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How short-term cycling training promotes cycling among schoolchildren in high-density cities

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ABSTRACT

This study explores how short-term, school-based cycling training programs can promote cycling among schoolchildren in the high-density city of Hong Kong. The schoolchildren's progression in cycling ability was monitored closely by professional cycling coaches. Fifty-two children (aged 8–17) at three schools participated. Before and after data on their cycling habits and perceptions of the children and their parents were collected. Children showed clear improvements in their cycling techniques and skills with each session of the cycling training. After the children's training, parents readily felt that cycling training helped to protect cyclists' safety, with three quarters of "yes" respondents, and children were in agreement to a lesser magnitude, at around 55%. Other perceptions of cycling and cycling training were explored as well, with varying results. 24% of children reported cycling more after training, the majority of those at the introductory level, who had hardly ever cycled prior to training. The results suggest that cycling training has improved schoolchildren's cycling ability, while perceptions and habits of cycling have begun to change as well. These findings can inform future policy direction in the implementation of formalized cycling training for schools situated in high-density cities like Hong Kong primarily to promote cycling for recreation and further as a form of sustainable transport. This needs to go hand in hand with improving neighborhood environments so they become more amenable for active travel especially for vulnerable road users, such as child cyclists.

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Children; cycling ability; cycling habits; cycling perceptions; cycling training program

1. Introduction and review

High-density cities are becoming more common in an increasingly urbanized world, and their compact urban form means that trip distances are more suited to active travel behavior like walking and cycling (De Vos et al., 2019; Lau et al., 2005; Leung et al., 2019). However, even with these self-evident opportunities to go about journeys on foot or by bicycle, dense urban agglomerations still present many barriers that discourage active travel, especially in highly motorized environments, not least for vulnerable road users like children. First, there are perceptions of hazardous traffic, poor neighborhood environment and social danger (Salmon et al., 2007; Willis et al., 2015); then, there are other external barriers, such as poor public transport facilities and steep topography (Timperio et al., 2004; Trapp et al., 2011). However, physical activity is highly important for children's physiological (Armstrong, 1993; Hills et al., 2007) and psychological (Ramanathan et al., 2014; Waygood et al., 2019) wellbeing, and it is clearly in the best interests of children and society at large for these barriers to be hurdled and for physical activity, including active travel, to be further promoted.

One method to promote more physical activity in children is through the introduction of school-based cycling training programs. Safety concerns related to cycling crash-related traffic injuries has emerged as a common theme in recent literature (Boufous et al., 2011; Loo & Tsui, 2010; Papadakaki et al., 2018; Robartes & Chen, 2018; Sze et al., 2011), especially single bicycle crashes (see Schepers et al., 2015), so helping children with their cycling ability for them to be more able to navigate hazardous environments and situations appears to be one way to address parents' worries. With this improvement in children's cycling ability and alleviation of parental concerns, it would be reasonable to expect that cycling frequency can increase. A review of cycling training initiatives in recent literature is presented in Section 1.1, to better understand the effectiveness of skills training programs around the world in improving cycling ability, confidence and safety perceptions, and whether this ultimately culminates in increased frequency of cycling. Section 1.2 provides an overview of cycling as a sustainable transport mode in Hong Kong and the relevant social and cultural context. Section 1.3 presents a conceptual framework for better understanding the efficacy of cycling training programs in the promotion of cycling among schoolchildren. The study objectives are also explained with close reference to the conceptual framework in this section.

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1.1. Review of cycling training initiatives

Cycling training generally refers to training programs that help to improve participants' ability and confidence to cycle, which may include different training levels from the most basic training in a traffic-free environment, to more advanced training on roads (Ducheyne et al., 2013a). There have been various local and national initiatives (e.g. Meester op de fiets, n.d.; Bikeability, 2013; Cycle for Health, 2011; Wellington City Council, 2012), as well as smaller scale interventions (Lehtonen et al., 2017; Schutzhofer et al., 2017; Twisk et al., 2014, 2018; Vansteenkiste et al., 2016; Zeuwts et al., 2016; Zeuwts et al., 2017). The effectiveness of cycling training has been widely discussed in the literature, mostly Western-centric in context. Previous studies demonstrated that cycling training (i) improves children's cycling knowledge and self-perceived confidence of cycling, (ii) increases frequency of cycling to school in boys, (iii) is largely viewed as beneficial by parents and (iv) has many advantages that are beneficial to adolescents in keeping them safe from traffic (Mandic et al., 2016, 2017, 2018a, 2018b). Trained cyclists also have safer cycling behavior than their counterparts without training (Savill et al., 1996; Telfer et al., 2006). Parents would consider their children to be able to cycle safely after participation in cycling training (The Royal Society for the Prevention of Accidents, 2001; Spence, 2003).

In contrast, however, some studies indicate that cycling training programs would neither improve safe cycling behavior nor change adolescents' attitudes towards cycling (Macarthur et al., 1998), and also fail to increase children's frequency of cycling (Goodman et al., 2016) and cycling to school (Ducheyne et al., 2014). Evidently, with the variety of cycling training programs being studied, in terms of program duration, target group, training scheme, surrounding environment, etc., it is difficult to definitively compare their efficacy in promoting cycling among children. Sersli et al. (2019) also came to the same conclusion in their recent review of studies on cycling training, and noted that future research should (i) present a conceptual framework to understand the processes at work, (ii) divulge in the study context in terms of location, target group, policy background, etc. and (iii) provide more precise details about the training content. With more details about the concept, context and content of cycling training programs, research in this area may begin to progress and be able to inform practitioners on how best to implement training programs that are able in terms of cycling skills, change attitudes and ultimately increase cycling frequency.

1.2. Cycling as a sustainable transport mode in Hong Kong

Hong Kong, as a highly motorized city (Yao & Loo, 2016), has a very low modal share of cycling—around 0.5% of total trips [Legislative Council Panel on Transport, 2010]. Cycling is considered as merely recreational in nature (Loo & Tsui, 2010), and it would be unreasonable to expect this to change in the short-term. Geographically, 97% of daily cycle trips were in the New Territories (Transport Department, 2004), which is mainly rural with several medium-density new town developments. Safety concerns have long been one major barrier against promoting cycling as a transport mode in Hong Kong. Especially in Hong Kong's urban areas where there are few cyclists, the safety-in-number benefits do not apply unlike in European countries such Germany or the Netherlands, where the substantial travel mode share of cyclists enables safer cycling experiences (Pucher & Dijkstra, 2003; Yao & Loo, 2016).

