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Published in:

Transportation Research. Part F: Traffic Psychology and Behaviour

DOI:

[10.1016/j.trf.2018.05.020](https://doi.org/10.1016/j.trf.2018.05.020)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version

Publisher's PDF, also known as Version of record

Publication date:

2018

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Engbers, C., Dubbeldam, R., Brusse-Keizer, M. G. J., Buurke, J. H., de Waard, D., & Rietman, J. S. (2018). Characteristics of older cyclists (65+) and factors associated with self-reported cycling accidents in the Netherlands. *Transportation Research. Part F: Traffic Psychology and Behaviour*, 56, 522-530. <https://doi.org/10.1016/j.trf.2018.05.020>

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Characteristics of older cyclists (65+) and factors associated with self-reported cycling accidents in the Netherlands

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ARTICLE INFO

Article history:

Received 22 May 2017

Received in revised form 7 March 2018

Accepted 16 May 2018

Keywords:

Cycling safety
Self-reported falls
Older cyclists
Traffic psychology
Questionnaire

ABSTRACT

Cycling supports the mobility, health and independency of the ageing population. However, older cyclists have an increased injury risk. On average, the risk of older people to sustain an injury in a cycling accident is three times higher per cycling kilometre than for middle-aged people and the injury risk increases with age. In comparison with middle-aged cyclists (<65 years), the risk of hospitalization is more than four times as high for older cyclists (≥65 years). The aim of this study was to reveal characteristics of older cyclists in general and to explore which of these characteristics are associated with self-reported cycling accidents from age 59. More than eight hundred older cyclists (>65 years) filled out a questionnaire, which included questions on demographics, bicycle specifications and personal characteristics. By means of a logistic regression, the relationship between personal factors and self-reported bicycle falls were studied. The univariate models showed that age, physical and mental impairments, bicycle model, living environment, feelings of uncertainty of the cyclist and changed cycling behaviour (such as more patience, lower speed) were related to falling off a bicycle. From the multivariate model we can conclude that several factors are associated with falling off a bicycle in the older population: (1) every year the cyclists becomes one year older (from the age of 65), the chance they have fallen increases with 7.3%, (2) If cyclists have mental impairments, the chance they have fallen increases with a factor 2.5, (3) if cyclists were less than completely confident the chance they have fallen increases with factor 1.8, (4) if cyclists live in a rural environment compared to an urban environment the chance they have fallen increases with a factor 2.1. In conclusion, demographic, cycling and personal factors can be related to increased self-reported fall risk. It is advised to take these factors into account when implementing new cycling related safety measures.

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1. Introduction

In the Netherlands cycling is a common mode of transport, and the Netherlands is a world leader in bicycle safety (Schepers et al., 2015). Conditions in the Netherlands are favourable for cycling as the consequence for several factors like climate, infrastructure, cycling facilities and the flat landscape (Heinen, Van Wee, & Maat, 2010; Ministry of Infrastructure and the Environment, 2009). The high amount of bicycle use increases safety, as it corresponds with a greater awareness of cyclists among drivers (Schepers, 2012). However, due to the ageing population, there are more older cyclists and they cycle longer into a higher age (Wegman, Zhang, & Dijkstra, 2012). It is important to make sure that the older population can continue cycling safely, as it contributes to physical health and overall fitness (Fishman, Schepers, & Kamphuis, 2015; Oja et al., 2011). Older adults experience increased feeling of independence and mobility, increased health and social contacts because of cycling (Fagerström & Borglin, 2010; Törnvall, Marcusson, & Wressle, 2016). However, while cycling supports the independence and health of the ageing population (Oja et al., 2011), older cyclists have an increased risk for being involved in a cycling accident (Martínez-Ruiz et al., 2014). In the Netherlands, 67% of all bicyclists fatalities were among cyclists aged 60 years and older. This is more than twice as much as fatally injured car drivers within the same age group (CBS, 2014). On average, the risk of older people to sustain an injury due to a cycling accident is 2–5 times higher per cycling kilometre than for middle-aged cyclists (Berveling & Derriks, 2012; Zeegers, 2010). The probability of a fatal accident outcome for cyclists aged 75 and older is 17 times higher than for cyclists younger than 75 years (SWOV, 2009). Furthermore, the risk of hospitalization is more than four times as high for older cyclists after visiting an emergency department (SWOV, 2009), compared with middle-aged cyclists. The number of seriously injured victims per kilometre travelled by bicycle increased slightly over the last decade for all age groups (Weijermars, Bos, & Stipdonk, 2016). However, the rise in number of victims in single sided accidents (i.e. where no other road user was involved) resulted mainly from the older, more vulnerable cyclists (Berveling & Derriks, 2012; Norden & Bijleveld, 2011; Schepers & Vermeulen, 2012). For these reasons, cycling safety has become a focus point in Dutch policy.

