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Adaptation and validation of a test to measure Greek elementary students' basic cycling skills

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Abstract
The aim of this study was to adapt a previously developed test to gain a detailed insight into the cycling skills of Greek children and examine the impact that sex, age and cycling experience have on cycling skills. Students (n=80) from a local elementary school in Attica region (Greece) took the adapted cycling skills test consisting of 12 test stations. An exploratory factor analysis was conducted to investigate the factor structure of the cycling test. Descriptive statistics were performed on children's cycling skill scores. Furthermore, independent sample t-tests and Pearson r correlations were executed to evaluate individual correlates of cycling skills. Two factors were extracted: the 'during cycling skills' and the 'attention/handling cycling skills' factor. Most children faced difficulties for skills that required more advanced attention skills and while cycling over obstacles. No significant differences in separate factors, as well as the overall cycling skill, were noted between boys and girls. Significant correlations were observed between years of cycling experience and cycling skills, while age was not correlated to these factors. The 12-item test battery adapted in the present study is suitable for the evaluation of cycling skills of Greek elementary students. Implications of the current research are further discussed.

Keywords: cycling, skills, test, validity, children, sex differences, cycling experience.

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Introduction

Cycling provides opportunities for regular physical activity for many individuals (Bauman et al. 2012). In addition, cycling is an effective way to meet the health-enhancing physical activity guidelines (Titze et al. 2014) and reduce the health hazard associated with their sedentary lifestyles (Darren et al. 2006; Faulkner et al. 2009), while it is accepted that the respective health benefits outweigh the injury risks (de Hartog et al. 2010). However, the potential risks during cycling influence children's life. Particularly in primary school, findings show that children are at risk of suffering from accidents (Lammar 2005; Tin Tin et al. 2010). While parental safety concerns and distances travelled are barriers to children's actively commuting (Davison and Lawson 2006), other factors such as lack of children's cycling skills affect negatively bike use (Larsen et al. 2009; McMillan 2007). Children with inadequate cycling skills seem to have significant higher accident rates compared to other children who may cycle less frequently (Preston 1980). In addition, falling from bicycle is the most common accident among children (Lammar 2005). Also, children's cycling knowledge, abilities and skills play a significant role in order to perform well and avoid bicycle-related accidents (Corden et al. 2005).

Motor control research has suggested that children cycling skills performance is contingent on various motor and cognitive functions during cycling. According to Corden and colleagues (2005) the bicycle operating skills (e.g. steering, balancing, pedaling, braking) are related to children's physical and mental developmental abilities, which are closely associated with children's age and cycling experience (Arnberg et al. 1978; Briem et al. 2004; Hansen et al. 2005). Children aged approximately 4 face difficulties to ride a bike properly in traffic due to lack of psychomotor skills (Hansen et al., 2005). On the other hand, 8 to 10 years old children have the basic cycling skills and are able to ride due to the development of their motor and cognitive abilities (Briem et al. 2004; Lammar 2005; Tin Tin et al. 2010). A negative aspect of children's increased independent mobility is that they tend to expose themselves to more risks resulting in an increase of bicycle related accidents (Kennedy 2008).

To explore and determine children's cycling competencies, valid and accurate tests are required. A recent study in Belgium developed a test in order to gain insight into the cycling skills of 9-10-year-old children (Ducheyne et al. 2013), based on previous skills tests (e.g. Belgisch Instituut voor de verkeersveiligheid 2009; Macarthur et al. 1998) and instructions of professionals in the field of cycling education. The study protocol included 13 test stages and 3 factors (i.e. *during cycling skills*, *before/after cycling skills* and *transitional cycling* *skills*) and a total of 93 children were examined. Researchers found that children had developed some motor components such as steering, balancing, pedalling, braking, as well as cognitive elements. However, they lacked the ability to ride a bicycle with one hand and had to develop it.

Similar research approaches do not exist in north Europe, while there is lack of evidence in south Europe. In order to fill this research gap, the aim of the present study was to adapt and validate a previously developed test battery (Ducheyne et al. 2013) in order to examine the basic cycling skills of elementary school children aged 7 to 10 years old in Athens, Greece. We chose to adapt an already existing tool because it is much more efficient than developing a new one. Till now, there is no evidence concerning suitability (regional relevance) for this instrument and for testing children from different contextual background and age group. The validity of this tool for the Greek population is an important condition for its usefulness in educational and research contexts. A second reason for this adaptation is that cross-national comparative studies require adapted tests. Taking into account contextual differences observed across different European countries, without appropriate validation across various contexts, results from the cycling skills test may not be appropriate.

