



The Influence of Early Cycling Initiation on Active Mobility, Cycling Behaviours and Safety Outcomes

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ABSTRACT

Although cycling is widely renowned for its benefits to transport sustainability and individual health, the impact of cycling initiation age on cycling behaviours and safety outcomes remains underexplored in the scientific literature. The present study aimed to investigate the relationship between the age of initiation and self-reported cycling behaviours, safety skills and willingness to increase cycling participation. For this purpose, we used the data provided by 1,741 cyclists from five Balkan countries. Overall, no significant differences in onset ages were found between male and female riders. Regarding self-reported cycling behaviour, individuals who started cycling at an earlier age were less prone to unintentional risky behaviours and consistently reported better knowledge of traffic rules. Notably, earlier starters are those who currently engage in longer and more sustained cycling trips. However, they were also less likely to wear a helmet and more likely to engage with connected devices while cycling. This suggests that while the relationship between cycling onset ages and subsequent riding outcomes is relatively clear, it is neither tautological nor linear, highlighting the ongoing need for safety literacy initiatives. On a practical level, these findings underline the need for strategies that promote early cycling engagement while fostering sustained growth in active mobility and safer cycling practices.

KEYWORDS

cycling; early initiation; cycling behaviour; safety skills; sustainable mobility; Balkan countries.

1. INTRODUCTION

Cycling is widely recognised as a sustainable mode of transportation with numerous benefits for individual well-being and public health [1]. Regular bicycle use has been linked to improvements in cognitive function, enhanced mental well-being and increased processing speed, effects that extend beyond physical activity alone [2]. Empirical studies reinforce these findings, highlighting cycling's association with higher quality of life, social benefits and increased empowerment [3].

Beyond its impact on individuals, cycling plays a key role in urban mobility and environmental sustainability. Its widespread adoption contributes to lower CO₂ emissions, reduced road congestion and improved road safety by replacing short car trips with bicycle journeys [4]. In countries such as the Netherlands, for instance, mass cycling is estimated to prevent approximately 6,500 deaths annually, extending life expectancy and generating economic benefits equivalent to more than 3% of the country's gross domestic product [5]. Additionally, urban environments benefit from a greater share of cycling in modal distribution, as it facilitates safer interactions among road users and contributes to the development of more sustainable transport systems [6].

Given these advantages, many cities have implemented policies to promote cycling. Across Europe, there is a growing trend toward reducing motorised vehicle dependency while increasing investment in cycling infrastructure, such as independent cycle lanes, secure bike parking and traffic calming measures [7]. These initiatives, supported by evidence-based policymaking, have driven a significant rise in cycling participation, particularly in Western Europe and North America [8].

However, despite the increasing attention to cycling's benefits and its promotion through urban policies, little research has explored how the age at which individuals begin cycling influences long-term cycling behaviours, safety-related outcomes and engagement with sustainable transport, making a potential understanding of this relationship particularly relevant in regions where cycling remains underdeveloped as a primary mode of transport, such as the Balkans.

2. LITERATURE REVIEW

2.1 Early cycling initiation and behavioural outcomes

Research in related fields suggests that earlier exposure to mobility experiences can shape long-term behavioural patterns. In motorised transport, for example, a study in Sweden found that allowing young drivers to accumulate more practice before full licensure reduced crash risk by approximately 40% [9]. A similar logic has been applied to cycling, with studies indicating that individuals who cycle from childhood tend to maintain more active lifestyles and report better mental and physical health indicators compared to those who primarily rely on motorised transport [10, 11].

However, while early cycling initiation appears to promote more ingrained cycling habits, its influence on safety behaviours remains complex [12, 13]. Some studies suggest that earlier exposure fosters stronger risk perception and traffic rule knowledge [14, 15], yet there is also evidence indicating that early enrollers may engage in more risky behaviours, such as using mobile phones while cycling, possibly due to overconfidence in their skills and age-related differences [12, 16], highlighting a growing need to examine the specific outcomes associated with early cycling initiation beyond broad assumptions about its benefits.