Human performance can be described by the International Classification of Functioning, Disability and Health (ICF WHO, 2017). The ICF, is a classification of health and health-related domains. As the functioning and disability of an individual occurs in a context, ICF also includes environmental factors and personal factors. However, most research on cyclist safety focussed on bicycle accidents types and characteristics, mainly related to external factors, such as infrastructure. As said, the older cyclist is mostly the victim of a single-sided accident (Schepers & Wolt, 2012). Accidents studies on single-sided accidents report as frequent types of single-sided accidents; loss of balance, colliding with an obstacle or entering the verge (Schepers & Wolt, 2012). However, according to Davidse et al. (2014), a considerable number of single-sided accidents are preceded by interaction with another road user (see also Westerhuis & De Waard, 2016).

Literature on single-bicycle accidents is limited, which can be explained by the fact that minor single-bicycle accidents are rarely reported in official road crash statistics (Schepers & Wolt, 2012; Wegman et al., 2012). Cyclists accidents are more likely to be reported when the injury severity increases (Langley, Dow, Stephenson, & Kypri, 2003), and the rate of reporting is much higher for bicycle accidents with motor vehicles involved than for bicycle accidents with no motor vehicles involved (Kroon, 1990; Langley et al., 2003; Reurings & Bos, 2011; Schepers et al., 2015). The underreporting of crashes in police statistics and the selective reporting are complicating factors hindering insight in factors associated with falling of a bicycle. Despite many studies about (single-)bicycle accident types, insight in the personal factors that could play a role and information about non-reported mostly non-severe bicycle falls, is missing in the scientific literature.

The increased risk of falling for older cyclists off a bicycle may be the results from both cognitive and physical decline (OECD, 2001). Mental impairments, like a decrease in attention, working memory, and a lower reaction time, could also make cycling in traffic more mentally demanding. Physical factors, like reduced (bone)strength and increased stiffness, may result in more severe injuries after falling off a bicycle. By gaining knowledge about the factors associated to falling, cycling accidents might be prevented (Rijkswaterstaat, 2016). Insight in factors related to the higher fall risk of older cyclists may result in the design of measures to reduce the number of injured older cyclists. These factors could include personal, bicycle or infrastructural factors.

This study focusses on exploring demographic, bicycle and personal factors related to self-reported bicycle falls, instead of focusing on accident characteristics. The focus of this study is on (1) revealing characteristics of the older cyclist who has been involved in a self-reported falling accident, and (2) exploring factors associated with self-reported cycling accidents.

2. Method

2.1. Participants

In total, more than 2000 older cyclists from the Netherlands, aged 65 years and older were asked to complete a questionnaire. The only inclusion criteria were that the participants had to be aged 65 years or over and could ride a bicycle.

The participants were mainly (76.5%) recruited during Cycling School Lessons of the Dutch Cycling Union (Fietsersbond). These Cycling School Lessons days were informative and informal days to gather information about cycling to experience difference bicycle types, to cycle together and receive advice. The instructors of these cycling lessons distributed the questionnaire and a stamped return envelope on 52 occasions. A link to the online version questionnaire was also distributed by

the Dutch Cycling Union. Other participants (23.5%) were recruited by including the questionnaire as an attachment to the monthly magazine of a senior association, at an e-bike convention and by distribution via personal contacts.