Further research questions were whether there were differences in cycling skill between children of different sex, as well as the extend that age and cycling experience contributed to the enhancement of these specific skills. These two later hypotheses are drawn from the limitations of a recent study, in which it is mentioned that researchers ‘did not ask the number of years’ experience of cycling each child had, nor did they link the findings to gender’ (Bromell and Geddis 2017, p. 148).

Materials and method

Sample and procedure

All students from a local elementary school in Nea Ionia (Attica, Greece) were invited to participate in the present study. Through a letter to the teachers and parents, children were asked to bring their bicycle to school in order to participate in a cycling skills test. A total sample of 80 children took the cycling skills test, of which 46 were boys (57.5%). They had an average age of 8.68±1.03 years, and their cycling experience was assessed with the question: “How many years have you been cycling?” (average cycling experience 3.90±1.77 years). The Ethics Committee of the local School of Physical Education and Sport Science granted ethical approval and this study was conducted in accordance with the ethical standards described by Harriss and Atkinson (2013). Informed consent from all participating children and their parents was obtained and it was made clear that participation was voluntary, and all recorded data were confidential.

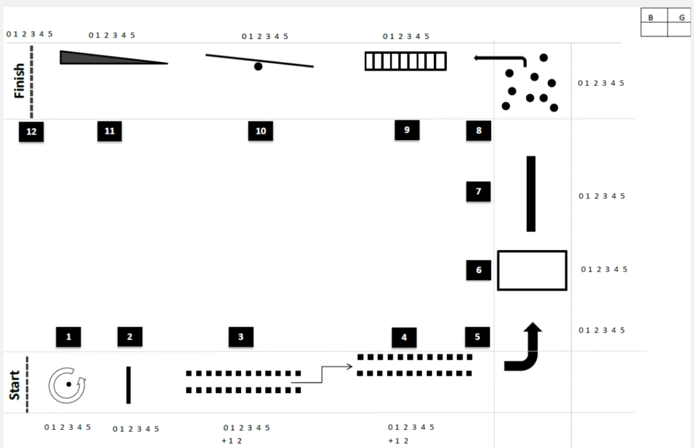

Figure 1. Overview of the different cycling test stations.

Cycling test

The cycling test was based on a cycling test developed in Belgium (Ducheyne et al. 2013) and other existing cycling tests described in the literature (Bromell and Geddis 2017; Macarthur et al. 1998). Ducheyne et al.’s test (2013) included 13 basic cycling skills that children should manage to cycle safely in right-hand traffic. The other tests had components such as straight-line riding, coming to a complete stop and shoulder checking before a left turn. These components were selected because the ability to perform hand signals and to check for traffic approaching from behind, while maintaining control of their bicycle and remaining within a cycle lane, are basic to safe cycling on public roads (Bromell and Geddis 2017; New Zealand Transport Agency 2013). In addition, the advice from an expert panel consisting of 3 cycling scientists and former athletes, with a large experience in cycling skills and fundamental motor skills testing in children, was taken into account in order to adapt these tests and establish content validity. Since Greece is a right-hand driving country, the basic cycling skills that were selected were based on the notion that children should learn to cycle safely in right-hand traffic situations.

The cycling test consisted of 12 test stations (see Table 1 and Figure 1). The tests were carried out on an asphalt surface on the school’s playground and the duration of the assessment ranged from 40 to 80 seconds per child. Children were provided with specific instructions on how to perform the tests but were not allowed to practice.

We advised participants to conduct the test using their own bicycles due to familiarity and comfortability issues that might arise. If a child was not able to bring his/her own bicycle to school, he/she could use a bicycle from a classmate of similar body height and weight. Before the implementation of the test, the main researcher checked the bicycle’s size and manually adjusted bicycle’s height and seat’s position according to participant’s height to fit his/her size (if needed).