The lack of sufficient safe cycling infrastructure, mixed traffic and insufficient training for cyclists are contributory factors for bicycle crashes in Hong Kong (Loo & Tsui, 2010). Hong Kong traffic accident data from 1996 to 2015 managed by the Transport Department (2015) showed that cycling casualties (i.e. injuries at all levels and fatalities) in Hong Kong have quadrupled over the past two decades, from 541 in 1996 to 2,395 in 2015, with the casualty rate per 100,000 population rising from 8.41 in 1996 to around 33 since 2011, and holding relatively stable since. This figure matches the UK's casualty rate per 100,000 population, also at 33 (The Royal Society for the Prevention of Accidents, 2016). However, bicycle mode share in England, at 1.9%, is nearly quadruple Hong Kong's (Department for Transport, 2016). This suggests that the risk of cycling in Hong Kong (risk = casualty/exposure) is much higher, though there are no systematic risk exposure figures about cyclists and pedestrians in Hong Kong and most other cities (Yao et al., 2015). The casualty rate for Hong Kong's cyclists aged 14 years and under have increased from 24.5 in 2009 to 35.6 in 2015, per 100,000 population, and 15 of these child cyclists have died since 1996, highlighting the importance of studying child cyclists in Hong Kong.

Furthermore, there are specific cultural and environmental considerations specific to the East Asian context, which may also contribute to explaining the low prevalence of cycling. Culturally, Chinese parents are very protective of their children (Lim, 2012), and believe it would be irresponsible even to let children as old as 12 move around the neighborhood freely without adult supervision (Karsten, 2015; Lam & Loo, 2014). This mindset is in great contrast with Hong Kong parents who are expatriates, despite both Chinese and expatriate parents acknowledging Hong Kong to be very safe (Karsten, 2015). Hong Kong's government recommends all children up until age 11 (i.e. including most primary school students) to still be supervised when walking or cycling (Transport Department, 2018), which matches the Chinese mindset described above. Children's schedules are also often packed with many extracurricular activities throughout a week (The Hong Kong Federation of Youth Groups, 2017; Leung & Loo, 2017), which means there is very little unstructured play time where, for example, children can go for a cycle in the park. Environmental barriers need to be accounted for as well. In urban areas, there are very few cycling facilities, and the central business district (CBD) areas are either too busy in traffic, too steep and uneven in topography, or both (Yao & Loo, 2016). Cycle tracks are more common in the New Territories region, and

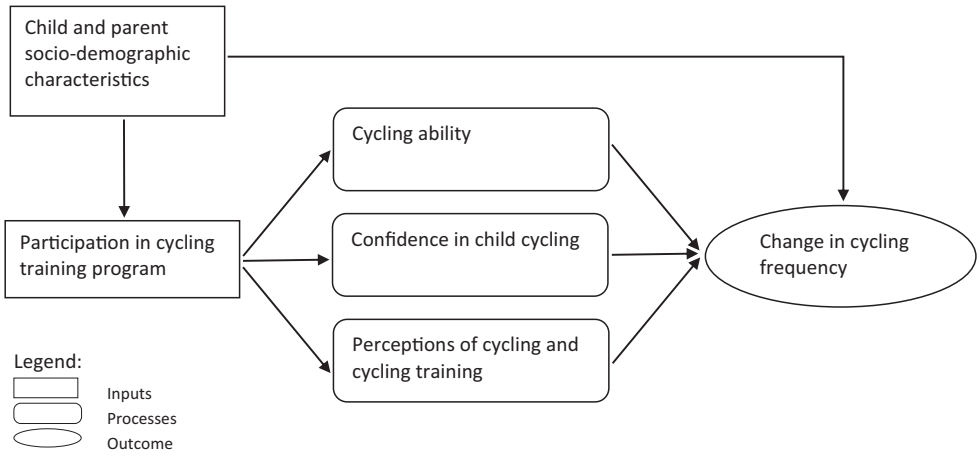

Figure 1. Conceptual framework to understand children's participation in cycling training programs and the subsequent change in cycling frequency.

they facilitate travel within new towns that have been built on flatter, primarily reclaimed, land (Loo & Tsui, 2010).

1.3. Conceptual framework and study objectives

Having reviewed cycling training initiatives and discussed the context of cycling in Hong Kong, it is clear amid the numerous challenges, there are opportunities for cycling frequency and safety to be increased in these compact, high-density cities. One course of action would be to implement cycling training programs and investigate their efficacy in changing cycling abilities, perceptions and habits, which has never previously been studied in East Asia. Echoing the call by Sersli et al. (2019) for conceptualization of the processes at work in and around cycling training initiatives, Figure 1 links up the aforementioned factors in a novel conceptual framework and provides a structure to more comprehensively understand cycling training, associated changes in cycling frequency and the processes behind these changes. Each linkage is discussed in this section and further elaborated in the sections thereafter.

The left-middle rectangle represents children's participation in the cycling training program as an input in the framework. Cycling training has not been systematically introduced in this part of the world (Loo and Tsui, 2010), and even so, only via ad hoc, independently run programs for the public and for a few schools. The dense urban form that is prevalent in these cities, like Hong Kong, differs considerably from Western cities, where residential and commercial developments are generally lower in density and more spaced out (Lau et al., 2005; Smith, 1984). This makes Hong Kong a highly worthwhile and important study context, helping to fill the research gap in the literature by providing an Asian perspective. The rectangle on the top left represents, also as an input, the child and parent socio-demographic characteristics obtained in this study, including age, gender, bicycle ownership, knowledge of how to cycle, purpose and frequency of cycling, independent mobility and transport mode for activities. These variables serve as the basic background information for participants of the cycling training program, and also for analysis of the change in cycling frequency after participation in cycling training, indicated by the oval on the right (see for example, Goodman et al., 2016; Mandic et al., 2018b).

