Original papers

Characteristics and risk factors of bike-related accidents: Preliminary analysis

Katarzyna Bogusiak[1,A,B,D,F], Michał Pyfel[1,C,F], Aleksandra Puch[2,D,F], Marta Kopertowska[1,C,F], Dominika Werfel[1,D,F], Aneta Neskoromna-Jędrzejczak[3,E,F]

[1] Department of Cranio-Maxillofacial and Oncological Surgery, University Teaching Hospital No. 1 in Łódź, Poland
[2] Department of Dentistry, Medical University of Lodz, Poland
[3] Clinic of Cranio-Maxillofacial Surgery, Medical University of Lodz, Poland

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

Advances in Clinical and Experimental Medicine, ISSN 1899-5276 (print), ISSN 2451-2680 (online) *Adv Clin Exp Med*. 2018;27(10):1403–1409

Address for correspondence
Katarzyna Bogusiak
E-mail: katarzyna.bogusiak@gmail.com

Funding sources
None declared

Conflict of interest
None declared

Received on March 6, 2017
Reviewed on April 1, 2017
Accepted on April 26, 2017

Abstract

Background. The growing popularity of cycling not only enhances self-efficacy, physical well-being and improves quality of life, but it also leads to the increasing number of bike-related injuries.

Objectives. The aim of this study was to characterize the population of cyclists in Poland, assess the occurrence of safety behaviors among them and to precise the risk factors for bike accidents. Additionally, we analyzed bike-related injuries.

Material and methods. The survey was based on a 39-item questionnaire created for this study. We collected data concerning the demographical status of respondents, their cycling preferences, attitude toward safety behaviors during cycling, and the characteristics of bike-related injuries. Our research covered 729 people who declared themselves as cyclists (302 women – average age: 31.5 ±10.3 years; 427 men – average age: 32.6 ±10.7 years).

Results. In the study, 71.3% of the interviewees declared that they did not always wear helmets. Women more often than men claimed that they did not always use head protection ($p < 0.001$). Among 729 people, 277 suffered from bike-related injuries. In this group, we noted 870 accidents that resulted in 1671 different injuries. In our study, wearing helmets did not influence the region of trauma nor its type ($p < 0.05$). We noted 811 injuries of the upper extremities and 541 of the lower extremities.

Conclusions. Young men constitute the main group of cyclists in Poland. The risk factors for bike-related accidents in our study proved to be: educational level (secondary education and incomplete higher education), number of children (having at least 3 children), frequency of using a bike (the more often, the more injuries), type of bike used (mountain bikes and fold-up bikes), and frequency of using a helmet (using helmets was correlated with a higher rate of injuries). The upper and lower extremities were the most common location of injuries.

Key words: bike-related accidents, wounds, injuries, cycling, maxillofacial fractures

DOI
10.17219/acem/70695

Introduction

The growing popularity of cycling as a means of transport, a part of a certain lifestyle and a simple and healthy way of spending time creates the possibility not only to reduce air pollution and traffic, but also to improve public health. A shift from motorized transportation to cycling could significantly contribute to the reduction of traffic congestion, noise, carbon dioxide emission, and air pollution.[1–3] The benefits of cycling are truly impressive and include physical and psychosocial aspects.

It has been proven that cycling enhances self-efficacy, physical well-being and improves quality of life.[1,4,5] By following the recommended 30 min of daily physical activity, the reduction of risk for cardiovascular diseases can be obtained. The researchers also hypothesized that it could have a positive, preventive effect against certain types of cancer.[1,6] Regular cycling also improves lipid profile, normalizes blood pressure, helps to control weight, and decreases insulin resistance.[6–8] This beneficial influence on health makes this kind of sport especially advisable for patients with type 2 diabetes.[8] It has been shown that cycling positively affects the musculoskeletal system, also in terms of rehabilitation.[9,10] Application of cycling leg exercise has shown beneficial effects on motor abilities in patients suffering from subacute and chronic diseases.[10,11] Moreover, cycling has a positive influence on instrumental activities of daily living and social function in elderly people with mobility limitations. Unfortunately, the elderly are the group which incur more accidents than adults.[12,13] New research reports that the loss of the ability to cycle can be a new warning sign for atypical parkinsonism.[14] Some authors indicated that cycling in big cities might be erroneously assessed as unfavorable for health, especially for the respiratory system because of exposure to air pollution. However, it has turned out that the benefits of active travel outweigh the harm caused by air pollution in all regions except for the most extreme air pollution concentrations.[2,15]

Considering the safety aspects during cycling, several factors of bike-related accidents should be mentioned. First of all, the environment and the infrastructure built may be correlated with bicycle injuries.[1,3] Cyclists are often forced to share the same road with cars, buses and trucks, and they are more vulnerable to accidents than motorized drivers.[2] Modification of the existing infrastructure is also important, e.g., replacing signal-controlled intersections with roundabouts.[4] Also demographic factors, and traffic speed and density influence the bike-related accident rate.[3,5] Different behaviors among cyclists, such as wearing helmets and reflective elements, using headphones, cell-phones or other devices, form a very differential group of factors.