2.2 Cycling in the Balkans: Infrastructure and cultural context

The use of cycling as a means of transport in the Balkan countries faces challenges, mainly related to the lack of adequate infrastructure, insufficient signage and the need for greater investment in sustainable mobility plans. A common feature in the region is the scarce presence of bike lanes, lack of safe parking and poor connectivity between existing routes [17-21]. Specifically, each country in this geographical area faces particular challenges that hinder the development of cycling. For instance, in Greece, cities are congested with cars, and the lack of off-street parking intensifies road problems [18]. In Romania, the absence of official statistics on cycling hampers planning and the formulation of effective policies [17]. Similarly, but specifically regarding cycling environments, in Bosnia and Herzegovina, infrastructure development has been slow, largely due to economic and social instability in the region [20].

In most of these countries, cycling development is considerably lower compared to other regions of Europe, limiting its adoption for both commuting and cycle tourism. However, it is not the same in all countries. In

Croatia, cycling accounts for 5% of the modal distribution of trips and it was pointed out that cyclists in Croatia cover an average of 3.5 kilometres per trip [21]. However, expanding the network of public bikes and investing in cycling infrastructure shows the possibility of increasing the share of cyclists in the modal distribution [22]. Meanwhile, in Romania, it is observed that the number of bicycles per 100 households has grown from 27.5 to 45.1 from 2010 to 2019, and 13.5% use them to commute to work [17].

Work is underway to promote urban cycling in these regions with specific initiatives and public policies that contribute to the increase of cycling in regular commuting. As an example, in Bosnia and Herzegovina, specifically in the city of Bania Luka, up to 10 km of bike lanes were built in 2018, in addition to implementing a bike sharing system around the city called “shares” that had results of more than 1,000 users and more than 11,000 registered rentals in the first eight months of implementation [20]. On the other hand, these regions have great conditions for cycling, as is the case with the Danube Route in Serbia, which attracts numerous tourists, promotes sustainable mobility and can be considered the backbone of future cycling policies [19].

A phenomenon shared in several of these countries is the perception of cycling mainly as a recreational tool rather than as a means of everyday transport. Along these lines, in Romania, it is calculated that almost half of cyclists use bicycles mainly for leisure, while only a minority consider cycling a practical alternative to massive travel means. Furthermore, it is noted that only 3.9% of people in this country consider the bicycle a faster means of transport than public transport [17].

2.3 Study aim and hypotheses

Given the limited research on the relationship between early cycling initiation and long-term engagement with cycling, the present study aims to explore how the age of initiation relates to self-reported cycling behaviours, safety skills and willingness to increase cycling participation.

Considering the literature-based insights available in this regard, it was hypothesised that cyclists who began cycling earlier could tend to show better self-reported cycling behaviours (i.e. lower risky behaviour patterns), enhanced cycling safety literacy (e.g. greater rule knowledge and risk perception) and a stronger commitment to long-term cycling engagement.

3. METHODOLOGY

3.1 Study sample

The sample is composed of a total of 1,741 cyclists from Croatia, Bosnia and Herzegovina, Greece, Romania and Serbia (37.1 % female, 62.2 % male and 0.7 % non-binary participants), with ages between 16 and 80 years and a mean $M = 34.21$ ($SD = 13.79$) years. The sociodemographic data of the participants are presented in *Table 1*.

3.2 Design, procedure and instruments

Participants responded to an online survey on cycling patterns, cycling safety skills, cycling history, risk and protective behaviours and safety outcomes. The data are part of the Bike-Barometer II project, investigating emerging factors and phenomena that are putting the safety and well-being of urban cyclists at risk.

The questionnaire was electronically administered. In terms of recruitment strategies, various actions were implemented, including social media advertisements, distributing questionnaires in classrooms, using mailing lists and collaborating with national cycling federations. Participants in the study did not receive any financial incentives.