2.2. Questionnaire

The questionnaire consisted of 47 questions, and included items about demographics (age, gender, living environment), cycling behaviour (bicycle specifications, cycling frequency, cycling habits, cycling adaptations, traffic violations, fall experiences) and health (activity level, medication, mental and physical impairments, experience with falling). For each theme, approximately three questions were asked, and a large part of the questions are represented in [Table 1](#). The questionnaire was developed based on literature of behaviour and fall- and accident risk on older cyclists. The questionnaire consisted of mostly closed-ended questions; i.e. questions with predefined answers and multiple answers were possible for most questions.

2.3. Data analyses

Participants were grouped as ‘fallers’ or ‘non-fallers’, based on the response to the question: “have you ever fallen off your bicycle after you became 59 years old”? Normal distribution checks based on histograms were conducted first. Comparisons between groups were made using independent samples student's *t* test for normally distributed continuous variables and Chi-square tests were used for categorical variables. Many questions had multiple answer categories, so secondly, several variables were made dichotomous or restructured. This was needed, because otherwise there would not be enough cases for each answer category to study associations. The variables which were made dichotomous or restructured were; province (13 provinces recoded into north, middle, east); living environments (rural and village were combined versus urban); cycling adaptations (when ‘yes’ on ‘low entry’, ‘mirrors’ or ‘side-wheels’ it was recoded into ‘adaptations’ versus ‘no-adaptations’, ‘folding bike’ was seen as ‘no adaptations’); taking weather and taking time of the day into account (when ‘yes’ on one of the different options it was recoded into ‘yes, taking into account’ versus ‘no, not taking into account’); medicines that influences driving (when ‘yes’ on one of the different medications it was recoded into ‘yes, using medicine that influence driving’ versus ‘no’); cycling certainty & confidence in cycling (this 5-point Likert scale was made dichotomous by regrouping the four answers into ‘less than completely confident/certain’ versus ‘completely confident/certain’); physical impairments & mental impairments (when ‘yes’ on one of the different impairments it was recoded into ‘yes, physical or mental impairments’ versus ‘no physical or mental impairments’); adaptation to cycling behaviour (when ‘yes’ on one of the different adaptations, it was recoded into ‘yes, adaptations in cycling behaviour’ versus ‘no adaptations in cycling behaviour’); violating traffic rules (when ‘yes’ on one of the different violations, it was recoded into ‘yes, traffic violations’ versus ‘no, never traffic rules violations’).

The variables associated with falling ($p < 0.05$) were tested in a univariate and multivariate logistic regression analyses. In the univariate analysis, variables related to falling were identified and the odds-ratio assessed to identify risk of falling. Secondly, using these identified variables, stepwise backward logistic regression was used in order to make a multivariate model. Odds ratio with 95% confidence interval (CI) were calculated. Where multi-collinearity was present, the variable with the best model fit (based on $-2 \log$ likelihood), was retained. Statistical analysis was performed using Statistical Package designed for the Social Sciences (IBM SPSS 19.0 Statistics).

3. Results

Within a period of four months, 2007 questionnaires were distributed. In total, 954 questionnaires (47.5%) were returned. From these, 75 did not meet the age inclusion criterion. From the remaining, 22 had not answered the question whether they were fallen since 59 years old, so they were also excluded. In result, 857 questionnaires were included for the description of population.

3.1. Description of the population

[Table 1](#) presents the characteristics of the self-reported fallers (416) and the non-fallers (441).