The aim of this study was to characterize the population of cyclists in Poland, assess the occurrence of safety behaviors among them and to precise the risk factors for bike accidents. Additionally, we analyzed bike-related injuries.

Material and methods

This survey was based on a 39-item questionnaire created for this study, covering a wide spectrum of issues related to cycling. It included 2 parts. In most questions, the participants were allowed to choose 1 answer, unless stated otherwise. A few questions additionally had an option for including comments. The 1st part consisted of 22 questions related to the demographical status of respondents (age, sex, professional activity, education, marital status, having children), their cycling preferences and attitude toward safety behaviors during cycling (e.g. type of bike, frequency of riding, season of cycling, wearing helmets). The 2nd part concerned only people who had at least 1 cycling injury. It included 17 detailed questions about the circumstances of the accident.

The survey was prepared in a digital version, using online service for creating surveys and tests – www.ankietka.pl. It was available on the website http://www.ankietka.pl/ankieta/206347/ankieta-dla-rowerzystow.html between November 20, 2015 and February 10, 2016. Our research covered 729 people who declared themselves as cyclists. To distribute the survey to the wide spectrum of respondents, link to the survey was published on Facebook fan pages devoted to cycling, active lifestyle or traveling, and on bicycling websites.

Statistical analysis

The Kolmogorov-Smirnov test was used to assess the normality of data distribution. The χ^2 and Mann-Whitney U tests were done to determine the relationship among variables. Univariate and multivariate logistic regression analyses were performed. The p-value <0.05 was considered statistically significant.

Results

Most respondents were male (58.6%). As shown in Fig. 1, almost half of the group were between 19 and 29 years old (43.8%), and around 1/3 was between 30 and 29 years old (31.3%). Cyclists younger than 19 years and older than 39 years accounted for <25% of the studied sample.

Important differences between men and women were observed during data analysis. The following graphs show these diverse patterns of using a bike by both sexes. Figure 2 illustrates that despite the fact that both men and women prefer spring and summer as the most suitable seasons for cycling, men significantly more often use bikes in spring (by 6.4 percentage points; $\chi^2 = 10.170$; $p = 0.002$), autumn (by 19.4 percentage points; $\chi^2 = 46.469$; $p < 0.001$) and winter (by 25.4 percentage points; $\chi^2 = 46.0234$; $p < 0.001$). No statistically significant difference among male and female groups in the frequency of riding a bike in summer was observed.

