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Predicting walking and cycling behaviour change using an extended Theory of Planned Behaviour

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ABSTRACT

Introduction: The psychological predictors of behaviour change may differ from the predictors of engaging in behaviour, and there is limited evidence on the associations between psychological constructs and changes in physical activity behaviours such as walking and cycling. This study of observational cohort data examined whether an extended version of the Theory of Planned Behaviour (eTPB) predicted change in walking and cycling for transport and recreation using a population-based sample of adults from three UK municipalities.
Methods: We used baseline, 1-year and 2-year follow-up data from the iConnect study. Nine psychological constructs from the eTPB as well as weekly time spent (i) walking and (ii) cycling, each (i) for transport and (ii) for recreation, were self-reported at all time points. Multinomial logistic regression was used to examine associations between baseline eTPB constructs and (i) increases and (ii) decreases in the four behavioural outcomes, adjusted for socio-demographic characteristics.
Results: 1796 and 1465 participants provided 1- and 2-year follow-up data, respectively. All eTPB constructs except subjective norms were associated with changes in at least one of the four outcomes, but these amounted to relatively few significant associations among the large number tested. In general, eTPB constructs were more often associated with increases than with decreases in time spent walking and cycling.
Conclusions: This is one of the first known studies to examine psychological predictors of change in walking and cycling for transport and recreation using an extended TPB. Future interventions to promote walking and cycling through individually delivered approaches might consider fostering the development of positive attitudes, perceived behavioural control, intentions, and habits for these behaviours.

Abbreviations: IPAQ, International Physical Activity Questionnaire; PBC, Perceived behavioural control; RCT, Randomised controlled trial; TPB, Theory of Planned Behaviour; eTPB, Extended Theory of Planned Behaviour

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1. Introduction

The benefits of physical activity for physical and psychological health are well documented (Penedo and Dahn, 2005; Reiner et al., 2013). In the United Kingdom (UK), guidelines suggest that adults of working age should achieve 150 min of moderate intensity physical activity per week (Chief Medical Officers of England, Scotland, Wales, and Northern Ireland, 2011). Walking and cycling can be integrated as part of a regular routine (Ogilvie et al., 2007; Yang et al., 2010) and provide one way to meet these guidelines.

Most research on the correlates of walking and cycling is underpinned by either socio-ecological or social-cognitive models (Armitage and Conner, 2000; Buchan et al., 2012). Cognitive models such as the Theory of Planned Behaviour (TPB) (Ajzen, 1991) are often used. This theory proposes that behaviour is a reasoned decision determined by intention, which in turn is influenced by one's attitude towards the behaviour (e.g. a positive or negative evaluation of the outcome to a situation), subjective norm (e.g. the perceived social pressure to perform the behaviour), and perceived behavioural control (PBC) (e.g. the perceived ease of control over performing that behaviour).

Studies of the predictive ability of TPB constructs in respect of walking and cycling have reported mixed findings. In most of the studies relating to walking, PBC was found to be the strongest predictor of behaviour (Darker et al., 2010; Eves et al., 2003; Galea and Bray, 2006; Lee and Shepley, 2012; Scott et al., 2007). In others, attitude was the strongest predictor (Beenackers et al., 2013; Rhodes et al., 2006; Rhodes et al., 2007). This lack of consensus may reflect differences between studies in the measurement of both outcomes and predictors (Eves et al., 2003) or in the characteristics of the samples (Rhodes et al., 2007), among other considerations (Buchan et al., 2012). Fewer studies have evaluated the predictive ability of TPB constructs in respect of cycling.

The TPB has received criticism for its focus on the influence of only three behavioural predictors (Hagger, 2010; Hardeman et al., 2002; Sniehotta et al., 2014). Researchers have overcome this limitation by including additional variables in the TPB; an acceptable strategy if proposed additional variables have the potential to increase the proportion of variance that is explained (Ajzen, 1991). Studies of both walking and cycling behaviours have found that subjective norm is consistently a weaker predictor of behaviour than PBC or attitude (Darker et al., 2010; de Bruijn et al., 2009; Eves et al., 2003; Galea and Bray, 2006; Rhodes et al., 2006; Rhodes et al., 2007; Scott et al., 2007). This may be due to the fact that the construct of subjective norm focuses on perceived social pressure from significant others, overlooking the potential importance of other social influences on behaviour, for example, the perceived visibility of walking and cycling behaviours in one's surroundings that have been explored in previous studies (Ball et al., 2010; Leonard et al., 2012; Sahlqvist et al., 2015). Extended TPB models for walking and cycling may therefore benefit from including a measure of visibility.

The influence of habit on behaviour has also received considerable attention (Gardner et al., 2011; Kwasnicka et al., 2016). According to the TPB, behaviour is under an individual's conscious control. However, when examining habitual behaviours, the role of consciousness may become less important as behaviours are more likely to be triggered and maintained automatically (Aarts et al., 1998). It has been suggested that everyday travel is a habitual behaviour (Verplanken et al., 1997), leading some researchers to extend the TPB to include a measure of habit (Anable, 2005; de Bruijn et al., 2009).

A second limitation of the TPB is that relatively few studies have applied TPB constructs to assess *changes* in walking and cycling behaviour (Akbar et al., 2015; Hagger, 2010; Hardeman et al., 2002) and this is particularly important to address. The predictors of behaviour may differ from those of behaviour change (Hankonen et al., 2010; Hardeman et al., 2011) and the ability of psychological constructs to predict physical activity behaviour change is contested (Sniehotta et al., 2014). In a meta-analysis investigating the relationship between intention and behaviour change, intention was found to predict a small-to-medium change in behaviour (Webb and Sheeran, 2006). In a more recent randomised controlled trial (RCT), however, TPB constructs did not predict physical activity behaviour change (Hardeman et al., 2011). Notably, the TPB has yet to be applied to predicting change in the specific behaviours of walking and cycling, and doing so could help strengthen the evidence base for interventions to promote walking and cycling in particular and physical activity in general.

