Journal of Transport & Health 4 (2017) 294–304

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

Adolescents' perceptions of cycling versus walking to school: Understanding the New Zealand context

Sandra Mandic [a,*], Debbie Hopkins [b], Enrique García Bengoechea [c], Charlotte Flaherty [d], John Williams [e], Leiana Sloane [a], Antoni Moore [f], John C. Spence [g]

[a] Active Living Laboratory, School of Physical Education, Sport and Exercise Sciences, University of Otago, Dunedin, New Zealand
[b] Transport Studies Unit, School of Geography and the Environment, University of Oxford, United Kingdom
[c] Participatory Research at McGill, Department of Family Medicine, McGill University, Montreal, Canada
[d] Dunedin City Council, Dunedin, New Zealand
[e] Department of Marketing, University of Otago, Dunedin, New Zealand
[f] School of Surveying, University of Otago, Dunedin, New Zealand
[g] Faculty of Physical Education and Recreation, University of Alberta, Edmonton, Canada

ARTICLE INFO

Article history:
Received 20 August 2016
Received in revised form
18 October 2016
Accepted 22 October 2016
Available online 2 November 2016

Keywords:
Adolescent
Physical activity
Active transportation
Walking
Cycling
Theory of planned behaviour

ABSTRACT

Background: Cycling to school is less common than walking in many developed countries. This cross-sectional study compared correlates and perceptions of walking versus cycling to school in Dunedin adolescents living ≤ 4 km from school.
Methods: Adolescents (n = 764; 44.6% males; 15.2 ± 1.4 years) from 12 secondary schools completed an online survey about perceptions of walking and cycling to school. Distance to school was calculated using Geographic Information Systems network analysis.
Results: Overall, 50.8% of adolescents walked and 2.1% cycled to school, 44.1% liked cycling for recreation and 58.8% were capable/able/confident to cycle to school. Adolescents expressed more positive experiential (walking: 45.9%; cycling: 34.9%) and instrumental beliefs (walking: 74.2%; cycling: 59.2%) towards walking versus cycling to school ($p < 0.001$). Compared to walking, adolescents reported that cycling to school was perceived as less safe by themselves (cycling vs walking; 61.3% vs 89.8%) and their parents (71.4% vs 88.6%) and was less encouraged by their parents (23.0% vs 67.0%), peers (18.8% vs 48.4%) and schools (19.5% vs 30.8%) (all $p < 0.001$). The route to school had fewer cycle paths compared to footpaths (37.2% vs 91.0%; $p < 0.001$). Cycle friendly uniforms (41.4%), safer bicycle storage at school (40.1%), slower traffic (36.4%), bus bicycle racks (26.2%) and bicycle ownership (32.7%) would encourage cycling to school.
Conclusions: Compared to walking, cycling to school among Dunedin adolescents was less common, perceived as less safe and had less social and infrastructure support. Future interventions should focus on creating supportive physical and social environments, and improving road safety for cyclists in New Zealand.

* Correspondence to: School of Physical Education, Sport and Exercise Sciences, University of Otago, PO Box 56, Dunedin, New Zealand.
E-mail addresses: sandra.mandic@otago.ac.nz (S. Mandic), debbie.hopkins@ouce.ox.ac.uk (D. Hopkins), enrique.garcia@mail.mcgill.ca (E.o.s. García Bengoechea), charlotte.flaherty@dcc.govt.nz (C. Flaherty), john.williams@otago.ac.nz (J. Williams), sloaneleiana@gmail.com (L. Sloane), tony.moore@otago.ac.nz (A. Moore), jc.spence@ualberta.ca (J.C. Spence).

http://dx.doi.org/10.1016/j.jth.2016.10.007
2214-1405/

1. Introduction

Public health goals of increased physical activity and societal interest in alternatives to automobile transportation place a focus on active modes of transport such as walking and cycling. In addition, the need to transition away from motorised transport, particularly the private car, has been publicized as an important way to reduce transport-related greenhouse gas emissions (Sims et al., 2014). Transport mode choice is one of the most environmentally-significant decisions made by individuals (Collins and Chambers, 2005), and addressing high-carbon personal transport represents a key opportunity to mitigate climate change.

Though walking is a popular form of active transport to school, cycling to school is less common among adolescents in many developed countries including United States (McDonald, 2007), Canada (Larsen et al., 2009), Spain (Chillon et al., 2009), Ireland (Murtagh et al., 2016), Australia (Leslie et al., 2010) and New Zealand (Mandic et al., 2015). In contrast, countries with long cycling traditions, comprehensive cycling-friendly infrastructure and flat landscape such as Belgium (Van Dyck et al., 2010) and Denmark (Cooper et al., 2006) have higher rates of cycling versus walking to school among adolescents. In New Zealand, rates of walking to school in adolescents have remained relatively stable (26% in 1989/1990; 28% in 2010–2014) while the rates of cycling to secondary school have declined from 19% in 1989/1990 to 3% in 2010–2014 (Ministry of Transport, 2015).