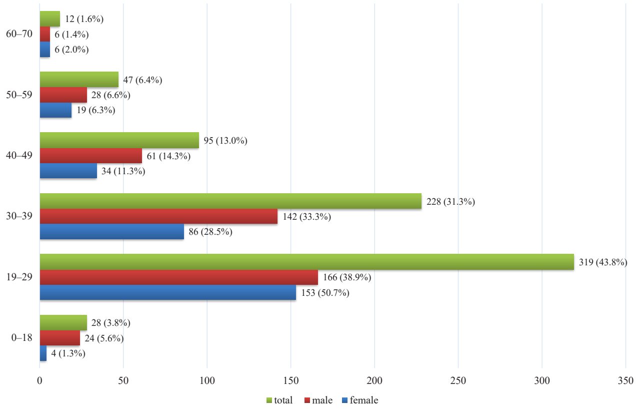

Fig. 1. Age of the respondents

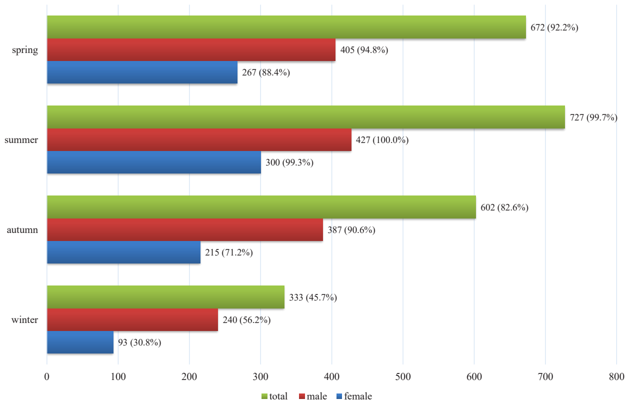

Fig. 2. Seasons of cycling

Generally, the respondents declared that they rode a bike a few times a week (45.5%) or every day (26.9%). But data presented in Fig. 3 confirms the fact that women used bikes less frequently than men ($\chi^2 = 51.082$; $p<0.001$). Female respondents usually declared that they rode a bike a few times a week (36.8%) or from time to time (27.5%), while more than half of male respondents stated that they used a bike a few times a week (51.8%, i.e., 15 percentage points more than women) and around 1/3 claimed that they used a bike every day (30.4%).

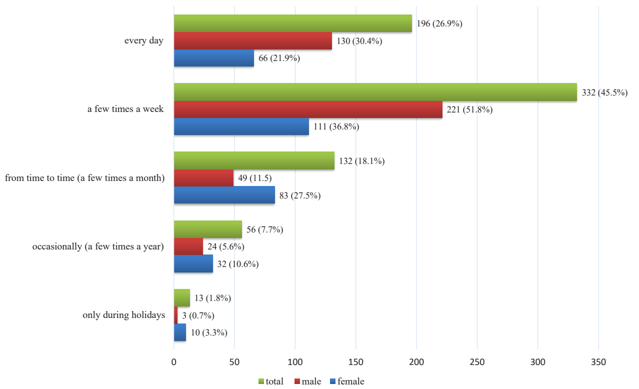

Fig. 3. Frequency of using a bike

According to the survey results, 3 types of bikes were the most popular – mountain bikes (40.9%), touring bikes (25.4%) and city bikes (24.3%). But here significant gender differences were also identified. For women, the most popular type of bike was a city bike (39.7%), while men more often preferred mountain (45%) and touring (28.6%) bikes. The popularity of city bikes among men (13.4%) was close to the popularity of road bikes (11.5%) ($\chi^2 = 51.082$; $p < 0.001$) (Fig. 4).

About 71.3% of the interviewees declared that they did not always wear helmets. Despite stereotypes about attitudes of men and women toward risk, women more often than men claimed that they did not always use helmets (19 percentage points more; $\chi^2 = 31.175$; $p < 0.001$) (Fig. 5). This can be explained by the fact that women usually used different type of bikes and also they used them less often than men.

To determine the risk factors, the logistic regression analysis was conducted. In the first step, 19 variables with possible impact on the probability of having an accident were identified and then used in binary logistic regressions with single categorical predictors. These variables were: gender, age group, professional activity, educational level, marital status, number of children and their age, time of the year when a bike is used, the frequency of using a bike, using reflectors, reason for cycling, listening to music, opinions about the obligatory use of helmets and about the usefulness of helmets, frequency of using a helmet, having a driving license and a cycling license, type of bike, and alcohol consumption. It turned out that 10 of these variables were statistically significant in these models ($p < 0.05$).

In the next step, these 10 variables were used as independent variables in a multivariable logistic regression model. The outcome of this model is presented in Table 1.

Out of 10 variables used in a multivariable logistic regression, 5 remained statistically significant ($p < 0.05$): educational level, number of children, frequency of using a bike, type of bike used, and frequency of using a helmet. People with secondary education ($p < 0.01$) or with an incomplete higher education ($p < 0.05$) were almost 2 times less likely to have an accident than people with a university degree. Another significant predictor was the number of children. Having at least 3 children increased the probability of accidents by 3 times ($p < 0.01$). What is quite intuitive, cyclists using a bike every day were more exposed to accidents than others. The probability of an accident for them was 3 times higher than the probability of an accident for people who used a bike a few times a month or only during holidays ($p < 0.01$). The type of bike used also strongly affected the probability of an accident. In comparison with people using city bikes, those riding mountain bikes and fold-up bikes were more prone to accidents – 2 times ($p < 0.01$) and 8 times ($p < 0.05$), respectively. The last significant variable was the frequency of using a helmet. People who did not always use head protection had less probability of having an accident than people always using helmets during their bike rides.