The three rounded rectangles in the middle, as processes, represent cycling ability (child), confidence in the child cycling (child and parent) and perception of cycling safety (child and parent), linking from the input rectangle on the left-middle, i.e. participation in the cycling training program, and to the outcome oval on the right, i.e. the change in cycling frequency. The improvement in cycling ability after participation in a cycling training program is a self-explanatory relationship (see for example, Ducheyne et al., 2013a, 2014; Telfer et al., 2006), and often serves as a major aim of cycling training programs (Goodman et al., 2016). However, this is not necessarily accompanied by an increase in cycling frequency (Ducheyne et al., 2014). With regards to confidence in cycling after participating in cycling training, Mandic et al. (2018a, 2018b) and van Lierop et al. (2016) found an improvement in confidence to cycle among child participants. On parental confidence, Spence (2003) notes that training can improve parental confidence to let their child to cycle. Meanwhile, Ducheyne et al. (2013b) and Mandic et al. (2016) both fall short of explicitly examining how confident parents are after their children's participation in the program, although they do explain the significance of parental confidence in children's cycling abilities with children cycling more. Finally, perceptions of cycling and cycling training have also been examined in the literature in child participants of the training programs (Mandic et al., 2016; van Lierop et al., 2016) and also their parents (Ducheyne et al., 2014; Mandic et al., 2017; van Lierop et al., 2016), with somewhat inconclusive results. Researchers have also yet to study if these changes in perception are associated with changes in cycling frequency either.

Whether these training programs ultimately change habits of cycling, especially in Asian cities, is up for debate. Current cycling education in Hong Kong is very limited, even at the classroom level, and the focus is on teaching general rules as a road user, with no actual cycling practice (The Sun, 2013). General attitudes in Hong Kong towards cycling remain lukewarm at best. With close reference to the

Table 1. Training program for Group 2 participants.

	First lesson	Second lesson	Third lesson
Course aims	Test children's actual cycling abilities	Teaching and improving cycling techniques	Supervising children to go out on cycling tracks and teaching cycling techniques in the real environment
Assessed course content	1. Starting off on the bicycle 2. Keeping in balance while cycling 3. Stopping on the bicycle	1. Riding single-handed 2. Turning corners	1. Positioning bicycle correctly on cycling track

conceptual framework described above, this study's aims are as follows. First, this study evaluates the change in children's cycling ability throughout their participation in a short-term cycling training program, in terms of their techniques (act of performing a movement) and skills (applying the appropriate technique) (British Cycling, 2005) necessary to cycle safely. Second, the impact of cycling training programs on child cyclists' and their parents' perceptions of cycling are investigated. It is important to understand perspectives of children and their parents. Parents have considerable influence over their child, as their perceptions directly affect their child's cycling habits (Ducheyne et al., 2012; Willis et al., 2015). Finally, this study examines the change (if any) in cycling habits after training, and explores the differences by (i) socio-demographic characteristics, (ii) overall self-perceived cycling skills improvement, (iii) post-training confidence ratings and (iv) perceptions of cycling and cycling training, of children and their parents. These perspectives are complemented by evaluations of the participating children's abilities as assessed by two professional cycling coaches, underlining this study's comprehensive and integrated approach.

2. Methodology

In this section, (i) participants and administration of the study, (ii) the cycling training program intervention, (iii) the outcome measures and measurement procedures and (iv) the analysis of data are described.

2.1. Study participants and administration

This article's focus is on schoolchildren studying at Primary 3 to Primary 6 (8–12 years old) and Secondary 1 to Secondary 4 (12–17 years old) in selected Hong Kong schools, who participated in school-based cycling training programs developed for this study. For continuity, these participants are referred to as "children" throughout this article, encompassing all non-adult participants (i.e. under 18 years of age), while noting well that part of the sample would be better described as "adolescents". The youngest age group joining the cycling training, at 8–9 years old, fit the suggested targeted groups for participation in the UK's Bikeability initiative (Bikeability, 2013).

This study was aimed at schools in Hong Kong's New Territories, where cycling infrastructure is more abundant and the terrain is flatter. Invitation letters were sent to all schools in the New Territories (518 in total) and three schools in the region agreed to participate in this study. In Hong Kong, most cycling trips were recorded in the New Territories (Loo & Chow, 2008), which explains the attractive proposition of cycling training programs for schools situated there, as there is better provision and planning of cycling infrastructure in the New Territories. Government-maintained bicycle tracks exist close to all three schools. After confirmation of the schools, child participants were recruited voluntarily from each school, and parental consent was obtained for participation. No financial incentives were given to schools, children or their parents for participation. Cycling training programs were conducted from June 2015 to May 2016, with training sessions arranged around busy school calendars and timetables typical of Hong Kong schools. All children and their parents were asked to complete before-and-after questionnaire surveys. Of the 52 children who participated in the cycling training programs, 33 full sets of questionnaire surveys were completed and usable for analysis.

2.2. Cycling training program intervention

The central focus of this study is a cycling training program for children at two different levels of cycling ability, fully accounting for safety issues and local context in Hong Kong: participants at no point in the training program cycled on the road, due to heavy vehicular traffic typical of Hong Kong. All cycling training programs were organized by the two professional cycling coaches free of charge, which sets this study apart from others where cycling training for children is usually provided by school teachers in physical education (PE) class (Sersli et al., 2019). Before training, children reported whether they could cycle or not and were placed into the "introductory" (Group 1) and "advanced" (Group 2) groups as appropriate.

Tailored programs based on the abilities of children in the group were developed by the coaches, consisting of three 90-min sessions spaced out over one month (scheduled at one session per week, but accounting for unforeseen circumstances such as inclement weather). Group 1 is introductory in nature and incorporates the most basic of Bikeability's first level learning outcomes, namely to (i) prepare bicycle and own self for cycling, (ii) get on and off bicycle without help and to (iii) control bicycle while starting off, pedaling and stopping (Bikeability, 2013). It is designed for novices who are just learning to ride the bicycle, and spends all three lessons going through these first level learning outcomes. Group 2 is more advanced and includes all of Bikeability's first level learning outcomes, including the abovementioned three covered in the first lesson, plus (i) use appropriate gears and avoid obstacles and (ii) look all around and behind and keep in balance, which were covered in the second lesson. Some second level outcomes were also

Table 2. Questionnaire items in this study.