The questionnaire included the following variables and scales.

Sociodemographic characteristics that were used as descriptive and statistical control variables comprised age, gender, current occupation and educational level. However, given their low representativeness in the sample, the category “others” (<1% of participants) was exclusively used for descriptive purposes.

Risky and positive cycling behaviours were assessed through the Cycling Behaviour Questionnaire (CBQ), the validity of which has been evaluated in different cultural contexts and languages, having proven its efficacy in 19 countries on five continents [23-24]. The questionnaire is composed of 29 items. The responses follow a Likert-type scale based on frequency, recorded on a 5-point scale (0=Never/ 4=Almost always). Its factorial composition is distributed into three factors; 1) cyclist violations, a total of 8 items assessing deliberate risk behaviours (CRI = .981; $\alpha = .768$; $\omega = .770$; example item “riding against traffic -wrong way-”, 2) cyclist

errors, a total of 15 items assessing unintentional risk behaviours (CRI = .994; α = .914; ω = .913; example item “not noticing the presence of pedestrians crossing when turning”); and 3) positive behaviours, composed of 6 items assessing protective behaviours and habits, (6 items; CRI = .983; α = .785; ω = .782).

Table 1 – Sociodemographic and cycling pattern-related data of the study sample

Demographic feature	Category	Total	
		n	%
Gender	Female	646	37.1%
	Male	1083	62.2%
	Non-binary	12	0.7%
	Total	1741	100.0%
Age range	<24 years	658	37.7%
	25-44	594	34.2%
	45-65	462	26.5%
	>65 years	26	1.6%
	Total	1741	100.0%
Occupation	Studying	699	40.1%
	Working	917	52.6%
	Other	125	7.3%
	Total	1741	100.0%
Cycling weekly intensity	< 1 hour	184	10.6%
	1-2 hours	593	34.1%
	3-5 hours	465	27.7%
	6-10 hours	357	21.5%
	> 10 hours	142	8.1%
	Total	1741	100.0%
Main reason(s) for cycling ¹	Daily commuting/work	808	46.6%
	Sport/fitness	1004	57.7%
	Leisure	1494	85.8%

Notes: ¹ Each participant could report more than one value. Therefore, the results correspond to relative frequencies, which do not sum to 100%.

Additionally, other specific cycling behaviours not contemplated in the 29-item version of the CBQ were evaluated: use of helmet, phone use and listening to music/using headphones while cycling, using a frequency ranging [0-4], where 0 is “strongly disagree” and 4 is “strongly agree”.

Cycling safety literacy indicators were measured using the Cyclist Risk Perception and Regulation Scale (RPRS). This is a self-report tool designed to evaluate cyclists’ awareness of risks and understanding of traffic regulations. This scale comprises 12 items divided into two subscales: (1) risk perception and (2) knowledge of traffic rules, and is commonly used as a concurrent validity factor for risky behavioural tools [16, 25]. The risk perception component assesses cyclists’ ability to identify safety concerns, such as recognising road hazards or obstacles. In contrast, the knowledge subscale evaluates their familiarity with fundamental traffic regulations, including basic road protocols. Participants respond to each item using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The RPRS has been validated in prior research, demonstrating robust reliability and efficacy in investigating factors influencing cyclists’ safety awareness.

Finally, some key cyclists’ trip and welfare-related characteristics were considered, namely: physical and psychological health self-assessment, riders’ willingness to increase cycling in the future and self-assessment of cycling performance (continuous 0–10 single-item scales), cycling weekly intensity (understood as the number of hours of cycling rode in an average week), frequency of trips (from daily to occasionally), reasons for using this means of transport (e.g. leisure, commuting, short trips, long trips) and the number of road incidents suffered while riding in the last five years, regardless of their severity.