Correlates of active transport to school in children and adolescents include demographic characteristics, individual and family factors, school factors, and social and physical environmental factors (Davison et al., 2008; Panter et al., 2008; Pont et al., 2009; Wong et al., 2011) Most previous studies either examined perceived barriers to walking and cycling to school together or focused on walking (Lu et al., 2014). Walking and cycling are different behaviours with distinct characteristics (Krizek et al., 2009) and therefore correlates of those behaviours are also likely to differ (Lu et al., 2014; Schlossberg et al., 2006). Compared to walking, cycling is faster, covers greater distances, requires more physical skills, demands more specific built environment characteristics, and has more prominent traffic safety concerns (Krizek et al., 2009). In addition, built environment characteristics that predict walking to school in children may not predict cycling (Schlossberg et al., 2006). For children, cycling to school is positively associated with high levels of independent mobility (Ducheyne et al., 2012), preference to cycle (Trapp et al., 2011), parental confidence in their child's cycling skills (Ducheyne et al., 2012; Trapp et al., 2011), peer and parental support (Ducheyne et al., 2012), and neighbourhood traffic safety (Ducheyne et al., 2012), and negatively associated with perceived convenience of driving children to school (Trapp et al., 2011).

Low rates of cycling to school reported in New Zealand adolescents (Mandic et al., 2015; Ministry of Transport, 2015) may be context-specific and related to the local cycling culture, social norms, non-supportive physical environments and the weather. The city of Dunedin (population: 130,000) is located on the South Island of New Zealand, has a maritime climate with cool and wet weather and diverse topographical landscape with the city centre being surrounded by hills. Coupled with New Zealand's high rates of bicycle-related accidents in adolescents (Tin et al., 2010), nation-wide high rates of private vehicle ownership per capita (The World Bank, 2014), school uniform requirements and lack of school enrolment schemes in Dunedin, these characteristics represent a challenge for promoting active transport to school, and particularly cycling, in this city. Previous studies in adolescents highlighted the importance of social support for active transport (Leslie et al., 2010; Carver et al., 2010) and specifically for cycling (Ducheyne et al., 2012) to school, with a distance of up to 4 km (2.5 miles) being reasonable for adolescents' cycling to school (Nelson et al., 2008). Therefore, this cross-sectional study compared perceptions of walking versus cycling to school drawing from the theory of planned behaviour and additional individual, environmental and safety factors among adolescents from Dunedin who lived within 4 km from school.

2. Materials and methods

2.1. Participants

Between February 2014 and April 2015, 1780 adolescents (13 to 18 years of age) from all 12 secondary schools in Dunedin, New Zealand, participated in the Built Environment and Active Transport to School (BEATS) Study (Mandic et al., 2015; Mandic et al., 2016). Participants with invalid surveys (n=38), incomplete student consents (n=20), lacking parental consent (n=59), missing survey data (n=48), boarders (n=162), missing distance to school data (n=11), and living >4 km from school (n=668) were excluded from the analysis, resulting in a final usable sample size of 774 adolescents.

2.2. Procedures

Recruitment procedures have been described in detail elsewhere (Mandic et al., 2016). Briefly, adolescents were recruited through schools and completed the online survey during class time under researcher assistants' supervision. All adolescents signed consent for taking part in the study. For those under 16 years of age, parents signed either parental opt-out or parental opt-in consent based on the school's preference. The study was approved by the University of Otago Ethics Committee.

2.3. Assessments

2.3.1. Questionnaire

The survey included questions about sociodemographic characteristics (age, gender, ethnicity, school, home address, home resources) travel to school habits, perceptions of walking and cycling to school and enablers of cycling to school. Response validity was strengthened by the fact that research assistants were present as participants completed the survey and were monitoring the manner in which participants responded. As a result, 38 invalid surveys were removed from the final sample.

2.3.2. Sociodemographic characteristics

Age was calculated from date of birth at the time of the survey. Home address data were used to determine New Zealand Index of Deprivation (a neighbourhood area deprivation score) as a surrogate for students' socioeconomic status (Salmond et al., 2006). The deprivation index was recoded from the original 10-point scale (1=least deprived to 10=most deprived) into five categories: lowest (1–2), middle-low (3–4), middle (5–6), middle-high (7–8) and highest (9–10) deprivation score. Adolescents also reported the number of bicycles and vehicles at home and whether they had a waterproof raincoat. Distance from home to school was determined using the Geographic Information Systems network analysis, based on geocoded addresses (Mandic et al., 2016).