Category	Item	Response categories	Child or parent	Pre or post
Frequency	Frequency of cycling	1. Every day 2. Around five times a week 3. Around three times a week 4. Once a week 5. Less than once a week 6. Never	C, P	Pre
	Change in cycling habit	1. No change in duration 2. Increase in duration, specify in minutes 3. Decrease in duration, specify in minutes 4. No change in frequency 5. Increase in frequency, specify no. times 6. Decrease in frequency, specify no. times	C	Post
Confidence	Confident to (let child) cycle Confident to (let child) cycle on cycle tracks Confident to (let child) cycle on the road Confident to (let child) cycle on routes with cycle tracks and roads Confident to (let child) cycle to and from school	Scale, from 1 (very unconfident) to 5 (very confident)	C, P	Post
Perception of cycling techniques	Most important cycling technique (for child) Most difficult cycling technique (for child) Most lacking cycling technique (for child)	Respondents may select one or more of the following: 1. Getting on and starting off 2. Turning left or right 3. Cycling in a straight line 4. Rounding corners 5. Cycling on a slope 6. Cycling around obstacles 7. Braking 8. Signaling left and right 9. Judging risks on the road 10. Correct positioning 11. Knowledge of traffic signals and signs 12. Other, specify:	C, P	Pre
	Most important cycling technique during training Most difficult cycling technique during training Most lacking cycling technique after training		C	Post
Perception of cycling and cycling training	Cycling on the road poses a safety threat to other road users Participation in cycling training helps to protect the safety of cyclists Participation in cycling training helps to protect the safety of other road users	1. Yes, specify: 2. Maybe, specify: 3. No, specify:	C, P	Pre, Post
	Most important thing(s) gained from participating in cycling training	Respondents may select one or more of the following: 1. I have/My child has increased in cycling ability 2. I have/My child has increased confidence to cycle 3. I have/My child has increased interest to cycle 4. My/My child's health and fitness has improved 5. I have/My child has better understanding of traffic signs and signal 6. I know/My child knows how to adjudge hazards on the road 7. I have/My child has improved in cycling safety, like wearing a helmet 8. Other, specify:	C, P	Post

Table 3. Summary of coach evaluation.

	First lesson	Second lesson	Third lesson
Course aims	Test children's actual cycling abilities and related knowledge	Teaching and improving cycling techniques	Supervise children to go out on cycling tracks and teach cycling techniques in the real environment
At the start of the lesson	1. 55% able to start off 2. 55% able to correctly brake 3. 75% able to keep in balance on their bicycle	1. 40% able to corner 2. 30% able to ride single-handed	1. 25% able to position their bicycle properly on cycle track
At the end of the lesson	1. 90% able to start off 2. 90% able to correctly brake 3. 100% able to keep in balance while cycling	1. 80% able to corner 2. 60% able to ride single-handed	1. 90% able to position their bicycle properly on cycle track

Note: All percentages based on data from the training program for Group 2 participants (33 children). The lesson plan and coaches' feedback indicate the progress made by children after training in terms of balance, turning, braking and stopping, among many important cycling techniques, with the coaches' guidance.

incorporated, namely to (i) recognize typical traffic hazards and (ii) let other road users know of own presence, adapted to fit trainees who already have a basic ability of cycling on bicycle tracks in Hong Kong. These items were covered in the third lesson, and children had the opportunity to handle a live traffic environment on cycle tracks. For Group 2, the coaches evaluated each child's cycling ability along the first level and applicable portions of the second level of the UK's National Standard learning outcomes for cycling (Bikeability, 2013). Each lesson for the Group 2 participants had specific targeted aims and content, as shown in Table 1, derived with close reference to the Bikeability learning outcomes.

2.3. Measurement procedures

For Group 1, the cycling coaches evaluated every child's ability to attain the learning outcomes before the first lesson, denoted as either "yes, able" or "no, unable". The participants were then taught the correct method for performing the techniques over the course of the three lessons, and at the end of the third lesson, they were assessed again on the same items. The process was the same for Group 2, except there were new targeted aims and content in each of the three lessons, and the coaches' assessments were made before and after each lesson.

Children (with teacher assistance as necessary) and their parents (self-administered) completed questionnaire surveys before the start of the training program and approximately four weeks after the program's completion. The questionnaires were developed with close reference to professional knowledge and advice from the cycling coaches. The questionnaire obtained perceptions of the techniques, skills and knowledge taught during the cycling training program. Respondents were also asked about other perceptions of cycling, including whether cyclists are a road hazard, the efficacy of cycling training programs in protecting the safety of cyclists and other road users, and also the self-perceived gain(s) of participating in cycling training. Confidence ratings for the child cycling in different scenarios were given by both the children themselves and their parents. The change in cycling frequency after the completion of training was also collected. Socio-demographic characteristics and relevant travel behavior was collected before training. The details of the questionnaire items and response categories are provided in Table 2.

2.4. Analysis of data

Given the sample size and exploratory nature of this study, the data analysis method for illustrating the results of the children's progression in the cycling training programs is primarily descriptive. The number of participants who had attained each assessed item was totaled and translated into a percentage for presentation in a table (as shown in the next section). Regarding the questionnaires, demographic characteristics and baseline data were analyzed using descriptive statistics. Crosstabs were used to gain an overview of the differences in categorical variables between groups, and these differences were further examined using the binomial test and Pearson's chi-squared test. These two tests have had wide applications in the transportation and activity-travel behavior literature (de Geus et al., 2008; Gamberini et al., 2013; Hadayeghi et al., 2007; Harms & Brookhuis, 2016). Differences in continuous variables between groups were compared using independent samples *t*-tests and Mann–Whitney U-tests, accounting for skewness (within ±2), excess kurtosis (within ±2) and Levene's test statistics ($p>.05$) in determining whether variables were parametric and of equal variance (McCrum-Gardner, 2008).

3. Results

In this section, the evaluation of children's performance and progression throughout the cycling training program by the professional coaches is described for the 31 primary school and 21 secondary school participants (32 boys and 20 girls). This is followed by results from the questionnaire survey for 11 and 22 child–parent, before-after matched-pairs for Groups 1 and 2 respectively, including descriptions of (i) basic characteristics of the sample, (ii) how children and their parents perceive cycling and cycling training and (iii) whether cycling habits have changed after cycling training and the relevant factors associated with these changes.

Table 4. Descriptive statistics of participating children and their parents.