3.3 Data analysis

After careful curation and scoring of the data, basic descriptive analyses (frequencies) were conducted to characterise the study variables, also calculating Cronbach's alphas, McDonald's omegas and composite reliability indexes (CRI) to assess their internal consistency and reliability. To compare groups based on the age of cycling initiation, robust comparative tests (controlling for cyclists' age), Pearson's contingency coefficients and chi-squared statistics were used. This approach was chosen to account for typical features of questionnaire data, such as ordinal factors and variance inequality between groups, as highlighted in previous cross-national comparison studies [26]. Specifically, comparisons were made for indicators of cycling behaviour, risk perception and knowledge of traffic regulations. In a subsequent analysis phase, a decision tree analysis was used to explore the relationship between willingness to increase cycling with age of cycling initiation and the other study variables. All statistical tests were carried out using ©IBM SPSS (Statistical Package for Social Sciences) version 28.0 (Armonk, NY, USA).

4. RESULTS

4.1 Descriptive results: Cycling onset age and demographic trends

The majority of cyclists in the study sample self-reported having learned to ride a bicycle before the age of 12. Specifically, 46.4% (n = 808) started at a "very early stage" (before the age of 5), while 47.8% (n = 833) reported learning to ride between the ages of 6 and 11. Only 5.7% (n = 100) learned to cycle during adolescence or later (see *Figure 1*). These figures suggest that cycling initiation in Balkan countries predominantly occurs in early childhood.

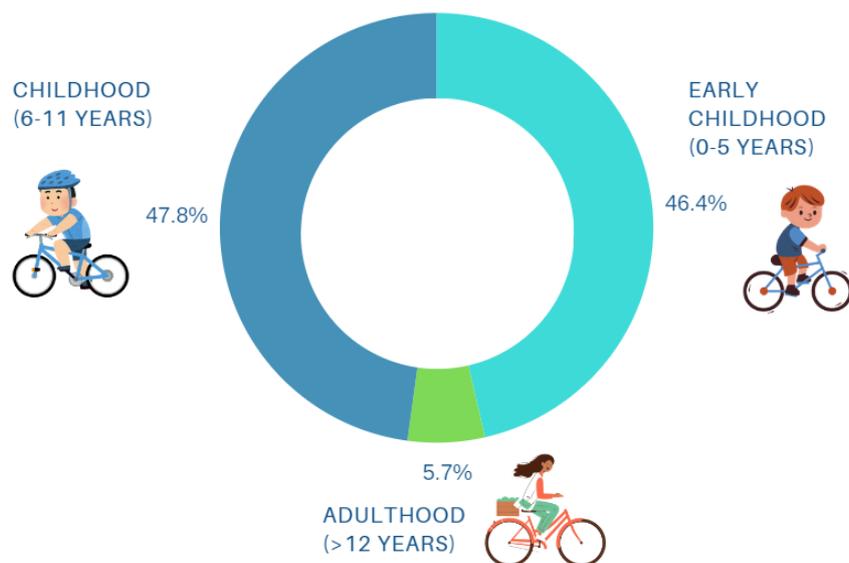


Figure 1 – Cycling enrolment life stages in the Balkan study sample

Moreover, when considering cyclists' self-reported gender as a potentially differentiating factor in cycling onset, and analysing it through robust mean difference tests, no significant differences were found in the enrolment ages of male and female cyclists from the Balkan countries included in the study ($t(2, 29.158) = 1.205$; $p = .315$). Similarly, the categorical labels revealed no contingency between the two variables, with a contingency coefficient (Pearson's C) of $C = .068$ and a chi-square of $\chi^2(6) = 7.965$; $p = .241$.

Even so, some slight, non-significant and mostly descriptive differences can be observed in the intra-gender frequencies presented in *Table 2*. For instance, a higher proportion of very early-onset cycling was reported among male participants, whereas female respondents tended to cluster more frequently in childhood (6-11 years). While these differences are not statistically meaningful, they may still reflect socially influenced patterns in cycling uptake.