Table 1. Coefficients of logistic regression model

Variable	OR	95% CI	p-value
Gender			
female	1.000	ref.	–
male	0.721	(0.498–1.044)	0.08303
Age [years]			
<30	1.000	ref.	–
30–39	1.457	(0.928–2.288)	0.10137
40–49	1.398	(0.791–2.469)	0.24783
50–70	1.717	(0.863–3.418)	0.12305
Professional activity			
student	1.000	ref.	–
employed	0.636	(0.377–1.0754)	0.09069
unemployed	1.111	(0.498–2.479)	0.79727
Educational level			
university degree	1.000	ref.	–
incomplete higher education	0.533	(0.321–0.883)	0.01451*
secondary education	0.428	(0.282–0.650)	0.00006*
elementary education	0.383	(0.142–1.036)	0.05825
Number of children			
<3	1.000	ref.	–
≥3	3.064	(1.395–6.727)	0.00520*
Time of the year when a bike is used			
only summer	1.000	ref.	–
other seasons as well	2.282	(0.849–6.130)	0.10122
Frequency of using a bike			
a few times a month or only during holidays	1.000	ref.	–
occasionally / a few times a year	1.283	(0.543–3.033)	0.56930
a few times a week	1.204	(0.723–2.002)	0.47497
every day	2.160	(1.202–3.882)	0.00988*
Type of bike used			
city bike	1.000	ref.	–
road bike	1.894	(0.929–3.859)	0.07819
touring bike	1.318	(0.793–2.191)	0.28602
mountain bike	2.079	(1.2773–3.383)	0.00318*
fold-up bike	7.525	(1.1956–47.4)	0.03129*
electric bike	0.621	(0.109–3.519)	0.58943
Reason for cycling			
leisure	1.000	ref.	–
way of spending free time with a family	0.760	(0.273–2.117)	0.59865
means of transport	1.366	(0.8695–2.146)	0.17550
exercising	1.235	(0.775–1.968)	0.37286
Does the interviewee use a helmet?			
always	1.000	ref.	–
not always	0.588	(0.402–0.860)	0.00615*

OR – odds ratio; CI – confidence interval; * statistically significant.

In our cohort, 277 out of 729 respondents suffered from bike-related injuries. In this group, we noted 870 accidents that resulted in 1,671 different injuries. The most common injuries were related to the upper and lower extremities (48.5% and 32.4% of all injuries, respectively). Injuries of the upper extremities were more often observed in the male group and they constituted 50.1% of all injuries in men ($p < 0.025$). Wounds of the upper extremities also appeared more frequently in males (17.3% of injuries; $p < 0.005$). Women more often suffered from injuries of the lower extremities in comparison to men (37.7% vs 30.6%; $p < 0.01$). This observation was similar for abrasions of lower limbs (24.6% vs 18.8%; $p < 0.02$). The female group was also at a higher risk of facial skeleton fractures in comparison to the male group (1.9% vs 0.2%; $p < 0.001$) (Table 2).

In our study, wearing helmets did not influence the region of trauma nor its type ($p < 0.05$). Detailed data regarding injuries in the helmeted and non-helmeted groups of cyclists was presented in Table 3.

Discussion

Bike-related accidents are becoming a high interest topic in the medical press, mainly due to the growing popularity of cycling and an observed peak of injuries among cyclist.[16,17] This research article examined the population of cyclists – their habits, cycling behavior in relation to potential risk factors of bike-related accidents – and also described the injury pattern.

In the analyzed literature, it was proven that demographic data like age and gender affected the injury rate and cycling patterns.[18–26] Most articles concerned the study population of adolescences with a small sample of elderly people. In the abovementioned articles, males were the main group of cyclists. However, bicycle users are not a homogenous group. On the basis of studies conducted all over the world, researchers divided cyclists into groups, taking into consideration their cycling behaviors.[4,27–29] One of the features being the basis for distinguishing bike users is the reason for cycling. For some people, this activity is only a form of recreation, for others, bicycle is a very effective and cheap means of transport (commuters), and lastly there is a group which treats it as a sport, also in its extreme version.[4,28,29] Additionally, the differences among cyclists are correlated with the frequency of cycling and the level of their experience.[22] Different classifications of cyclists have been developed, but none of them is widely accepted. The proportion of cycling population differs among different countries. In Australia and the United States, bicycles are used by a relatively small group of inhabitants; cycling is treated mostly as a form of recreation and rarely as a means of transport.[30,31] In the European countries, such as the Netherlands, Denmark or Germany, cycling is much more popular and mainly used as a mainstream mode of transport.[31] Researchers observed that cyclists