2.3.3. Travel to school habits

Transport to school (*"How do you usually travel to school?"*) was assessed for different transport modes with response categories *"never"*, *"rarely"*, *"sometimes"*, *"most of the time"* and *"all of the time"*. Dominant modes of transport to school (used "most/all of the time") and multi-modal transport were used to classify adolescents into active transport (walking, cycling, or riding a non-motorised scooter "most/all of the time"), motorised transport or combined motorised and active transport. Adolescents were also asked how often they walked and cycled to school in the previous two weeks ("never", "almost never", "sometimes", "almost every day" or "every day") and to estimate how long would their journey to school take if they walked or cycled to school ("1–5 min", "6–10 min", 11–20 min", "21–30 min", "31+ min" or "I don't know").

2.3.4. Beliefs about walking and cycling to school

Beliefs related to perceptions of walking and cycling to school were informed by the theory of planned behaviour (Ajzen, 1991). Specifically, questions about *attitudes towards walking and cycling, subjective norm, perceived behavioural control (PBC) and behavioural intentions* were measured with standard items and had good internal reliability (Armitage, 2005). Additional items were developed specifically for this study. Survey items have been described in detail elsewhere (Mandic et al., 2016).

Briefly, items assessing *attitudes* towards walking and cycling to school used the stem "For me, regularly walking to school / riding to school by bicycle would be…" rated on a six bipolar (-3 to +3) semantic differential scales, anchored by the adjectives "dull"-"interesting", "unpleasant"-"pleasant", "boring"-"stimulating" for *experiential beliefs* and "unhealthy"-"healthy", "bad"-"good" and "useless"-"useful" for instrumental beliefs (Armitage, 2005). Given the conceptual similarities, individual items for experiential and instrumental beliefs were summed and then averaged to create two composite scores (*experiential beliefs* composite score*:* Cronbach's α=0.87 (walking), 0.95 (cycling); *instrumental beliefs* composite score: Cronbach's α=0.82 (walking), 0.84 (cycling)).

Subjective norm was assessed using the items "My parents/guardians think I… should/should not walk/ride a bicycle to school", "My friends think I… should/should not walk/ride a bicycle to school" and "One or both of my parents/guardians walk/bicycle frequently" (Mandic et al., 2016). Adolescents also reported frequency of walking/cycling with parents and peers and schools' encouragement for walking/cycling to school (Mandic et al., 2016).

The *capability* component of *PBC* for walking and cycling was measured using an item "How confident are you that you could walk/cycle to school?" (*not very confident-very confident)* (Armitage, 2005). Two additional items were used to assess *capability* for cycling: "To what extent do you see yourself as being capable of riding a bicycle to school? (*incapable-capable)*"; and "I believe that I have the ability to ride a bicycle to school" (*definitely do not-definitely do)* (Armitage, 2005). Given the conceptual similarities, the scores for ability/capability/confidence items for cycling to school were summed and then averaged to create a *cycling capability* composite score (Cronbach's α = 0.90).

The *autonomy* component of PBC to walk/cycle to school was measured using an item "How much personal control do you yourself have over whether or not you walk/ride a bicycle to school?" (*no control-complete control*).

Behavioural intentions were measured using two items: "How often do you intend to walk/ride a bicycle to school? (never-frequently), and "I want to regularly walk/ride a bicycle to school (definitely do not-definitely do) (Armitage, 2005).

2.3.5. Incentives and personal barriers for walking and cycling to school

Incentives (getting exercise, opportunity to socialize) and personal barriers (time constraints, need for planning, after-school schedule, too much to carry, sweating, feeling tired and lack of interest/desire to walk/cycle to school) were assessed using separate items for each mode of transport to school using a 4-point Likert scale anchored in "strongly disagree" (1) and "strongly agree" (4). Personal barriers were also combined into a composite score (Cronbach's α = 0.85, and 0.84 for walking and cycling, respectively; all corrected item-total correlations greater or equal than 0.53).

2.3.6. Environmental barriers and safety

Environmental barriers (distance, lack of footpaths/bike lanes, and weather) and safety perceptions (adolescents' and parental perceptions) related to walking and cycling to school were assessed using separate items for each mode of transport to school. All items were assessed using a 4-point Likert scale anchored in "strongly disagree" (1) and "strongly agree" (4).

2.3.7. Route to school

Route to school (hills, insufficient lighting, too much traffic, dangerous crossing(s), boring route) and convenience of being driven to school were assessed for walking and cycling together using a 4-point Likert scale with response options ranging from "strongly disagree" (1) to "strongly agree" (4).

2.3.8. Enablers of cycling to school

Factors that would encourage cycling to school were examined using a statement *"I would cycle to school more often if…"* focusing on speed of traffic (*"if the traffic on the road(s) was slower"*), availability of bus bike racks (*"if buses had bike racks free of charge"*), safer bike storage at school (*"if there were safer places to lock up my bike at school")*, lockers for storing belongings at school (*"if I had a locker at school for storing my things"*), cycle friendly uniform (*"if I had a cycle-friendly uniform"*), cycling without a helmet (*"if I was allowed to cycle without a helmet"*) and bike ownership (*"if I owned a bike"*). These items were assessed using a 4-point Likert scale anchored in "strongly disagree" (1) and "strongly agree" (4).