Table 2 – Specific gender-based cycling enrolment life stages of cyclists in the Balkans (males vs. females)

Gender label	Category	Early childhood (0-5 years)	Childhood (6-11 years)	Adolescence (12-18 years)	Young adulthood (19-26 years)	Adulthood (> 27 years)	Total
Females	% Gender	49%	45%	3%	1%	2%	100%
	% Total	18%	17%	1%	0%	1%	37%
Males	% Gender	45%	50%	3%	1%	1%	100%
	% Total	28%	31%	2%	0%	1%	63%
Total	% Gender	47%	48%	3%	1%	1%	100%

4.2 Self-reported cycling behavioural patterns and cycling safety literacy

In relation to self-reported cycling behaviour, some interesting significant differences were observed, but specifically in terms of non-deliberate risky cycling behaviours, i.e. riding errors. Concretely, those individuals who learned to cycle after the age of 12 years make fewer errors compared to those who started cycling at an earlier age (see Table 3). This trend is consistent across specific behaviours evaluated, with later learners showing greater use of helmets and a lower frequency of risky behaviours, such as using a telephone or listening to music with headphones while cycling. However, no significant differences were identified in traffic violations or the positive behaviours assessed through the Cycling Behaviour Questionnaire (CBQ).

Table 3 – Differences in cycling behaviour as a function of age at starting to ride a bicycle

Study variable	Test value	p	Early childhood (0-5 years)		Childhood (6-11 years)		Adulthood (>12 years)	
			M	SD	M	SD	M	SD
Riding errors	13.930	***	0.91	0.81	0.75	0.68	0.61	0.66
Traffic violations	2.227	0.11	0.68	0.73	0.62	0.62	0.61	0.65
Positive behaviours	0.335	0.71	2.97	0.86	3.01	0.83	3.02	1.05
Headphones use	12.217	***	1.67	1.51	1.42	1.51	1.03	1.36
Phone use	16.860	***	1.14	1.15	0.94	1.07	0.60	0.91
Helmet use	11.019	***	1.74	1.65	1.87	1.71	2.57	1.69

Notes: p-value: *significant at the level $p < .050$; **significant at the level $p < .010$; ***significant at the level $p < .001$.

Both risk perception and knowledge of cycling regulations were shown to be significantly higher among current cyclists who learned to ride in early childhood, compared to those who did so at a later age. In other words, early enrollers tended to self-report a significantly greater cycling safety literacy (see Table 4, Figure 2). In contrast and very interestingly, the group of late enrollers (i.e. having done so during their adulthood) has shown a higher score on willingness to increase cycling. The intensity and frequency of cycling did not show significant differences as a function of this variable.

Table 4 – Differences in bicycle use characteristics and safety literacy

Study variable	Test value	p	Early childhood (0-5 years)		Childhood (6-11 years)		Adulthood (>12 years)	
			M	SD	M	SD	M	SD
Rule knowledge	4.004	**	3.30	0.65	3.29	0.65	3.02	0.95
Risk perception	1.047	*	3.46	0.55	3.47	0.48	3.34	0.89
Hours a week	0.770	0.46	4.62	5.14	4.65	5.05	5.53	7.08
Most common cycling trip length	0.082	0.92	47.72	41.00	48.47	42.35	49.11	45.82
Willingness to increase cycling	3.505	*	3.58	0.77	3.67	0.79	3.69	0.79

Notes: p-value: *significant at the level $p < .050$; **significant at the level $p < .010$; ***significant at the level $p < .001$.