As can be studied in [Table 1](#), for both groups, the distribution within a variable was (almost) equal for the variables: age, gender, provinces (north, middle, south), bicycle type (e-bike, c-bike, both) and physical impairments. However, the majority from this population are living in a rural environment, compared to an urban environment. The bicycle model on which this population cycled, was mainly a lady's model. In case of an electrical bicycle, more than half have their engine located in their front wheel, followed by rear-wheel. The cycling frequency during summer and winter is different: Most respondents cycle every day in the summer and cycle less in the winter. The vast majority take the time of the day into account, or the weather into account. More than 70% of the respondents state their own health as ‘(very) good’, with a vast majority carrying out light activity or average activity in daily life. More than 70% do not use medication that influences driving. A higher percentage in the non-fallen group can be found on the variables ‘cycling certainty’ and ‘cycling confidence’, compared to fallers. This pattern can also be found at mental impairments, which are more present in the fallen-group, compared to

Table 1

Characteristics for the entire group as for the fallers and non-fallers.

	Fallen n = 416	Non-fallen n = 441	p
Age (Mean in years, SD)	73.5 (5.9)	71.2 (5.2)	<0.001
Gender (n)	403	433	0.093
Male (n, %)	173 (42.9%)	211 (48.7%)	
Female (n, %)	230 (57.1%)	222 (51.3%)	
Province (n)	416	440	0.249
North	141 (33.9%)	163 (37.0%)	
Middle	146 (35.1%)	163 (37.0%)	
East	129 (31.0%)	114 (25.9%)	
Living environment (n)	404	429	<0.001
Rural	284 (70.3%)	348 (81.1%)	
Urban	120 (29.7%)	81 (18.9%)	
Bicycle type (n)	405	433	0.204
E-bike & C-bike	127 (31.4%)	116 (26.8%)	
E-bike	123 (30.4%)	127 (29.3%)	
C-bike	155 (38.3%)	190 (43.9%)	
Bicycle model (n)	399	434	<0.005
Ladies	304 (76.2%)	288 (66.4%)	
Gents	95 (23.8%)	146 (33.6%)	
Place of the engine (n)^a	245	235	0.579
Front wheel	128 (52.2%)	126 (53.6%)	
Rear wheel	73 (29.8%)	74 (31.5%)	
Middle	25 (10.2%)	24 (10.2%)	
Don't know	19 (7.8%)	11 (4.7%)	
Cycling frequency winter (n)	413	438	0.390
Every day	146 (35.4%)	144 (32.9%)	
Min. once a week	184 (44.6%)	220 (50.2%)	
Min. once a month	41 (9.9%)	37 (8.4%)	
Don't cycle	42 (10.2%)	37 (8.4%)	
Cycling frequency summer (n)	414	439	0.186
Every day	276 (66.7%)	286 (65.1%)	
Min. once a week	120 (29.0%)	140 (31.9%)	
Min. once a month	14 (3.4%)	13 (3.0%)	
Don't cycle	4 (3.4%)	0 (0.0%)	
Takes time of the day into account (n)	408	437	0.301
No	254 (62.3%)	287 (65.7%)	
Yes (such as, avoiding darkness)	154 (37.7%)	150 (34.3%)	
Takes weather into account? (n)	400	428	0.481
No	61 (15.3%)	73 (17.1%)	
Yes (such as, avoiding snow/fog/rain)	339 (84.8%)	355 (82.9%)	
General health perception (n)	412	440	0.034
Excellent	31 (7.5%)	53 (12.0%)	
Very good	91 (22.1%)	97 (22.0%)	
Good	232 (56.3%)	251 (57.0%)	
Fair	57 (13.8%)	37 (8.4%)	
Poor	1 (0.2%)	2 (0.5%)	
Activity level (max) (n)	402	433	0.028
Light movement (activities such as easy walking, household work)	161 (40.0%)	137 (31.6%)	
Average movement (activities such as aerobics, swimming, brisk walking)	186 (46.3%)	219 (50.6%)	
Intensive movement (activities such as strenuous sports, running)	55 (13.7%)	77 (17.8%)	
Uses medications that influence driving (n)	416	441	0.092
No	309 (74.3%)	349 (79.1%)	
Yes	107 (25.7%)	92 (20.9%)	
Certainty during cycling (n)	406	436	<0.001
Complete certain	193 (47.5%)	289 (66.3%)	
Less than complete certain	213 (52.5%)	147 (33.7%)	
Confidence in own cycling (n)	408	434	<0.001
Complete confidence	206 (50.5%)	315 (72.6%)	
Less than complete confidence	202 (49.5%)	119 (27.4%)	
Cycles less than when 50 years old (n)	411	429	<0.001
Yes	124 (30.2%)	82 (19.1%)	