Two raters were trained on the scoring procedure of all test stations during a three-hour workshop. In this workshop, the main researcher thoroughly explained and demonstrated correct performance for all 12 test stations. Subsequently, raters observed and rated actual video-recorded participants, were provided with immediate feedback concerning the accuracy of their ratings and maintained their interest by encouraging informal group discussions on the rating procedure. In addition, the two professionals independently assessed the performances of 30 children (37.5% of the total sample), as evidence of inter-rater reliability. After confirming inter-rater reliability for each test station, each one of the two raters assessed half of the remaining children.

For each test a 5-point scale was used to assess the general performance of the skill. The speed and accuracy of the performance, as well as the ability to keep balance and to perform the test without interruptions, were taken into account when scoring the general performance. Furthermore, for 2 test stations (instead of 11 on the original test), the researchers additionally indicated if the child was able to fulfill some specific points of interest. For each specific point of interest that was fulfilled, one point was added to the general performance score. This

Table 1. Description of the cycling test stations and the scoring procedure.

Cycling skills	Description of the test	Points of interest	Performance score on	Points of interest score on	Total score on	Converted total score on
1. Walk with the bicycle in a circle	Children walk with the bicycle around a cone, making a full circle of 2 m radius. During the whole test, the children hold their bicycle at the left side of their body and with both hands hold the handlebar		/5		/5	/5
2. Lift the bike and overpass an obstacle	Children lift the bicycle with both hands and overpass an obstacle of 1.2 m width and 20 cm height		/5		/5	/5
3. Look left and right while cycling in a straight line	Children cycle between two parallel lines of 5 m long and 40 cm apart. A helper stands left or right from the cyclist and as the cyclist starts to cycle the helper holds up a card showing a number. The rider looks left or right and shouts out what the number is. During watching the cycle must continue in a straight line	- Cycle between the lines	/5	/2	/7	/5
4. Signal left while cycling in a straight line	Children cycle between two parallel lines of 5 m long and 40 cm apart. While cycling, the children need to signal left, with arm held out at shoulder height to inform the examiner that they will turn left	- Shout the right number	/5	/2	/7	/5
5. Cycle while turning left	Children turn left to continue without exiting the boarders of the test	- Cycle between the lines	/5		/5	/5
6. Pass under an arch	Children cycle and pass under an arch of 1 m width and 1.5 m height. They have to stoop while cycling to avoid hitting the arch	- Signal at shoulder height	/5		/5	/5
7. Cycle in a straight line over an obstacle	Children cycle on a wooden plank of 3 m long and 20 cm wide. During the entire length, the children should cycle in a straight line on the plank without loss of balance and without leaving the plank		/5		/5	/5
8. Cycle in and out of markers	Nine cones are placed apart in a non-symmetrical way, with gaps that reduce toward the end. Children must pass through without touching them and turn left		/5		/5	/5
9. Cycle over obstacles	Children cycle over three obstacles that are placed in a straight line behind each other. The distance between each obstacle is about 5 m. The first obstacle is a 2 m long and 40 cm wide wooden plank with ladder profile. While cycling over the obstacles the children need to maintain their balance and speed		/5		/5	/5
10. Cycle over a seesaw	The second obstacle is a seesaw of 2.20 m long and 40 cm wide		/5		/5	/5
11. Cycle on a sloping surface	Children cycle on a wooden plank of 3 m long and 20 cm wide. The plank has a gradient of 15 degrees. During the entire length, the children should cycle in a straight line on the plank without loss of balance and without leaving the plank		/5		/5	/5
12. Brake and dismount the bicycle	Children cycle at a normal speed and then they stop within a box marked out with cones. The box is 2 m long and 1 m wide. Children have to brake when their front wheel passes the first two cones of the box. Children need to come to a controlled stop within the box and dismount the bicycle		/5		/5	/5

sum score (sum of the general performance score and the points of interest) was then converted to a score on ten, following previous guidelines (Ducheyne et al. 2013). The sum of the scores on the different tests was used as the dependent variable (overall cycling skill score).

Statistical analysis

The statistical analysis was conducted with the use of the statistical package SPSS version 23.0 (IBM SPSS Corp., Armonk, NY, USA), the significance level was set at $p<.05$ and the Cohen's *d* effect sizes were further computed. A Cohen's *d* value of .20 was associated with a small effect, .50 with a medium effect and .80 or greater with a large effect (Cohen 1988). Before the main procedures, variables were screened for accuracy of data entry, missing values, potential outliers and distribution (skewness and kurtosis). No missing values were observed, and the box plots, skewness and kurtosis analysis indicated that no extreme values existed, and data were normally distributed.