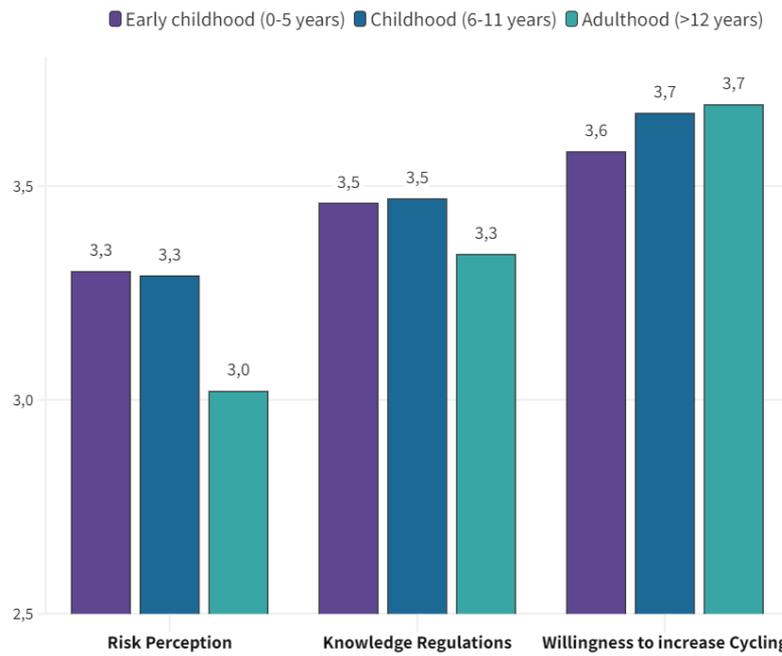


Figure 2 – Differences in self-reported risk perception, normative knowledge and willingness to increase cycling based on age at cycling onset

4.3 Health and well-being differences

Overall, the analysis presented in Table 5 suggests that there are no differences in the physical and psychological health self-reported by cyclists, nor in their subjective well-being. However, individuals who began cycling at a younger age report better cycling performance. Notably, as shown above in Table 3, this group of *early enrollers* also exhibits higher self-reported engagement in risky behaviours compared to those who learned to cycle at an age older than 12 years. This latter category includes teenagers and the residual percentage (<1%) of cyclists whose onset occurred even later.

Table 5 – Differences in self-reported health and performance indicators

Study variable	Test value	p	Early childhood (0-5 years)		Childhood (6-11 years)		Adulthood (>12 years)	
			M	SD	M	SD	M	SD
Self-rated physical health	2.564	0.08	7.73	1.78	7.58	1.80	7.35	1.93
Self-rated mental health	0.795	0.45	7.79	2.05	7.73	2.04	7.49	2.37
Subjective well-being	1.614	0.20	7.61	1.96	7.56	1.88	7.19	2.25
Self-rated cycling performance	23.206	***	8.13	1.64	7.71	1.65	6.88	2.25

Notes: p-value: *significant at the level $p < .050$; **significant at the level $p < .010$; ***significant at the level $p < .001$.

Figure 3 represents a decision tree that analyses the willingness to increase cycling as a function of the study variables. The initial node (Node 0) shows the general distribution in which 54.3% of the respondents have a low willingness to increase cycling, while 45.7% have a higher willingness to continue cycling in the future.

The first division criterion used by the tree is the age of learning to ride a bicycle. This factor divides the sample into two groups. On the one hand, those who started cycling during late childhood (6-11 years) or adulthood (>12 years), representing Node 1 of Figure 3, and on the other hand, those who did so during early childhood (0-5 years), representing Node 2.

Regarding Node 1, an equal distribution is identified, with 49.5% of cyclists showing a high disposition and 50.5% with a low disposition. In contrast, Node 2 presents a higher proportion of cyclists with low willingness to increase their use (58.8%). In both cases, risk perception is an important factor, being the variable applied for the following division. Ultimately, the resulting nodes are subdivided by the variables addressing unintentional risky behaviour, intentional risky behaviours and knowledge of cycling regulations.

