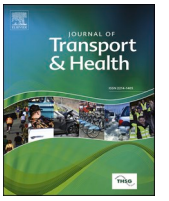
Journal of Transport & Health 35 (2024) 101765

Contents lists available at ScienceDirect

Journal of Transport & Health

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



Barriers and enablers for cycling: A COM-B survey study of UK schoolchildren and their parents

Daniel T. Bishop [a,*], Prathiba Batley [b], Huma Waheed [a], Tamara S. Dkaidek [a], Gabriela Atanasova [a], David P. Broadbent [a,c]

[a] Centre for Cognitive and Clinical Neuroscience, Brunel University London, Kingston Lane, Uxbridge, Middlesex, UB8 3PH, United Kingdom
[b] Daiichi Sankyo, 3-5-1, Nihonbashi-honcho, Chuo-ku, Tokyo 103-8426, Japan
[c] Centre for Sport Research, Institute for Physical Activity and Nutrition, Deakin University, Burwood, Australia

ARTICLE INFO

Keywords:
Active travel
Adolescents
Attitudes
Bike
Health
Physical activity

ABSTRACT

Introduction: Cycling confers many health-related benefits but is rarely used as a mode of travel in the UK. There is comparatively limited research on enablers and barriers to cycling in children and their parents, even though understanding this dyad is key for developing effective active school travel interventions. We used the COM-B (capability, opportunity, and motivation to engage in an identified behaviour) model as a framework to design and interpret data from an online survey administered to schoolchildren and their parents, regarding barriers and enablers for cycling.

Methods: Two hundred-and-forty-six UK schoolchildren aged 9–15 years (M = 12.2 yrs; SD = 1.1 yrs) and one of their parents completed an online survey in which they reported their cycling behaviour, physical and psychological capabilities regarding cycling on roads, social and physical opportunities for cycling, and their motivation to cycle on roads. A structural equation model was hypothesized and fitted to the data. Model modifications were made to improve the model fit.

Results: A structural equation model of survey data revealed that parents' cycling frequency predicted the frequency of their children's cycling. Both children's and parents' cycling frequencies were determined by their affective judgements regarding cycling – i.e., their automatic motivation to cycle – and whether they had access to a roadworthy cycle. Parents' cycling frequency was also influenced by the proportion of their close friends who cycled.

Conclusions: Interventions targeted at enhancing children's and parents' attitudes toward cycling, and increasing parents' cycling behaviour, may increase children's cycling frequency journeys such as the school commute.

1. Introduction

Despite the benefits of regular physical activity for physical and mental health (Henson et al., 2013; Cao et al., 2022; Bell et al., 2019; Cheng et al., 2020; Hoare et al., 2016), the percentage of UK children and young people classified as *physically active* is less than 50% at the time of writing (England, 2023). However, the physical inactivity problem is a multifaceted one (Blair, 2009): Many factors

* Corresponding author.
E-mail addresses: daniel.bishop@brunel.ac.uk (D.T. Bishop), pnbatley@gmail.com (P. Batley), 1915162@brunel.ac.uk (H. Waheed), tamara.dkaidek@brunel.ac.uk (T.S. Dkaidek), 2048817@brunel.ac.uk (G. Atanasova), david.broadbent@deakin.edu.au (D.P. Broadbent).

https://doi.org/10.1016/j.jth.2024.101765
Received 27 June 2023; Received in revised form 7 January 2024; Accepted 8 January 2024
Available online 2 February 2024

influence people's physical activity levels, including their perceptions of social support for physical activity (Schalkwijk et al., 2015; Sawka et al., 2013), opportunities in the built environment to be physically active (Tappe et al., 2013; Arvidsen et al., 2022) and their expectations regarding the consequences of being more active (Garcia et al., 2022). Consequently, successful behaviour change strategies require consideration of a multitude of barriers and enablers for physical activity and the various contexts in which it occurs (Harvey and Kitson, 2015; Koenders et al., 2021).

Active travel presents an ideal context for children and young people to incorporate physical activity into their daily routines. There is recent evidence that higher levels of active travel to and from school (e.g., walking and cycling) are associated with greater moderate-to-vigorous-physical activity in children (Salway et al., 2019). It has been shown that 76% of school journeys are under 2 miles (Department for Transport, 2014), and cycling is underrepresented as a mode of active school travel relative to walking, driving, and taking a bus in UK children over this journey range (Department for Transport, 2022). Hence, it is important to deepen our understanding of the factors that influence active travel behaviour in adolescents, so that we can design appropriate interventions to increase children's physical activity levels.

Several researchers have examined individual, social and environmental influences on cycling-related attitudes and behaviour, both in children and adults (Charreire et al., 2021; Bishop et al., 2023a; Verhoeven et al., 2017; Ikeda et al., 2019; Salmon et al., 2007; Liu et al., 2023). A recent systematic review on barriers and enablers for cycling in adults showed that the main barriers were infrastructure- and safety-related – particularly concerns about sharing the road with motor vehicles (Pearson et al., 2023a). However, research has also highlighted the importance of the individual's motivation to cycle and social support for cycling (Benson and Scriven, 2012; Mendoza et al., 2014; Ross and Wilson, 2021). In fact, research has suggested that the individual's motivation to cycle and social support for cycling may supersede environmental barriers (Bjørnarå et al., 2020; Fitch et al., 2019). For example, Fitch and colleagues (Fitch et al., 2019) coded several road characteristics to describe the cycling and walking environments in three Northern California communities (e.g., bike lane presence and width, on-street parking, speed limit), and surveyed high school children from these communities about their usual travel modes and personal attitudes. Using a series of categorical regression models, the authors showed that the children's attitudes toward cycling predicted their travel mode choices almost twice as strongly as the road environment. That said, evidence suggests that motivations and attitudes toward cycling changes over the course of childhood, adolescence and into early adulthood (Underwood et al., 2014; Thigpen and Handy, 2018). Cycling is perceived as fun in childhood whereas in adolescence, cars replace cycling as the mode of transport related to fun and independence, and teenagers may discontinue cycling even if they enjoy it, because of unsupportive social norms (Underwood et al., 2014). Efforts to explore the complex interaction between individual, social, and environmental influences on cycling behaviours is warranted to develop multi-pronged behaviour change interventions that increase children and adolescents' cycling frequency (Emond and Handy, 2012).

Parental attitudes and confidence appear to be strong determinants of their child's active travel patterns (Salmon et al., 2007; Ross and Wilson, 2021; Woldeamanuel, 2016; Trapp et al., 2011; Wilson et al., 2018). Parents' positive cycling behaviour and attitudes can serve as a model for the children and assist in overcoming common barriers to cycling – although parents with negative perceptions of cycling can impose rules that restrict the child's cycling behaviour (Thigpen and Handy, 2018), even when the child's attitudes and confidence are in direct contradiction to theirs (Pfledderer et al., 2021). For example, Chillón and colleagues' (Chillón et al., 2014) found that parents' safety and weather concerns, and their perceptions of their child's unwillingness to walk or cycle, increased the likelihood that they would chauffeur their children to school (Carver et al., 2013); unfavourable parental attitudes regarding commuting distance also increases car usage (Woldeamanuel, 2016; Trapp et al., 2011; Ridgewell et al., 2009; Mandic et al., 2022). That said, the child's attitude to cycling, and their perceptions of control over their cycling behaviour, are also significant enablers of cycling as a mode of active travel in children (Bjørnarå et al., 2020; Zaragoza et al., 2020). Therefore, it is important to examine the attitudes of children and their parents in tandem.

The combined influence of child and parent attitudes on children's active travel is captured in the conceptual framework developed by Panter and colleagues (Panter et al., 2008), which is based on their review of evidence from 24 studies of children and adolescents. The framework also highlights other environmental determinants of active travel in children, such as parent and child characteristics (e.g., physical ability, ethnicity, household income, occupational status, etc.), and factors related to the physical environment (e.g., route length, neighbourhood attributes, and destination attributes) – including the parents and children's perceptions of this environment. However, Panter et al. acknowledged the inconsistent findings regarding environmental influences, and the potential influence of unmeasured child and parent characteristics. Consideration of such individual characteristics may facilitate the tailoring of behaviour change interventions for active travel, to maximise their efficacy.

The COM-B model (Michie et al., 2011) was proposed as a framework for designing and implementing behaviour change interventions. It encompasses three overarching factors that individually and collectively influence people's behaviour: their *motivation to engage in the behaviour*, both *reflective* (e.g., reasons to be active) and *automatic* (e.g., attitudes towards physical activity); *opportunities in their social and physical environments* to engage in the behaviour (e.g., social norms and the built environment); and their *physical and psychological capabilities* regarding the behaviour (e.g., skills, thought processes and knowledge). The COM-B model framework has been used successfully to identify the contributions of these factors to people's physical activity in a variety of contexts and populations (Howlett et al., 2019; Huynh et al., 2023; van Kasteren et al., 2020; Johnson et al., 2022; Ellis et al., 2019; McDermott et al., 2022), and has good explanatory power for young adults' physical activity levels (Willmott et al., 2021). Other frameworks have been used to explore cycling behaviour, in both adults and children – for example, those based on social-cognitive models such as the Theory of Planned Behaviour (Liu et al., 2023; Murtagh et al., 2012) – and many have identified individual, social, and physical enablers and barriers for cycling as a mode of active travel. However, the COM-B model not only explicitly acknowledges such opportunities to perform a behaviour, but also recognises the contributions of the individual's physical and psychological capabilities.

