An Implementation of A Cycling Safety Education Program Among School Children Without Previous Formal Cycling Training: A Case Study in Serbia

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Abstract

Background: The promotion of cycling as a healthy and socio-economically acceptable way of moving has led to a significant increase in these road users. Moreover, the indisputable fact is that children cyclists belong to the group of the vulnerable road users. All this clearly indicates that cycling education programs for children are the only correct approach. The primary goal of the presented research are inception and implementation of a cycling safety education program for school-age children without formal cycling knowledge and skills.

Methods: Students from the 4th grade (9 and 10 years old) from nine randomly schools on the territory of the Republic of Serbia participated in a survey. In order to measure and evaluate the knowledge and skills, the students were put through testing before and after the cycling safety education program. Data were analysed using repeated multivariate analysis of variance test.

Results: Comparing the intervention group and the control group before and after the training program implementation, children's total cycling knowledge increased in the intervention group. The cycling education program improved children's knowledge of road signs, age requirements, and risky behaviours. The results show that the cycling education program achieved significant improvements in all tested children's cycling skills. However, it was noticed that there was no significant intervention effect between control and intervention group in terms of the bicycle checking before riding.

Conclusions: The current research, as a pilot study, provides evidence that cycling education programs might be effective in improving cycling-related knowledge and cycling skills among children. Future efforts should be directed towards promotion and implementation of cycling safety education programs in elementary schools where there is no formal cycling training for children on traffic safety, as well as towards monitoring of long-term effects of cycling training.

Background

In recent years, there has been an obvious tendency to promote cycling as a way to improve health, socio-economic and traffic conditions within a community. There are multiple advantages of cycling, such as improvement of physical development [1] and mental health in children [2-4]. Furthermore, there are significant advantages in environment protection as well (cleaner air, less noise, fewer traffic jams), it is cheaper than all other means of transportation, and all that means higher quality of life for everyone [5,6]. Cycling also affects development of emotional health and healthy habits, improvement of recreational and sports activities, as well as socializing with family and friends [7].

In addition to all the positive sides of cycling, one of the negative aspects refers to the safety of traffic participants, especially children, who have limited psychological and physical abilities [8-10]. The statistics of child casualties in European Union countries have shown that, in the last ten years, 8100 children were killed in traffic accidents (up to 15 years of age), out of which 13% were child cyclists [9]. On the territory of the Republic of Serbia, in the past ten years (2009-2018), there were a total of 12 child

cyclist fatalities, up to 14 years of age, which is about 8% of total child fatalities [11]. That brings to the foreground the need to improve the readiness of children, as cyclists, to master the tasks and problems that arise in the complex traffic environment. All over the world there are cycling education programs that goal is general improvement of children safety in traffic, with special focus on elementary school children [12]. Research has revealed that cycling education programs for children between 8 to 10 years of age played an important role in promotion of cycling among children, adopting positive habits, social norms and favourable attitude towards traffic safety [13].

Previous studies were dealing with effects of children's cycling education programs and their influence on the change of knowledge, skills, attitudes, safety awareness and increasing cycling frequency and confidence, as well as decrease of share in the crashes or injures rate [13-19]. Cycling education programs in many countries in the world are implemented within curricular activities, as "The New Jersey Bike School program" from the USA [17], "Bike It" from the UK [20], "Miami BikeSafe" from the USA [16], "Safe Cycle" from Australia [14], "South Dunedin Cycling Project" from New Zealand [21].

Through analysis of the developed and applied cycling education programs and trainings, numerous differences in curriculum content, training duration, monitoring of knowledge after the training have been noticed [12], as well as in the population of children they target, in terms of age [13, 18, 22], gender, sociodemographic status, content of training (improvement of knowledge, skills, behaviour) [23], living areas and space where the training was conducted (traffic free environment or summer camp that included an on road component) [17, 21]. Besides, there are obvious differences in the evaluation of training results (improvement was noticed or there was no change) [18,19]. Evaluation of most cycling safety education programs was related to their effects on skills and knowledge, and improvement was noticed in most cases [24]. Programs of knowledge improvement for children usually include knowledge with respect to understanding of cycling-related laws, traffic light signals, road signs, road rules, helmet use and fit, parts of the bike, visibility, while practical cycling skills programs refer to, for example, to following actions: straight-line riding, braking, shoulder check, bicycle safety checks etc.