An exploratory factor analysis (EFA) of unweighted least squares method with varimax rotation was conducted to investigate the factor structure of the cycling skills test. This method was selected over the previously used principal components method (Ducheyne et al. 2013) because it has received favorable reviews for coping with small sample sizes and many variables, while not being as limited by distributional assumptions (Jöreskog 2003; Zygmont and Smith 2014). The eigenvalue >1 rule was used to determine the number of factors to extract, as well as single communalities over .30. Items that had a loading of .40 or greater, without cross-loadings and demonstrated a difference of .20 between their primary and alternative factor loadings, were assigned to a factor (Howard 2016). To investigate inter-rater reliability of the cycling test stations, a subsample of 38 children was scored on each test station by the two researchers. Intraclass correlation coefficients (*ICC*; two-way mixed, absolute agreement) were then calculated to investigate inter-rater reliability of each cycling test station. Furthermore, an independent sample t-test was performed to examine differences in cycling skills according to sex. Lastly, Pearson *r* correlation analysis was performed between the overall cycling skill score, the extracted factors and age.

Results

EFA and inter-rater reliability

Bartlett's test of sphericity (χ^2=456.64, *df*=66, *p*<.001) and Kaiser-Meyer-Olkin (KMO=.842) indices were satisfactory. Based on single communalities (>.30) and eigenvalues, two factors were extracted with an eigenvalue above 1 (Table 2). These factors accounted for 57.58% of the total variance. Factor one accounted for the largest proportion of the total variance (45.00%) as most of the items loaded on this factor. The seven items that loaded on the first factor were mainly skills that are performed while cycling (*cycle while turning left, cycle in a straight line over an obstacle, cycle in and out of markers, cycle over obstacles, cycle over a seesaw, cycle on a sloping surface, brake and dismount the bicycle*). Therefore, the first factor was called the *during cycling skills factor*.

Factor two accounted for the remaining 12.58% of the total variance and five items loaded on this factor, namely: *walk with the bicycle in circle, lift the bike and overpass an obstacle, look left and right while cycling in a straight line, sign left while cycling in a straight line* and *pass under an arch*. This factor was called *attention/handling cycling skills* factor, as the items that loaded on this factor required extra attention and handling skills developed by the participants, before and

Table 2. Exploratory factor analysis of the cycling skills test.

Cycling skills	During cycling skills	Attention/handling cycling skills
10. Cycle over a seesaw	**.879**	.084
9. Cycle over obstacles	**.766**	.213
5. Cycle while turning left	**.687**	.263
11. Cycle on a sloping surface	**.684**	.070
12. Brake and dismount the bicycle	**.643**	.285
8. Cycle in and out of markers	**.611**	.388
7. Cycle in a straight line over an obstacle	**.571**	.321
4. Signal left while cycling in a straight line	.354	**.672**
6. Pass under an arch	.389	**.603**
3. Look left and right while cycling in a straight line	.210	**.578**
2. Lift the bike and overpass an obstacle	-.018	**.500**
1. Walk with the bicycle in a circle	.151	**.433**
Eigenvalue	5.40	1.51
Factor variance (%)	45.00	12.58
Total variance (%)	45.00	57.58

Table 3. Descriptive statistics for each cycling skill, for each factor and total score.

Cycling skills	Range	*M*	*SD*	MIN	MAX	*ICC*
1. Walk with the bicycle in a circle	0 - 5	4.29	1.18	0	5	0.93
2. Lift the bike and overpass an obstacle	0 - 5	3.46	1.61	0	5	0.93
3. Look left and right while cycling in a straight line	0 - 5	3.32	1.55	0	5	0.89
4. Signal left while cycling in a straight line	0 - 5	2.87	1.51	0	5	0.95
5. Cycle while turning left	0 - 5	3.31	2.23	0	5	0.93
6. Pass under an arch	0 - 5	4.04	1.84	0	5	0.94
7. Cycle in a straight line over an obstacle	0 - 5	2.51	1.95	0	5	0.90
8. Cycle in and out of markers	0 - 5	4.06	1.55	0	5	0.90
9. Cycle over obstacles	0 - 5	3.30	2.02	0	5	0.93
10. Cycle over a seesaw	0 - 5	3.28	2.08	0	5	0.98
11. Cycle on a sloping surface	0 - 5	1.98	1.84	0	5	0.87
12. Brake and dismount the bicycle	0 - 5	3.84	1.95	0	5	0.96
During cycling skills	0 - 35	17.97	5.42	2	25	
Attention/handling cycling skills	0 - 25	22.28	10.55	0	35	
Total cycling skills score	0 - 60	40.25	14.28	2.71	60	