(continued on next page)

Table 1 (continued)

	Fallen n = 416	Non-fallen n = 441	p
No	287 (69.8%)	347 (80.9%)	
Cycles more than when 50 years old (n)	397	424	0.607
Yes	212 (53.4%)	234 (55.2%)	
No	185 (46.6%)	190 (44.8%)	
Physical impairments (n)	399	432	<0.001
No	163 (40.9%)	244 (56.5%)	
Yes	236 (59.1%)	188 (43.5%)	
Mental impairments (n)	397	429	<0.001
No	194 (48.9%)	332 (77.4%)	
Yes	203 (51.1%)	97 (22.6%)	
Violating traffic rules (n)	410	433	0.082
No	318 (77.6%)	338 (78.1%)	
Yes	92 (22.4%)	95 (21.9%)	
Changed cycling behaviour since 50 years (n)	413	437	<0.001
No	43 (10.4%)	88 (20.1%)	
Yes (such as more patience, lower speed, avoiding situations)	370 (89.6%)	349 (79.9%)	
Bicycle adaptations (n)	408	433	<0.001
No	277 (67.9%)	343 (79.2%)	
Yes (low entry, sidewheels, mirrors)	131 (32.1%)	90 (20.8%)	

E-bike is an electric bicycle and C-bike a common European City Bike; n = number of participants; min is minimum.

^a Some categories do not add up to the total number of participants because of missing answers. For example; the number of respondents for 'place of engine' do not add up to the total number of participants who used an e-bike as there are missing answers for the question about 'bicycle type (e-bike and c-bike, e-bike, c-bike)'. This same applies to some other categories.

the non-fallen group. Most mentioned mental impairments were 'feeling uncomfortable in complex and busy traffic situations', 'fear of falling' and 'having to focus to a large degree'. A low percentage of this population states to violate the traffic rules. Finally, it was found that a large proportion has changed their cycling behaviour since they became 50 years of age. Statistical significant differences ($p < 0.05$) between the two groups for the assessed variables can be found in the forth column of Table 1.

3.2. Univariate analysis comparing fallers and non-fallers

First a subset of independent variables, that were univariate associated with self-reported falling were identified, namely changed cycling behaviour (such as being more patient, cycling at lower speed, avoiding situations), physical impairments, health, bicycle model, bicycle adaptations (such as low entry, sidewheel, mirrors), activity level, age, mental impairments, living environment, confidence and cycling frequency.

The risk that somebody has fallen increases; with every year the cyclist gets older; when the cyclist has mental or physical impairments; when living in a rural environment; when less than completely confident or less than completely sure during cycling; with changed cycling behaviour since 50 years of age; with bicycle adaptations; with a fair general health perception and with a low activity level. The risk that a cyclist has fallen decreases; when the perception of general health is good; when using a gent's bicycle model and when the cyclist did not reduce cycling less since the age of 50. The results of the univariate regression analysis, comparing all self-reported fallers with non-fallers are shown in the three left columns in Table 2.

3.3. Multivariate analysis of fall factors

Second, stepwise backward logistic regression analysis was used in order to make a multivariate model. The univariate variables significantly related with a self-reported fall were included in the model. Because of multicollinearity between 'cycling confidence' and 'cycling certainty' only the variable with the best model fit was entered to the multivariate regression model, which was 'cycling confidence'.