Even though there are numerous studies of children cycling training, it is not well known which cycling training program for children is the best, for which population, under which conditions it is implemented [25]. Based on positive results and experience from previous researches, that refer to already existing cycling education programs that have been implemented in many school settings, it is obvious that in the countries that have not had training programs yet, there is a necessity for selection, development and integration of the best practices, programs and approaches in the school system through the curriculum. It is widely known that children do not normally approach adult performance levels until around 11–12 years of age [26]. Because of this, it is very important to develop and implement training programs for younger school children who do not have the knowledge and experience to deal with numerous tasks they encounter in traffic on a daily basis [12]. If we look at the existing cycling programs in different part of the world, they are mostly directed towards older school children, from grades 4 to 8 (10 to 14 years) and adolescents [18, 21, 23, 27].

An initiation of a research and proposition of an education program and training for child cyclists is a special challenge in countries or regions where there is no organized approach to this very important issue. Serbia is one of four European countries where children learn about elementary traffic safety topics in primary school only [28]. According to the school curriculum, there are no individual subjects dedicated to traffic education; instead, there are only some topics (how to safely get to school, what are dangers in traffic, how to behave and what to do in these situations) within some subjects that the children learn. Consequences of such approach are children who have low level of traffic knowledge and skills to safely participate in a complex traffic environment. In addition, there are no benchmark studies and research on the territory of Serbia that deal with improvement of knowledge and skills of child cyclists. The foregoing facts clearly indicate the need for a pilot project implementation within primary schools and its promotion. It is especially important to point out and develop an approach for education of children in grades 1-4 of elementary schools in Serbia, who have not received formal education on cycling programs.

The main goal of the presented research is proposition of the concept of cycling safety education program and its implementation in the primary school curriculum where there is no such program, as well as evaluation of its effects on children's cycling knowledge and skills.

Methods

Sampling

A random sample of seventeen elementary schools in Serbia was selected to participate in the study. The school principals were sent a recruitment letter and afterwards contacted by phone. Nine schools agreed to participate of which five were allocated to the intervention group. In the process of evaluation of knowledge and skills of child cyclists the total number of students who participated in the research is 210 (115 students were from an intervention group, while 95 students were from a control group). Among lower elementary school grades, only students from the 4th grade were selected (between 9 to 10 years of age), since it is assumed that children of that age possess a skills and cognitive abilities to ride [29].

The presiding ethical committee sent Information Statement and Consent Form to all the parents of the children who were chosen to participate in the research. All the children who returned consent forms signed by parents as a confirmation that they are allowed to participate in the training, as well as in the knowledge and skills testing, were participants of the research.

The assumptions for analysis was that each student went through pre-training and post-training test of bicycle knowledge, as well as pre-training and post-training skills survey, and that the students from control group wasn't exposed to cycling training. A certain number of students from these schools did not meet the required assumptions for the following reasons: they did not attend the training or did not participate in the post-training test, also in the control group a certain number of students completed a test of bicycle knowledge, but did not participate to the training skills survey. The number of students who fulfilled the assigned requirements is 179 (96 students were from an intervention group, while 83 students were from a control group). Out of the total number of children in the intervention group, 40 (41.7%)

students were male, and 56 (58.3%) female. In the control group, the sample consisted of 42 male students (50.6%), and 41 female students (49.4). After the training, the knowledge and skills testing was applied to the same students within the control group ($n=83$ students) and intervention group ($n=96$ students).

Measurements

Evaluation of students' knowledge pre-training and post-training was done through a test at the first session and the final session. The adapted knowledge test [23] consisted of a series of 17 multiple choice questions with three or four options, in the form of a text, picture (situation), where they were supposed to circle the correct ones (Additional file 1). The duration of the test was 30 minutes. The test items referred to 7 learning models: age requirements (1 question), risky behaviour (1 question), bicycle parts and equipment (2 questions), cycling clothing gear (3 questions), road signs (3 questions), hand signals (3 questions) and understanding the road environment (4 questions).