1.1. The iConnect study

The iConnect study aimed to evaluate the effects of new, purpose-built infrastructure for walking and cycling constructed as part of Connect2, a programme of projects to build or improve walking and cycling routes at 84 UK sites (Ogilvie et al., 2012). The study was based on an original theoretical framework hypothesising that Connect2 may improve the physical accessibility of local destinations by improving the convenience, safety, psychological perceptions or other aspects of the routes to those destinations and that these changes may lead to increases in walking and cycling and wider changes in physical activity behaviours (Ogilvie et al., 2011). Findings from the main outcome evaluation revealed increases in walking, cycling and physical activity after two years (Goodman et al., 2014). Subsequent path analyses indicated that improvements to the physical environment played an important role in intervention effectiveness (Panter and Ogilvie, 2015), and findings from qualitative interviews suggested that the visibility of newly constructed walking and cycling schemes might be an important mechanism in supporting walking and cycling behaviour change in the local population (Sahlqvist et al., 2015). In the current study, we aimed to build on these findings by examining the extent to which an extended version of the TPB predicted change in walking and cycling for transport and recreation. We then use these findings to put forward strategies to be explored in future development of interventions to promote walking and cycling behaviours.

2. Methods

2.1. Study setting and participants

The present study comprised an observational cohort analysis of iConnect survey data from a population-based sample of adults from three municipalities in the UK. Full details of the conceptual framework, development of measurement tools, study design and sampling methods have been reported elsewhere (Ogilvie et al., 2011; Ogilvie et al., 2012). Briefly, three sites in Cardiff, Kenilworth and Southampton were purposively selected. In April 2010, 22,500 adults aged 18 and over living within 5 km by road of the Connect2 case study sites were randomly selected from the electoral register and sent a survey pack including questions on travel and physical activity behaviours, psychological constructs including those from the TPB, and socio-demographic characteristics. Respondents were sent an identical follow-up survey in April 2011 and again in April 2012. Ethical approval was obtained from the University of Southampton Ethics Committee (CEE200809-15).

2.2. Measures

2.2.1. Extended Theory of Planned Behaviour constructs

A nine-item measure was developed to assess constructs from an extended Theory of Planned Behaviour (eTPB) framework at baseline, and at 1- and 2-year follow-up (item wording shown in Table S1 of the online Supplemental materials). Six items, measuring attitude, subjective norm and PBC (i.e. a pair of items per construct) were adapted from those used in the ProActive trial (Hardeman et al., 2009). An additional single item was used to assess intention to do more of a given activity over the coming months (adapted from Hardeman et al., 2009). A single item assessing the automaticity of activity, which has been shown to be strongly related to habit, was drawn from the 12-item index of habit strength (Verplanken and Orbell, 2003). Finally, a single item was constructed to assess the perceived visibility of neighbourhood walking and cycling behaviours ("I see people in my neighbourhood walking for travel"). Participants reported their level of agreement with each item according to a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) in respect of walking and cycling for transport and recreation separately; as such, they responded to each item four times as it applied to each mode and purpose of travel. This approach was chosen because the predictors of walking and cycling are known to differ between behaviours (McCormack and Sheill, 2011) and purposes (Dill et al., 2014; Krizek et al., 2009).

2.2.2. Change in walking and cycling for transport or recreation

In line with previous iConnect study methods (Ogilvie et al., 2012), at each time point the time spent walking or cycling for transport was derived by asking participants to report the total time spent over the last seven days (min/week) undertaking five different journey purposes (journeys to and from work; on business (in the course of work); to and from school or place of study; for shopping and personal business; and visiting friends and relatives and for other social activities). Similarly, walking or cycling for recreation was derived by asking participants to report the total time spent in the last seven days (min/week) undertaking these behaviours for recreation, health or fitness. This approach, based on a modified short International Physical Activity Questionnaire (IPAQ), has been shown to demonstrate adequate test-retest reliability comparable to similar existing questionnaires including the original IPAQ (Adams et al., 2014). Total past-week time was truncated at 1260 min/week (21 h/week) for each behavioural outcome. Baseline time spent walking or cycling for transport or recreation was subtracted from time spent walking or cycling for transport or recreation at 1- and 2-year follow-up to derive change scores for each of the four behavioural outcomes (Sahlqvist et al., 2013). Consistent with previous iConnect study methods (Goodman et al., 2014) individuals reporting a change in walking or cycling for transport or recreation of more than 900 minutes per week were excluded from analysis as such large outliers may reflect self-report errors.

2.3. Analyses

Data were analysed using IBM SPSS version 21. In line with previous analyses (Sahlqvist et al., 2013), the four behavioural outcomes were categorised to indicate whether the time participants spent in each activity had increased by > 15 min/week, decreased by > 15 minutes/week or been maintained (changes of ≤ ± 15 min/week). Scores from the eTPB constructs (attitude, subjective norm, PBC, intention, habit and visibility) were recoded into three categories: 'broadly positive' (those who somewhat or strongly agreed with the statement); 'neutral' (those who neither agreed nor disagreed); and, 'broadly negative' (those who somewhat or strongly disagreed). Recoding the data in this way allowed low-frequency values to be combined with others and form a smaller number of logical categories for analysis (Kirch, 2008).

Multinomial logistic regression was used to examine the associations between behaviour-specific baseline eTPB constructs and change in time spent a) walking for transport, b) cycling for transport, c) walking for recreation, and d) cycling for recreation after one and two years, separately. For each behavioural outcome three models were fitted: (1) a 'standard' TPB model (including attitude, PBC, subjective norm and intention at baseline); (2) an extended TPB model (eTPB) (including baseline TPB scores and baseline habit and visibility); and (3) an eTPB model with additional adjustment for socio-demographic variables (sex, age, ethnicity, education, household income, and access to a motor vehicle), and time spent engaging in the behaviour of interest at baseline (e.g. baseline walking for transport in models of change in walking for transport). Accounting for covariates in this way adjusts for potential imbalances in baseline variables that may be related to the outcome of interest. All eTPB constructs associated with the outcome variable for a given model in univariable analysis ($p < 0.25$) (Hosmer and Lemeshow, 1989) were included in multivariable models.

