67 (0.57, 0.77)	0.80 (0.68, 0.94)
Trails/paths/off-road	574	0.62 (0.50, 0.76)	0.93 (0.75, 1.17)

[a] Multivariate model mutually adjusted for all variables presented.
[b] No reported use is referent category for each item of equipment.

Injury sustained in a cycling accident was reported in 54.3% of the sample, and 12.5% experienced more than two accidents in the past 5 years. We examined demographic and behavioural factors associated with risk of accidents (see Table 2). There was a linear trend for reduced risk of accidents with advancing age (p=0.003). Women were less likely to have an accident than men (OR=0.86, 95% CI, 0.75–1.00). Weekly cycling distance was associated with greater risk in a dose-dependent manner, although the association between cycling experience and accidents was curvilinear, with the greatest risk observed in cyclists with 6–17 yrs experience compared with < 5yrs. Commuting was associated with higher risk (OR=1.33, 95% CI, 1.17–1.51). The use of helmets and lights was associated with higher likelihood of an accident, although no association was observed in relation to high visibility clothing or wearing headphones whilst cycling. Always stopping at red lights was linked with lower risk (OR=0.86, 95% CI, 0.73–0.99), as was regular use of minor roads as oppose to major roads (OR=0.80, 95% CI, 0.68–0.94).

Participants provided details of injuries due to cycling accidents. In total, information on 5880 injuries due to cycling accidents was recorded, which is summarised in Table 3. Over two thirds of injuries were sustained to the arm and leg. The most common type of injury was soft tissue. 16% of reported injuries involved a fractured bone, of which fractures involving arm (including collarbone), hand, spine and leg were most common at 48%, 17%, 12% and 12%. 64 (6.6%) of the fractures involved the head or face. The odds ratio for sustaining a head or face fracture without a helmet compared to with a helmet was 1.07 (95% CI, 0.63–1.80). There were 842 reported head injuries, 15% of which required an overnight stay in hospital. Helmet use was associated with lower odds of being admitted overnight (OR=0.59, 95% CI, 0.40–0.86) in cyclists presenting with head injuries. There were 424 reported back/spinal injuries, 9.7% of which required an overnight stay in hospital. Helmet use was also associated with lower odds of being admitted overnight for a back/spinal injury (OR=0.46, 95% CI, 0.23–0.94).

4. Discussion

We present results regarding cycling behaviour and cycling-accident related injury of the largest survey of cyclist in the United Kingdom ever conducted. Our key findings are that a large proportion of cyclists surveyed suffered a cycling accident-related injury, the risk of which are associated with different aspects of cycling behaviour – the most important being high weekly cycling distance. Of the reported injuries, a significant proportion required medical attention and, in some cases, overnight hospital stay suggesting that healthcare costs could be reduced by increased cycling safety.

Table 3
Details of injuries related to cycling accidents (5880 events).

Variable	*N* (%)
Part of body injured	
Head	842 (14.3)
Arm	1723 (29.3)
Leg	2179 (37.1)
Foot	126 (2.1)
Hand	586 (10.0)
Back/spine	424 (7.2)
Type of injury	
Fractured bone	964 (16.3)
Dislocated joint	137 (2.3)
Sprained joint	486 (8.2)
Soft tissue damage	3592 (60.9)
Not described	722 (12.3)
Medical attention	
None	3000 (51.0)
Went to GP	610 (10.4)
Went to hospital	1886 (32.0)
Overnight hospital stay	390 (6.6)
Treatment	
None	3165 (54.1)
Splint/bandage	1475 (25.2)
Medication	804 (13.7)
Surgery	408 (7.0)

In our survey we found women and cyclists over 40 years of age were the least likely to suffer a cycling accident-related injury. Indeed, we demonstrated a trend of decreasing odds of suffering a cycling accident-related injury with increasing age. These associations were not explained by any of the variables included in our analysis since the effect estimates remained robust to multivariate adjustments. Thus, other factors must explain this finding. For example, in a meta-analysis comparing risk taking behaviour in scenarios such as driving and physical activities men were found to consistently demonstrate increased rates of risk taking behaviour (Byrnes et al., 1999). Furthermore, similar trends observed in our study concerning age have been reported between age and motor car accidents: Turner and McClure, 2003, demonstrate increasing odds of having one and two or more car accidents with decreasing age (Turner and McClure, 2003). With this in mind, it may be that associations of accident-related injury in younger male cyclists may be reflected by inherent differences in risk taking behaviour.

Weekly cycling distance demonstrated a dose–response relation with risk of cycling accident-related injury. This demonstrates a logical relationship between cycling behaviour and cycling accident-related injury: the longer people cycle in terms of distance and time may be associated with increased risk for accident-related injury. Previously, the increasing number of cycling accidents on Britain's roads has been attributed to increasing numbers of cyclists (Department of Transport Statistics, 1949). However, our results would suggest that this may be also due to cyclists cycling longer distances. Indeed, this is in keeping with an increase in yearly UK cycling mileage by 600 million since 1993 (Department of Transport Statistics, 1949). Current infrastructure aims to facilitate bicycle travel but by encouraging more people to cycle further our results would suggest cyclists are being exposed to excess risk. Therefore, infrastructure that promotes cycling should be coupled with measures to decrease harm to accommodate for this excess risk. The notion has been posited in the UK mass media blaming '*an astonishing rise in cycling deaths … on inexperienced cyclists*' (Daily Mail, 2006); however, our findings suggest the converse. We demonstrated that less than 5 years experience of regular cycling was associated with the lowest risk of accident-related injury suggesting that cycling inexperience is not a major component in increasing risk.