Michail and colleagues (Michail et al., 2021) used the COM-B model to investigate active school travel in 192 schoolchildren, only

5% of whom cycled to school. The children completed a short survey to report their usual mode of school travel, their experiences of their journeys, and their likes/dislikes relating to those journeys. Using thematic analysis, the authors identified several sub-themes pertaining to the children's motivation to engage in active school travel (traffic, personal safety, and comfort), and their opportunities to do so (planning, street design, nature, family, friends, and community), which the authors summarised as four overarching domains, namely, *environmental context*, *emotions*, *social influences*, and *trip factors*. However, Michail et al. did not collect data relating to the individual's physical and psychological capabilities.

Research into the influence of children's physical and psychological abilities on cycling to school is scarce (Panter et al., 2008; Yang et al., 2016). Pearson et al.'s (Pearson et al., 2023b) systematic review of barriers and enablers for cycling identified eight studies that suggested a 'lack of fitness' as a perceived barrier to cycling in adults. Findings are comparable for children: The extra effort required to cycle to school, compared to travelling by car, has been identified as a deterrent for cycling, particularly for teenage girls (Higgins and Ahern). Relatedly, if individuals perceive that the distance to their workplace or school is too far to cycle, possibly because of their physical abilities, they are unlikely to cycle – and perceptions of distance are more strongly associated with cycling behaviour than actual distance (Emond and Handy, 2012). Regarding psychological capabilities, a recent systematic review of children's cycling skills showed that perceptual-cognitive skills including hazard perception, attention, planning, and decision-making, are important considerations when investigating cycling behaviour (Zeuwts et al., 2020). For example, high levels of attentional control are required to navigate complex road networks, particularly in built-up areas, whilst engaging with other road users in a safe manner. Given the contributions of inattention to collisions involving cyclists (Møller et al., 2021; Salmon et al., 2022), and the relationship between poor attentional control and cycling errors and violations (Bishop et al., 2023a), attentional control is a psychological capability that deserves closer scrutiny. Moreover, explicit knowledge of rules of the road and awareness of road user priorities are a feature of the National Standard for Cycle Training (Department for Transport and Driver & Vehicle Standards Agency, 2019) and should also be considered.

1.1. Aims of the present study

There is a dearth of research using the COM-B (capability, opportunity, and motivation for behaviour) model as a framework to investigate enablers and barriers for children's cycling, despite its explanatory power for physical activity (Willmott et al., 2021). Our aim was to use the COM-B model as a framework to investigate the contributions of children's and parents' physical and psychological capabilities for cycling, their social and physical opportunities to cycle, and their motivation to cycle, to *the child's cycling frequency* (Department for Transport, 2014; Department for Transport, 2022).

To build on existing research, we characterised participants' psychological capabilities in terms of their cycling-related knowledge and their attentional control (Bishop et al., 2022, 2023a), and their physical abilities in terms of their cycle control (Bishop et al., 2023a) and their ability to cycle under various environmental demands. We conceptualised social and physical environment determinants similarly to previous studies. Individual motivation was characterised in terms of deliberative reasons to cycle (e.g., societal, health; *reflective motivation*), and affective judgements regarding cycling on roads (*automatic motivation*). Because habitual

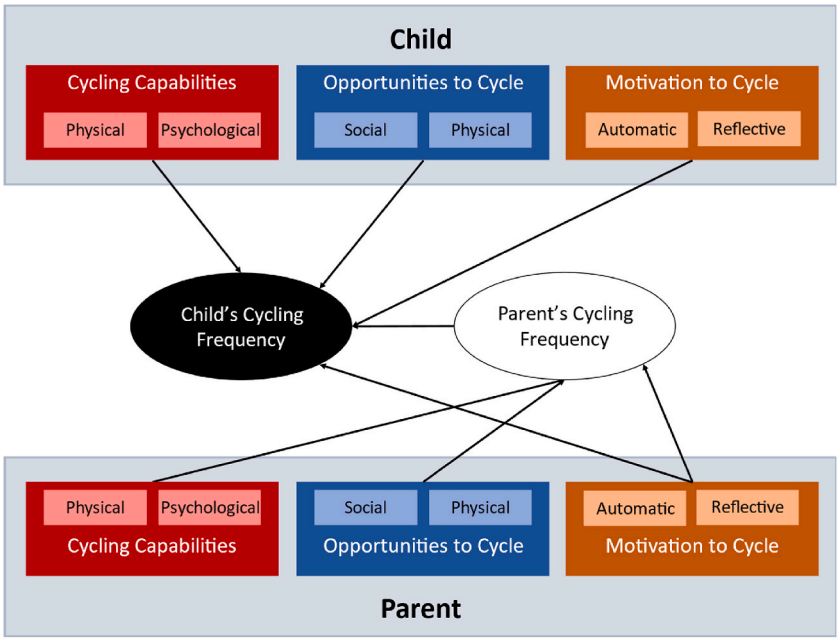


Fig. 1. Conceptual Model of Children's and Parents' Capabilities, Opportunities and Motivation Regarding Cycling on Roads, and their Associations with Cycling Behaviour.

behaviour is a reliable predictor of future behaviour in health contexts (Moran and Mullan, 2021; Zhang et al., 2022), and the prevalence of weather as a barrier to active school travel (Bjørnarå et al., 2020; Kamargianni and Polydoropoulou, 2013), we also sought to ascertain the influences of the types of cycling performed by participants, and the seasonality of their cycling behaviour – notably, their cycling frequency in spring/summer versus autumn/winter. Hypothesized associations between elements of the COM-B model and participants' cycling behaviour are depicted in Fig. 1. Considering the research evidence presented above, which shows that cycling-supportive attitudes, social norms, and infrastructure all influence cycling behaviour, we predicted that the participants' motivation to cycle and their social and physical opportunities to cycle would predict their cycling frequency. We also hypothesized that their judgements of their cycling capabilities (in the absence of an existing reliable measure of cycling ability) would predict their cycling frequency, because there is evidence that such judgements are related to use of cycling as a mode of active travel (Mertens et al., 2019; Lois et al., 2015). Finally, we predicted that parents' motivation to cycle and their cycling frequency would predict the children's cycling frequency, because of the demonstrable influence of parental attitudes and behaviour on children's active travel behaviour.

2. Methods

2.1. Study setting, participants and design

The population of the United Kingdom in mid-2021 was estimated to be 67.0 million, of which approximately 8% were children aged 9–15 years (Office for National Statistics, 2022); most children in England within this age range are offered formal cycle training via their schools (The Bikeability Trust, 2022). In the same year, an estimated 3% of children aged 5–16 years cycled to school (Department for Transport, 2021).

Two hundred and forty-six children aged 9–15 years ($M = 12.2$ yrs; $SD = 1.1$ yrs; median = 12 yrs) who attended state primary and secondary schools in five boroughs of west London, UK – namely, Brent, Ealing, Harrow, Hillingdon and Hounslow – and one of their parents/carers (hereafter *parents*; M age = 43.6 yrs; SD = 6.33 yrs; median = 43 yrs) who could confirm their eligibility (see Procedure) completed an online cross-sectional survey; this included information regarding demographics, which are summarised in Table 1 (NB: age is summarised above). Parents' education levels, employment statuses and marital statuses are summarised in Tables A-C of Supplementary Information. Participants also reported the frequency with which they cycled on different types of thoroughfares – namely, *segregated cycle lanes*, *cycle paths*, *residential streets*, *busy urban roads*, *minor roads*, *dual carriageways*, and *pavements/sidewalks* – the number of years for which they had cycled, whether they could ride a cycle, their membership of cycling clubs or organisations, and any formal cycle training they had undertaken. These are summarised in Tables D and E of Supplementary Information.

2.2. Procedure

After obtaining institutional research ethics committee approval, emails were circulated via local Bikeability training providers from March to June 2022, to parents of children aged 9–15 years in the five London boroughs (see Section 2.1) whose schools offer

Table 1
Participants' demographics – summary.