3. Results

3.1. Sample characteristics

A total of 3516 participants completed and returned baseline surveys (16% response rate). After excluding those participants who moved home or reported extreme (≥900 min/week) changes in walking or cycling for transport or recreation (Goodman et al., 2014), the 1-year follow-up population consisted of 1796 participants (51% retention and 8% of those originally approached) and 1465 participants at 2-year follow-up (42% retention and 7% of those originally approached). As a result of missing data the final sample sizes for each regression model ranged from 1457 to 1698 for the 1-year sample and from 1179 to 1380 for the 2-year sample. The characteristics of participants in the 1- and 2-year samples were similar (Table S2). The majority of participants in both samples were female; most were aged 50 years or over; over 96% were of white ethnic origin; and most were living in households with a high level of car ownership compared with the latest figures for England and Wales (74%) (Office for National Statistics, 2011).

3.2. eTPB constructs

Baseline eTPB constructs in 1- and 2-year samples were at least moderately correlated (all $r > .30$, $p < .05$). Inter-item analysis confirmed that item pairs for attitude (i.e. instrumental and affective items), subjective norm (injunctive and descriptive) and PBC constructs (self-efficacy and controllability) were relatively stable (all $\alpha > .60$) (Table S3). On average, participants reported more favourable responses to eTPB items for walking for transport than for cycling for transport, and to those for walking for recreation than for cycling for recreation (all $p < .01$ in 1- and 2-year samples).

3.3. Change in walking and cycling for transport or recreation

At 1-year follow-up, weekly time spent walking for transport had increased in 32% of the participants ($n = 584$), had decreased in 35% ($n = 627$) and had been maintained in 33% ($n = 593$) (Table S4). Similarly, weekly time spent walking for recreation had increased in 33% ($n = 589$), had decreased in 35% ($n = 633$), and had been maintained in 32% ($n = 582$). In contrast, weekly time spent cycling for transport had increased in 7% ($n = 128$), had decreased in 6% ($n = 108$), and had been maintained in 87% ($n = 1568$). Similarly, weekly time spent cycling for recreation had increased in 7% ($n = 123$), had decreased in 8% ($n = 142$) and had been maintained in 85% participants ($n = 1539$). Findings were broadly similar at 2-year follow-up.

3.4. Regression analysis

3.4.1. Model summary

A comparison of the models tested for each behavioural outcome of interest revealed an increase in pseudo R^2 values when habit and visibility constructs were added to the standard TPB constructs (Table S5). Maximally adjusted models, including socio-demographic variables and the baseline measure of the behavioural outcome of interest, revealed further increases in pseudo R^2 values.

3.4.2. Associations between eTPB constructs and walking and cycling

Table 1 provides a simplified summary of the maximally-adjusted regression models of the associations between changes in each of the four behavioural outcomes of interest and the eTPB constructs. Detailed results for each outcome are presented in subsequent tables for walking for transport (Table 2), walking for recreation (Table 3), cycling for transport (Table 4) and cycling for recreation (Table 5). In general, eTPB constructs were more often associated with increases in walking and cycling behaviour than with decreases.

3.4.2.1. 'Standard' TPB constructs. After adjustment for socio-demographic factors (model 3 in each table), positive attitudes were associated with increases in walking for transport after one and two years (1 year: RRR 1.84, *95% CI* 1.12, 3.00; 2 years: RRR 2.01, *95% CI* 1.16, 3.52), and in cycling for transport after one year (RRR 2.54, *95% CI* 1.10, 5.87). Compared to those with a neutral attitude, those with a negative attitude were less likely to report a decrease in walking for recreation after two years (RRR 0.28, *95% CI* 0.08, 0.94). Attitude was not associated with change in cycling for recreation. Those participants who reported control over their behaviour (PBC) were more likely to report an increase in walking for transport (RRR 1.70, *95% CI* 1.10, 2.62) and cycling for recreation (RRR 5.07, *95% CI* 1.38, 18.70) after one year, and more likely to report an increase in cycling for transport after two years (RRR 3.05, *95% CI* 1.12, 8.34). Subjective norms were not associated with any of the outcomes.

A positive intention to walk more was associated with an increase in walking for recreation after one year (RRR 1.41, 95% CI 1.03, 1.93), but contrary to expectations was also associated with decreases in walking for recreation after one and two years (1 year: RRR 1.58, 95% CI 1.12, 2.22; 2 years: RRR 1.48, 95% CI 1.02, 2.15). Negative intentions to cycle more were associated with increases in cycling for recreation and transport after one year (RRR 0.15, 95% CI 0.06, 0.39; RRR 0.48, 95% CI 0.24, 0.93).

3.4.2.2. Extended TPB constructs and baseline behaviour. Strong habits for behaviour were associated with increases and decreases in walking for recreation and increases in cycling for transport after one and two years. A strong habit was also associated with an increase in walking for transport after two years (RRR 2.24, *95% CI* 1.42, 3.57). Habit strength was not associated with cycling for recreation. Those who reported they saw others cycling were more likely to report a decrease in cycling for recreation after one year

Table 1
Synthesis table reflecting the maximally-adjusted result for each domain of the eTPB.

	Walking for transport				Walking for recreation				Cycling for transport				Cycling for recreation			
	Increase		Decrease		Increase		Decrease		Increase		Decrease		Increase		Decrease	
Construct	1-year	2-year	1-year	2-year	1-year	2-year	1-year	2-year	1-year	2-year	1-year	2-year	1-year	2-year	1-year	2-year
Attitude	+	+	0	0	0	0	0	#	+	0	0	0	0	0	0	0
Subjective norm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBC	+	0	0	0	0	0	0	0	0	+	0	0	+	0	0	0
Intention	0	*	0	0	+	0	+	+	*	0	0	0	*	0	+	0
Habit	0	+	0	0	+	+	+	+	+	+	0	0	0	0	0	0
Visibility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	†	–

Note. Maximally adjusted models adjusted for sex, age, ethnicity, education, household income, access to motor vehicle, and baseline value of the outcome in question.
Increase: increase in weekly time spent walking and cycling for transport or recreation (change score ≥ 15 min/week).
Decrease: decrease in weekly time spent walking and cycling for transport or recreation (change score ≥ 15 min/week).
+: Positive association at $p < 0.05$.
-: Negative association at $p < 0.05$.
0: No association at $p < 0.05$.
†: Those reporting high and low visibility of people cycling for recreation were more likely to decrease weekly time spent cycling for recreation.
*: Those with no intention to walk or cycle more at baseline were less likely to increase time spent walking or cycling than to stay the same.
#: Those with a negative attitude towards walking for recreation at baseline were less likely to decrease time spent walking for recreation than to stay the same.