The use of safety equipment meant to reduce accidents was not associated with lower risk of cycling accident-related injury. Indeed, helmets and bicycle light usage were associated with slightly increased risk of suffering a cycling accident-related injury. We cannot interpret causality with these data as cyclists may employ these measures *after* an injury or when road conditions are unfavourable. Alternatively, safety equipment may be associated with decreased levels of caution amongst cyclists. Indeed, safety equipment has been shown to increase risk-taking behaviour in some groups (Morrongiello et al., 2007). Despite these speculations, we cannot conclude that usage of safety equipment is associated with lower risk of cycling accident-related injury. Our survey suggests that the minority of our sample use headphones while cycling. Advice from Mayor of London, Boris Johnson, recently discouraged the use of headphones while cycling (Withnall, 2013); Indeed, in unadjusted models we did observe an elevated risk of accident in cyclists using headphones although this association was attenuated in fully adjusted models. This might suggest that cyclists using headphones also display other forms of risky behaviour that are more important in predicting accident risk.

Road choice was associated with cycling injury: minor road and paths closed to traffic were associated with a lower risk of accident-related injury. Accident-related injury risk did not differ significantly between minor roads and paths closed to traffic; this suggests that some shared motorist-cyclist environments, particularly with low traffic volume, have similar accident-injury risk compared to traffic-free cycle routes. Violating red light traffic signals, reported in 19.4% of our sample, was associated with a small increase in risk of cycling accident-related injury. It is possible that jumping red lights is also a proxy for more risky (less cautious) cycling behaviours, rather than in itself being a risk factor for injury.

In addition to demonstrating demographic and behavioural factors in cycling injury-related accidents, the data demonstrates that a large proportion of cyclists suffer an injury due to an accident. Indeed, nearly half of these injuries required medical attention implying that reducing cycling accident-related injury could save significant healthcare costs. Some data from previous studies in Europe have suggested traumatic brain injuries were the leading cause (25.7%) of cycling related hospital admissions although the largest resource consumption was attributed to fractures of the upper extremities (Juhra et al., 2012). Behavioural factors such as helmet use should be encouraged owing to a decreased likelihood of hospital admission following head injury suggesting helmet use is associated with less severe head injury. However, the use of helmets was not associated with a reduction in accident-related injury.

4.1. Strengths and limitations

This study represents the largest survey to date of cyclists regarding health in the UK. We recruited cyclists through cycling networks thus our findings may not be generalisable. Indeed, in the present sample 52% commuted to work by bicycle compared to only 3% in a representative sample of the UK (Laverty et al., 2013). Also, the survey would have been less likely to capture people suffering the most serious injuries who can no longer cycle. The conclusions drawn from this cross-sectional study are limited by the inability to infer causality and direction, furthermore, self-report as a means of data collection in the study may invite uncertain inaccuracy and bias. Self-reported injury regarding number and site of injuries remains valid at least a year after injury (Gabbe et al., 2003), although the present study relied on 5 year recall. In addition, the self-reported cycling data demonstrated validity since there was a significant inverse relationship between reported cycling volume and resting heart rate (Hollingworth et al., 2014), which is commonly used to validate physical activity assessment since bradycardia is a cardiac manifestation of aerobic conditioning. Lastly, we cannot account for unmeasured variables, such as type of bicycle, the effects of road conditions and time of day that might have partially explained some of the observed associations. For example, we found that commuters were at higher risk but this might simply reflect their tendency to cycle in rush hour in the highest traffic density. Also the use of collision prevention measures (lights, high visibility clothing) might reflect the fact these cyclists ride in unfavourable road conditions. In 2018 years, this cohort will be re-contacted with a view to seeking physician-supplied data, which will improve accuracy and improve our ability to infer causality.

5. Conclusion

Our results represent the largest health survey of UK cyclists to date and reflect the experience of many UK cyclists regarding accident related-injury. Increased rates of cycling accident-related injury were associated with demographic and behavioural factors. Younger male cyclists reported the greatest risk of accident related injury, which may be attributable to differences in risk-taking behaviour. In contrast to popular views, cycling inexperience, use of safety equipment and stopping at red traffic signals had negligible associations with risk of accident-related injury.

Author contributions

Hamer had full access to the data to perform all analysis, and takes responsibility for the integrity and accuracy of the results. Hollingworth drafted the paper. Hollingworth and Hamer designed the study. Hollingworth and Harper collected the data. All authors were responsible for interpretation of data and critical revision of the manuscript. All authors have approved the final version to be published. We affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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