Education process and skills testing for child cyclists were done at training ground which was designed for this research according to previous research [30, 31] (Fig 1). For the training and testing needs, the children were provided with youth sized bicycles and bicycle helmets. The students that had their own bicycle or helmet had to go through a testing and verification process, in order to ensure their safety and proper fit. Fifteen different aspects of child cyclists' behaviour were monitored in the process of practical evaluation of cycling skills on the school testing grounds before and after the implementation of the program, as it shown in Fig 1. So, for example, adjusting and checking the bicycle, as well as fitting and checking the helmet, left-turn signal, left turn, sudden braking skills, etc. were monitored and evaluated. Trained observers evaluated them on a five-degree scale, where 1 was the lowest mark, and 5 the highest (Additional file 2).

Procedures

The training program lasted for three months. Theoretical training was done by trained teachers with their students in school classrooms, while the practice was done on specially prepared training grounds within school yards. Taking into consideration the research goals and tasks for evaluation of knowledge and behaviour of children concerning traffic safety, in the schools that were the subject of the research, quasi-experimental research was applied (Fig 2). The reasons for application of this concept are: (1) partitions the students into control and intervention groups were done utilizing random selection method, (2) measurements were done in two time sessions (before and after the implementation of the program).

Knowledge of child cyclists

Theoretical activities were implemented in school classrooms once a week, for 45 minutes and consisted of 4 sections. Algorithm of cycling safety education program with the content of the units is given in Fig 3. The teachers discussed the given unit topic with the children, after which they performed didactic activities in the classroom. The teachers were provided with educational materials, presentations and

outlines that they used in the training process. An example of a theoretical activity done by the teachers while improving cyclists' knowledge is shown in Table S1 for the unit that deals with the importance of helmet use for cyclists (Additional file 3).

Child cyclists' skills

The cycling skills program was also implemented by trained teachers on training grounds within schools. Sessions were done in one school period per week (45 minutes). The contents of the training program were based on practical exercises that children conducted on the training grounds, with the teacher's help. In order for the children to learn the planned skills more easily, the session topics also contained game elements, so the training process was more interesting and attractive for the children. The content of the cycling skills programs was based on similar exercises and material that was shown in earlier research [14]. Within the unit that deals with bicycle control and steering, a list of practical cycling skills that the teachers practiced with the children was given (Fig 3). An example of a practical activity that the teachers did during child cyclists' skills improvement is shown in Table S1, for the unit that deals with manoeuvring skills (Additional file 3).

Results

Data analysis was performed using IBM's SPSS Statistical Package (Version 22). Descriptive statistics were used to examine the basic features of the sample. Furthermore, data were analysed using repeated multivariate analysis of variance test.

Analysis of child cyclists' knowledge

Table 1 displays results of the two-way repeated multivariate analysis of variance (MANOVA) test. The test was carried out in order to examine the intervention effect on children's knowledge on cycling safety. The findings indicated that there was a statistically significant difference between the intervention and control group on children's cycling knowledge for the period of time $F(8, 170) = 2.99, p < 0.01, \eta^2=0.12$. Univariate test was performed on each dependent variable, and revealed that intervention had a statistically significant multivariate effect on children's knowledge concerning age requirements for riding a bicycle on public roads $F(1, 177) = 7.37, p < 0.01, \eta^2=0.04$, identification of risky cycling behaviour $F(1, 177) = 4.50, p < 0.05, \eta^2=0.03$, road signs $F(1, 177) = 8.15, p < 0.01, \eta^2=0.04$, and total knowledge score $F(1, 177) = 5.89, p < 0.05, \eta^2=0.03$. In regards to knowledge of bicycle parts and equipment $F(1, 177) = 0.03, p > 0.05, \eta^2=0.00$, cycling clothing gear $F(1, 177) = 0.03, p > 0.05, \eta^2=0.00$, using proper hand signals $F(1, 177) = 0.57, p > 0.05, \eta^2=0.00$, and understanding of the road environment $F(1, 177) = 0.89, p > 0.05, \eta^2=0.00$ statistically significant impacts for the time by condition interaction were not found.