Descriptors for participating children and their parents		Group 1 (introductory)	Group 2 (advanced)	Total
Child	No. participants	11	22	33
	Mean age	10.6	11.9	11.5
	Boy	45.5%	63.6%	57.6%
	Owns a bicycle	30.0%	76.2%	61.3%
	Occasionally or never goes out alone	45.5%	36.4%	39.4%
	Cycling frequency			
	Once a week or less	100.0%	81.8%	78.8%
	Never	*63.6%*	*0.0%*	*21.2%*
	Main purpose of past five cycling trips (of those who cycle)			
	Play	50.0%	54.5%	53.8%
	Health	50.0%	31.8%	34.6%
	To school	0.0%	9.1%	7.7%
	Travel mode to school			
	Walk	27.3%	45.5%	39.4%
	Public transport	54.5%	40.9%	45.5%
	Other	18.2%	13.6%	15.2%
Parent	Father	18.2%	27.3%	24.2%
	Owns a bicycle	18.2%	40.9%	33.3%
	Knows how to cycle	81.8%	85.7%	84.4%
	Cycling frequency			
	Once a week or less	100.0%	100.0%	100.0%
	Never	*45.5%*	*19.0%*	*28.1%*
	Main purpose of past five cycling trips (of those who cycle)			
	Leisure	83.3%	83.3%	83.3%

3.1. Professional cycling coaches' evaluation of children participating in the cycling training

This section summarizes the professional cycling coaches' evaluation of each participant's cycling ability throughout the training programs. After the three sessions for Group 1 participants, 85% of the children achieved the training goals for novices, namely to (i) to perform a bike check, and (ii) to start, ride in balance and stop on a bicycle. The cycling coaches had an opportunity during the final session to supervise these novice-level children to go out on cycle tracks to experience what cycling is like outside of the school playground. This was not part of the coaches' assessment.

For Group 2, there were more training goals to achieve. Even in Group 2, many children were unable to start off properly, though many of them could stay in balance and keep going after starting off. After the first lesson, proper starting off was achieved by most participants. The more advanced cycling techniques such as rounding corners and riding single-handed taught in the second lesson were only attained by around two thirds of the trainees. In the third lesson, where children had the opportunity to go out on cycle tracks and ride inside the school's neighborhood, proper bicycle positioning on the cycle track was weak at the start, but this improved considerably after the 90-minute supervised session. The attainment of training goals before and after each lesson for Group 2 participants is shown in Table 3.

The findings here clearly illustrate the efficacy of this cycling training program in improving cycling techniques and skills, in line with Ducheyne et al. (2013a, 2014) and Telfer et al. (2006). This validates the linkage in the conceptual framework between participation in cycling training and the improvement in cycling ability, fulfilling the first aim of this study.

3.2. Description of questionnaire survey respondents

Descriptive statistics of the questionnaire survey respondents are shown in Table 4. The sample shows a sizeable divide between Group 1 and Group 2 of the cycling training program, whether for the children themselves, or their parents. More Group 2 participants were boys, owned a bicycle themselves, had greater independent mobility in going out alone and cycled more frequently, compared to Group 1. Cycling purpose of Group 2 participants was generally for fun and play, and they were also more active in terms of their travel to school, though none in either group reported their primary travel mode to school as cycling. Parents who answered the parent questionnaire of Group 2 participants were more likely to be the father, own a bicycle, know how to cycle and cycle more frequently, in comparison with parents of the novices. No parent cycled more than once a week overall, and cycling purpose was primarily for leisure. Presentation of the baseline characteristics of the survey respondents better informs readers about the backgrounds of the cycling training participants and their parents, and also provides information for the linkage between socio-demographic characteristics and cycling training participation in the conceptual framework.

3.3. General perceptions of cycling and cycling training before and after the cycling training program

Perceived safety of cycling for cyclists themselves or for other road users was low. Children and their parents alike elaborated about various concerns relating to traffic danger: (i) other road users must often swerve to avoid cyclists, increasing accident occurrence; (ii) cyclists are difficult to see on the road and are slower than cars; (iii) motorists have low awareness of cyclists on the road; and (iv)

Table 5. Children's and parents' perceptions of cyclists and cycling training.

		Child's view			Parent's view		
Description of perception		Before training	After training	*p* value*	Before child's training	After child's training	*p* value*
Cyclists are a threat to other road users' safety	Yes	39.4%	27.3%	.412	64.5%	59.4%	.069
	Maybe	51.5%	66.7%		22.6%	37.5%	
	No	9.1%	6.1%		12.9%	3.1%	
Cycling training can improve safety of cyclists	Yes	54.8%	56.3%	.350	69.7%	75.0%	.626
	Maybe	41.9%	43.8%		27.3%	21.9%	
	No	3.2%	0.0%		3.0%	3.1%	
Cycling training can improve safety of other road users	Yes	54.5%	43.8%	.047	66.7%	62.5%	.253
	Maybe	36.4%	56.3%		30.3%	31.3%	
	No	9.1%	0.0%		3.0%	6.3%	

*All *p* values calculated by performing binomial tests on the observed proportion of "yes" and "maybe" respondents combined after training compared with the same proportion before training for the descriptions.

motorists are unsure of cyclists' riding ability, in line with conclusions from previous literature (Hopkins & Mandic, 2017; Kaplan & Prato, 2016; Kaplan et al., 2019). Table 5 provides the proportions of "yes", "maybe" and "no" responses of children's and parents' perceptions on cycling and cycling training, and also the results of a binomial test comparing the observed proportion of "yes" and "maybe" responses combined, before and after training. It is apparent that whether before or after their children's training, more parents perceived cycling on the road to be a threat to other road users' safety, at 65% and 59%, respectively, than children, at 39% and 27%, respectively. Notably for both groups, the "maybe" respondents increased after participation in the cycling training. However, the binomial test did not find a statistically significant change in the children's nor parents' perceptions for this item.

Considering that around 80% of parents remarked that they felt judging risks on the road to be an important and difficult skill for children (and over two-thirds feeling their child was lacking in this skill), parents readily felt that cycling training would help to protect cyclists' safety, with "yes" respondents standing at 70%–75% in the before and after questionnaires. For children, this same figure was around 55% for both questionnaires. Results of the binomial tests indicated that there were no significant changes in this perception item after participation in the cycling training compared with before, for both children and their parents.

While most children considered the cycling techniques of braking to be important (over 90%), and signaling to be difficult and lacking in themselves (over three quarters), they did not link participation in cycling training with cyclists' safety. For the helpfulness of cycling training in protecting other road users' safety, the proportion of "yes", "maybe" and "no" responses from parents were relatively similar before and after cycling training at 63%–67%, 30%–31% and 3%–6%, respectively, and the binomial test showed no statistical significance. In child cyclists, however, the combined "yes" and "maybe" responses increased from 91% before to 100% after participation in cycling training, and the binomial test for this perception item was statistically significant at the $p<.05$ level. In this respect, participation in cycling training does appear to have shifted children's perceptions, who now all grasp the importance of cycling training in safeguarding other road users like pedestrians, drivers and vehicle passengers.