Table 2. Characteristic of injuries among the female and male groups of cyclists

Variable	Female	Male	Total	Statistical analysis	p-value
Alcohol consumption*	4 (0.46%)	5 (0.57%)	9 (1.03%)	1.63779	>0.05
Head injuries	52 (12.56%)	174 (13.84%)	226 (13.52%)	0.43770	>0.05
brain concussion	4 (0.97%)	13 (1.03%)	17 (1.02%)	0.01431	>0.05
injuries of the cerebral part of the head	4 (0.97%)	29 (2.31%)	33 (1.97%)	2.89251	>0.05
Face injuries	44 (10.63%)	132 (10.50%)	176 (10.53%)	0.00532	>0.05
abrasions	21 (5.07%)	80 (6.36%)	101 (6.04%)	0.91526	>0.05
wounds	15 (3.62%)	49 (3.90%)	64 (3.83%)	0.06393	>0.05
fractures	8 (1.93%)	3 (0.24%)	11 (0.66%)	13.66112	<0.001**
Upper extremity injuries	181 (43.72%)	630 (50.12%)	811 (48.53%)	5.10609	<0.025**
abrasions	118 (28.50%)	357 (28.40%)	475 (28.43%)	0.00158	>0.05
wounds	45 (10.87%)	218 (17.34%)	263 (15.74%)	9.84027	<0.005**
fractures	18 (4.35%)	55 (4.38%)	73 (4.37%)	0.00057	>0.05
Lower extremity injuries	156 (37.68%)	385 (30.63%)	541 (32.38%)	7.07530	<0.01**
abrasions	102 (24.64%)	237 (18.85%)	339 (20.29%)	6.44102	<0.02**
wounds	53 (12.80%)	135 (10.74%)	188 (11.25%)	1.32624	>0.05
fractures	1 (0.24%)	13 (1.03%)	14 (0.84%)	2.35526	>0.05

* The percentage was calculated with regard to the total number of accidents (n = 870). For the rest of the factors, the percentage was calculated with regard to the total number of injuries in each group (female = 414, male = 1257, total = 1671); ** statistically significant.

Table 3. Characteristic of injuries among the helmeted and non-helmeted groups of cyclists

Variable	With a helmet	Without a helmet	Total	Statistical analysis	p-value
Alcohol consumption*	5 (0.57%)	4 (0.46%)	9 (1.03%)	0.91689	>0.05
Head injuries	102 (14.76%)	124 (12.65%)	226 (13.52%)	1.53996	>0.05
brain concussion	9 (1.30%)	8 (0.82%)	17 (1.02%)	0.95106	>0.05
injuries of the cerebral part of the head	15 (2.17%)	18 (1.84%)	33 (1.97%)	0.23358	>0.05
Face injuries	78 (11.29%)	98 (10.00%)	176 (10.53%)	0.71343	>0.05
abrasions	47 (6.80%)	54 (5.51%)	101 (6.04%)	1.19034	>0.05
wounds	26 (3.76%)	38 (3.88%)	64 (3.83%)	0.01452	>0.05
fractures	5 (0.72%)	6 (0.61%)	11 (0.66%)	0.07683	>0.05
Upper extremity injuries	335 (48.48%)	476 (48.57%)	811 (48.53%)	0.00134	>0.05
abrasions	197 (28.51%)	278 (28.37%)	475 (28.43%)	0.00402	>0.05
wounds	110 (15.92%)	153 (15.61%)	263 (15.74%)	0.02875	>0.05
fractures	28 (4.05%)	45 (4.59%)	73 (4.37%)	0.28258	>0.05
Lower extremity injuries	216 (31.26%)	325 (33.16%)	541 (32.38%)	0.67118	>0.05
abrasions	134 (19.39%)	205 (20.92%)	339 (20.29%)	0.58370	>0.05
wounds	78 (11.29%)	110 (11.22%)	188 (11.25%)	0.00164	>0.05
fractures	4 (0.58%)	10 (1.02%)	14 (0.84%)	0.95096	>0.05

* The percentage was calculated with regard to the total number of accidents (n = 870). For the rest of the factors, the percentage was calculated with regard to the total number of injuries in each group (female = 691, male = 980, total = 1671).

who used bicycles as a means of transport tended to be younger and travel more frequently (more days per week), in the morning and evening peak hours, than those who rode for recreational purposes. Recreational cyclists treated cycling as physical exercise that helped them maintain a good physical condition; they more frequently used road bikes, while commuters spent more time on hybrid, city, cruiser and comfort bikes.[26]

In our article, we additionally included other sociological factors, such as professional activity, education, marital status, having children, cycling preferences, and attitude toward safety behaviors during cycling, as potential risk factors for bike-related injury. Our cohort included mostly adult cyclists at the age 19–29 years and only a small group of very young or old people, similarly to the major part of research considering cycling patterns. Also, in our study, like in most publications, males constituted the main group of respondents. Our interviewees most frequently declared that they treated cycling as a form of recreation or a means of transport. Women declared riding a bike a few times a week or from time to time, and they more often chose city bikes. Men on the other hand stated that they used a bike more often, i.e., a few times a week or every day, and they usually preferred riding a mountain bike. Other studies also indicated that men had larger experience in cycling. When it comes to safety considerations, women more often than men claimed that they did not always wear helmets. This can be explained by the fact that women used bikes less often than men. However, more than half of the cyclists declared to have reflective elements on their clothes or bikes.