Protected Characteristic	Category	Percentage of Sample	
		Child	Parent
Gender	Female	42.7%	61.0%
	Male	52.0%	36.6%
	Non-binary/Third Gender	1.2%	0.0%
	Prefer not to say/no response	4.1%	2.4%
Race/Ethnic Group	White	37.4%	40.2%
	Indian	17.9%	17.9%
	Black or African American	5.3%	6.1%
	Middle Eastern	2.8%	2.8%
	Pakistani	2.4%	3.7%
	Bangladeshi	2.0%	2.0%
	Other ethnic groups (all n's < 5)*	23.6%	22.0%
	Prefer not to say/no response	8.9%	5.7%
Religion or belief	Christian	34.6%	37.4%
	No religion/atheist	20.7%	19.5%
	Hindu	12.2%	12.2%
	Muslim	11.4%	12.6%
	Sikh	7.3%	7.7%
	Other religions (all n's < 5)	2.8%	3.3%
	Prefer not to say/no response	11.0%	7.3%
Disability	No impairment	54.5%	55.3%
	Long-term health condition (e.g., cancer, HIV, diabetes, chronic heart disease, epilepsy)	0.4%	2.0%
	Learning difference (e.g., dyslexia, dyspraxia, ADHD)	2.4%	0.8%
	Prefer not to say/no response	42.7%	41.9%

cycle training to their pupils – a total of 415 schools. Participation was incentivised by the offer of a £10 gift card; participants also had the opportunity to express their interest in three other cycling-related studies, each of which included participation incentives. Those who expressed an interest in completing the survey were invited to a brief video call with one of the research team to establish their identity. We used this process to confirm participants' authenticity, because visual inspection of early survey responses contained erroneous responses (e.g., *straightlining*; see section 2.4.1). Those who were willing to verify their identity and confirm their eligibility received a unique link to the survey, which was completed via an online survey platform (Qualtrics, Provo, UT), in their own time and in a location of their choosing. The survey was completed by the parent and child together, but they provided responses in sections clearly demarcated as relating to 'Parent' or 'Child'. It was stated clearly which question related to which participant and how they should respond to each question. In the instructions, the parent was asked to neither influence the child's responses nor respond for them, and only to help them read and understand questions. The survey was to be completed within one week of receipt of the link before the link expired. Data collection ceased once an adequate sample size was obtained to conduct suitably powered analyses, and when expressions of interest dwindled. A total of 1123 participants provided responses, only 428 of whom completed the survey in full – a completion rate of 38.1%. The final sample size after screening for response quality (see Results) – 246 – is adequate considering the previous suggestions for sample sizes of 100–200 (Boomsma, 1985)' (Wolf et al., 2013) and of 5–10 observations per parameter (Bentler et al., 1987).

2.3. Measures

The survey was designed using the COM-B behaviour change wheel (Michie et al., 2011) as a framework. Respondents self-identified their physical and psychological capabilities regarding cycling on roads; the social and physical opportunities they perceive for cycling; and their motivation to cycle, both reflective and automatic. Child and parent were asked to provide responses to all items, except for those relating to highest level of education and employment status, to which only the parent responded.

2.3.1. Outcome variable

In 2021, most trips made in the United Kingdom via active travel modalities were 2 miles or less (Department for Transport, 2022). Parents and children stated the frequency with which they travelled journeys of 2 miles or less using various modalities: *walking*, *bus*, *train*, *car*, *motorcycle*, *taxi*, *cycle*, *scooter*, or *other* (participants could specify). They did so via a scale ranging from 1 (Never) through 2 (Occasionally) and 3 (Frequently) to 4 (Very frequently). Almost one-third of child participants (29.3%) and just over one-fifth of their parents (20.2%) stated that they cycle frequently or very frequently; the majority either did so only occasionally (39.8% and 30.9%, respectively) or never (19.1%) and 41.5%, respectively) (see Table F, Supplementary Information).

The response to the cycling item above was combined with the *number of hours per month that participants typically cycled in spring/summer* and *in autumn/winter* (see Table G, Supplementary Information), and the *frequency with which they performed recreational cycling* and the *frequency with which they performed commuter cycling* (see Table H, Supplementary Information) to form two composite outcome variables, one for children and one for parents.

2.3.2. Physical activity

Children and parents self-reported their moderate and vigorous physical activity levels (hours per week), height (m), and weight (kg); the latter were used to calculate participants' body mass indices. These data are summarised in Table I (Supplementary Information).

2.3.3. Physical and psychological capabilities

Physical Capabilities. Participants indicated their confidence in their ability to "Control your cycle and come to a safe stop with a front tyre puncture when travelling at speed", on a scale ranging from 1 (Not at all confident) through 2 (Fairly confident) to 3 (Very confident). This item has been used previously to ascertain cyclists' self-reported abilities (Bishop et al., 2023a).

Participants also stated their belief in their ability to cycle under various environmental conditions: *when it is raining*, *it is cold*, *the road surface is slippery*, *you have a heavy load to carry*, *your route is hilly*, *there are lots of motor vehicles around you*, *motorists are driving aggressively*, *there are lots of cyclists around you*, and *there are lots of pedestrians around you*, on the same scale as above. These items were chosen to collectively represent a proxy for the participants' physical fitness (Pearson et al., 2023b), and ability to navigate their environment safely (Bishop et al., 2023a), in the absence of objective performance data in this regard.

Psychological Capabilities. Because inattention is a contributory factor in collisions involving cyclists (Salmon et al., 2022), and experienced cyclists' inability to control distractions is associated with greater errors and violations (Bishop et al., 2023a), items relating to attention allocation and distraction control while cycling were included in the survey. Children and parents responded to 21 cycling-specific items based on a revised version of the Attentional Style Questionnaire (Bishop et al., 2022). Collectively, all 21 items referred to inattention and distraction in relation to external (e.g., "I fail to notice pedestrians in the road ahead") and internal (e.g., "I daydream") stimuli; all items were prefaced by the following sentences: "The following statements relate to your allocation of attention when you are cycling. Please indicate how frequently each of them happens to you when you are cycling on roads".

In addition, participants self-reported their confidence in their ability to "Cycle safely at speed through a narrow gap" (visual perception), to "Judge the distance of a car behind you, using only your hearing" (auditory perception), and to "Safely avoid a pedestrian who steps into the road 10 m in front of you, when you are travelling at speed" (reaction time) (Bishop et al., 2023a), on a scale ranging from 1 (Not at all confident) through 2 (Fairly confident) to 3 (Very confident). They also answered a series of multiple-choice items relating to knowledge of cycling good practice, for example, "Which brakes should you use to stop your cycle?"

(The Bikeability Trust, 2022), and the rules of the road, such as "According to the Highway Code, when are you allowed to cycle on a pavement?" (Department for Transport and Driver & Vehicle Standards Agency, 2023); responses were coded binarily (1 for correct responses, 0 for incorrect responses).

2.3.4. Perceived social and physical opportunities to cycle

2.3.4.1. Social opportunities. Social norms and social support are important indicators of physical activity in the context of the COM-B model (Willmott et al., 2021). Accordingly, participants responded to five bespoke items, that reflected the proportion of the following groups of people they knew who cycle on roads, namely *close friends*, *family*, *peers*, *people in their immediate neighbourhood*, and *people in their town*, on a scale ranging from 0 (None) through 1 (Some) and 2 (Many) to 3 (All).

They also indicated the extent of their agreement with ten bespoke statements relating to cycling-supportive social norms (e.g., "Most people my age cycle on the roads") and wider social support for cycling (e.g., "The UK government promotes cycling as a mode of active travel"), on a five-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

2.3.4.2. Physical opportunities. ***Current Access to Cycling Resources.*** Participants indicated the extent of their access to resources including a roadworthy cycle (owned/shared, within/outside of household), cycle lights, high-visibility garments, cycle clothing, and a cycle helmet, by selecting all items that applied (Yes/No).

Physical Barriers to Cycling. Participants also stated the extent to which aspects of the physical environment (e.g., the cost of renting or purchasing a cycle, poor road surfaces, air pollution) made it *less likely* that they would cycle, on a three-point scale ranging from 1 (Not at all) through 2 (Somewhat) to 3 (Very much so).

2.3.5. Reflective and automatic motivation to cycle

Willmott et al.'s (Willmott et al., 2021) data suggest that two strong indicators of people's motivation to be physically active are *identity* and *positive affect*. Items relating to each of these are summarised below as reflective motivation and automatic motivation to cycle respectively.

Reflective Motivation to Cycle. Children and parents independently indicated their reasons for cycling by stating the extent of their agreement with the following four statements, each of which was prefaced by the stem "It is important to cycle, to be …": (1) "… socially responsible", (2) "… a role model for others", (3) "… more independent" and (4) "… an active person". They did so via a five-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Automatic Motivation to Cycle. Because changes in people's affective judgements of physical activity may increase physical activity behaviour (Rhodes et al., 2019), participants also independently indicated their agreement with nine descriptors prefaced with "Cycling is …": *tiring*, *efficient*, *stressful*, *comfortable*, *convenient*, *relaxing*, *enjoyable*, *good for my physical health*, and *good for my mental health*, and with a tenth item, "Cycling makes me anxious", via the same five-point scale (Bishop et al., 2023b).

2.4. Data analysis and hypotheses

2.4.1. Data screening and preprocessing

The Qualtrics (Provo, UT) *ExpertReview* function was used initially to flag cases containing unanswered questions and *straightlining* – when identical answers are provided across rows in the response matrix. Also, the first and last authors visually inspected the data.