(RRR 2.50, 95% CI 1.19, 5.24), and those who reported not seeing others cycling were also more likely to report decreases in cycling for recreation after both one and two years (1 year: RRR 3.98, 95% CI 1.60, 9.91; 2 years: RRR 2.88, 95% CI 1.13, 7.38). Baseline walking and cycling for transport and recreation was associated with small increases and decreases in walking and cycling behaviours in 1- and 2-year samples (all RRR = 1.01–1.06).

4. Discussion

Previous research suggests that the TPB can be used to predict health behaviours in the general population (Hagger et al., 2002), but studies examining predictors of behaviour change are sparse and findings that have been reported to date are mixed (Blue, 2007; Hardeman et al., 2011). In general, findings from this study provided limited support for an eTPB model in predicting changes in walking and cycling and indicate that the model might not be a useful standalone framework for predicting changes in walking and cycling for transport or recreation outcomes. However, closer inspection of individual constructs revealed that all eTPB constructs, with the exception of subjective norm, were positively associated with change in at least one of the four walking and cycling outcomes examined in this study, although these amounted to relatively few significant associations among the large number tested.

While previous studies have identified attitude as a predictor of walking more generally (Beenackers et al., 2013; Rhodes et al., 2006; Rhodes et al., 2007), this is one of the first studies to identify attitude as a significant predictor of change in time spent walking for transport. Interventions designed to increase walking through the promotion of attitudinal change are relatively under-researched, but one study found that individuals with a negative or neutral attitude towards walking were more likely to be deterred from walking due to environmental factors (e.g. crime rates, proximity of neighbourhood amenities) than those with a positive attitude towards walking (Joh et al., 2012). As such, future interventions may benefit from the promotion of positive walking-related attitudes for those with negative or neutral attitudes, with messages individually tailored to address the underlying factors influencing such attitudes.

Consistent with previous research on walking (Darker et al., 2010; Eves et al., 2003; Galea and Bray, 2006; Lee and Shepley, 2012; Scott et al., 2007), this study lends support to the inclusion of PBC in an eTPB framework when examining changes in walking for transport. Applications of the TPB to cycling behaviour are relatively rare (Bamberg, 2012) and cycling behaviour change rarer still. Our finding that PBC was associated with an increase in cycling for transport are in line with the findings of two previous studies of commuter cycling behaviour; individuals who do not cycle for transport were found to perceive less control over that behaviour than those already cycling for transport (de Geus, 2007; Gatersleben and Appleton, 2007). Taken together, these findings suggest that the promotion of perceived control over cycling for transport may have a positive influence on cycling behaviour and behaviour change. Trip distance, bicycle availability, cycling infrastructure, and personal circumstances have been identified as four factors having a potential influence over people's perceptions of control relating to utility cycling (Bamberg, 2012). Future interventions promoting cycling for transport may need to address these broader underlying socio-ecological factors in order to promote perceptions of control that may have a positive influence on changes in cycling for transport. However, it is acknowledged that the evidence base relating to cycling for transport behaviour change is sparse and based on association, making it difficult to draw clear causal links.

This study has shown that those with no intention to spend more time walking or cycling were less likely to report increases in walking and cycling for transport and cycling for recreation. It is important to recognise that this finding does not equate to a

Table 2
Associations between eTPB constructs and changes in walking for transport in 1- and 2-year samples.

	Increase (a)					
	1-year sample (N = 1698) RRR (95%CI)			2-year sample (N=1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	2.50 (1.56–3.98)***	1.91 (1.18–3.07)**	1.84 (1.12–3.00)*	2.85 (1.70–4.77)***	2.14 (1.26–3.64)**	2.01 (1.16–3.52)*
Negative	1.36 (0.77–2.40)	1.40 (0.80–2.44)†	1.41 (0.80–2.50)†	1.20 (0.65–2.25)	1.22 (0.65–2.30)	1.20 (0.62–2.33)
Subj. norm						
Positive	0.88 (0.64–1.20)	NS	NS	1.25 (0.88–1.79)†	1.10 (0.76–1.59)	1.02 (0.69–1.50)
Negative	0.80 (0.54–1.19)	NS	NS	1.02 (0.66–1.59)	1.08 (0.68–1.69)	0.96 (0.59–1.56)
PBC						
Positive	2.08 (1.37–3.16)**	1.75 (1.14–2.66)*	1.70 (1.10–2.62)*	1.35 (0.85–2.15)†	1.11 (0.69–1.80)	1.20 (0.73–1.99)
Negative	1.46 (0.89–2.41)†	1.62 (0.98–2.68)†	1.67 (0.99–2.79)†	1.02 (0.59–1.75)	1.10 (0.64–1.90)	1.23 (0.69–2.19)
Intention						
Positive	1.10 (0.82–1.46)	1.04 (0.78–1.39)	1.02 (0.76–1.39)	0.92 (0.66–1.27)	0.90 (0.64–1.25)	0.86 (0.60–1.23)
Negative	0.80 (0.56–1.14)†	0.79 (0.55–1.14)†	0.82 (0.57–1.20)	0.64 (0.43–0.97)*	0.60 (0.40–0.92)*	0.64 (0.41–0.99)*
Habit						
High	NT	1.76 (1.18–2.63)**	1.27 (0.84–1.92)	NT	3.15 (2.02–4.89)***	2.24 (1.41–3.57)**
Low	NT	0.79 (0.71–1.30)	0.81 (0.52–1.26)	NT	1.19 (0.75–1.90)	1.30 (0.79–2.12)
Visibility						
High	NT	0.96 (0.71–1.30)	0.94 (0.69–1.27)	NT	0.84 (0.60–1.18)	0.75 (0.53–1.08)†
Low	NT	0.88 (0.61–1.26)	0.88 (0.61–1.28)	NT	0.91 (0.60–1.38)	0.86 (0.55–1.33)