The multivariate regression model revealed that the following four variables were significantly related to a self-reported fall. (1) Age, for each year the cyclist is older (starting at 65 years of age), the risk that they have fallen increases with 7.3%. (2) Mental impairments: in case of experience mental impairments, the risk they have fallen increases with a factor 2.5. (3) Confidence level: If cyclists are less than completely confident while cycling, the risk they have fallen increases with a factor 1.8. And (4) living environment: if cyclists live in a rural environment compared to urban environment, the risk they have fallen increases with a factor 2.1. The results comparing all fallers with non-fallers using multivariate logistic regression analysis are shown in the three right columns of Table 2.

Table 2

Univariate & multivariate logistic regression analyses of the variables related to self-reported falling within demographic, bicycle and personal factors. With CI = confidence interval, uOR = univariate Odds Ratio, mOR = multivariate Odds Ratio with corresponding p-value.

	uOR	95%CI	p	mOR	95% CI	p
Age	1.08	1.051–1.109	<0.001	1.07	1.042–1.106	<0.001
Mental impairments			<0.001			<0.001
No -	–			–		
Yes	3.58	2.654–4.834		2.51	1.79–3.52	
Physical impairments			<0.001			
No -	–	–				
Yes	1.88	1.426–2.476				
Bicycle model			=0.002			
Ladies -	–	–				
Gents	0.62	0.455–0.836				
Living environment			<0.001			<0.001
Rural	1.82	1.315–2.506		2.06	1.440–2.953	
Urban -	–	–		–	–	
Cycling confidence			<0.001			=0.001
Yes, completely -	–	–				
No, no completely	2.60	1.949–3.460		1.80	1.293–2.152	
Cycling certainty			<0.001			
Yes, completely -	–	–				
No, less than completely	2.17	1.643–2.865				
Changed cycling behaviour since 50 years			<0.001			
Yes	2.17	1.465–3.214				
No -	–	–				
Adapted Bicycle			<0.001			
Yes	1.80	1.320–2.461				
No	–	–				
General health perception			<0.05			
Excellent	0.63	0.392–0.102				
Very good	1.12	0.724–1.422				
Good -	–					
Fair	1.67	1.062–2.616				
Poor	0.54	0.049–6.005				
Activity level			<0.05			
Light	1.38	1.025–1.868				
Moderate-	–	–				
Intensive	0.84	0.565–1.251				
Cycling less than at the age of 50			<0.001			
Yes-	–	–				
No	0.55	0.397–0.753				

4. Discussion

The aim of this study was to gain insight into personal characteristics of older cyclists and factors associated with their bicycle fall risk. The current study sought to attain understanding of fall risk in this age group through the inclusion of general factors related to common cycling, personal factors related to the cyclists and living habits. Therefore, characteristics of older cyclists were assessed, by means of a questionnaire, and the relationship between these self-reported personal factors and self-reported cycling accidents were studied. In this study, 48.5% of the participants reported at least one fall since they became 59 years old. Univariate factors related to falling were: age, mental impairments, physical impairments, living environment, feeling not confident, or feeling uncertain, while cycling and adaptation of cycling behaviour. The actual variables, which were independently significantly related to a self-reported fall were age (for each year the cyclists are older (starting at 65 years of age), the risk they have fallen increases with 7.3%), mental impairments (in case of experience mental impairments, the risk they have fallen increases with a factor 2.5), confidence level (if cyclists are less than completely confident while cycling, the risk they have fallen increases with a factor 1.8) and living environment (if cyclists live in a rural environment compared to urban environment, the risk they have fallen increases with a factor 2.1).