Descriptive statistics were computed for all measures. All responses for categorical data reported in Section 2.1 were summarised as counts and percentages, whereas means, standard deviations, medians and ranges were reported for continuous data – notably, those for moderate-to-vigorous-physical activity levels and body mass index.

All scale responses for which participants selected descriptors (e.g., 'Frequently') were converted to numerical equivalents for inclusion in factor and structural equation modelling analyses. For instance, if they comprised a 4-point scale, they were given values between 1 and 4, and for binary responses (e.g., Yes/No) they were assigned 1 or 0, respectively.

2.4.2. CFA and SEM

Coefficient alphas and omegas were computed for each factor to estimate the internal consistency reliability. Less than 6% of the data were missing. Therefore, we did not use any multiple imputation procedures to deal with the missing data. Several models were fitted to address the hypothesized relationships. R (R Core Team) was used for the analysis. Specifically, lavaan (Rosseel, 2012) and psych (Revelle) packages were used to fit the models and compute reliability coefficients, respectively. Following Bentler et al. (1987), we retained models that fit the data adequately well. These include the comparative fit index (CFI) ≥ 0.90, $0.05 <$ the root mean square error of approximation (RMSEA) ≤ 0.08, and the standardized root mean squared residual (SRMR) ≤ 0.08 for acceptable fit, and comparative fit index (CFI) ≥ 0.90, RMSEA ≤ 0.05, and the standardized root mean squared residual (SRMR) ≤ 0.08 for good fit. We used weighted least squares means and variances (WLSMV) estimation to account for the ordinal nature of the data. When the model did not have acceptable fit as deemed by these rules, we examined the modification indices and the standardised residuals for model modification suggestions. Two models were fitted – a confirmatory factor analytic model (CFA, Model A) and a structural equation model (SEM, Model B).

Model modification was performed according to whether the variables were statistically significant predictors of the outcome variables. Statistically non-significant variables were removed, the altered model fitted, and retained based on fit indices. Hence,

included variables were determined by their convergence and goodness of fit in the models, and the groupings were determined according to the predetermined structure defined in the COM-B model and Fig. 1. Model A was a confirmatory factor analytic model (CFA) to test the factor structures of factors pertaining to reflective motivation to cycle, automatic motivation to cycle, physical barriers to cycling, physical capabilities, and psychological capabilities. Model B, the structural equation model (SEM) was modelled to predict the child's and parent's cycling behaviour. These composite variables were computed as sums of the standardized scores (z scores) of their *Cycling Frequency* (the frequency with which they cycled journeys of 2 miles or less, the frequency with which they performed recreational and commuter cycling, and the number of hours per month they typically cycled in spring/summer and in autumn/winter). Parents' cycling frequency was predicted by their *reflective motivation* (their reasons to cycle); a*utomatic motivation* (their affective judgements regarding cycling on roads); whether they owned a roadworthy bicycle; and the proportion of friends who cycle on roads. Child's cycling frequency was predicted by their parent's cycling frequency, their reflective and automatic motivation, and whether they owned a roadworthy cycle (see Fig. 2). Model modifications were based on the suggestions provided by the modification indices when the fit indices were not adequate. However, these relationships were modified only if they made substantive sense. For instance, the measurement errors of finding cycling as relaxing could be correlated for the parent and the child because of their relationship. Thus, modifications were made and the final model that was fitted is discussed in the Results section.

3. Results

3.1. Data screening – retained responses

Four-hundred and twenty-eight survey responses were received. One-hundred and fifty-one flagged cases were visually inspected by the first and last authors; all were consequently removed from the analysis. The remaining 277 cases were also visually inspected by the first and last authors, and a further 31 cases were removed because of erroneous and/or inconsistent information; for example, a response that indicated a participant had not yet learned to ride a cycle but frequently used one.

3.2. CFA and SEM

The descriptive statistics for variables included in Models A and B are shown in Tables J and K (Supplementary Information). The

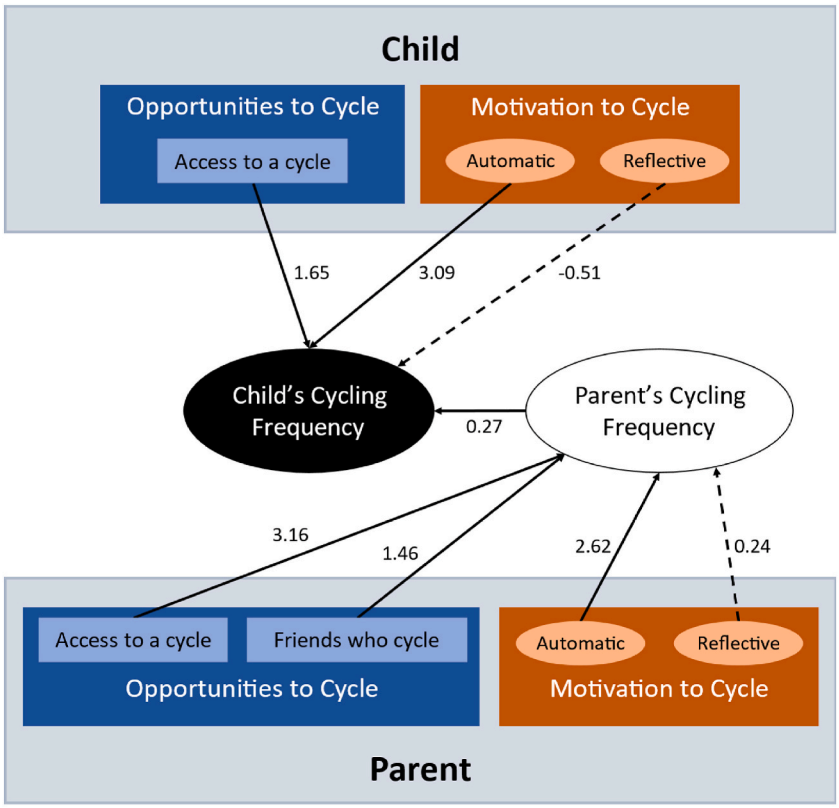


Fig. 2. Structural diagram showing the relationships between the items and the factors in Model B.
Note. Numbers are standardized beta coefficients – the expected change in the outcome variable given a one-unit change in the predictor; dashed lines represent statistically nonsignificant relationships; ovals represent latent variables.

reliability coefficients (omega and alpha) for each of the factors originally tested in CFA are given in Table 2. All coefficients were greater than 0.75, indicating good reliability. However, only the factors relating to reflective and automatic motivation for both children and parents were retained. None of the other factors were retained in the model because they led to non-converging solutions. Errors were allowed to be correlated for some items across children and parents in the retained factors (see Table M, Supplementary Material), which was entirely logical; parents and children's behaviours are similar, cycling-related and otherwise. The ultimate retained CFA model had CFI = 0.94, χ^2 = 2154.28, df = 153, TLI = 0.92, RMSEA = 0.067 [0.055, 0.079], SRMR = 0.058. The factor coefficients and error correlations for all statistically significant indicators are provided in Table 3, and the factor correlations for all statistically significant relationships between factors are in Table 4.

The final structural equation model that was retained (Model B) is shown in Fig. 2 below (CFI = 0.961, TLI = 0.964, RMSEA = 0.059 [0.047, 0.070], SRMR = 0.077). The associated regression coefficients are provided in Table 5. The children's cycling frequency was statistically significantly predicted by affective judgements regarding cycling (*automatic motivation*) and owning a roadworthy cycle (*physical opportunity*), and their parents' cycling frequency – arguably a social opportunity to cycle, albeit characterised as an outcome variable in the present analysis. Parents' cycling frequency was statistically significantly predicted by their *automatic motivation*, the proportion of their friends who cycled on roads (*a social opportunity*), and whether they owned a roadworthy cycle (*a physical opportunity*). In sum, both children's and parents' cycling frequency were predicted by their opportunities and motivation to cycle.

4. Discussion

We collected responses to a survey based on the COM-B model from a sample of 246 UK schoolchildren and their parents, to ascertain the contributions of their *cycling-related capabilities*, their *opportunities to cycle*, and their *motivation to cycle*, on their cycling frequency. Key determinants of the child's cycling frequency were the parent's cycling frequency, the child's automatic motivation to cycle – i.e., their affective judgements regarding cycling, as manifested through responses to survey items such as "cycling is relaxing" – and their access to a cycle helmet. The parent's cycling frequency was similarly predicted by their automatic motivation to cycle and their access to a cycle, but also the proportion of their close friends who also cycled. Neither the children's nor the parents' psychological and physical capabilities appeared to influence their cycling frequency; the physical environment was similarly uninfluential. Participants' reflective motivation – i.e., their deliberative reasons for cycling such as "It is important to cycle, to be socially responsible" – was a component of the final model but did not make a statistically significant contribution to either the children's or the parents' cycling frequencies.