	Decrease (a)					
	1-year sample (N = 1698) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	2.26 (1.44–3.53)***	1.71 (1.08–2.70)*	1.43 (0.86–2.38)†	2.47 (1.50–4.05)***	1.76 (1.05–2.94)*	1.64 (0.91–2.97)†
Negative	0.60 (0.33–1.10)†	0.67 (0.37–1.21)†	0.60 (0.31–1.16)†	0.83 (0.44–1.56)	0.85 (0.45–1.62)	0.75 (0.36–1.58)
Subj. norm						
Positive	1.05 (0.77–1.44)	NS	NS	1.44 (1.00–2.05)*	1.22 (0.84–1.76)	1.21 (0.79–1.85)
Negative	0.91 (0.60–1.38)	NS	NS	0.97 (0.62–1.52)	1.04 (0.66–1.65)	1.04 (0.61–1.78)

(*continued on next page*)

Table 2 (*continued*)

	Decrease (a)					
	1-year sample (N = 1698) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
PBC						
Positive	1.79 (1.19–2.70)**	1.54 (1.02–2.33)*	1.40 (0.87–2.24)†	1.58 (0.98–2.54)†	1.28 (0.78–2.09)	1.32 (0.75–2.32)
Negative	1.24 (0.74–2.06)	1.40 (0.84–2.34)†	1.50 (0.84–2.68)†	1.02 (0.58–1.79)	1.13 (0.64–1.99)	1.20 (0.62–2.30)
Intention						
Positive	1.19 (0.90–1.58)†	1.16 (0.87–1.55)	0.93 (0.67–1.30)	0.90 (0.65–1.25)	0.86 (0.62–1.21)	0.72 (0.49–1.06)†
Negative	0.76 (0.53–1.09)	0.76 (0.53–1.10)†	0.83 (0.55–1.25)	0.73 (0.48–1.09)†	0.68 (0.44–1.03)†	0.77 (0.48–1.26)
Habit						
High	NT	1.67 (1.13–2.47)*	0.84 (0.54–1.31)	NT	3.17 (2.05–4.92)***	1.43 (0.86–2.38)†
Low	NT	0.71 (0.46–1.09)†	0.78 (0.49–1.25)	NT	1.09 (0.68–1.75)	1.21 (0.70–2.07)
Visibility						
High	NT	1.20 (0.88–1.62)†	1.15 (0.82–1.62)	NT	1.17 (0.83–1.65)	1.04 (0.70–1.55)
Low	NT	0.99 (0.68–1.44)	0.97 (0.73–1.28)	NT	1.20 (0.78–1.83)	1.07 (0.66–1.75)

Note. a = The reference category is no change in walking for transport (± 15 minutes). b = The reference category is neutral. Positive or High = somewhat or strong agreement with eTPB statement; Negative or Low = somewhat or strong disagreement. RRR = Relative risk ratio. PBC = Perceived behavioral control. NT = Not tested. NS = Not significant and thus not carried forward to later model (s). Model 1: Standard TPB model (including attitude, PBC, subjective norm and intention scores at baseline); Model 2: Extended TPB model (eTPB) (including baseline TPB scores and baseline habit and visibility scores); Model 3: Adjusted for sex, age, ethnicity, education, household income, access to motor vehicle, and baseline walking for transport.

† $p < 0.25$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 3
Associations between eTPB constructs and changes in walking for recreation in 1- and 2-year samples.

	Increase (a)					
	1-year sample (N = 1673) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	1.87 (1.00–3.50)*	1.38 (0.73–2.62)	1.43 (0.75–2.74)	1.66 (0.80–3.43)†	1.08 (0.51–2.27)	0.96 (0.45–2.05)
Negative	0.84 (0.34–2.07)	0.93 (0.38–2.30)	0.95 (0.38–2.39)	0.55 (0.19–1.62)	0.54 (0.18–1.60)	0.48 (0.16–1.45)†
Subj. norm						
Positive	1.20 (0.84–1.72)	1.10 (0.76–1.59)	1.06 (0.72–1.55)	1.72 (1.16–2.55)**	1.39 (0.92–2.10)†	1.42 (0.93–2.16)†
Negative	0.79 (0.46.1.36)	0.86 (0.49–1.50)	0.92 (0.52–1.63)	1.67 (0.89–3.15)†	1.76 (0.92–3.37)†	1.74 (0.90–3.36)†
PBC						
Positive	1.87 (1.01–3.47)*	1.57 (0.83–2.94)†	1.43 (0.75–2.72)	2.21 (1.01–4.83)*	1.74 (0.78–3.86)†	1.46 (0.65–3.30)
Negative	0.80 (0.31–2.08)	0.75 (0.29–1.96)	0.75 (0.28–1.99)	0.74 (0.24–2.29)	0.73 (0.24–2.25)	0.64 (0.21–2.01)
Intention						
Positive	1.61 (1.20–2.16)**	1.55 (1.14–2.09)**	1.41 (1.03–1.93)*	1.41 (1.01–2.00)*	1.34 (0.96–1.89)†	1.27 (0.90–1.81)†
Negative	0.74 (0.46–1.19)†	0.79 (0.48–1.31)	0.83 (0.50–1.40)	0.82 (0.48–1.40)	0.88 (0.50–1.55)	0.98 (0.55–1.74)
Habit						
High	NT	2.29 (1.58–3.31)***	1.89 (1.29–2.77)**	NT	2.81 (1.86–4.27)***	2.36 (1.53–3.65)***
Low	NT	0.85 (0.55–1.30)	0.88 (0.56–1.36)	NT	0.84 (0.52–1.36)	0.86 (0.52–1.40)
Visibility						
High	NT	0.94 (0.69–1.28)	0.89 (0.64–1.22)	NT	1.06 (0.74–1.52)	1.00 (0.69–1.44)
Low	NT	1.03 (0.66–1.60)	1.01 (0.64–1.59)	NT	1.06 (0.64–1.74)	1.13 (0.68–1.89)
	Decrease (a)					
	1-year sample (N = 1673) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	2.35 (1.21–4.58)*	1.45 (0.72–2.89)	1.23 (0.59–2.56)	1.49 (0.73–3.02)	0.71 (0.34–1.49)	0.54 (0.25–1.17)†
Negative	0.63 (0.22–1.77)	0.76 (0.27–2.17)	0.54 (0.18–1.66)	0.38 (0.12–1.19)†	0.40 (0.12–1.27)†	0.28 (0.08–0.94)*
Subj. norm						
Positive	1.41 (0.99–2.01)†	1.15 (0.79–1.66)	1.08 (0.71–1.63)	1.75 (1.20–2.55)**	1.31 (0.87–1.96)†	1.21 (0.78–1.87)
Negative	0.59 (0.33–1.05)†	0.62 (0.34–1.14)†	0.71 (0.37–1.38)	0.79 (0.39–1.58)	0.81 (0.39–1.68)	0.93 (0.44–1.99)