during the actual cycling movement. Furthermore, *ICC* coefficients for all test stations ranged from .87 to .98 (see Table 3).

Descriptive and inferential analysis

Means, standard deviations, minimum and maximum scores of children's cycling skills are presented in Table 3. The highest scores were found for *walking with the bicycle in a circle* (*M*=4.29, *SD*=1.18), *cycling in and out of markers* (*M*=4.06, *SD*=1.55) and *passing under an arch* (*M*=4.04, *SD*=1.84). The lowest scores were found for *cycling on a sloping surface* (*M*=1.98, *SD*=1.84), *cycling in a straight line over an obstacle* (*M*=2.51, *SD*=1.95) and *signaling left while cycling in a straight line* (*M*=2.87, *SD*=1.51).

Additionally, Figure 2 represents the percentage of score distribution of the different cycling skills. For 6 cycling skills, namely *walk with the bicycle in a circle, cycle while turning left, pass under an arch, cycle in and out of markers, cycle over a seesaw* and *brake and dismount the bicycle*, more than 50.0% of children scored the maximum score (i.e. 5 out of 5). The highest score was observed for *passing under an arch* (75.0%), while the lowest score for a perfect execution was at *cycling on a sloping surface* (15.0% scored maximum). Furthermore, 30% of children scored lower than 3 out of 5 (i.e. 0, 1, or 2) for *looking left and right while cycling in a straight line, signalling left while cycling in a straight line, cycling while turning left, cycling in a straight line over an obstacle, cycling over obstacles, cycling over a seesaw* and *cycling on a sloping surface* (31.4%-60.1%).

When grouping the cycling skills under the predefined factors, the *attention/handling cycling skills* factor had the highest score (*M*=22.28 out of 25, *SD*=10.55), followed by the *during cycle skills* (*M*=17.97 out of 35,

Table 4. T-test results for group differences among boys and girls.

Cycling skills factors	Sex	*M*	*SD*	*t*	*p*	Cohen's *d*
Attention/handling cycling skills	Boys Girls	17.67 18.38	5.82 4.86	-.58	.565	.13
During cycling skills	Boys Girls	21.83 22.88	11.26 9.63	-.44	.661	.10
Total cycling skills score	Boys Girls	39.50 41.27	15.48 12.62	-.55	.587	.13

Table 5. Pearson *r* correlations between age, independent factors and total cycling skill score.

	Age	Cycling experience	During cycling skills	Attention/handling cycling skills	Total cycling skills score
Age	-	.600**	.052	.218	.121
Cycling experience		-	.279*	.353**	.340**
During cycling skills			-	.554**	.949**
Attention/handling cycling skills				-	.788**
Total cycling skills score					-

*Correlation is significant at .01 level (two-tailed). ** Correlation is significant at .001 level (two-tailed).