The above discussion achieves the second aim of the study in terms of understanding the general perceptions toward cycling and cycling training of children and their parents, and also addresses the linkage in the conceptual framework between participation in cycling training with changes in perceptions. Regarding the linkage between perceptions in cycling and cycling training with change in cycling frequency, the trends were not dissimilar with the overall results, although the children who reported cycling more did appear to be less certain in their perceptions (more "maybes"), while parents held steadfast in their belief that cycling training would be able to protect cyclists' and other road users' safety regardless of whether their child reported cycling more or not.

3.4. Factors associated with cycling more after completion of cycling training

After completing cycling training, 24% of the participating children reported cycling more (in terms of frequency and/or duration). Percentage comparisons for various socio-demographic characteristics are shown in Figure 2. Statistically significant differences were seen for training level, where 45% of Group 1 (introductory) participants cycled more, but only 14% of Group 2 (advanced) participants reported the same ($\chi^2=4.04$, $p=.044$). Also statistically significant was original cycling frequency: of those who had never cycled prior to training, 57% of cycled more after the training program, while for those with some prior cycling experience, only 15% cycled more ($\chi^2=5.24$, $p=.022$). This indicates that those who cycled more after the completion of the training program were more likely to be novices with no previous cycling experience. Other measures, such as those for age, gender, independent and active mobility etc., can be similarly interpreted. None had a discrepancy as large as the two variables aforementioned, and indeed, testing using the Pearson's chi-squared statistic revealed no significant relationships for these variables ($p>.05$). These findings address the linkage in the conceptual framework between the child and parent socio-demographic characteristics with the likelihood of cycling more.

Perceived improvements in cycling ability and confidence are shown in Figure 3. Overall, 73% of children mentioned improvement in cycling ability as one of the important things gained from participating in the cycling training

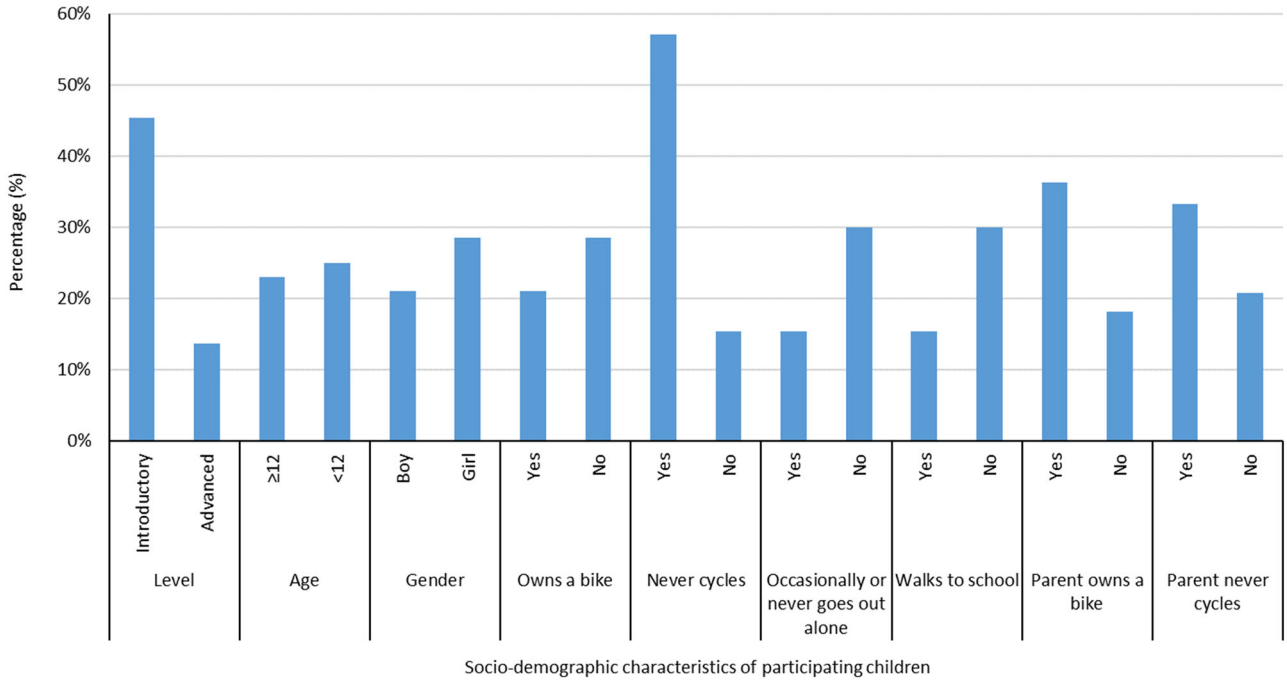

Figure 2. Comparison of socio-demographic characteristics of children who cycled more after participation in cycling training.

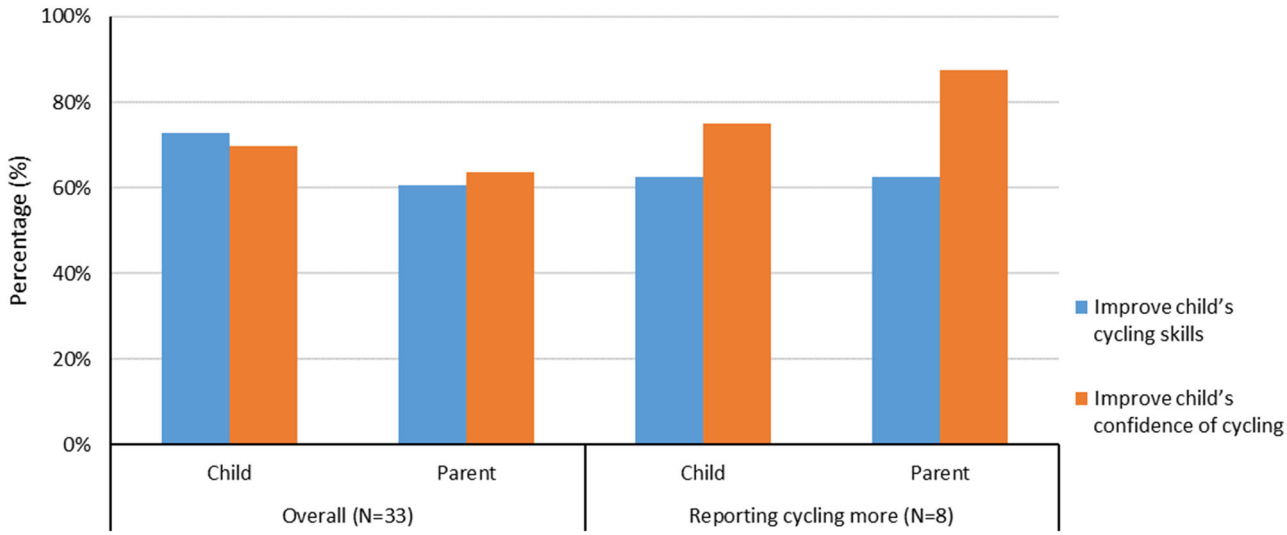

Figure 3. Evaluation of training about improvements in cycling skills and confidence.