2.4. Data analysis

Variables assessing perceptions of walking versus cycling using 4-point or 7-point Likert scales were analysed as continuous variables using paired t-tests. For those items, data are reported as both mean $\pm$ SD and frequency (%) of adolescents agreeing with each statement. To calculate the proportion of adolescents agreeing with each statement, 4-point Likert scale items were also recoded into "disagree" and "agree" and 7-point Likert scale items were recoded as "disagree", "neutral" or "agree". Data analysis was performed using SPSS Statistical Package (Version 22). To account for multiple tests, a p-value of < 0.001 was chosen to indicate statistical significance.

3. Results

3.1. Sociodemographic characteristics

Among 764 adolescents surveyed (age: 15.2 $\pm$ 1.4 years; 44.6% males), 71.8% had at least one bicycle available for their use and 61.0% had two or more vehicles at home (Table 1). Average distance to school was 1.9 $\pm$ 1.0 km (Table 1). Adolescents' estimates revealed that 51.7% could walk and 58.8% could cycle to school within 20 min and 29.3% did not know the estimated time to cycle to school (Table 2).

3.2. Transport to school habits

Common modes of transport to school were being driven in a car and walking, whereas only 2.1% cycled to school (Table 1). Overall, 44.0% of adolescents used active transport, 42.4% motorised transport and 13.6% combined motorised and active transport. The rates of active transport to school did not differ by gender (males: 45.0%, females: 43.1%; $p=0.050$), age (42.5%, 41.8%, 53.1%, 42.1%, 40.4%, 38.5% for age 13 to 18 years, respectively; $p=.129$), ethnicity (New Zealand European: 43.6%, Māori: 45.1%, other: 44.9%; $p=.142$) or socioeconomic status (41.3%, 43.2%, 42.1%, 49.7% and 45.7% for quintiles of neighbourhood deprivation scores from quintile 1 (least deprived) to quintile 5 (most deprived), respectively; $p=.389$). In the previous two weeks, 48.7% of adolescents walked and 1.9% cycled to school on most days (Table 2). The rates of active transport to school ranged from 19.2% to 59.1% per school (Fig. 1).

3.3. Route to school

Approximately one third of adolescents reported too much traffic (36.0%), dangerous crossing(s) (32.9%), too many hills (33.4%) and boring route (33.0%) for walking or cycling to school. Poor lighting (12.2%) and stray dogs (6.9%) were less common. More than half of adolescents (52.9%) found being driven to school convenient.

3.4. Attitudes, social norm, perceived behavioural control and behavioural intentions

On average, adolescents had more positive experiential and instrumental beliefs towards walking compared to cycling to school (Table 3). One third of adolescents perceived that cycling to school was not cool (Table 3). Adolescents received significantly less parental, peer and school support and less parental role modelling for cycling versus walking to school (Table 3). In addition, 16.3% and 21.0% of adolescents often cycled with friends or parents, respectively. Intention and

Table 1
Sociodemographic characteristics and travel to school habits.

	Study sample n = 764
Age (years)	15.2 ± 1.4
Gender [n(%)]	
Males	341 (44.6)
Females	423 (55.4)
School year [n(%)]	
Year 9	258 (33.8)
Year 10	162 (21.2)
Year 11	141 (18.5)
Year 12	107 (14.0)
Year 13	96 (12.6)
Ethnicity [n(%)]	
New Zealand European	556 (72.8)
Māori	71 (9.3)
Other	137 (17.9)
Neighbourhood deprivation score [n(%)]	
1 (least deprived)	184 (24.3)
2	162 (21.4)
3	173 (22.9)
4	143 (18.9)
5 (most deprived)	94 (12.4)
Distance to school (km)	1.9 ± 1.0
Usual transport modes to school [n(%)]	
By car (driven by others)	292 (38.2)
By car (driving myself)	28 (3.7)
By school bus	24 (3.1)
By public transport	21 (2.7)
On foot	388 (50.8)
By bike	16 (2.1)
Other	18 (2.4)
Active and motorised transport to school [n(%)]	
Active transport	334 (43.3)
Motorised transport	335 (43.4)
Combination of active and motorised transport	103 (13.3)
Number of bicycles available to use to get to school (n)	
None	215 (28.1)
One	157 (20.5)
Two or more	392 (51.3)
Number of vehicles at home (n)	
None	35 (4.6)
One	263 (34.4)
Two or more	466 (61.0)

self-perceived confidence was lower for cycling compared to walking to school (Table 3). Using a composite score for cycling capability, 58.8% of adolescents had high, 10.7% average and 30.5% low self-perceived capability to cycle to school.