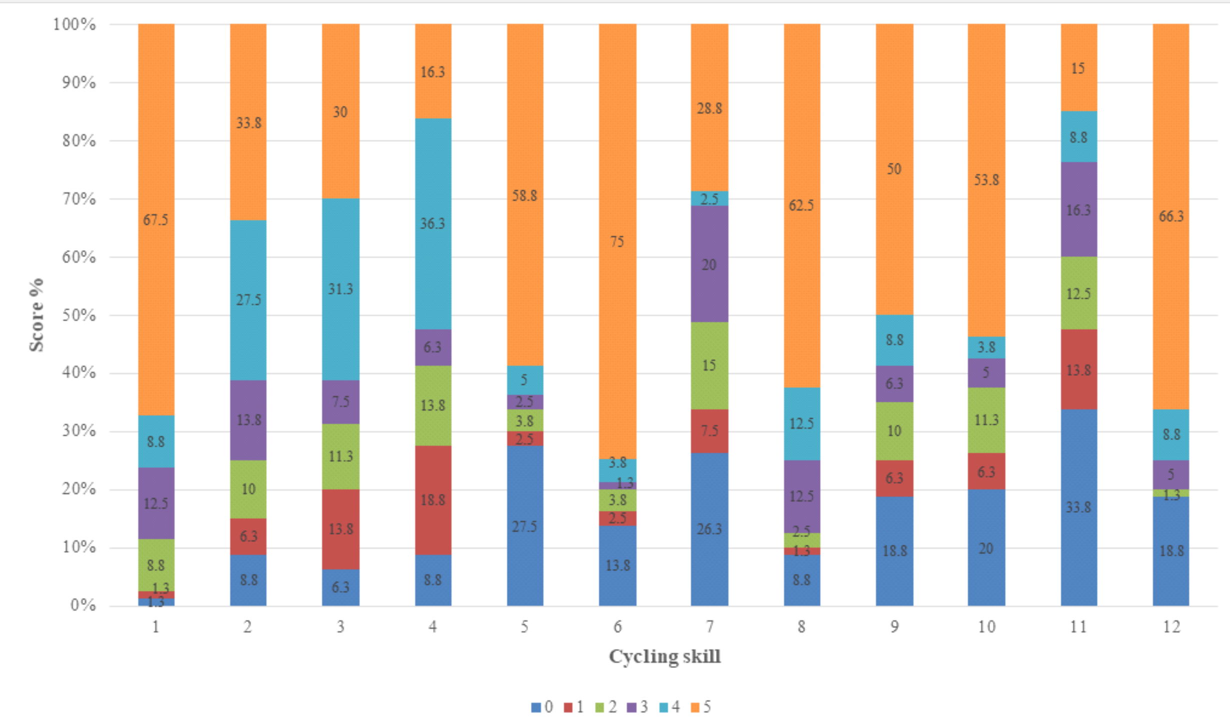

Figure 2. Percentage of score distributions of the different cycling skills.

SD=5.42). The mean overall cycling skill score (sum of the different cycling skills) was 40.25/60 (*SD*=14.28).

No significant differences in separate factors, as well as the overall cycling skill, were noted between boys and girls (p>.05). All independent sample *t*-test results are presented in Table 4. Additionally, Pearson *r* correlations did not highlight any significant correlations between participants' age and cycling skill factors - total cycling skill score (p>.05). However significant correlations were observed between cycling experience and *during cycling skills* (r=.279, p=.012), *attention/handling cycling skills* (r=.353, p<.001) and total cycling skills score (r=.340, p=.001). Lastly, the two factors were significantly correlated amongst them, meaning that they were dependent one from the other (Table 5).

Discussion

This study was designed to adapt and validate a basic cycling skills test for children in Greece. To our knowledge, this is the first study adapting a cycling test suitable for children in South Europe, based on a similar study contacted in North Europe (Belgium) 5 years ago (Ducheyne et al. 2013). The 12-item test battery proposed can be considered suitable for the evaluation of basic cycling skills of Greek elementary children 7 to 10 years old.

An EFA of the cycling test revealed a 2-factor model, indicating that cycling skills in our context could be divided into 2 components, namely: *during cycling skills* and *attention/handling cycling skills*. Most previous studies on cycling skills (Bromell and Geddis 2017; Macarthur et al. 1998) included a few components of safe cycling behavior (i.e. straight-line riding, coming to a complete stop and shoulder checking before a left turn) and did not explore the structure of their proposed tests. The factorial structure of a similar cycling skills test was examined in Ducheyne et al. (2013) research and showed a 3-factor model. Of the 13 items, 8 loaded on the first factor, 3 on the second factor and 2 on the third one. The distribution of the items to the factors was not optimal because researchers have suggested varying numbers of item per factor, ranging from 3 to 5, for representing each factor and, if the resulting scale has 2 items, it is likely to have low reliability and thus have a problem with replication of the factor across samples (Howard 2016).