Bike accidents are a growing public health problem worldwide. Risk factors of these incidents were discussed in many medical publications. Researchers around the world confirmed that the age of cyclist is correlated with the number of accidents – children, adolescents and people older than 65 years of age take part in more accidents than adults.[20,22,23,25] Taking into consideration the number of accidents that take place, the exposure indicator should not be omitted. Subjectively, a higher number of bike crashes noted in the urban areas is strongly correlated with a greater number of bike users. Some authors compared the number of cyclists and the number of bike-related injuries in and outside the city and it turned out that off-road cycling was much more unsafe.[18,20] There is little information in the literature about the correlation of the bicycle type and bike-related injuries. It is probably related to the belief that many kinds of bicycles are used not necessarily in line with their main purpose, e.g., mountain bikes are often used as a means of transport in the city and city bikes can be seen on short off-road trips.

Our study recognized several groups of cyclists with a higher probability of undergoing bike-related accidents. They included people with secondary education and incomplete higher education, parents with at least 3 children, people who used a bike every day (higher exposure), people riding city bikes, mountain bikes and fold-up bikes. People who declared always wearing helmets during cycling proved to be more prone to accidents. This seems counterintuitive, but there can be 2 possible explanations. The first one is similar to the conclusion made by Peltzman, who suggested that the probability of risky behaviors increase along with the increase in perceived safety.[32] Some studies also indicate that drivers can act less carefully toward cyclists wearing helmets than toward those without.[33] It should be stated that both these hypotheses are controversial. Several studies have shown that head injuries are more common and more severe in cyclists that do not wear helmets.

Some epidemiological data indicates that head injuries are the most common traumas among cyclists.[34,35] It was estimated that among victims of fatal accidents, around

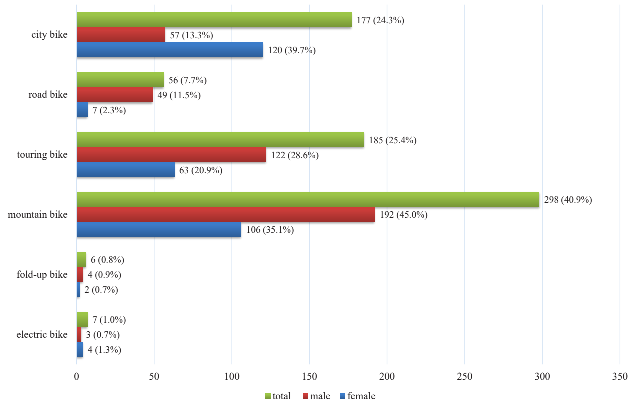

Fig. 4. Type of bike used

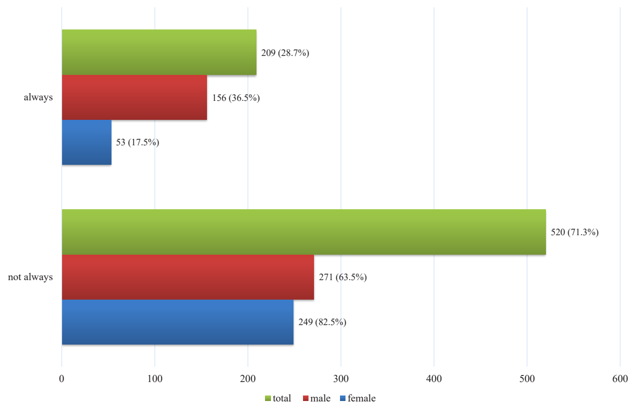

Fig. 5. Protective helmet usage among respondents

2/3 of them sustained head traumas.[36] The most frequent head injuries in bike-related accidents are skull fractures and cerebral contusions.[35] Cyclists are also at a higher risk of undergoing facial fractures.[37] The studies on the impact of wearing helmets on injuries of the facial region led to controversial conclusions.[38–40] Some authors emphasized that wearing bicycle helmets did not reduce the incidence of mid-facial fractures and was even associated with an increased risk of mandibular fractures.[37]

Contrary to the abovementioned articles, in our studies, the most common injuries were those of the upper extremities (48.53% of all injuries) and lower extremities (32.38%). Injuries of the upper extremities, including wounds, were more often observed in the male group. Women more often suffered from injuries of the lower extremities (37.68%), comprising abrasions of the lower limbs. The female group was also at a higher risk of facial skeleton fractures in comparison to the male group. In our study, wearing helmet did not influence the region of trauma nor its type.