Our findings suggest that parents' cycling frequency may be a strong predictor of their children's cycling frequency. This finding is unsurprising, given the age range of the children completing the survey – they are still highly dependent on their parents – and previous research has suggested that parents' cycling behaviours and attitudes serve as a model for their children (Thigpen and Handy, 2018). This finding is also consistent with the conceptual framework put forward by Panter and colleagues (Panter et al., 2008), and with evidence that parental attitudes influence their children's school travel behaviour (Ross and Wilson, 2021), if we assume that the parents' cycling behaviour is indicative of their favourable attitudes towards cycling – a notion that is also supported by our data. Attitudes and physical activity are correlated (Chevance et al., 2019), and recent evidence suggests that parents' physical activity behaviour positively influences their children's physical activity levels (Carter et al., 2022; Rhodes et al., 2021). Hence, cycling interventions focused on parents, rather than children, may be an effective means to increase children's cycling and physical activity. However, although adult cycle training is offered by Bikeability training providers in the UK, delivery and uptake of such training is low, despite government subsidisation (The Bikeability Trust, 2023) – an observation that is mirrored somewhat in our data: More than 70% of parents had not undertaken formal cycle training (NB: the proportion of children who had received no training was similarly high [48.4%]; see Table F in Supplementary Information). Moreover, the amount of funding available for adult training in the UK has been aimed at novice riders focusing more often on confidence building-style activities, rather than delivering according to the National Standard for Cycle Training (Department for Transport and Driver & Vehicle Standards Agency, 2019).

Behaviour change interventions aimed at developing healthy habits are typically complex (Gardner et al., 2023), although some evidence suggests that merely repeating the desired behaviour can be effective – notably when the task is simple, the environment is conducive and the person's attitudes towards the behaviour are positive (Kaushal and Rhodes, 2015). For example, research has shown that attitudes are a good predictor of people's intention to be physically active and their physical activity levels (Forster et al., 2018).

Table 2
Reliability coefficients for the factors.

	Child		Parent	
	Omega	Alpha	Omega	Alpha
Reflective motivation to cycle [a]	0.77	0.73	0.83	0.8
Automatic motivation to cycle [b]	0.85	0.79	0.89	0.85
Physical barriers to cycling [c]	0.90	0.87	0.90	0.86
Physical capabilities – Perceptual Judgements and Cycle Control [d]	0.81	0.77	0.81	0.63
Physical capabilities under various environmental conditions [e]	0.91	0.89	0.94	0.93
Attention allocation/distraction control while cycling (*psychological capabilities*) [f]	0.84	0.75	0.83	0.73

Note. Associated survey items are as follows: a = 37; b = 38; c = 42; d = 63; e = 64; f = 65. (please see supplementary materials for the survey).

Table 3
Factor coefficients– reflective and automatic motivation.

Factor	Indicator	Std Estimate	SE	z value	P(>|z|)
Reflective Motivation					
Child: It is important to cycle, to be …	…socially responsible	0.694	0.049	14.099	<0.01
	…a role model for others	0.712	0.051	13.957	<0.01
	…more independent	0.666	0.051	13.117	<0.01
	…an active person	0.644	0.074	8.707	<0.01
Parent: It is important to cycle, to be …	…socially responsible	0.834	0.041	20.393	<0.01
	…a role model for others	0.805	0.038	20.912	<0.01
	…more independent	0.753	0.042	17.725	<0.01
	…an active person	0.805	0.054	14.838	<0.01
Automatic Motivation					
Child: Cycling is …	…convenient	0.487	0.066	7.422	<0.01
	…relaxing	0.756	0.047	16.252	<0.01
	…enjoyable	0.763	0.061	12.498	<0.01
	…good for my physical health	0.694	0.079	8.742	<0.01
	…good for my mental health	0.657	0.065	10.18	<0.01
	…convenient	0.565	0.055	10.366	<0.01
	…relaxing	0.774	0.04	19.211	<0.01
Parent: Cycling is …	…enjoyable	0.847	0.037	23.065	<0.01
	…good for my physical health	0.813	0.063	12.876	<0.01
	…good for my mental health	0.845	0.045	18.971	<0.01

Note. Only statistically significant indicators are shown.

Table 4
Factor correlations.

	Parent: Reflective Motivation	Child:Reflective Motivation	Parent: Automatic Motivation
Parent: Reflective Motivation			
Child: Reflective Motivation	0.85		
Parent: Automatic Motivation	0.54	0.45	
Child: Automatic Motivation	0.48	0.65	0.64

Note. Only statistically significant relationships are shown.

Table 5
Regression coefficients in the structural equation model (Model B).

Variable	Estimate	SE	z value	P(>|z|)
Outcome Variable: Child Cycling Frequency				
Parent: *Cycling Frequency*	0.27	0.03	8.26	<0.01
Child: Reflective Motivation to Cycle	−0.51	0.45	−1.15	0.249
Child: Automatic Motivation to cycle	3.09	0.70	4.43	<0.01
Child: Access to a roadworthy cycle	1.65	0.73	2.25	0.02
Outcome Variable: Parent Cycling Frequency				
Parent: Proportion of Close Friends who Cycle	1.465	0.363	4.032	<0.01
Parent: Reflective Motivation to Cycle	0.242	0.504	0.481	0.631
Parent: Automatic Motivation to Cycle	2.617	0.629	4.161	<0.01
Parent: Access to a roadworthy cycle	3.156	0.909	3.472	<0.01

Relatedly, Thigpen and Handy (2018) found that positive attitudes towards cycling in children were associated with greater cycling frequency, especially so in adolescents who were frequent cyclists: They increasingly enjoyed the independence and convenience that cycling afforded them; infrequent cyclists did not express such attitudes. The authors argued that the positive attitudes arose from frequent positive cycling experiences in the former group – evidence for the importance of repeating and reinforcing desired behaviour. Because most of the present sample were able to cycle (96.3% of children; 85.8% of parents), the task is seemingly a simple one, and the physical environment did not emerge as a significant barrier, it may also be appropriate to focus on interventions designed to improve children's and parents' attitudes – i.e., their automatic motivation – regarding cycling as a mode of active travel. Indeed, Panter et al.'s (Panter et al., 2008) findings suggest that the child's attitudes towards active travel may positively influence their perception of the physical environment, including the perceived dangers of cycling in that environment, and so our inclusion of affective judgement items such as "cycling makes me anxious" could be particularly appropriate measures of children's and parents' attitudes towards cycling on roads. Interventions that focus on the playful element of cycling, through gamification (Bishop et al., 2023b), may also prompt children to view cycling as recreational, rather than utilitarian; such 'playfulness' may promote adherence to physical activity interventions (Yang et al., 2020). Indeed, recent work on immersive cycle training suggests that even a brief gamified intervention can improve adolescents' attitudes and confidence regarding cycling on roads (Rhodes et al., 2019).

4.1. Limitations and future directions

Recruitment of participants was challenging, and the approaches taken may have introduced potential biases into the sample. For example, it was clear to prospective participants that the focus of the project was on cycling, which may have biased the sample toward those interested or actively engaged in cycling. Moreover, the video call screening process used to ensure genuine responses might have deterred otherwise willing participants and biased the sample further toward those with stronger opinions or experiences related to cycling as a mode of travel. These potential biases can be seen in the fact that almost all the children who took part had access to a cycle, which is not representative of children in the Greater London area or across the UK (Department for Transport, 2021). However, we should note that a proportion of the sample had never cycled despite seemingly having access to a cycle. Moreover, the data relating to respondents' travel patterns (Table F, Supplementary Information) do seem to reflect those of the UK population (Department for Transport, 2022). To address potential sample biases, one avenue for future research would be to conduct in-depth psychometric analyses of the survey items – for example, fitting a possible bifactor model to the data – to ascertain the most parsimonious version of the survey for future administration. Many of the items we included in the survey, such as those relating to the cyclists' physical and psychological capabilities, are highly novel, but did not emerge as significant predictors in the final model, and so further exploration of the predictive value of these factors is warranted.

The survey we administered was extensive: the average completion time was approximately 30 min, which might have prompted the low completion rate. Although the sample size is adequate, it is on the lower end of the spectrum when considering the complexity of the model. The same model, when fitted with a larger sample would yield higher power, which would be more desirable. Another potential limitation of the survey is the response formats for our cycling frequency measures. For example, we asked children and parents to indicate the frequency with which they travelled journeys of two miles or less by indicating 'Never', 'Occasionally', 'Frequently' or 'Very Frequently'. Such response categories are open to interpretation and may consequently be imprecise. However, there is recent evidence to show that recall of highly personal information (e.g., parents' recall of their children's dental treatment over a 2-year period (Stormon and Sexton, 2023)) is poor, so broad response categories may be less prone to biased estimates than those requiring numerical approximations. Moreover, our combination of multiple cycling frequency self-report items into one composite measure may have mitigated this, by reducing overreliance on participants' estimates for individual items; retrospective recall of physical activity is often inaccurate (Welk et al., 2014). Nonetheless, it would be prudent to combine data obtained from different response scales in future studies, and these would ideally be reconciled with GPS recordings of cycling behaviour.