The test developed for the present study was based on that of Ducheyne et al. (2013), however the factorial structure proposed was not similar. Even though the first factor (*during cycling skills*) shared similar items in both studies, we believe that our model is more coherent since the two factors contain 7 and 5 items respectively. From this point of view, our study provides an instrument with higher reliability and more easily replicable by future researches, which need to be carried out in order to validate the consistency of our findings. The differences observed between the two tests may be related to different samples and context, slightly different test items and scoring procedure, as well as different EFA method used.

The proposed test incorporated many elements included in previous tests, such as straight-line riding and right-hand turning signal, which are considered important to safe cycling on right-hand traffic public roads. It also included more aspects of real-life cycling conditions, such as handling a bicycle, overcoming and stooping obstacles while cycling. Based on this, as well as the fact that the test was carried out in natural settings with features participants were familiar with (i.e. asphalt surface on the school's playground), we believe that the experimental situation captured the critical aspects of the real-world environment. This approach provides evidence of ecological validity, mainly in terms of verisimilitude, that is the degree to which tasks performed during testing are sufficiently similar to those performed in daily life (Franzen and Arnett 1997).

For *walking with the bicycle in a circle, cycling while turning left, passing under an arch, cycling in and out of markers, cycling over a seesaw* and *braking and dismounting the bicycle,* more than 50% of children scored maximum. The fact that children scored high in and out of markers, as in Ducheyne et al. (2013) study, indicated that most children had good steering skills when cycling both handed. Also, for the *braking and dismounting the bicycle* test the children scored highly and this result is consistent with previous findings (Arnberg et al. 1978; Ducheyne et al. 2013).

Lowest mean scores were found for skills that required more advanced attention skills, i.e. *look left and right while cycling in a straight line and signal left while cycling in a straight line*. The latter skill is very important, as cyclists should be able to signal at least left to warn other drivers of the direction change. Similar findings were obvious in most previous studies (Bromell and Geddis 2017; Ducheyne et al. 2013; Macarthur et al. 1998), even though Bromell and Geddis (2017) reported that children in their study were better at performing hand signals than looking over their shoulders. In Macarthur et al. (1998) intervention program to improve cycling skills, neither children's experience nor the intervention, were sufficient to improve shoulder checking before left turns. However, not signalling and checking over the shoulder while cycling may be the underlying mechanism of cycling accidents (Lammar 2005). Therefore, parents and teachers who teach children to cycle should pay sufficient attention to the use of hand signals while cycling and allow children to cycle unaccompanied on public roads only if they know the various hand signals required for safe cycling and can maintain control of their bicycle while performing these hand signals.

Most of the children faced difficulties while cycling over obstacles (i.e. *cycling in a straight line over an obstacle, cycling over obstacles, cycling over a seesaw* and *cycling on a sloping surface*). This finding is not consistent with previous research (i.e. Ducheyne et al. 2013), in which children scored relatively high, possibly because of the simplicity of the relevant tests. The most difficult test for participants to overcome was the cycling on a sloping surface station. In order a child to complete successfully this task, he/she must keep a steady, relatively increased speed to overcome the gradient of 15 degrees. However, as observed during the cycling procedure, children were not able to increase the bicycle's speed to such an extent to go up the sloping surface without losing their balance. To conclude, 50% of children scored higher than 4 out of 5 for every cycling skill except 2 (i.e. *cycle in a straight line over an obstacle* and *cycle on a sloping surface*), so we can conclude that, based on the results of the cycling test, children scored sufficiently well on cycling skills.

Subsequently, we examined whether boys and girls had different basic cycling skills. As in Ducheyne et al. (2013) study, no difference in cycling skills was found between sex, as opposed to previous research on fundamental movement skills, in which sex was correlated with motor competencies and motor performance (e.g. Barnett et al. 2010). However, taking into account that there is no direct relationship between cycling-related skills and motor skills (Scheuer, Bund and Herrmann, 2019), it might be the case that cycling motor components (e.g. slalom riding, braking) are not directly related to basic movement (e.g. running, throwing) and, thus, boys and girls perform at a similar level. Further research is clearly needed on this topic. Sex equality in the present study has two implications:

1. The proposed cycling test does not depend on sex differences and the underlying measuring model should not have a different factorial structure depending on sex.
2. Unlike fundamental movement skills and motor performance, cycling abilities do not seem to depend on sex.