program, and 61% of parents agreed. 70% of children acknowledged that participating in cycling training improved their confidence, while 64% of parents concurred. In particular, for children cycling more, there was a greater perception of improvement in the child's confidence to cycle among both children (75%) and parents (88%) than improvement in cycling ability (both 63%). In summary, the benefit of participation in cycling training not only allows children to cycle to improve on their techniques and skills, but also provides children especially at the introductory level with the confidence to start cycling, which is consistent with the discussion in the above paragraph. This discussion also corresponds well with Goodman et al.'s (2016) notion that the relationship between participation in cycling training and cycling behavior change can be interpreted in multifaceted ways, addressing the linkages between increases in cycling frequency with improvement in cycling ability and confidence to cycle.

To go further into the notion of confidence in the child cycling, Table 6 shows the discrepancies in perceptions of children and their parents, especially with on-road cycling and cycling to school. Parents were concerned about their child's safety foremost, and were unconfident about allowing their child to cycle on the road even after cycling training. While cycling in general and cycling on bicycle tracks received relatively positive responses from parents, cycling to school received a low average score. No children changed their primary travel mode to school to cycling. Children who reported cycling more after training were more confident to cycle in the different situations listed, particularly cycling on the road and to school, which were significant to the $p<.01$ and $p<.05$ levels, respectively. This was contrasted

Table 6. Confidence to cycle/let their child cycle in different situations after cycling training.

		Overall[a]	Reporting cycling more[a]	Reporting no change[a]	*t*-statistic*	df	*p* value
Child	Confident to cycle	4.29 ± 0.73	4.38 ± 0.70	4.26 ± 0.74	−0.43	31	.669
	Confident to cycle on cycle tracks	4.29 ± 0.77	4.50 ± 0.50	4.22 ± 0.83	−0.78	30	.442
	Confident to cycle on the road	3.42 ± 1.34	4.38 ± 0.48	3.09 ± 1.38	−3.84	30	.001
	Confident to cycle on routes with cycle tracks and roads	3.42 ± 1.07	4.00 ± 0.71	3.22 ± 1.10	−1.88	30	.07
	Confident to cycle to school	3.74 ± 1.16	4.50 ± 0.71	3.48 ± 1.17	−2.24	29	.033
Parent	Confident to let the child to cycle	4.09 ± 0.95	3.63 ± 1.22	4.25 ± 0.78	1.64	31	.111
	Confident to let the child to cycle on cycle tracks	4.06 ± 0.90	3.50 ± 1.12	4.25 ± 0.72	59.5[b]	/	.068
	Confident to let the child to cycle on the road	2.50 ± 1.12	2.38 ± 1.22	2.54 ± 1.08	0.22	31	.826
	Confident to let the child to cycle on routes with cycle tracks and roads	3.25 ± 1.00	3.13 ± 1.17	3.29 ± 0.93	0.4	30	.695
	Confident to let the child to cycle to school	3.16 ± 1.28	3.00 ± 1.41	3.21 ± 1.22	0.39	30	.701

[a]These are mean scores, with a higher score indicating higher reported confidence. The score ranges from 1 to 5, and a score of 3 suggests "neutral". The standard deviation is also provided.
[b]This variable was not normally distributed and was tested non-parametrically using the Mann–Whitney U-test instead. The Mann–Whitney U-statistic is given here.
*The independent samples *t*-test was used, unless otherwise specified, with *t*-statistic, degrees of freedom and *p*-value provided.

by the parents' perceptions, where the relationship contradicted that of the children's. Children who reported cycling more do not seem to have parents more confident of their child's ability to cycle in the different situations. These findings are in line with those in the paragraphs above, in that children who reported cycling more were the ones who increased in confidence to cycle, but not necessarily the most skillful. This completes the linkage in the conceptual framework between the confidence in the child cycling (from the parents' perspective) with the change in cycling frequency.

Together, the above findings help to accomplish the third aim of the study in understanding the relationship between changes in cycling frequency with (i) socio-demographic characteristics, (ii) overall self-perceived improvement in cycling skills, (iii) post-training confidence ratings and (iv) perceptions of cycling and cycling training, of children and their parents. The factors and linkages in the conceptual framework have thus all been explained in this results section. The following section discusses the findings and their implications for future research efforts and cycling policy towards children.

4. Discussion

This study examined (i) children's progression in cycling ability through a short-term cycling training program designed for cyclists at different ability levels, (ii) children's and their parents' confidence and perceptions related to cycling before and after the cycling training program and (iii) whether and why children's frequency of cycling changed after the cycling training program. Generally, children in Group 1 still need further training before being able to safely ride on their bicycles in a live traffic environment without assistance. These participants were the most enthusiastic to cycle more after training, because many of them had no prior cycling experience. Parents would naturally harbor safety concerns, and while children more self-confident with their own cycling abilities did go ahead to cycle more, children cycling more seemed to have some connection with parents being unconfident in their children's abilities, which differs from previous findings (Trapp et al., 2011; Willis et al., 2015). This seems counterintuitive, but it is plausible that children may have been accompanied during their increased cycling episodes, e.g. in enclosed cycling parks, where parental concerns about cycling safety can be alleviated, allowing children, especially novices, to practice their newly learnt cycling techniques and skills. It may also be to do with the variant aims of participation in cycling training, namely to increase in confidence for novices and to improve in cycling ability for those who already know how to cycle (Goodman et al., 2016). Those who increased in cycling frequency, mainly novices, cannot be expected to improve their abilities significantly after a short-term training program, and it would thus be sensible that parents of the novices remain unconfident in their child's abilities. Not owning a bicycle was cited numerous times as a reason for not cycling more, but the similar proportions for cycling more and not cycling more indicates that perhaps some children owning bicycles did not use it more than before training. With the introduction of bike-sharing systems in Hong Kong (Sun, 2017), and some with family-friendly children's bikes (Hoba Bike, 2018), bicycle ownership may become more of a moot point in future.