Similarly difficult to explain is that reflective motivation to cycle did not contribute significantly to the children's cycling frequency, despite its retention in the model. When we removed this factor from the model, the model did not fit the data. This could mean that this is still an important variable, but the relationship is not significant, due to sample size or other covariances. Nonetheless, the final model enables us to establish this contrast between this non-significant relationship and the significant relationship of automatic motivation (i.e., participants' affective judgments) with the DVs. Therefore, we retained reflective motivation, not least because it makes theoretical sense to do so. Nonetheless, previous research suggests that such deliberative attitudes commonly influence active travel mode choices, in adolescents and adults (Fitch et al., 2019; Kamargianni and Polydoropoulou, 2013; Heinen et al., 2011; Swiers et al., 2017), although it may be prudent to explore the relative contributions of reflective motivation and affective judgements (i.e., automatic motivation) to children's cycling frequency in future. To achieve this, qualitative approaches such as interviews would also be worthwhile.

We would also have preferred to have seen the intermediate models converge. When the models were run without indicating the ordinal nature of the items, they converged. So clearly the ordinal nature of the items interfered with the convergence. This could have been further exacerbated by the possibility that the participants were similar to some degree; for example, almost all of the children owned a cycle or had shared access to one, within or outside of their households. The reliability coefficients were large enough to indicate the internal consistency of the factors. However, the combination of the similarity of participants and the ordinal scale of the data might have interfered with convergence.

Finally, we acknowledge that structural equation modelling is a reductionist technique that may fail to capture nuances in the data. For example, previous studies have shown that a multitude of factors – personal, social, and environmental – influence children's cycling behaviour [e.g., 20-22, 24-29], and so the picture is likely to be more complex than our final model suggests. For example, a child's negative attitudes (*automatic motivation*) towards using their first bicycle might have influenced their parents' decision *not* to buy them another one when they outgrew that bicycle – which would almost certainly result in reduced access to a bicycle. Conversely, if the child exhibited a positive attitude towards cycling from a young age, and therefore cycled frequently during their early years, this might prompt their parents to replace the outgrown bicycle – thereby providing the child with access to a bicycle. There are many other nuanced relationships that might benefit from a more microscopic analysis. For example, parents of young children living in built-up areas surrounded by fast roads and no accessible green spaces may decide not to purchase bicycles for their child for these reasons. Hence, availability of a bicycle is one of several factors in the model that could be directly related to the child's automatic motivation or entirely independent of it; many similar interrelationships may exist in our data. However, we will explore these interrelationships in follow-up interviews with parent and child survey respondents.

Considering the parents' influence on their child's cycling behaviour, and that access to a cycle determined the parents' cycling frequency, appropriate interventions may be those that facilitate parental access to cycles, such as cycle share schemes; a more inclusive approach to such schemes has recently been called for in the UK (Armstrong, 2022). The apparent influence of close friends on parents' cycling behaviour in the present analysis suggests that interventions designed to change social norms for cycling may also be an important catalyst for active travel behaviour change in parents and carers, which could, in turn, promote changes to social norms for their children; there is evidence that this can increase active school travel (Ross and Wilson, 2021). Driving, walking, and taking a

bus are all more popular modes of transport than cycling for adults in the UK (Department for Transport, 2022). Providing parents and carers with easier access to cycles, and to group cycle training – a format that is not widely available for UK adults (The Bikeability Trust, 2023) – may shift these norms in favour of cycling.

4.2. Conclusion

Children's cycling frequency is strongly influenced by their parents' cycling behaviour, as well as their own affective judgements regarding cycling on roads. Access to a roadworthy cycle may also influence children's and parents' cycling behaviour. Given the diversity of the present sample, these findings may be generalisable to the wider UK population. Hence, we tentatively propose that interventions designed to increase children's and parents' habitual cycling behaviour, and to improve their attitudes towards cycling, may be particularly effective vehicles for behaviour change vis-à-vis active school travel and physical activity.

Financial disclosure

This work was funded by a widening access grant from The Department of Transport and The Bikeability Trust.

CRediT authorship contribution statement

Daniel T. Bishop: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Prathiba Batley:** Writing – review & editing, Writing – original draft, Validation, Methodology, Funding acquisition, Formal analysis. **Huma Waheed:** Project administration, Investigation, Data curation. **Tamara S. Dkaidek:** Project administration, Investigation, Data curation. **Gabriela Atanasova:** Visualization, Investigation, Formal analysis, Data curation. **David P. Broadbent:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

We are indebted to the children and their parents/carers who gave their time to complete this important survey.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2024.101765.

References

Armstrong, R., 2022. Guide to Cycle Share Schemes. https://www.cyclinguk.org.

Arvidsen, J., Schmidt, T., Præstholm, S., et al., 2022. Demographic, Social, and Environmental Factors Predicting Danish Children's Greenspace Use, vol. 69. Urban Forestry & Urban Greening. https://doi.org/10.1016/j.ufug.2022.127487. N.PAG.

Bell, S.L., Audrey, S., Gunnell, D., Cooper, A., Campbell, R., 2019. The relationship between physical activity, mental wellbeing and symptoms of mental health disorder in adolescents: a cohort study. Int. J. Behav. Nutr. Phys. Activ. 16 (1), 138. https://doi.org/10.1186/s12966-019-0901-7.

Benson, J., Scriven, A., 2012. Psychological, social and environmental barriers to cycling to school. Int. J. Health Promot. Educ. 50 (1), 34–44. https://doi.org/10.1080/14635240.2012.661956.

Bentler, P.M., Chou, Chih-Ping, 1987. Practical issues in structural modeling. Socio. Methods Res. 16 (1), 78. https://doi.org/10.1177/0049124187016001004.

Bishop, D.T., Batley, P.N., Graham, A., Broadbent, D.P., 2022. An item-level evaluation of the attentional style questionnaire (ASQ) using a sample of experienced cyclists. Psychological Test Adaptation and Development 3 (1), 134–142. https://doi.org/10.1027/2698-1866/a000030.

Bishop, D.T., Broadbent, D.P., Graham, A., Natesan Batley, P., 2023a. Psychological and experiential contributors to experienced cyclists' on-road cycling behaviour: a path analysis study. Transport. Res. F Traffic Psychol. Behav. 93, 55–67. https://doi.org/10.1016/j.trf.2022.11.016.

Bishop, D.T., Daylamani-Zad, D., Dkaidek, T.S., Fukaya, K., Broadbent, D.P., 2023b. A Brief Gamified Immersive Intervention to Improve 11-14-Year-Olds' Cycling-Related Looking Behaviour and Situation Awareness: A Pilot Study.

Bjørnarå, H.B., Westergren, T., Fegran, L., et al., 2020. Cumbersome but desirable-breaking the code of everyday cycling. PLoS One 15 (9), e0239127. https://doi.org/10.1371/journal.pone.0239127.

Blair, S.N., 2009. Physical inactivity: the biggest public health problem of the 21st century. Br. J. Sports Med. 43 (1), 1–2.