Of the 2007 questionnaires that were distributed, 47.5% were returned. This high response rate, could be due to a selective distribution, in which the cycling school could play a role. In total, 857 older cyclists, aged 65 or over, completed the questionnaire about demographics, mental and physical impairments, cycling habits and cycling experiences. The respondents from this study were all frequent cyclists displaying common Dutch cycling behaviour. The mentioned physical and mental impairments are common for this age group (OECD, 2001). According to Fildes, Langford, Pronk, and Anderson (2000) the

disabled conditions associated with ageing that have an impact on driving conditions or accident risk include sight- and hearing disabilities, cognitive and motor functions, and a decrease or loss of strength and endurance. This corresponds with the physical limitations of older cyclists in the Netherlands (SWOV, 2010, 2014), namely; reduced sight and hearing abilities, increased stiffness of the neck and decreased motor skills and strength. In general, the study sample is representative for the Dutch older cyclists' population.

The number of self-reported falls in this study is much higher than the official number in road accident statistics. This may be explained by the fact that serious injuries requiring medical treatment or medical damage not always occur after a self-reported fall and thus such falls are not reported as bicycle accidents in the accident database. The questionnaire did not address injury severity as result of their self-reported falls. A major strength of our study however is that it allows for the identification of personal factors associated with self-reported cycling accidents in the older population, by conducting this questionnaire in a very large group of older cyclists. These factors give more insight in accidents with not per definition, serious injuries as a result, but also minor consequences. These factors are expected to help answer a wide range of theoretical and practical questions concerning traffic psychology.

The results showed that older cyclists are at greater risk of having a self-reported fall for each year they become older. According with the literature, age is significantly associated with increased risk of falling off a bicycle (Boufous, de Rome, Senserrick, & Ivers, 2012; Bíl, Bílová, and Müller, 2010; Kaplan, Vavatsoulas, & Prato, 2014; Martínez-Ruiz et al., 2015; Martínez-Ruiz et al., 2014; Schepers & Vermeulen, 2012; Siman-Tov et al., 2012). From the literature it is known that with increasing age, cyclists are more likely to have more serious injuries when diagnosed at the emergency department after an accident (Kaplan et al., 2014; Siman-Tov et al., 2012). The latter may be explained by the fact that older adults are more vulnerable in general (Martínez-Ruiz et al., 2014). The findings in this study suggest that the higher risk of sustaining more serious injuries for older cyclists may not just be caused by the older cyclists being more vulnerable, but also when the cyclist ages, the higher the chance they have fallen off their bicycle. In general, it can be stated that when people cycle more or cycle more kilometres, they have more chance to fall, due to more exposure.

In addition to age, other important fall related factors are mental impairments and not being completely confident regarding cycling. This stresses the importance of keeping the older adult not only physically healthy, but also mentally healthy.

The finding that living in a rural environment is related to more self-reported falls is in can be explained by the study from Boufous et al. (2012), who concluded that cyclists are especially at risk in rural areas. Shown by Lawson, Ghosh, and Pakrashi (2015) was that preference to cycle in an urban environment was significantly improving the perception of cycling safety. Empirical studies show that fall risk decreased as exposure increases (Elvik, 2009), so cycling frequency seems to have an influence. Besides that, the Safety in Number phenomenon (Jacobsen, 2003) is a factor which normally contributes to a safer environment for cyclist safety in crowded traffic, as can be found in urban areas. This phenomenon refers to the adaptive behaviour of motorist when there is a high incidence of cyclists. However, in contrast with this, Hagemeister and Tegen-Klebingat (2012) found that in general cycling in the city is more dangerous than elsewhere. Reason for this can be that cyclists are especially at risk on intersections (Dozza & Werneke, 2014), at curves (Boufous et al., 2012) and on designated cycling infrastructure (Schleinitz, Petzoldt, Franke-Bartholdt, Krems, & Gehlert, 2015), which are all elements that are more common in urban areas than in rural areas. Perhaps, at such infrastructure, accidents occur more often with other road users, possibly leading to more severe injuries and thus are more frequently reported in accident analysis studies. Furthermore, we did not ask whether the respondents in this study cycled usually in a rural environment or in an urban environment; it is possible that some respondents avoided certain (urban) situations, like busy city centres or complex roundabouts. As know from Davidse (2007), older car drivers tend to compensate for their functional limitations, which can prevent safety problems. It is also possible that older cyclists spend more time in rural areas for example for recreational cycling. Environmental factors, like sharing the road with motorized traffic (Kaplan et al., 2014), involvement of other road users (Heesch, Sahlqvist, & Garrard, 2011), high speed limits (Boufous et al., 2012; Kaplan et al., 2014) are all related to an increased fall risk and injuries risk. Schepers and den Brinker (2011) investigated single-bicycle crashes types and characteristics in more detail. He concluded that the visibility of the infrastructure can play an important role in single bicycle accidents. Visibility might be a bigger issue in rural areas compared to urban areas for older cyclists. Concluding, the fact that the cycling infrastructure outside urban areas is different from the infrastructure in urban areas, may play a role with regard to falling off their bicycle in rural areas.