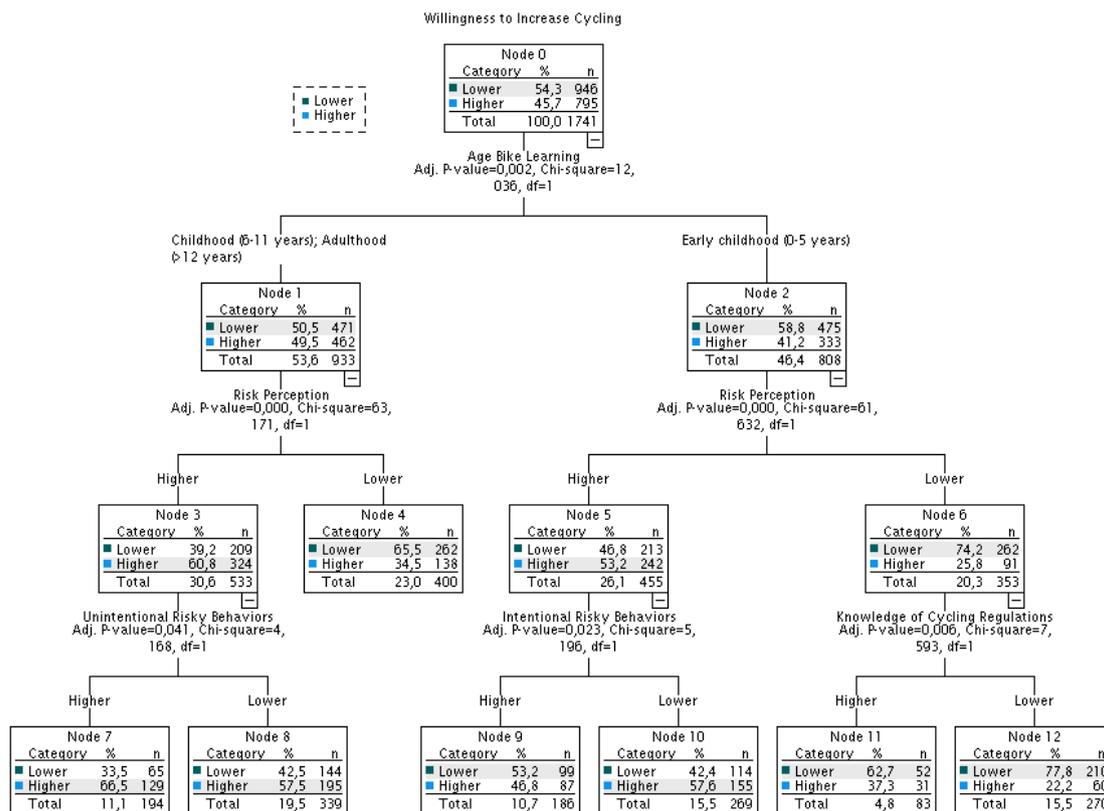


Figure 3 – Decision tree for self-reported willingness to increase cycling in the next few years, split by onset ages

5. DISCUSSION

The core aim of the current study was to explore the relationships between the age of initiation of cycling of current bicycle riders and their self-reported cycling behaviours, safety skills, and their willingness to increase cycling in urban cycling in five Balkan countries. Overall, the findings appear to support the notion that an earlier onset of cycling may positively influence these outcomes, particularly in relation to behavioural and safety-related indicators. However, certain particularities and peculiarities warrant discussion in the context of existing literature to thoroughly assess the study hypothesis and interpret the results.

5.1 Does starting cycling at an early age lead to better health and developmental outcomes?

The core theory-based hypothesis of this study posited that cyclists with an earlier onset of cycling might exhibit better self-reported cycling behaviours (i.e. a decreased frequency of risky cycling behaviour) [24], enhanced cycling safety literacy (e.g. risk perception and rule knowledge) [27] and a stronger intention to maintain their engagement with cycling throughout life. Overall, our results seem to support this hypothesis, as they indicate that cyclists who began cycling at an early age reported higher self-rated cycling performance, better risk perception and greater knowledge of traffic regulations.