3.5. Incentives and personal barriers

Compared to walking, cycling to school provided less opportunity for socializing with friends (Table 4). Although cycling would be faster than walking, cycling to school had more personal barriers (such as too much to carry, after-school schedule, need for planning and getting sweaty) (Table 4). Half of adolescents felt too tired or could not be bothered to walk or cycle to school (Table 4).

3.6. Environmental barriers and safety perceptions

One quarter of adolescents living within 4 km from school perceived that it was too far to walk or cycle to school (Table 4) with perceived distance being a greater barrier for walking versus cycling. Routes to school had less bike lanes compared to walking paths (Table 4). Adolescents reported that both they and their parents considered cycling to school less safe than walking. Wet and cold weather was a major barrier for both modes of transport.

Table 2
Transport to school in the previous two weeks and estimated time to walk and cycle to school.

	Total sample (n=774)	
	Walking to School n (%)	**Cycling to School** n (%)
Frequency of cycling to school in the previous two weeks		
Never	211 (27.6)	714 (93.5)
Almost never	71 (9.3)	19 (2.5)
Sometimes	110 (14.4)	16 (2.1)
Almost every day	149 (19.5)	8 (1.0)
Every day	223 (29.2)	7 (0.9)
Estimated time to walk/cycle to school		
1–5 min	84 (11.0)	182 (23.8)
6–10 min	124 (16.2)	134 (17.5)
11–20 min	187 (24.5)	134 (17.5)
21–30 min	180 (23.6)	54 (7.1)
31+ min	172 (22.5)	36 (4.7)
Don't know	17 (2.2)	224 (29.3)

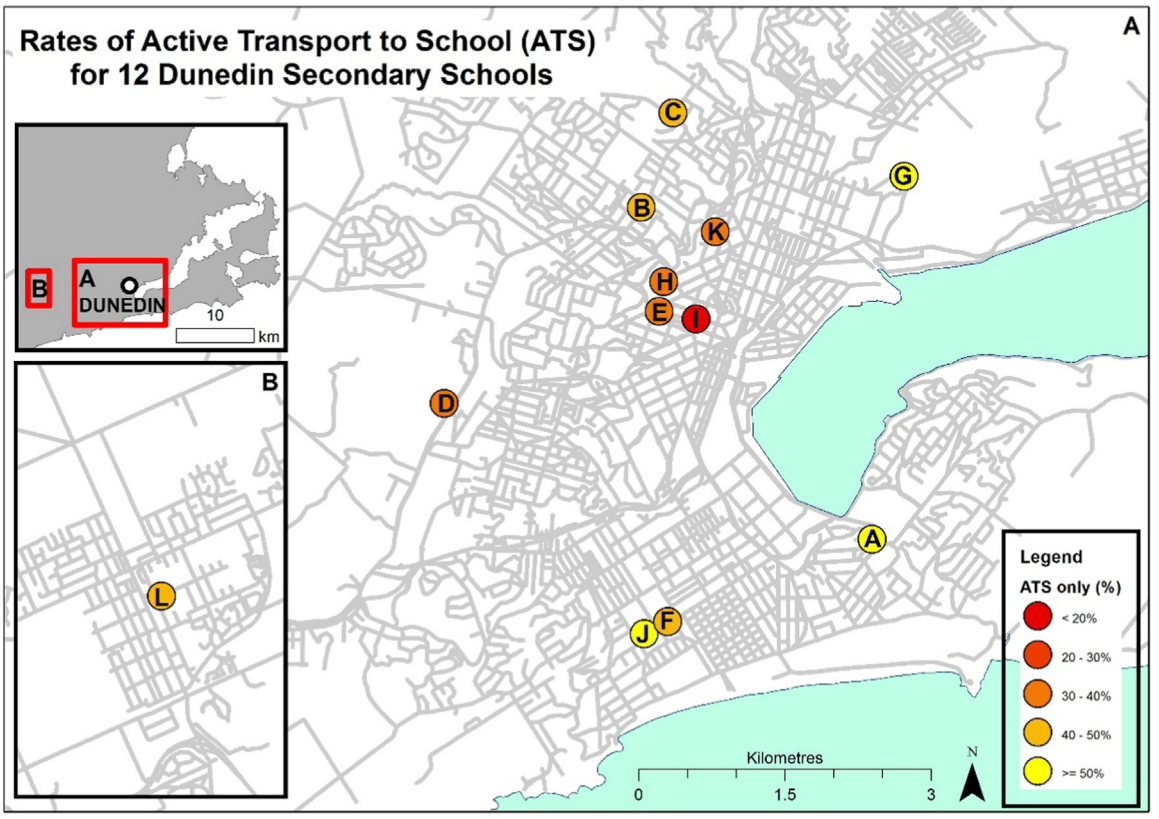

Fig. 1. Rates of active transport to school in Dunedin secondary schools (ATS=Active transport to school).