For Group 2 participants, they may already participate in some cycling for fun and play, and the cycling training program has perhaps represented an opportunity to equip themselves with the appropriate cycling techniques and skills, but not an incentive to cycle more than they already do. Although all Group 2 participants claimed to know how to cycle, some only completed the basic cycling techniques taught in the first lesson with considerable difficulty. This only gradually improved with the guidance of the professional cycling coaches. Before training, few children could confidently ride single-handed or look backwards while riding, two cycling techniques that are vital for riding in a real-life traffic environment. Children's claims of knowing how to cycle seem to be based primarily on their ability to cycle in balance only, but not other important techniques and skills that enable full control over the bicycle. Participation in these cycling training sessions has enabled them to understand the importance of being able to handle real-time traffic on cycle tracks, at crossings and at intersections, and ultimately improve their cycling abilities, as shown in the professional cycling coaches' evaluation.

Overall, in terms of efficacy of the cycling training programs, children perceived cyclists as less of a "threat" to

other road users after the training program compared with their own and their parents' perceptions prior to training, and viewed cycling training as helpful to protect cyclists' and other road users' safety. Parents strongly agreed that on-road cycling would pose a safety hazard to other road users, and they were also highly confident that cycling training would help to improve the safety of cyclists, though less so of other road users. These findings shed light into how children and their parents perceive cycling and cycling training, pointing toward the important notion of road safety as a joint responsibility of all road users, cyclists and motorists alike. Improvements in children's cycling safety would logically require cycling training with more practice to build up experience to better judge live traffic environments, and appropriate government policies that enable and encourage active travel through improvements to cycling infrastructure and active travel campaigns. This discussion echoes those of Spence (2003, p. 694), who described the importance of cycling training as a "final ingredient" for improvement in cycling safety, in conjunction with maintenance of safe routes to and from school. Ultimately, although there was an increase in cycling frequency overall, the fact that no children changed their school travel mode to cycling indicates that the promotion of cycling as a safe and healthy mode of transportation clearly still has a long way to go, at least until when cycling on urban roads becomes more common (Loo & Tsui, 2010; Yao & Loo, 2016). Given the evidence of positive feedback between increased bicycle use and improved attitudes toward cycling (e.g. Thigpen, 2019), wider implementation of cycling training would be a proactive and feasible way forward to promote cycling, in conjunction with further improvements in the safety of neighborhood environments.

The training period for participating children, at 4.5 h per child, was quite short-term. Future research may seek to arrange and investigate cycling training programs that run for a longer period. For comparison, the Bikeability program at Levels 1 and 2, organized by the Kingston Borough Council in London, runs for 10 h (Kingston Council, 2018). Although the exploratory nature of this study means that findings and generalizability of this study need to be interpreted with care, there are cultural similarities in the East Asian Confucian-influenced parenting style (Lim, 2012) as well as environmental similarities in terms of high-density developments (Barter, 2012) that enable useful comparisons within the East Asian context. The implications from this study represent an opportunity to further understand cycling training programs in East Asia, and how they can be used to first promote cycling for leisure and recreation in a place where cycling is still only a minor travel mode. As the first study to discuss cycling training in Hong Kong, it sets the scene for further research related to cycling training programs in the city, in the region and beyond. While all linkages in the conceptual framework were addressed and explained in descriptive terms for this study, there is an opportunity for educators, policymakers and researchers alike to investigate cycling training programs that run district- or town-wide, to gather a larger sample and cater for more children across more diverse socioeconomic backgrounds, such as Mandic et al. (2018a, 2018b), and go further in more rigorous statistical analyses. A larger study would also account for differences in cycling training efficacy for children versus adolescents. Longitudinal studies may also be helpful when considering the long-term effects of participation in cycling training, in understanding whether the changed habits and improved cycling abilities persist over time, such as that of Ducheyne et al. (2014).

To implement further change in the Hong Kong context, there may need to be a redefinition of what it means to know how to cycle. A proper gauge for whether one knows how to ride a bicycle is important, to enable more people to understand that learning to cycle is not just to learn traffic rules, and that knowing how to cycle should not only be about being able to keep in balance. The focus of cycling education needs to shift towards educating children by engaging them in actual practice with professional cycling coaches out-of-classroom in cycling training programs. It is also important for there to be sufficient professional cycling coaches to teach children and the wider public how to cycle and cycle safely. Chinese culture seems to ordain parents to be more protective of their children, unlike Western parents (Karsten, 2015; Lam & Loo, 2014), which shows that it is all the more important that cycling education is implemented, to convince parents that the ability and safety of child cyclists can be improved (Spence, 2003). School-based cycling training is a realistic prospect that is supported by children and their parents alike. Proactive support from schools would facilitate the process, especially for small-scale and short-term training programs, which require limited financial input. To go further in promoting cycling, however, favorable government policies with financial support are needed to encourage more schools to implement these programs (e.g. in Hong Kong, for schools in the New Territories that have sufficient cycle tracks and parks nearby). The changing of cycling perceptions and habits need to go hand in hand with improvements of the neighborhood environment and cycling infrastructure, in terms of both quantity and quality (Aldred et al., 2019; Braun et al., 2016; De Vos et al., 2019; Lee et al., 2016; Ohlms & Kweon, 2018; Scheepers et al., 2014). If city governments play a leading role here to implement these changes, in promoting cycling training and improving neighborhood environments for active travel, cycling may start to become an increasingly safe and viable option for all city dwellers in earnest.

5. Conclusion

This study has investigated whether children's participation in short-term, school-based cycling training programs can promote cycling for schoolchildren in high-density cities, in terms of changes in cycling ability, perceptions, confidence and habits for Hong Kong schoolchildren. The children showed improvements in their cycling ability with the progression of each training session. After the training, fewer children perceived cyclists on the road to be a threat to other road users, and all of the children agreed that cycling

training may enhance cyclists' and other road users' safety. Parents generally held the notions of cycling on the road posing as a clear hazard to other road users, and believed that cycling training would be able to improve the safety of cyclists and other road users. After participation in cycling training, some children have begun to cycle more, which is a positive sign. More action is required to promote safe cycling as an activity not only for recreation, but also beyond, as a sustainable transport mode for school and work commutes. Cycling training programs have an important role to play in the further development of cycling in Hong Kong, East Asia and beyond.

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