Boomsma, A., 1985. Nonconvergence, improper solutions, and starting values in LISREL maximum likelihood estimation. Psychometrika 50 (2), 229–242. https://doi.org/10.1007/BF02294248.
Cao, Z., Xu, C., Zhang, P., Wang, Y., 2022. Associations of sedentary time and physical activity with adverse health conditions: outcome-wide analyses using isotemporal substitution model. EClinicalMedicine 48, 101424. https://doi.org/10.1016/j.eclinm.2022.101424.
Carter, J.S., DeCator, D.D., Patterson, C., McNair, G., Schneider, K., 2022. Examining direct and indirect mechanisms of parental influences on youth physical activity and body mass index. J. Child Fam. Stud. 31 (4), 991–1006.
Carver, A., Timperio, A., Crawford, D., 2013. Parental chauffeurs: what drives their transport choice? J. Transport Geogr. 26, 72–77. https://doi.org/10.1016/j.jtrangeo.2012.08.017.
Charreire, H., Roda, C., Feuillet, T., et al., 2021. Walking, cycling, and public transport for commuting and non-commuting travels across 5 european urban regions: modal choice correlates and motivations. J. Transport Geogr. 96 https://doi.org/10.1016/j.jtrangeo.2021.103196. N.PAG.
Cheng, L., Pohlabeln, H., Ahrens, W., et al., 2020. Cross-sectional and longitudinal associations between physical activity, sedentary behaviour and bone stiffness index across weight status in european children and adolescents. Int. J. Behav. Nutr. Phys. Activ. 17 (1), 1–13. https://doi.org/10.1186/s12966-020-00956-1.
Chevance, G., Bernard, P., Chamberland, P.E., Rebar, A., 2019. The association between implicit attitudes toward physical activity and physical activity behaviour: a systematic review and correlational meta-analysis. Health Psychol. Rev. 13 (3), 248–276. https://doi.org/10.1080/17437199.2019.1618726.
Chillón, P., Hales, D., Vaughn, A., Gizlice, Z., Ni, A., Ward, D.S., 2014. A cross-sectional study of demographic, environmental and parental barriers to active school travel among children in the United States. Int. J. Behav. Nutr. Phys. Activ. 11, 1–21. https://doi.org/10.1186/1479-5868-11-61.
Department for Transport, 2014. National Travel Survey 2014: Travel to School. The Department for Transport, pp. 1–2.
Department for Transport, 2021. National Travel Attitudes Study: Wave 5. The Department for Transport, pp. 1–14.
Department for Transport. National travel survey: 2021. The Department for Transport. 2022:1-18.
Department for Transport and Driver & Vehicle Standards Agency, 2019. National Standard for Cycle Training: Moving Britain Ahead. https://assets.publishing.service.gov.uk.
Department for Transport and Driver & Vehicle Standards Agency, 2023. The Official Highway Code, p. 35.
Ellis, K., Pears, S., Sutton, S., 2019. Behavioural analysis of postnatal physical activity in the UK according to the COM-B model: a multi-methods study. BMJ Open 9 (8), e028682. https://doi.org/10.1136/bmjopen-2018-028682.
Emond, C.R., Handy, S.L., 2012. Factors associated with bicycling to high school: insights from davis, CA. J. Transport Geogr. 20 (1), 71–79. https://doi.org/10.1016/j.jtrangeo.2011.07.008.
England, Sport, 2023. Active Lives Children and Young People Survey. Sport England.
Fitch, D.T., Rhemtulla, M., Handy, S.L., 2019. The relation of the road environment and bicycling attitudes to usual travel mode to school in teenagers. Transport. Res. Pol. Pract. 123, 35–53. https://doi.org/10.1016/j.tra.2018.06.013.
Forster, A.S., Buykx, P., Martin, N., et al., 2018. Using affective judgement to increase physical activity in British adults. Health Promot. Int. 33 (4), 648–656. https://doi.org/10.1093/heapro/dax004.
Garcia, L., Mendonça, G., Benedetti, T.R.B., et al., 2022. Barriers and facilitators of domain-specific physical activity: a systematic review of reviews. BMC Publ. Health 22 (1), 1–22. https://doi.org/10.1186/s12889-022-14385-1.
Gardner, B., Arden, M.A., Brown, D., et al., 2023. Developing habit-based health behaviour change interventions: twenty-one questions to guide future research. Psychol. Health 38 (4), 518–540. https://doi.org/10.1080/08870446.2021.2003362.
Harvey, G., Kitson, A., 2015. Single versus multi-faceted implementation strategies - is there a simple answer to a complex question? A response to recent commentaries and a call to action for implementation practitioners and researchers. Int. J. Health Pol. Manag. 5 (3), 215–217. https://doi.org/10.15171/ijhpm.2015.214.
Heinen, E., Maat, K., Wee, Bv, 2011. The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. Transport. Res. Transport Environ. 16 (2), 102–109. https://doi.org/10.1016/j.trd.2010.08.010.
Henson, J., Yates, T., Biddle, S.J.H., et al., 2013. Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. Diabetologia 56 (5), 1012–1020. https://doi.org/10.1007/s00125-013-2845-9.
Higgins R, Ahern A. Students' and parents' perceptions of barriers to cycling to School—An analysis by gender. Sustainability. ;13(13213):1-16. doi: https://doi.org/10.3390/su132313213.
Hoare, E., Milton, K., Foster, C., Allender, S., 2016. The associations between sedentary behaviour and mental health among adolescents: a systematic review. Int. J. Behav. Nutr. Phys. Activ. 13, 1–22. https://doi.org/10.1186/s12966-016-0432-4.
Howlett, N., Schulz, J., Trivedi, D., Troop, N., Chater, A., 2019. A prospective study exploring the construct and predictive validity of the COM-B model for physical activity. J. Health Psychol. 24 (10), 1378–1391. https://doi.org/10.1177/1359105317739098.
Huynh, T.L.T., Silveira, S.L., Motl, R.W., 2023. Physical activity behavior in persons newly diagnosed with multiple sclerosis: applying the capability - opportunity - motivation - behavior (COM-B) model. Mult Scler Relat Disord 69, 104432. https://doi.org/10.1016/j.msard.2022.104432.
Ikeda, E., Hinckson, E., Witten, K., Smith, M., 2019. Assessment of direct and indirect associations between children active school travel and environmental, household and child factors using structural equation modelling. Int. J. Behav. Nutr. Phys. Activ. 16 (1) https://doi.org/10.1186/s12966-019-0794-5. N.PAG.
Johnson, M., Judah, G., Cunningham, D., Olander, E.K., 2022. Individualised physical activity and physiotherapy behaviour change intervention tool for breast cancer survivors using self-efficacy and COM-B: feasibility study. Eur J Physiother 24 (2), 119–128. https://doi.org/10.1080/21679169.2020.1804616.
Kamargianni, M., Polydoropoulou, A., 2013. Hybrid choice model to investigate effects of teenagers' attitudes toward walking and cycling on mode choice behavior. Transport. Res. Rec. 2382 (1), 151–161. https://doi.org/10.3141/2382-17, 10.3141/2382-17.
Kaushal, N., Rhodes, R., 2015. Exercise habit formation in new gym members: a longitudinal study. J. Behav. Med. 38 (4), 652–663. https://doi.org/10.1007/s10865-015-9640-7.
Koenders, N., Marcellis, L., Nijhuis-van der Sanden, M.W.G., Satink, T., Hoogeboom, T.J., 2021. Multifaceted interventions are required to improve physical activity behaviour in hospital care: a meta-ethnographic synthesis of qualitative research. J. Physiother. 67 (2), 115–123. https://doi.org/10.1016/j.jphys.2021.02.012.
Liu, J., Chen, X., Pei, M., 2023. Analyzing the cycling behaviors of Chinese adolescents through structural equation models. J. Transport Health 28, 1–10. https://doi.org/10.1016/j.jth.2023.101566.
Lois, D., Moriano, J.A., Rondinella, G., 2015. Cycle commuting intention: a model based on theory of planned behaviour and social identity. Transport. Res. F Traffic Psychol. Behav. 32, 101–113. https://doi.org/10.1016/j.trf.2015.05.003.
Mandic, S., García Bengoechea, E., Hopkins, D., Coppell, K., Spence, J.C., 2022. Adolescents' perceptions of walking and cycling to school differ based on how far they live from school. J. Transport Health 24, 1–12. https://doi.org/10.1016/j.jth.2021.101316.
McDermott, G., Brick, N.E., Shannon, S., Fitzpatrick, B., Taggart, L., 2022. Barriers and facilitators of physical activity in adolescents with intellectual disabilities: an analysis informed by the COM-B model. J. Appl. Res. Intellect. Disabil. 35 (3), 800–825. https://doi.org/10.1111/jar.12985.
Mendoza, J.A., Cowan, D., Liu, Y., 2014. Predictors of children's active commuting to school: an observational evaluation in 5 U.S. communities. J. Phys. Activ. Health 11 (4), 729–733.
Mertens, L., Van Dyck, D., Deforche, B., De Bourdeaudhuij, I., Brondeel, R., Van Cauwenberg, J., 2019. Individual, social, and physical environmental factors related to changes in walking and cycling for transport among older adults: a longitudinal study. Health Place 55, 120–127. https://doi.org/10.1016/j.healthplace.2018.12.001.
Michail, N., Ozbil, A., Parnell, R., Wilkie, S., 2021. Children's experiences of their journey to school: integrating behaviour change frameworks to inform the role of the built environment in active school travel promotion. Int. J. Environ. Res. Publ. Health 18 (9). https://doi.org/10.3390/ijerph18094992.
Michie, S., van Stralen, M.M., West, R., 2011. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement. Sci. 6 (1), 42–53. https://doi.org/10.1186/1748-5908-6-42.
Møller, M., Janstrup, K.H., Pilegaard, N., 2021. Improving knowledge of cyclist crashes based on hospital data including crash descriptions from open text fields. J. Saf. Res. 76, 36–43. https://doi.org/10.1016/j.jsr.2020.11.004.