3.7. Enablers of cycling to school

Adolescents perceived that cycle friendly school uniforms (41.4%), safer bike storage facilities at school (40.1%), slower traffic on the roads (36.4%), bus bike racks available free of charge (26.2%) and bike ownership (32.7%) would encourage

Table 4
Personal incentives and barriers, environmental factors and safety perceptions of walking and cycling to school.

		Total sample (n=764)						P-value
		Walking to school			**Cycling to school**			
		Average (mean ± SD)	Disagree n (%)	Agree n (%)	Average (mean ± SD)	Disagree n (%)	Agree n (%)	
Personal incentives								
	Waking/cycling to school is a great way to get some exercise	3.3 ± 0.7	71 (9.3)	693 (90.7)	3.2 ± 0.9	122 (16.0)	642 (84.0)	< 0.001
	I can chat to my friends on my walk/cycle to school	2.4 ± 1.1	401 (52.5)	363 (47.5)	1.6 ± 0.8	670 (87.7)	94 (12.3)	< 0.001
Personal barriers								
	Waking/cycling to school takes too much time	2.3 ± 1.1	421 (55.1)	343 (44.9)	1.9 ± 0.9	580 (75.9)	184 (24.1)	< 0.001
	It involves too much planning ahead to walk/cycle to school	1.6 ± 0.9	640 (83.8)	124 (16.2)	2.1 ± 1.0	491 (64.3)	273 (35.7)	< 0.001
	I get too hot and sweaty walk/cycling to school	1.9 ± 1.0	530 (69.4)	234 (30.6)	2.3 ± 1.1	426 (55.8)	338 (44.2)	< 0.001
	I have too much stuff to carry to walk/cycle to school	2.4 ± 1.1	382 (50.0)	382 (50.0)	2.8 ± 1.1	282 (36.9)	482 (63.1)	< 0.001
	It is not convenient for me to walk/cycle to school because of my after-school schedule	2.0 ± 1.0	519 (67.9)	245 (32.1)	1.4 ± 1.1	409 (53.5)	355 (46.5)	< 0.001
	I often feel too tired to walk/cycle to school	2.4 ± 1.0	406 (53.1)	358 (46.9)	2.3 ± 1.1	445 (58.2)	319 (41.8)	0.016
	I often cannot be bothered to walk/cycle to school	2.4 ± 1.0	388 (50.8)	376 (49.2)	2.5 ± 1.1	373 (48.8)	391 (51.2)	0.021
	Personal barriers composite score	2.2 ± 0.7	494 (64.7)	270 (35.3)	2.2 ± 0.8	459 (60.1)	305 (39.9)	< 0.001
Environmental factors								
	It is too far to walk/cycle to school	1.9 ± 1.0	558 (73.0)	206 (27.0)	1.8 ± 1.0	589 (77.1)	175 (22.9)	0.189
	There are no footpaths/cycle paths along the way	1.3 ± 0.7	695 (91.0)	69 (9.0)	2.8 ± 1.1	284 (37.2)	480 (62.8)	< 0.001
	The weather is too cold and wet to walk/cycle to school	2.5 ± 0.9	337 (44.1)	427 (55.9)	2.5 ± 1.0	342 (44.8)	422 (55.2)	0.845
Safety perceptions								
	It is unsafe to walk/cycle to school	1.5 ± 0.8	686 (89.8)	78 (10.2)	2.2 ± 1.0	468 (61.3)	296 (38.7)	< 0.001
	My parents think it is not safe to walk/cycle to school	1.5 ± 0.8	677 (88.6)	87 (11.4)	2.0 ± 1.0	538 (70.4)	226 (29.6)	< 0.001

Data collected on a 4-point Likert scale (1=strongly disagree to 4=strongly agree). Data recoded as 1,2=disagree and 3,4=agree to create categorical variables.

them to cycle to school more often. Having a locker at school for storing belongings (23.6%) and being allowed to cycle without helmet (21.7%) were also seen as favourable conditions.

4. Discussion

Key findings of the present study include: 1) although half of adolescents enjoyed cycling for recreation, few cycled to school; 2) compared to walking, cycling to school among Dunedin adolescents was less common and a less preferred mode of transport, had more personal barriers, received less social and infrastructure support and was perceived as less safe; 3) approximately one third of adolescents living within 4 km from school perceived themselves as incapable of cycling to school; 4) revisiting school uniform policy, availability of bike racks on the school grounds, reducing traffic speed and availability of a low-cost bike library may increase the rates of cycling to school in adolescents. These findings suggest that social norms and local cycling culture in Dunedin may in part explain the lower preference for cycling versus walking to school in adolescents. Future active transport initiatives should be context-specific and consider the local cycling culture and environment as well as different incentives and personal barriers for cycling versus walking to school.