At a practical level, these outcomes suggest that starting to cycle earlier may facilitate the development of core cycling competencies, as highlighted in prior research on childhood mobility skill acquisition [15, 28]. However, there appears to be a “flip side” to this. While better general behavioural indicators were observed, certain particularities related to technological and passive safety device usage patterns emerged, even after controlling for age in these analyses. Specifically, this group (early enrollers) also demonstrated higher engagement in certain risky behaviours, such as using connected devices while cycling, which contrasts with findings linking early exposure to protective habits [9]. Interestingly, while cyclists with a later onset were less prone to risky behaviours such as phone use or riding without a helmet, they reported lower overall cycling performance and safety skill levels.

From a theoretical standpoint, and although the literature in this area remains substantially limited, these findings align with the existing evidence, collectively suggesting that early exposure to cycling provides a foundation for skill development that is less readily acquired later in life [10, 28, 29]. However, the greater caution observed in later-onset cyclists highlights the influence of maturity and external safety awareness factors, as highlighted in prior analyses of adult cycling conducted in other regions of the world, given the absence of empirical studies addressing this in Balkan countries [30-32].

5.2 Does this affect future cycling willingness?

The results regarding cyclists' willingness to increase urban cycling reveal another important dimension. Although willingness was generally high across groups, cyclists with an earlier onset were less likely to report an intention to increase their cycling activity, a trend observed in studies conducted across different regions and age groups [33]. As a possible interpretation, this pattern may reflect a saturation effect, as these cyclists' established cycling habits leave limited room for expansion compared to those who began cycling later and are still exploring its benefits.

The regional context of the Balkan countries provides further insights into these findings. Studies highlight several barriers to cycling in this region, including limited cycling lanes, inadequate infrastructure and cultural perceptions that frame cycling primarily as a recreational activity rather than a primary transport mode. These conditions likely shape cycling behaviours and attitudes, particularly among those who take up cycling later in life, as they may face greater challenges integrating it as a regular mode of transport [17, 18]. Additionally, research conducted in Southeastern Europe has emphasised how infrastructural deficiencies and low safety awareness contribute to increased cycling-related risks, particularly in urban areas where road use is shared, and enforcement of traffic laws remains inconsistent [31].

Nevertheless, the results of this study, summarised through the decision tree presented in *Figure 3*, align with the limited existing empirical literature. These findings emphasise the necessity of complementing infrastructural improvements with initiatives that enhance inclusive transport settings [34], active mobility dynamics [35], cycling safety skills, such as risk perception and knowledge of traffic norms and local cycling potentialities. This perspective is supported by prior research in other European contexts, such as studies by Volgemute et al. [15], Felix et al. [31] and Corr et al. [35]. On a practical level, these elements could contribute to variations in cycling willingness and underscore the need for infrastructural and cultural transformations to promote cycling as a sustainable urban mobility choice [33, 37].

6. CONCLUSIONS

This study provides evidence that the age of cycling matters for riders' subsequent cycling patterns, outcomes and expectations. In other words, the age at which individuals start cycling seems to differentiate their behaviours, safety skills and overall current engagement with cycling.

Overall, cyclists who began riding at an earlier age reported better safety skills and performance, supporting the idea that early exposure fosters skill development.

Yet, early initiation does not guarantee uniformly safe behaviour. Those who started early also showed higher engagement in certain risky practices, suggesting that other factors, such as cycling habits and environmental context, may also play a role.

In contrast, cyclists who began later were less likely to engage in risky behaviours but reported lower confidence in their abilities. This divergence suggests different pathways in cycling development, particularly in regions with limited infrastructure and distinct cultural challenges, such as the Balkans.

This study advances our understanding of how early cycling experiences shape long-term engagement and highlights areas for future research. On a practical level, the findings call for integrated strategies that combine early cycling promotion with targeted safety education and infrastructural improvements – measures that could foster the cycling maturation of the region.

Regarding future research, subsequent studies could benefit from exploring these dynamics across diverse contexts and using complementary methods, contributing to a deeper understanding of how early life experiences influence long-term cycling engagement. These insights may help inform decision-making and strengthen cycling promotion initiatives.

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