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Table 3 (*continued*)

	Decrease (a)					
	1-year sample (N = 1673) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
PBC						
Positive	1.79 (0.96–3.35)[†]	1.33 (0.69–2.55)	1.09 (0.55–2.19)	2.67 (1.14–6.23)[*]	1.89 (0.78–4.56)[†]	1.32 (0.54–3.24)
Negative	1.12 (0.44–2.85)	1.02 (0.39–2.64)	1.07 (0.39–2.91)	1.80 (0.60–5.39)	1.87 (0.61–5.77)	1.40 (0.45–4.41)
Intention						
Positive	1.65 (1.23–2.20)[**]	1.54 (1.14–2.08)[**]	1.58 (1.12–2.22)[**]	1.42 (1.03–2.00)[*]	1.34 (0.96–1.88)[†]	1.48 (1.02–2.15)[*]
Negative	0.83 (0.52–1.34)	0.90 (0.54–1.49)	1.07 (0.61–1.88)	0.80 (0.47–1.36)	0.87 (0.49–1.53)	1.11 (0.60–2.06)
Habit						
High	NT	3.07 (2.11–4.47)[***]	1.67 (1.10–2.53)[*]	NT	4.30 (2.80–6.60)[***]	2.43 (1.52–3.87)[***]
Low	NT	0.68 (0.43–1.08)[†]	0.80 (0.49–1.31)	NT	0.67 (0.40–1.13)[†]	0.69 (0.40–1.20)[†]
Visibility						
High	NT	1.21 (0.88–1.67)[†]	1.18 (0.83–1.67)	NT	0.99 (0.69–1.41)	1.02 (0.59–1.75)
Low	NT	1.33 (0.85–2.08)[†]	1.25 (0.76–2.05)	NT	1.06 (0.64–1.75)	1.02 (0.59–1.75)

Note. a = The reference category is no change in walking for recreation (± 15 minutes). b = The reference category is neutral. Positive or High = somewhat or strong agreement with eTPB statement; Negative or Low = somewhat or strong disagreement. RRR = Relative risk ratio. PBC = Perceived behavioral control. NT = Not tested. NS = Not significant and thus not carried forward to later model (s). Model 1: Standard TPB model (including attitude, PBC, subjective norm and intention scores at baseline); Model 2: Extended TPB model (eTPB) (including baseline TPB scores and baseline habit and visibility scores); Model 3: Adjusted for sex, age, ethnicity, education, household income, access to motor vehicle, and baseline walking for recreation.

† $p < 0.25$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 4
Associations between eTPB constructs and changes in cycling for transport in 1- and 2-year samples.

	Increase (a)					
	1-year sample (N = 1504) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	3.43 (1.56–7.52)[**]	2.97 (1.31–6.74)[**]	2.54 (1.10–5.87)[*]	2.84 (1.22–6.58)[*]	2.37 (0.99–5.63)[†]	1.58 (0.64–3.89)
Negative	1.53 (0.59–3.95)	1.63 (0.61–4.36)	1.62 (0.60–4.37)	0.83 (0.29–2.37)	0.85 (0.29–2.49)	0.81 (0.27–2.38)
Subj norm						
Positive	0.84 (0.50–1.40)	0.64 (0.37–1.13)[†]	0.78 (0.43–1.43)	0.95 (0.53–1.69)	0.62 (0.33–1.18)[†]	0.72 (0.35–1.45)
Negative	0.68 (0.39–1.17)[†]	0.78 (0.43–1.40)	0.94 (0.50–1.75)	0.77 (0.42–1.43)	0.83 (0.43–1.61)	0.88 (0.43–1.78)
PBC						
Positive	2.83 (1.39–5.77)[**]	2.25 (1.08–4.72)[*]	1.78 (0.83–3.80)[†]	5.05 (1.94–13.15)[**]	3.91 (1.47–10.38)[**]	3.05 (1.12–8.34)[*]
Negative	1.46 (0.63–3.39)	1.53 (0.65–3.61)	1.38 (0.58–3.28)	12.00 (0.66–6.01)[†]	2.02 (0.66–6.13)[†]	1.65 (0.54–5.06)
Intention						
Positive	1.60 (0.97–2.66)[†]	1.28 (0.75–2.20)	1.29 (0.73–2.28)	1.55 (0.85–2.81)[†]	1.17 (0.62–2.21)	1.63 (0.80–3.31)[†]
Negative	0.39 (0.21–0.71)	0.47 (0.24–0.90)[*]	0.48 (0.24–0.93)[*]	0.68 (0.35–1.36)	0.75 (0.36–1.55)	0.95 (0.44–2.09)
Habit						
High	NT	5.15 (2.61–10.15)[***]	2.89 (1.37–6.06)[**]	NT	5.33 (2.37–12.00)[***]	3.33 (1.31–8.45)[*]
Low	NT	0.81 (0.41–1.62)	0.86 (0.42–1.77)	NT	0.98 (0.44–2.21)	1.39 (0.56–3.45)
Visibility						
High	NT	0.64 (0.37–1.08)[†]	0.63 (0.36–1.10)	NT	0.90 (0.49–1.68)	0.76 (0.39–1.27)
Low	NT	0.73 (0.40–1.35)	0.69 (0.37–1.30)	NT	0.69 (0.34–1.44)	0.59 (0.28–1.26)[†]
	Decrease (a)					
	1-year sample (N = 1504) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	4.52 (1.71–11.94)[**]	2.95 (1.05–8.26)[*]	2.08 (0.64–6.79)[†]	5.95 (1.76–20.13)[**]	3.96 (1.07–14.65)[*]	1.90 (0.39–9.17)
Negative	0.75 (0.17–3.38)	0.88 (0.18–4.25)	0.51 (0.08–3.37)	0.83 (0.13–5.39)	1.20 (0.16–8.80)	0.42 (0.03–5.35)
Subj norm						
Positive	1.84 (1.05–3.24)[*]	1.25 (0.67–2.36)	1.41 (0.63–3.15)	1.80 (0.97–3.33)[†]	1.09 (0.54–2.21)	2.25 (0.84–6.07)[†]
Negative	0.78 (0.39–1.56)	0.83 (0.38–1.79)	0.82 (0.31–2.20)	0.75 (0.34–1.62)	0.74 (0.31–1.77)	0.84 (0.25–2.87)