Though nearly half of adolescents living ≤ 4 km from school walked to school, cycling to school was less common, less preferred and less desirable mode of transport to school among adolescents in the present study. Lower rates of cycling

versus walking to school have been observed among adolescents in many developed countries (McDonald, 2007; Larsen et al., 2009; Chillon et al., 2009; Murtagh et al., 2016; Leslie et al., 2010; Mandic et al., 2015; Nelson et al., 2008) with a steep decline in cycling to school reported among New Zealand adolescents in the last three decades (Ministry of Transport, 2015). In contrast, countries with strong cycling traditions, extensive cycling-friendly infrastructure and flat landscape, consistently report higher rates of cycling versus walking to school (e.g., Denmark (Cooper et al., 2006) and Belgium (Van Dyck et al., 2010)).

The local cycling culture in Dunedin (New Zealand) may in part explain the lower preference for cycling versus walking to school among adolescents. In the present study, half of adolescents enjoyed cycling for recreation but less than one fifth often cycled with friends or parents and less than a quarter received encouragement from parents, peers and school to cycle to school. In addition, one third of adolescents perceived that cycling to school was not 'cool'. Previous studies highlighted the importance of social support for active transport (Leslie et al., 2010; Carver et al., 2010; Simons et al., 2013; Verhoeven et al., 2016) and specifically for cycling to school in adolescents (Ducheyne et al., 2012).

Parental perceptions of personal safety and the dangers posed by traffic (speed and volume) and dangerous intersections have been identified as key parental barriers to walking and cycling to school (Broberg and Sarjala, 2015), especially in adolescent girls (Esteban-Cornejo et al., 2016; Carver et al., 2005). In the present study, road safety concerns (too much traffic and/or dangerous crossing[s]) on the way to school were reported by one third of adolescents and reducing traffic speed was seen as a favourable strategy for promoting cycling to school. Adolescents also reported that cycling to school was perceived as less safe by themselves and their parents compared to walking. Focus groups with students and parents conducted as a part of the BEATS Study identified a complex range of factors that contribute to perceptions of cycling safety, including features and perceptions of the built environment, traffic safety (including behaviours of other road users), previous cycling experiences (including accidents) and adolescents' cycling skills and on-road experiences (Hopkins and Mandic, 2016). Taken together, these findings suggest that low perceived social support for cycling to school among Dunedin adolescents may be in part mediated by adolescents' and parental road safety concerns.

Safety concerns including poor walking and cycling facilities, traffic danger and personal safety concerns decrease the likelihood of active transport to school in children and adolescents (Trapp et al., 2011; Kerr et al., 2006). Specific to cycling, parental confidence in their child's ability to cycle to school mediates the association between the perceived safety and cycling in children (Trapp et al., 2011). In the present study, adolescents reported that they and their parents perceived cycling to school as less safe compared to walking. In addition, one third of adolescents living <4 km from school did not perceive themselves as capable to cycle to school. These findings emphasise the need for not only creating safer environments but also offering programmes such as cycle skills training (Mandic et al., 2016) to improve adolescents' cycle skills.

Other barriers to active transport to school such as the weather (Gustat et al., 2015; Aibar et al., 2015), hills (Timperio et al., 2006), high rates of private vehicle ownership (Mandic et al., 2015; McDonald, 2008) and convenience of being driven (e.g. trip chaining) (Schlossberg et al., 2006; Gustat et al., 2015) may in part explain the low preference for cycling versus walking to school among Dunedin adolescents. Although half of adolescents in the present study reported cold and wet weather as a barrier to active transport, the weather was not a greater barrier for cycling versus walking to school. One third of surveyed adolescents reported too many hills on the way to school and one-half reported convenience of being driven to school by someone on the way to something else. Considering greater personal barriers to cycling versus walking to school observed in the present study (too much to carry, after-school schedule, need for planning and sweating), future studies should examine if perceived convenience of being driven to school has a greater impact on cycling versus walking to school in adolescents.

School's support for active transport plays an important role in promoting active transport to school (Gustat et al., 2015; Buliung et al., 2011) through activities such as safety education, special events and infrastructure improvements (Buliung et al., 2011). Our findings suggest that cycling-specific interventions at the school level should address school uniform policy (e.g., allow students to cycle to school without a school uniform) as well as school grounds infrastructure to provide safe bicycle storage facilities and lockers at school.

In the present study, owning a bicycle and having bus bike racks available free of charge were perceived as enablers of cycling to school by one third and one quarter of adolescents, respectively. Therefore, community-based or city-wide interventions such as availability of the low-cost bike library or bus bike racks free of charge may be effective in promoting cycling to school in adolescents. A law requiring the wearing of a bike helmet was a barrier to cycling to school in only one in five adolescents. Other previously suggested interventions (Gustat et al., 2015; Larouche et al., 2013) should be considered for promoting cycling to school such as a minimum busing distance laws, developing a well-connected network of cycle lanes along low traffic streets and encouraging both adolescents and their parents to reconsider what constitutes a reasonable cycling distance.