Table 1 Effects of the intervention on children's cycling related knowledge

Cycling knowledge	Group	Pre-intervention	Post intervention	F – value
		Mean (SD)	Mean (SD)	
Age requirements	Control	79.5 (40.6)	77.1 (42.3)	7.37**
	Intervention	76.0 (42.9)	89.6 (30.7)	
Risky behaviors	Control	100.0 (0.0)	96.4 (18.8)	4.50*
	Intervention	89.6 (30.7)	94.8 (22.3)	
Bicycle parts and equipment	Control	53.6 (34.7)	54.2 (42.2)	0.03
	Intervention	61.5 (36.6)	63.0 (35.7)	
Cycling clothing gear	Control	72.7 (27.7)	72.7 (31.7)	0.03
	Intervention	80.2 (24.5)	80.9 (26.4)	
Road signs	Control	68.0 (22.1)	67.7 (24.0)	8.15**
	Intervention	64.6 (23.5)	73.1 (23.5)	
Hand signals	Control	83.1 (37.7)	85.5 (35.4)	0.57
	Intervention	82.3 (38.4)	80.2 (40.1)	
Understanding the road environment	Control	56.9 (31.6)	54.8 (34.1)	0.89
	Intervention	59.1 (29.7)	61.7 (29.7)	
Total	Control	68.1 (19.1)	67.3 (20.2)	5.89*
	Intervention	68.9 (17.8)	73.4 (17.4)	

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Child cyclists' cycling skills analysis

The MANOVA was performed with the purpose of testing the effect of intervention on children's cycling skills (see Table 2). A statistically significant multivariate effect was obtained $F(15, 163) = 11.01$, $p < 0.001$, $\eta^2=50.30$, which demonstrates a significant difference between pre-intervention and post-intervention period. The univariate tests indicated significant effect for fitting $F(1, 177) = 10.35$, $p < 0.01$, $\eta^2=0.06$ and checking a helmet $F(1, 177) = 24.35$, $p < 0.001$, $\eta^2=0.12$, adjusting a bicycle $F(1, 177) = 5.00$, $p < 0.05$, $\eta^2=0.03$, starting the movement $F(1, 177) = 7.16$, $p < 0.01$, $\eta^2=0.04$, cycling in a straight line $F(1, 177) = 6.77$, $p < 0.05$, $\eta^2=0.04$, obeying the "stop" sign $F(1, 177) = 18.96$, $p < 0.001$, $\eta^2=0.10$, riding through intersections $F(1, 177) = 34.02$, $p < 0.001$, $\eta^2=0.16$, manoeuvring to avoid obstacles $F(1, 177) = 52.03$, $p < 0.001$, $\eta^2=0.23$, giving the signal for turning $F(1, 177) = 39.76$, $p < 0.001$, $\eta^2=0.18$, turning left $F(1, 177) = 98.15$, $p < 0.001$, $\eta^2=0.36$, giving way to pedestrians $F(1, 177) = 15.57$, $p < 0.001$, $\eta^2=0.08$, sudden braking

and with control $F(1, 177) = 12.62, p < 0.001, \eta^2 = 0.07$, manoeuvring around cones $F(1, 177) = 7.77, p < 0.01, \eta^2 = 0.04$, using a pedestrian crossing $F(1, 177) = 17.59, p < 0.001, \eta^2 = 0.09$, and total cycling skills score $F(1, 177) = 127.20, p < 0.001, \eta^2 = 0.42$. However, a non-significant interaction effect between control and intervention group was found in terms of checking the bicycle before riding $F(1, 177) = 2.21, p > 0.05, \eta^2 = 0.01$.