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Table 4 (*continued*)

	Decrease (a)					
	1-year sample (N = 1504) RRR (95%CI)			2-year sample (N = 1380) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
PBC						
Positive	2.46 (1.11–5.46)*	1.68 (0.71–3.98)†	1.59 (0.51–4.93)	3.45 (1.29–9.23)*	1.80 (0.62–5.24)	1.00 (0.24–4.17)
Negative	0.83 (0.27–2.54)	1.11 (0.34–3.59)	1.18 (0.29–4.92)	1.03 (0.26–4.12)	1.29 (0.31–5.46)	0.79 (0.14–4.65)
Intention						
Positive	1.20 (0.72–2.00)	0.92 (0.52–1.64)	1.20 (0.56–2.56)	0.88 (0.51–1.53)	0.61 (0.32–1.14)†	1.30 (0.52–3.24)
Negative	0.20 (0.09–0.45)***	0.28 (0.12–0.67)**	0.38 (0.13–1.08)†	0.17 (0.07–0.44)***	0.22 (0.08–0.61)**	0.55 (0.15–1.97)
Habit						
High	NT	7.75 (3.69–16.26)***	1.77 (0.65–4.80)	NT	7.49 (3.31–16.95)***	2.31 (0.73–7.27)†
Low	NT	0.47 (0.20–1.14)†	0.79 (0.28–2.22)	NT	0.39 (0.15–1.04)†	0.72 (0.21–2.53)
Visibility						
High	NT	1.00 (0.50–2.00)	0.74 (0.32–1.72)	NT	1.16 (0.52–2.56)	0.86 (0.38–1.80)
Low	NT	1.81 (0.83–3.96)†	1.35 (0.52–3.52)	NT	1.47 (0.60–3.63)	0.95 (0.28–3.22)

Note. a = The reference category is no change in cycling for transport (± 15 minutes). b = The reference category is neutral. Positive or High = somewhat or strong agreement with eTPB statement; Negative or Low = somewhat or strong disagreement. RRR = Relative risk ratio. PBC = Perceived behavioral control. NT = Not tested. NS = Not significant and thus not carried forward to later model (s). Model 1: Standard TPB model (including attitude, PBC, subjective norm and intention scores at baseline); Model 2: Extended TPB model (eTPB) (including baseline TPB scores and baseline habit and visibility scores); Model 3: Adjusted for sex, age, ethnicity, education, household income, access to motor vehicle, and baseline cycling for transport.

† $p < 0.25$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 5
Associations between eTPB constructs and changes in cycling for recreation in 1- and 2-year samples.

	Increase (a)					
	1-year sample (N = 1457) RRR (95%CI)			2-year sample (N = 1179) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	1.62 (0.68, 3.90)	1.32 (0.54, 3.26)	1.27 (0.49, 3.29)	2.08 (0.83, 5.21)†	1.67 (0.64, 4.36)	1.52 (0.56, 4.16)
Negative	0.86 (0.22, 3.35)	0.82 (0.21, 3.24)	1.02 (0.25, 4.21)	1.15 (0.32, 4.14)	1.13 (0.31, 4.19)	1.15 (0.30, 4.46)
Sub norm						
Positive	0.88 (0.54, 1.43)	0.74 (0.45, 1.24)	0.67 (0.39, 1.15)†	1.48 (0.84, 2.60)†	1.37 (0.75, 2.50)	1.60 (0.82, 3.11)†
Negative	0.75 (0.38, 1.47)	0.81 (0.40, 1.64)	0.72 (0.34, 1.49)	0.75 (0.35, 1.59)	0.92 (0.41, 2.03)	0.93 (0.40, 2.17)
PBC						
Positive	5.90 (1.68, 20.71)**	5.08 (1.39, 18.56)*	5.07 (1.38, 18.70)*	3.34 (1.13, 9.91)*	3.11 (1.00, 9.68)*	2.75 (0.88, 8.66)†
Negative	3.99 (0.92, 17.32)†	4.28 (0.96, 19.12)†	4.32 (0.95, 19.58)†	1.38 (0.36, 5.20)	1.44 (0.37, 5.59)	1.28 (0.32, 5.17)
Intention						
Positive	1.70 (1.05, 2.75)*	1.33 (0.80, 3.30)	1.22 (0.71, 2.11)	1.80 (1.02, 3.19)*	1.31 (0.70, 2.42)	1.20 (0.61, 2.35)
Negative	0.13 (0.05, 0.30)***	0.14 (0.06, 0.36)***	0.15 (0.06, 0.39)***	0.54 (0.25, 1.13)†	0.79 (0.35, 1.78)	0.95 (0.40, 2.22)
Habit						
High	NT	3.46 (1.86, 6.42)***	1.92 (0.97, 3.77)†	NT	2.79 (1.39, 5.59)**	1.21 (0.56, 2.60)
Low	NT	0.93 (0.49, 1.77)	0.90 (0.47, 1.76)	NT	0.50 (0.24, 1.04)	0.48 (0.22, 1.03)†
Visibility						
High	NT	1.01 (0.62, 1.66)	1.02 (0.60, 1.75)	NT	0.82 (0.47, 1.43)	0.88 (0.47, 1.63)
Low	NT	0.82 (0.42, 1.63)	0.76 (0.37, 1.57)	NT	0.80 (0.38, 1.68)	0.77 (0.34, 1.72)
	Decrease (a)					
	1-year sample (N = 1457) RRR (95%CI)			2-year sample (N = 1179) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Attitude						
Positive	5.31 (1.24, 22.85)*	3.56 (0.80, 15.75)†	2.29 (0.47, 11.14)	3.50 (1.03, 11.90)*	2.15 (0.60, 7.74)†	1.68 (0.39, 7.28)
Negative	1.60 (0.21, 12.27)	1.21 (0.15, 9.68)	0.64 (0.05, 8.47)	0.62 (0.06, 6.39)	0.48 (0.05, 5.02)	0.47 (0.03, 6.89)
Sub norm						
Positive	1.49 (0.91, 2.44)†	1.15 (0.67, 1.99)	0.81 (0.42, 1.55)	2.05 (1.16, 3.60)*	1.88 (1.01, 3.49)*	2.12 (0.96, 4.70)†
Negative	0.76 (0.36, 1.63)	0.80 (0.35, 1.79)	0.39 (0.14, 1.11)†	0.83 (0.36, 1.93)	0.98 (0.40, 2.43)	0.77 (0.25, 2.39)