In this study, self-reported falls were not associated with violating traffic rules, which is not in agreement with the results from the study from Hagemeister and Tegen-Klebingat (2012), who found self-reported violating traffic rules as an important predictor in the accidents risk of the older cyclist in Germany. In agreement with Hagemeister and Tegen-Klebingat (2012), physical impairments and distance of cycling were not related to self-reported fall risk, however; physical impairments are related to problems with mounting and dismounting the bicycles, which are cycling tasks related to a higher accident risk (Ormel, Klein-Wolt, & Den Hertog, 2008). Furthermore, Hagemeister and Tegen-Klebingat (2012) found that cyclist who cycled daily or nearly daily had a higher accident fall risk than cyclists who cycled less often. This finding is not confirmed in our study, but this can be explained by the fact that the study population from our study were mostly frequent cyclists and that the German cycling infrastructure differs from the Dutch cycling infrastructure.

This study has some limitations. Despite we assume that the study sample in general is representative for the Dutch older cyclist's population, it should be kept in mind that the recruitment strategy could have had influence on the selection of respondents. The respondents were in the majority participants of the cycling lessons of the Dutch Cycling Union. It is

possible that these older adults are more aware of their cycling behaviour and in particular of their limitations. They may feel more insecure while cycling and have therefore joined the cycling lessons. In addition, from the questionnaire responses we know if people had a falling accident after being 59 years of age, but we do not know at what exact age they had the accidents and how the exact situation was. We checked the characteristics for the participants recruited through the cycling lessons and compared them with the characteristics for the participants recruited in another way and there were no differences in percentages of falls and most of the other characteristics. The only characteristics that differed were 'gender (more women in the cycling lesson group), living environment (more rural in the cycling lesson group), place of engine (more front wheel in the cycling lesson group) and adaptations in cycling behaviour (more adaptations in the cycling lesson group).

As stated by Prati, Puchades, and Pietrantonio (2017), cyclists as a group of road users have been banned to a second position. In order to encourage safe cycling, we need to reduce the hazards that cyclists face. From the literature it is known that regular daily physical exercise through cycling has great health benefits, Fishman et al. (2015) claim that Dutch people have half-a-year longer life expectancy due cycling. It is therefore important to understand how cycling safety can be improved. By gaining knowledge about the factors that are associated to falling, it might be possible to prevent cycling accidents in future. Recommendations for practitioners could be to focus more on the mental health and level of confidence of older cyclists. For the cycling infrastructure it is important to make the rural environment safer for the older cyclists. As found by Schepers, Twisk, Fishman, Fyhri, and Jensen (2017), a lower motor vehicle driving speed on so-called 'mixed roads', where cyclists are on same road as motor vehicles, contributed to a high level of cycling safety in the Netherlands. Future research should focus more on longitudinal quantitative research on personal factors that predict cycling fall accidents.

In conclusion, four characteristics of the older population and self-reported factors are associated to an increased risk of a fall accident: increasing age, experiencing mental impairments, lack of cycling confidence and living in rural environment. If possible, these factors should be taken into account when implementing new cycling related safety measures.

Funding

This work was supported by the Dutch Ministry of Infrastructure and Environment (grant number 31080043).

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