Lastly, we controlled the hypothesis that cycling skills were related to children's age and previous cycling experience. According to previous research, the ability of children to perform cycling skills depends mainly on their physical and mental developmental abilities (Corden et al. 2005), which are strongly related to age (Arnberg et al. 1978; Bromell and Geddis 2017; Maring and van Schagen 1990). For example, 9-10-year olds should be able to cycle based on the development of their motor and cognitive abilities (Strickland 2001) and from this age, independent mobility starts to change (Alexander 2005). In our study, in which 7 to 10-year-old children participated, age was not correlated with cycling skills, meaning that, in this context, students shared similar results independently of their age and maturation.

On the other hand, we also hypothesized that cycling skills might be related to cycling experience (years of cycling), and this hypothesis was marginally supported. We mention 'marginally' because, even though the correlations were statistically significant, the correlations indices were relatively low. As expected, the more cycling experience children had, the more competent they were at the assessment. This result is in line with that of Bromell and Geddis (2017), who also found that 82.8% of the children that rode their bicycle every day completed successfully the practical assessment, in comparison to 55.0% of those who rode a few times per week. Even though these results are not directly comparable, it is possible that maturation of basic cycling skills is dependent and enhanced through regular practice and increased experience, while biological age does not significantly impact these skills.

Study limitations and possible implications

Several study limitations and directions for future work, as well as possible implications for policy makers and practitioners, warrant comment. Our data are cross-sectional in nature, indicating that causal relationships cannot be drawn. Also, generalization of this study is limited by the nature of the sample used, which comprised of elementary students aged 7 to 10 years. Future similar studies should include younger and older children. Also, the sample was drawn from urban cities so whether the results would apply to rural populations is not known. Although the current study has provided initial evidence of factorial validity for the basic cycling skills test in Greece, further research to establish the validity of the test is very much needed. The use of confirmatory factor analysis is suggested to evaluate the proposed model in different contexts and samples and future studies should investigate whether the results of this study emerge as a consistent finding or as an artefact of the present sample. The researchers are encouraged to proceed with applying the test to other countries and social settings, as well as addressing further validity issues, such as its invariance among educational level (elementary school and high school), cultures and contexts.

The results of the study may hold practical implications for policy makers, practitioners and parents. An important point in this research was that children's cycling skills were objectively measured by a cycle test that was carefully developed based on existing literature and knowledge of an expert panel. This is more important considering that bicycle skills training programs are common in schools and communities, but few published data on their effectiveness exist. Future cycling training programs should use valid and reliable practical, context-specific assessments, similar to the one proposed in our study, in order to evaluate the effectiveness of cycling on-task behaviour. This is an important issue, because only instruments with acceptable validity and reliability can be used to collect data to enrich or generate new knowledge.

In addition, it could be useful to investigate the influence of each component independently on cycling accidents, as proposed by Ducheyne et al. (2013). If 1 of the 2 factors are more related to cycling accidents, interventions developed should target that cycling component to maximize the effect. Furthermore, results of the factor analysis suggest that the evaluation of children's cycling skills does not have to include all items. A simplified cycling test may be developed focusing on 1 of the 2 components. An important benefit of a simplified test is that more children can be tested within a shorter timeframe. This approach would further enable an easy distribution of the data, with easy-to interpret results in the practical application of the test instrument.

Conclusion

In summary, the 12-item test battery adapted and validated in the present study is suitable for the evaluation of basic cycling skills of Greek elementary children 7 to 10 years old. Cycling skills in our context can be divided into 2 components, namely: *during cycling skills* and *attention/handling cycling skills*. The test instrument is beneficial because the testing procedure is fast, the test items are easy to evaluate, and the results are interpretable without a standard table and statistical distribution. Furthermore, most of the children scored well on cycling skills, however lowest mean scores were found for tests that required more advanced attention skills and cycling over obstacles. In addition, boys and girls had similar cycling skills, which might indicate that cycling motor components are not directly related to basic movement skills. Lastly, in our study, cycling skills were not correlated with age but were significantly correlated with cycling experience. It is possible that maturation of basic cycling skills is dependent and enhanced through regular practice and increased experience, while biological age does not significantly impact these skills.

Conflict of Interest

The manuscript has been read and approved by all the listed co-authors and meets the requirements of co-authorship as specified in the Authorship Guidelines. The authors report that they have no conflicts of interest.

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