Table 2 Effects of the intervention on children’s cycling skills

Cycling skills	Group	Pre-intervention	Post intervention	F – value
		Mean (SD)	Mean (SD)	
Fitting the helmet	Control	1,01 (0.11)	1,04 (0.19)	10.35**
	Intervention	1,04 (0.20)	1,46 (1.11)	
Checking the helmet	Control	1,01 (0.11)	1,07 (0.30)	24.35***
	Intervention	1,04 (0.20)	1,71 (1.03)	
Adjusting the bicycle	Control	1,02 (0.22)	1,06 (0.24)	5,00*
	Intervention	1,03 (0.17)	1,24 (0.59)	
Checking the bicycle	Control	1,05 (0.44)	1,04 (0.19)	2.21
	Intervention	1,04 (0.41)	1,19 (0.74)	
Starting the movement	Control	4,17 (1.46)	4,07 (1.31)	7.16**
	Intervention	3,83 (1.63)	4,34 (1.37)	
Cycling in a straight line	Control	4,52 (1.15)	4,53 (1.05)	6,77*
	Intervention	4,20 (1.44)	4,63 (1.13)	
Obeying the 'stop' sign	Control	3,39 (1.87)	3,42 (1.65)	18,96***
	Intervention	3,29 (1.89)	4,45 (1.38)	
Riding through intersections	Control	2,10 (1.36)	2,21 (1.30)	34,02***
	Intervention	2,27 (1.50)	3,74 (1.42)	
Maneuvering to avoid obstacles	Control	1,60 (0.62)	1,68 (0.61)	52,03***
	Intervention	1,46 (0.58)	2,70 (1.21)	
Giving the signal for turning	Control	1,28 (1.00)	1,24 (0.62)	39,76***
	Intervention	1,01 (0.10)	2,43 (1.88)	
Turning left	Control	1,67 (1.21)	1,70 (1.06)	98,15***
	Intervention	1,45 (1.02)	3,52 (1.30)	
Giving way to pedestrians	Control	3,92 (1.54)	3,88 (1.43)	15,57***
	Intervention	3,89 (1.69)	4,60 (1.08)	
Sudden braking and with control	Control	3,78 (1.65)	3,73 (1.46)	12,62***
	Intervention	3,83 (1.63)	4,50 (1.19)	
Maneuvering around cones	Control	3,64 (1.48)	3,72 (1.46)	7,77**

	Intervention	3,48 (1.51)	4,09 (1.47)	
Using a pedestrian crossing	Control	1,48 (0.92)	1,51 (0.68)	17,59***
	Intervention	1,83 (1.04)	2,64 (1.21)	
Total	Control	2,38 (0.57)	2,44 (0.45)	127,20***
	Intervention	2,31 (0.58)	3,15 (0.71)	

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Discussion

The purpose of this study are inception, implementation and evaluation the effects of the education program for school children cyclists in the sense of knowledge and improvement of practical skills for safe participation in traffic environment. A major strength of the present study is a carefully designed training program based on previous research and experience in this area and its application in school conditions while working with children who do not possess any aspect of formal cycling training.

The results of the presented study show that the cycling education program had an influence on the results in the sense of improving the knowledge of school children cyclists and that the acquired knowledge is the result of the implemented curriculum. This was in accordance with the previous studies which concluded that cycling education programs included in school settings resulted in improvement of knowledge on child safety [16, 17, 24]. That was confirmed by individual student answers to some questions and differences in pre- and post-training test scores. One of the most important indicators of improvement in test scores was noticed in questions that refer to who can ride a bicycle on public roads, as well as the questions about the importance of road signs and questions about risky behaviour in traffic. The students showed the lowest level of knowledge and improvement after the training through answers to questions that refer to the equipment and bicycle parts, as well as the understanding of the road environment. Knowledge improvement on understanding the road environment can be attributed to the lack of teachers' knowledge on the topic and their style of interpretation during the training. In regards to the obtained results, the future programs should pay special attention to the improvement of the curriculum and units that refer to this topic. The results also show that the children have good theoretical knowledge on certain safety topics, such as cycling clothing gear and hand signals, where most students showed admirable existing knowledge, so no significant knowledge improvement was noticed after the training. Similar results were confirmed in previous research, for example about good existing knowledge on the importance of helmet use [17]. There are several explanations for such results: the questions were clear and understandable for the students, it is possible that they heard about certain segments from their parents or someone from their environment, or they learned about some aspects previously at school.