4.1. Limitations

This study has limitations that should be recognized. First, the cross-sectional design prevents claims about causality. Second, the unique setting of Dunedin may limit generalizability of findings to other cities and countries with different topography, built environment features and cycling culture. Finally, travel patterns from school to home and objective measures of the environment were not available. Despite the limitations, the strengths include a comprehensive survey of factors affecting walking and cycling behaviour in adolescents and a large representative sample of adolescents from one

city in New Zealand, with high participation rates among the schools. Future studies should examine walking and cycling as distinct active transport behaviours in different populations and geographic settings.

5. Conclusions

Compared to walking, cycling to school was less common in adolescents, was perceived as less safe and had less social and infrastructure support in Dunedin (New Zealand). Future interventions to promote cycling to school should focus on modifying psychosocial barriers such as raising parental awareness of the benefits of cycling to school and increasing parental and peer support for cycling to school. Initiatives designed for promoting cycling in New Zealand adolescents should be comprehensive and focus on building a positive cycling culture, creating supportive physical and social environments, improving road safety and improving adolescents' cycling skills.

Authors' contributions

SM is the principal investigator who conceptualized the overall study, led the project implementation and drafted this manuscript. SM, DH, JW, AM, EGB and JC contributed to the design of the study and questionnaires. SM, JW, AM, EGB and JC obtained research funding. SM, JW, DH, AM and CF conceptualized this particular study. SM, JW and LS were responsible for statistical analysis. AM was responsible for Geographic Information Systems data analysis. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

Mrs Charlotte Flaherty works at the Dunedin City Council and has been a part of the BEATS Study research team from the study inception. Other authors do not have any competing financial interests.

Funding

This work was supported by National Heart Foundation of New Zealand (1615), Lottery Health Research Grant (Applic 341129), University of Otago Research Grant (UORG 2015), Dunedin City Council and internal grants from the School of Physical Education, Sport and Exercise Sciences, University of Otago.

Acknowledgements

The BEATS Study is a collaboration between Dunedin Secondary Schools' Partnership, Dunedin City Council and University of Otago. We would like to acknowledge our research team members, the members of the BEATS Study Advisory Board (Mr Andrew Lonie, Mrs Ruth Zeinert, Dr Tara Duncan, Dr Susan Sandretto, Dr Janet Stephenson), research personnel (research assistants, students and volunteers), and all participating schools and students.

References

Aibar, A., Bois, J., Generelo, E., García Bengoechea, E., Paillard, T., Zaragoza, J., 2015. Effect of weather, school transport, and perceived neighborhood characteristics on moderate to vigorous physical activity levels of adolescents from two European cities. Environ. Behav. 47 (4), 395–417.

Ajzen, I., 1991. The theory of planned behaviour. **Organ Behav. Hum. Decis.** Process 50 (2), 179–2011.

Armitage, C.J., 2005. Can the theory of planned behaviour predict the maintenance of physical activity? Health Psychol. 24 (3), 235–245.

Broberg, A., Sarjala, S., 2015. School travel mode choice and the characteristics of the urban built environment: the case of Helsinki, Finland. Transp. Policy 37, 1–10.

Buliung, R., Faulkner, G., Beesley, T., Kennedy, J., 2011. School travel planning: mobilizing school and community resources to encourage active school transportation. J. Sch. Health 81 (11), 704–712.

Carver, A., Timperio, A., Hesketh, K., Crawford, D., 2010. Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk? Soc. Sci. Med. 70 (11), 1799–1805.

Carver, A., Salmon, J., Campbell, K., Baur, L., Garnett, S., Crawford, D., 2005. How do perceptions of local neighborhood relate to adolescents' walking and cycling? Am. J. Health Promot. 20 (2), 139–147.

Chillon, P., Ortega, F.B., Ruiz, J.R., Perez, I.J., Martin-Matillas, M., Valtuena, J., et al., 2009. Socio-economic factors and active commuting to school in urban Spanish adolescents: the AVENA study. Eur. J. Public Health 19 (5), 470–476.

Collins, C.M., Chambers, S.M., 2005. Psychological and situational influences on commuter-transport-mode choice. Environ. Behav. 35, 640–661.

Cooper, A.R., Wedderkopp, N., Wang, H., Andersen, L.B., Froberg, K., Page, A.S., 2006. Active travel to school and cardiovascular fitness in Danish children and adolescents. Med. Sci. Sport. Exerc. 38 (10), 1724–1731.

Davison, K.K., Werder, J.L., Lawson, C.T., 2008. Children's active commuting to school: current knowledge and future directions. Prev. Chron. Dis. 5 (3), A100.

Ducheyne, F., De Bourdeaudhuij, I., Spittaels, H., Cardon, G., 2012. Individual, social and physical environmental correlates of 'never' and 'always' cycling to