In the cited articles, the injuries of the upper and lower extremities were the second most common type of traumas. No correlations between type and location of injuries with regard to cyclists' gender were reported.[34,38–40]

Conclusions

Young men prevailed among cyclists in Poland. Gender-related dependencies can be observed in preferences for bike type, and cycling characteristics and pattern. For women, the most popular type of bike is a city bike, while men more often prefer mountain and touring bikes. The overwhelming majority of bike users admitted to not wearing protective helmets. In our study, we identified 5 risk factors for bike-related accidents. People with secondary education and incomplete higher education were at a higher risk of injuries as well as those who have at least 3 children. Frequency of using a bike (the more often, the more injuries), type of bike used (mountain bikes and fold-up bikes) and frequency of wearing helmets constituted the other group of factors correlated with a higher rate of injuries. The most common locations of injuries proved to be the upper and lower extremities.

References

1. Yang L, Sahlqvist S, McMinn A, et al. Interventions to promote cycling: Systematic review. *BMJ*. 2010;341:c5293. doi: 10.1136/bmj.c5293
2. Rojas-Rueda D, de Nazelle A, Andersen ZJ, et al. Health impacts of active transportation in Europe. *PLoS ONE*. 2016;11(3):e0149990. doi: 10.1371/journal.pone.0149990
3. Mueller N, Rojas-Rueda D, Cole-Hunter T, et al. Health impact assessment of active transportation: A systematic review. *Prev Med*. 2015;76:103–114.
4. Badland H, Knuiman M, Hooper P, et al. Socio-ecological predictors of the uptake of cycling for recreation and transport in adults: Results from the RESIDE study. *Prev Med*. 2013;57(4):396–399.
5. Humphreys DK, Goodman A, Ogilvie D. Associations between active commuting and physical and mental well-being. *Prev Med*. 2013;57(2):135–139.
6. Hamer M, Chida Y. Active commuting and cardiovascular risk: A meta-analytic review. *Prev Med*. 2008;46(1):9–13.
7. Poggio R, Serón P, Calandrelli M, et al. Prevalence, patterns, and correlates of physical activity among the adult population in Latin America: Cross-sectional results from the CESCAS I study. *Glob Heart*. 2016;11(1):81–88.
8. Laverty AA, Palladino R, Lee JT, et al. Associations between active travel and weight, blood pressure and diabetes in six middle-income countries: A cross-sectional study in older adults. *Int J Behav Nutr Phys Act*. 2015;12:65. doi: 10.1186/s12966-015-0223-3
9. Østergaard L, Støckel JT, Andersen LB. Effectiveness and implementation of interventions to increase commuter cycling to school: A quasi-experimental study. *BMC Public Health*. 2015;15:1199. doi: 10.1186/s12889-015-2536-1
10. Barbosa D, Santos CP, Martins M. The application of cycling and cycling combined with feedback in the rehabilitation of stroke patients: A review. *J Stroke Cerebrovasc Dis*. 2015;24(2):253–273.
11. Alkatan M, Machin DR, Baker JR, et al. Effects of swimming and cycling exercise intervention on vascular function in patients with osteoarthritis. *Am J Cardiol*. 2016;117(1):141–145.
12. Sakurai R, Kawai H, Yoshida H, et al. Can you ride a bicycle? The ability to ride a bicycle prevents reduced social function in older adults with mobility limitation. *J Epidemiol*. 2016;26(6):307–314.
13. Sakurai R, Kawai H, Fukaya T. Incidence of bicycle-related accidents and subsequent injury in community-dwelling older adults: Understanding potential accidents. *Nihon Koshu Eisei Zasshi*. 2015;62(5):251–258.
14. Miwa H, Kondo T. Bicycle sign for differential diagnosis of parkinsonism: Is it of use in a hilly country like Japan? *J Parkinsons Dis*. 2011;1(2):167–168.
15. Tainio M, de Nazelle AJ, Götschi T, et al. Can air pollution negate the health benefits of cycling and walking? *Prev Med*. 2016;87:233–236.
16. Vanparijs J, Int Panis L, Meeusen R, et al. Exposure measurement in bicycle safety analysis: A review of the literature. *Accid Anal Prev*. 2015;84:9–19.