Moran, A., Mullan, B., 2021. Exploring temporal self-regulation theory to predict sugar-sweetened beverage consumption. Psychol. Health 36 (3), 334–350. https://doi.org/10.1080/08870446.2020.1774055.
Murtagh, S., Rowe, D.A., Elliot, M.A., McMinn, D., Nelson, N.M., 2012. Predicting active school travel: the role of planned behavior and habit strength. Int. J. Behav. Nutr. Phys. Activ. 9, 65–74. https://doi.org/10.1186/1479-5868-9-65.
Office for National Statistics, 2022. Population Estimates for the UK, England, Wales, Scotland and Northern ireland: Mid-2021.
Panter, J.R., Jones, A.P., van Sluijs, E.M., 2008. Environmental determinants of active travel in youth: a review and framework for future research. Int. J. Behav. Nutr. Phys. Activ. 5 (1), 1–14. https://doi.org/10.1186/1479-5868-5-34, 10.1186/1479-5868-5-34.
Pearson, L., Berkovic, D., Reeder, S., Gabbe, B., Beck, B., 2023a. Adults' self-reported barriers and enablers to riding a bike for transport: a systematic review. Transport Rev. 43 (3), 356–384. https://doi.org/10.1080/01441647.2022.2113570.
Pearson, L., Berkovic, D., Reeder, S., Gabbe, B., Beck, B., 2023b. Adults' self-reported barriers and enablers to riding a bike for transport: a systematic review. Transport Rev. 43 (3), 356–384. https://doi.org/10.1080/01441647.2022.2113570.
Pfledderer, C.D., Burns, R.D., Byun, W., Carson, R.L., Welk, G.J., Brusseau, T.A., 2021. Parent and child perceptions of barriers to active school commuting. J. Sch. Health 91 (12), 1014–1023.
R Core Team. A Language and Environment for Statistical Computing.
Revelle W. Psych: procedures for psychological, psychometric, and personality research. . ;R package 2.3.6.
Rhodes, R.E., Gray, S.M., Husband, C., 2019. Experimental manipulation of affective judgments about physical activity: a systematic review and meta-analysis of adults. Health Psychol. Rev. 13 (1), 18–34. https://doi.org/10.1080/17437199.2018.1530067.
Rhodes, R., Quinlan, A., Naylor, P., Warburton, D.E.R., Blanchard, C.M., 2021. Predicting family and child physical activity across six-months of a family-based intervention: an application of theory of planned behaviour, planning and habit. J. Sports Sci. 39 (13), 1461–1471.
Ridgewell, C., Sip, N., Buchanan, N., 2009. School travel modes: factors influencing parental choice in four brisbane schools. Urban Pol. Res. 27 (1), 43–57. https://doi.org/10.1080/08111140802304793.
Ross, A., Wilson, K., 2021. The power of the neighborhood: perceived normative behaviors moderate individual predictors of walking and biking to school. J. Transport Health 22. https://doi.org/10.1016/j.jth.2021.101236.
Rosseel, Y., 2012. Lavaan: an R package for structural equation modeling. J. Stat. Software 48 (2), 1–36. https://doi.org/10.18637/jss.v048.i02.
Salmon, J., Salmon, L., Crawford, D.A., Hume, C., Timperio, A., 2007. Associations among individual, social, and environmental barriers and children's walking or cycling to school. Am. J. Health Promot. 22 (2), 107–113.
Salmon, P.M., Naughton, M., Hulme, A., McLean, S., 2022. Bicycle crash contributory factors: a systematic review. Saf. Sci. 145 https://doi.org/10.1016/j.ssci.2021.105511. N.PAG.
Salway, R., Emm-Collison, L., Sebire, S.J., Thompson, J.L., Lawlor, D.A., Jago, R., 2019. The association of school-related active travel and active after-school clubs with children's physical activity: a cross-sectional study in 11-year-old UK children. Int. J. Behav. Nutr. Phys. Activ. 16 (1), 72. https://doi.org/10.1186/s12966-019-0832-3.
Sawka, K.J., McCormack, G.R., Nettel-Aguirre, A., Hawe, P., Doyle-Baker, P., 2013. Friendship networks and physical activity and sedentary behavior among youth: a systematized review. Int. J. Behav. Nutr. Phys. Activ. 10, 130–138. https://doi.org/10.1186/1479-5868-10-130.
Schalkwijk, A.A.H., Bot, S.D.M., de Vries, L., Westerman, M.J., Nijpels, G., Elders, P.J.M., 2015. Perspectives of obese children and their parents on lifestyle behavior change: a qualitative study. Int. J. Behav. Nutr. Phys. Activ. 12, 1–8. https://doi.org/10.1186/s12966-015-0263-8.
Stormon, N., Sexton, C., 2023. Parental recall bias in observational studies: child dental service use. Int. J. Paediatr. Dent. 33 (5), 450–456. https://doi.org/10.1111/ipd.13051.
Swiers, R., Pritchard, C., Gee, I., 2017. A cross sectional survey of attitudes, behaviours, barriers and motivators to cycling in university students. J. Transport Health 6, 379–385. https://doi.org/10.1016/j.jth.2017.07.005.
Tappe, K.A., Glanz, K., Sallis, J.F., Zhou, C., Saelens, B.E., 2013. Children's physical activity and parents' perception of the neighborhood environment: neighborhood impact on kids study. Int. J. Behav. Nutr. Phys. Activ. 10, 39–48. https://doi.org/10.1186/1479-5868-10-39.
The Bikeability Trust, 2022. Bikeabillity Delivery Guide. https://www.bikeability.org.uk. (Accessed 17 October 2022). https://www.bikeability.org.uk/wp-content/uploads/2022/01/Bikeability-Delivery-Guide-2022-1.pdf.
The Bikeability Trust. Funding and Delivery. https://www.bikeability.org.uk. Web site. https://www.bikeability.org.uk/about/funding-and-delivery. Updated 2023. Accessed 21 September 2023.
Thigpen, C.G., Handy, S.L., 2018. Effects of building a stock of bicycling experience in youth. Transport. Res. Rec. 2672 (36), 12–23. https://doi.org/10.1177/0361198118796001, 10.1177/0361198118796001.
Trapp, G.S.A., Giles-Corti, B., Christian, H.E., et al., 2011. On your bike! A cross-sectional study of the individual, social and environmental correlates of cycling to school. Int. J. Behav. Nutr. Phys. Activ. 8.
Underwood, S.K., Handy, S.L., Paterniti, D.A., Lee, A.E., 2014. Why do teens abandon bicycling? A retrospective look at attitudes and behaviors. J. Transport Health 1 (1), 17–24. https://www.sciencedirect.com/science/article/pii/S2214140513000145, 10.1016/j.jth.2013.12.002.
van Kasteren, Y.F., Lewis, L.K., Maeder, A., 2020. Office-based physical activity: mapping a social ecological model approach against COM-B. BMC Publ. Health 20 (1), 1–10. https://doi.org/10.1186/s12889-020-8280-1.
Verhoeven, H., Ghekiere, A., Van Cauwenberg, J., et al., 2017. Which physical and social environmental factors are most important for adolescents' cycling for transport? an experimental study using manipulated photographs. Int. J. Behav. Nutr. Phys. Activ. 14 (1), 1–13. https://doi.org/10.1186/s12966-017-0566-z.
Welk, G.J., Kim, Y., Stanfill, B., Osthus, D.A., Calabro, M.A., Nusser, S.M., Carriquiry, A., 2014. Validity of 24-h physical activity recall: physical activity measurement survey. Med. Sci. Sports Exerc. 46 (10), 2014–2024. https://doi.org/10.1249/MSS.0000000000000314.
Willmott, T.J., Pang, B., Rundle-Thiele, S., 2021. Capability, opportunity, and motivation: an across contexts empirical examination of the COM-B model. BMC Publ. Health 21 (1), 1–17. https://doi.org/10.1186/s12889-021-11019-w.
Wilson, K., Clark, A.F., Gilliland, J.A., 2018. Understanding child and parent perceptions of barriers influencing children's active school travel. BMC Publ. Health 18 (1), 1053. https://doi.org/10.1186/s12889-018-5874-y.
Woldeamanuel, M., 2016. Younger teens' mode choice for school trips: do parents' attitudes toward safety and traffic conditions along the school route matter? Int. J. Sustain. Transport. 10 (2), 147–155. https://doi.org/10.1080/15568318.2013.871664.
Wolf, E.J., Harrington, K.M., Clark, S.L., Miller, M.W., 2013. Sample size requirements for structural equation models: an evaluation of power, bias, and solution propriety. Educ. Psychol. Meas. 73 (6), 913–934. https://doi.org/10.1177/0013164413495237.
Yang, Y., Ivey, S.S., Levy, M.C., Royne, M.B., Klesges, L.M., 2016. Active travel to school: findings from the survey of US health behavior in school-aged children, 2009-2010. J. Sch. Health 86 (6), 464–471.
Yang, X., Ma, L., Zhao, X., Kankanhalli, A., 2020. Factors influencing user's adherence to physical activity applications: a scoping literature review and future directions. Int. J. Med. Inf. 134 https://doi.org/10.1016/j.ijmedinf.2019.104039. N.PAG.
Zaragoza, J., Corral, A., Ikeda, E., García-Bengoechea, E., Aibar, A., 2020. Assessment of psychological, social cognitive and perceived environmental influences on children's active transport to school. J. Transport Health 16. https://doi.org/10.1016/j.jth.2020.100839.
Zeuwts, L.H.R.H., Deconinck, F.J.A., Vansteenkiste, P., Cardon, G., Lenoir, M., 2020. Understanding the development of bicycling skills in children: a systematic review. Saf. Sci. 123 https://doi.org/10.1016/j.ssci.2019.104562.
Zhang, C., Vanschoren, J., van Wissen, A., Lakens, D., de Ruyter, B., Ijsselsteijn, W.A., 2022. Theory-based habit modeling for enhancing behavior prediction in behavior change support systems. User Model. User-Adapted Interact. 32 (3), 389–415. https://doi.org/10.1007/s11257-022-09326-x.