A very positive finding of the present study is that the applied training program made significant improvements in children's basic cycling skills. This was in accordance with the previous studies that showed that training programs made significant improvements in primary school children's cycling skills

[12, 18, 19, 32]. The results of the presented study show that improvement is obvious in as many as fourteen out of the fifteen observed different cycling skills. That is justified by the fact that the children encountered the traffic safety skills training process for the first time and that, until then, they had not received any type of formal practical knowledge. A significant improvement was found in left turn, manoeuvring to avoid obstacles, giving the turn signal and riding through an intersection. Similar results were confirmed in previous research, where the biggest improvement was noticed in signalling [12]. Signalling by child cyclists is especially important, because in that way they send a message to other traffic participants on the change in their direction of movement. Such good results can be explained by the fact that these skills were well taught and practiced during practical sessions on school training grounds. Improvements were also found in checking the helmet. Out of all observed skills, there was no improvement only in checking a bicycle, while slight improvement was noticed in cycling in a straight line and starting the movement, which was also confirmed by the results of the research [12] that did not notice improvement before and after training for the named skills. Such result was expected, because the children probably learned these actions as primary skills as soon as they learned to ride a bicycle or while riding a bicycle with their parents.

The cycling training program in teachers' work with children showed that there are some results in improving children's knowledge and skills shortly after the training. This type of approach is especially important for countries, where there is no systematic and organized approach to solve the problem of child cyclists' education in grades one to four of elementary school.

Limitations

Besides the sound results of the study that show that the implemented training program for child cyclists was efficient in improving cycling knowledge and almost all skills, several limitations of the study should also be taken into account. As far as the sample is concerned, only nine of elementary schools (from seventeen that were chosen) were accepted participation in the research, but the number of children who participated in the research was satisfactory. This is the significant arguments that the awareness of the importance of cycling safety education program for school-age children is not at a satisfied level, so future research should be directed towards the promotion and implementation of it in many schools in the country. Also, during the testing on the training grounds, the children were trying to make conversation with the researchers who were evaluating the training course. In order to avoid that issue, it is advisable that, in future research, children might be recorded while they do the practical cycling test. Moreover, the small difference in the results of theoretical tests between the intervention and control groups may be attributed to the self-initiated activities of teachers in educating students about traffic behaviour.

Within this study, long-term effects of cycling training were not evaluated, which should be taken into consideration in future research.

Conclusions

Children, especially child cyclists, are the most vulnerable road users. Therefore, it is necessary to actively include them in programs that help raise awareness on the importance of traffic safety and acquiring skills needed to safely participate in traffic. It is especially important to point out that trainings can have an important influence when they are done with children under ten years old. The results of the training program evaluation showed that a cycling safety education program incorporated into school curriculum can result in an increase of children's knowledge relevant to cycling safety, and above all in improvement of child cyclists' skills for safe participation in traffic shortly after the training. The results undoubtedly confirm that the presented pilot study should serve as an initiative for starting, defining and implementation of an official training program for child cyclists in Serbia at the state or provincial level. Besides that, positive results of such approach and its application at the school level should also encourage the community and local government to get involved and support schools through construction of training grounds, promotion of classroom and training grounds competitions, to increase children's participation in cycling.

Abbreviations

MANOVA: multivariate analysis of variance; SPSS: Statistical Package for the Social Sciences; SD: standard deviation.

Declarations

Ethics approval and consent to participate

All procedures performed in this study were in accordance with the ethical standards and all participants completed informed written consent. We confirm that all methods were performed in accordance with the relevant guidelines and applicable regulations. Permission was obtained from Ministry of Education, Science and Technological Development of Republic of Serbia that the research can be conducted in schools. The age of the participants was between 9 to 10 years of age. Written informed consent was obtain from all the parents of the children who were chosen to participate in the research. The study was approved by review board which was formed by Public enterprise Roads of Serbia.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SB, DJ and BM are the main investigator and were involved in the study Design. SB, BM and MP were also involved in the data collection and analysis. SB, DS, DJ and BM contributed to the theory and design of the manuscript, and critically revised the final article. All authors read and approved the final manuscript.

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Figures

Figure 1

Quasi-experimental research concept

Figure 1

Quasi-experimental research concept

Figure 2

Quasi-experimental research concept

Figure 2

Quasi-experimental research concept

Figure 3

Implementation algorithm for cycling safety education program - lesson progression

Figure 3

Implementation algorithm for cycling safety education program - lesson progression

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