17. Dozza M. Crash risk: How cycling flow can help explain crash data. *Accid Anal Prev*. 2017;105:21–29. doi:10.1016/j.aap.2016.04.033
18. Aultman-Hall L, Hall FL. Ottawa-Carleton commuter cyclist on- and off-road incident rates. *Accid Anal Prev*. 1998;30(1):29–43.
19. Blaizot S, Papon F, Haddak MM, et al. Injury incidence rates of cyclists compared to pedestrians, car occupants and powered two-wheeler riders, using a medical registry and mobility data, Rhone County, France. *Accid Anal Prev*. 2013;58:35–45.
20. de Geus B, Vandenbulcke G, Int Panis L, et al. A prospective cohort study on minor accidents involving commuter cyclists in Belgium. *Accid Anal Prev*. 2012;45:683–693.
21. Mindell JS, Leslie D, Wardlaw M. Exposure-based 'like-for-like' assessment of road safety by travel mode using routine health data. *PLoS ONE*. 2012;7(12):e50606. doi: 10.1371/journal.pone.0050606
22. Poulos RG, Hatfield J, Rissel C, et al. Exposure-based cycling crash, near miss and injury rates: The Safer Cycling Prospective Cohort Study protocol. *Inj Prev*. 2012;18(1):e1. doi: 10.1136/injuryprev-2011-040160
23. Teschke K, Harris MA, Reynolds CC, et al. Route infrastructure and the risk of injuries to bicyclists: A case-crossover study. *Am J Public Health*. 2012;102(12):2336–2343.
24. Twisk DAM, Reurings M. An epidemiological study of the risk of cycling in the dark: The role of visual perception, conspicuity and alcohol use. *Accid Anal Prev*. 2013;60:134–140.
25. Vandenbulcke G, Thomas I, de Geus B, et al. Mapping bicycle use and the risk of accidents for commuters who cycle to work in Belgium. *Transp Policy*. 2009;16(2):77–87.
26. Poulos RG, Hatfield J, Rissel C, et al. Characteristics, cycling patterns, and crash and injury experiences at baseline of a cohort of transport and recreational cyclists in New South Wales, Australia. *Accid Anal Prev*. 2015;78:155–164.
27. Pikora T, Giles-Corti B, Bull F, et al. Developing a framework for assessment of the environmental determinants of walking and cycling. *Soc Sci Med*. 2003;56(8):1693–1703.
28. Damant-Sirois G, Grimsrud M, El-Geneidy A. What's your type: A multidimensional cyclist typology. *Transportation*. 2014;41:1153–1169.
29. Heesch KC, Sahlqvist S, Garrard J. Gender differences in recreational and transport cycling: A cross-sectional mixed-methods comparison of cycling patterns, motivators, and constraints. *Int J Behav Nutr Phys Act*. 2012;9(1):106. doi: 10.1186/1479-5868-9-106
30. Munro C. *Australian Cycling Participation*. *Results of the 2013 National Cycling Participation Survey*. Sydney: Austroads, Ltd.; 2013.
31. Pucher J, Buehler R. Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany. *Transp Rev*. 2008;28(4):495–528.
32. Peltzman S. The effect of automobile safety regulation. *J Polit Econ*. 1975;83(4):677–726.
33. Walker I. Drivers overtaking bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender. *Accid Anal Prev*. 2007;39(2):417–425.
34. Eilert-Petersson E, Schelp L. An epidemiological study of bicycle-related injuries. *Accid Anal Prev*. 1997;29(3):363–372.
35. Depreitere B, Van Lierde C, Maene S, et al. Bicycle-related head injury: A study of 86 cases. *Accid Anal Prev*. 2004;36(4):561–567.
36. National Center for Statistics and Analysis. *Traffic Safety Facts 1993. Pedal Cyclists*. Washington, DC: National Center for Statistics and Analysis; 1994.
37. Stier R, Otte D, Müller C, et al. Effectiveness of bicycle safety helmets in preventing facial injuries in road accidents. *Arch Trauma Res*. 2016;5(3):e30011.
38. Hansen KS, Engesaeter LB, Viste A. Protective effect of different types of bicycle helmets. *Traffic Inj Prev*. 2003;4(4):285–290.
39. Thompson DC, Thompson RS, Rivara FP, et al. A case-control study of the effectiveness of bicycle safety helmets in preventing facial injury. *Am J Public Health*. 1990;80(12):1471–1474.
40. Thompson RS, Rivara FP, Thompson DC. A case-control study of the effectiveness of bicycle safety helmets. *N Engl J Med*. 1989;320(21):1361–1367.