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Table 5 (*continued*)

	Decrease (a)					
	1-year sample (N = 1457) RRR (95%CI)			2-year sample (N = 1179) RRR (95%CI)		
eTPB construct (b)	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
PBC						
Positive	5.50 (1.28, 23.66)*	3.74 (0.84, 16.71)†	6.70 (0.76, 59.31)	4.94 (1.14, 21.49)*	3.49 (0.76, 15.90)†	3.18 (0.57, 17.72)†
Negative	1.62 (0.25, 10.36)	1.66 (0.25, 10.89)	4.35 (0.34, 54.91)	0.99 (0.13, 7.45)	0.97 (0.13, 7.44)	0.71 (0.06, 8.33)
Intention						
Positive	3.05 (1.81, 5.15)***	2.03 (1.15, 3.58)*	2.65 (1.27, 5.52)**	3.07 (1.74, 5.42)***	1.85 (0.98, 3.46)†	1.77 (0.80, 3.95)†
Negative	0.30 (0.12, 0.72)**	0.47 (0.18, 1.23)†	0.40 (0.12, 1.34)†	0.44 (0.18, 1.09)	0.69 (0.26, 1.83)	0.76 (0.24, 2.47)
Habit						
High	NT	6.70 (3.49, 12,88)***	1.84 (0.83, 4.08)†	NT	6.01 (2.83, 12.77)***	1.20 (0.49, 2.95)
Low	NT	0.7 3 (0.34, 1.56)	0.75 (0.32, 1.77)	NT	0.62 (0.27, 1.43)	0.49 (0.19, 1.29)†
Visibility						
High	NT	1.79 (1.02, 3.12)*	2.50 (1.19, 5.24)*	NT	1.09 (0.60, 2.00)	1.20 (0.54, 2.66)
Low	NT	2.51 (1.24, 5.08)*	3.98 (1.60, 9.91)**	NT	2.02 (0.96, 4.27)†	2.88 (1.13, 7.38)*

Note. a = The reference category is no change in cycling for recreation (± 15 minutes). b = The reference category is neutral. Positive or High = somewhat or strong agreement with eTPB statement; Negative or Low = somewhat or strong disagreement. RRR = Relative risk ratio. PBC = Perceived behavioral control. NT = Not tested. NS = Not significant and thus not carried forward to later model (s). Model 1: Standard TPB model (including attitude, PBC, subjective norm and intention scores at baseline); Model 2: Extended TPB model (eTPB) (including baseline TPB scores and baseline habit and visibility scores); Model 3: Adjusted for sex, age, ethnicity, education, household income, access to motor vehicle, and baseline cycling for recreation.

† $p < 0.25$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

significant positive association between intention and certain behavioural outcomes, but it does lend support to interventions that promote intention formation through encouraging people to set a general behavioural goal (e.g. “I will walk more for transport next week”) (Abraham and Michie, 2008). This is supported by the findings of a systematic review of behaviour change techniques (BCT) used to promote walking and cycling, in which the BCT ‘prompt intention formation’ was recommended for inclusion in future walking and cycling intervention development (Bird et al., 2013).

A somewhat counterintuitive finding was that intention and habit constructs were found to predict both an increase and decrease in time spent walking for recreation. With respect to intention, it is well documented that intentions do not always translate into behaviour – often known as the intention-behaviour gap (Sheeran, 2002) – and empirical evidence indicates that individual-level influences, such as planning and self-efficacy, may mediate between physical activity intentions and actual behaviour (Sniehotta et al., 2005). In the case of habit, one possible explanation is that those who are habitually walking for recreation are, by definition, already spending time walking for recreation and thus have the potential to increase or reduce the time they spend doing so (for example, in response to adverse weather or poor health) (Prins et al., 2015), whereas those not habitually walking for recreation are less likely to have the potential to reduce this activity over time. Future longitudinal studies examining the causal pathways linking intention and habit to changes in walking for recreation would be beneficial.

Habit strength was found to predict changes in walking and cycling for transport at 2-year follow-up. This is somewhat surprising as one might imagine that time spent walking and cycling for transport is an everyday behaviour incorporated into the average working week, with limited potential for change. While we cannot determine from this study whether habit forms part of a causal mechanism for changes in walking and cycling for transport, future intervention studies could encourage ‘repetition or substitution’ to promote habit formation (Michie et al., 2013). Such an intervention might use a BCT to promote habit formation a strategy which has been shown to have potential for long-term maintenance of behaviour (Rothman et al., 2009) or could explore whether new environments might foster the development of positive habits by providing cues or prompts for behaviour (Marteau et al., 2011). In the case of the former, one study found that encouraging adults to perform a new activity each day (walking for 10 minutes after breakfast) led to increased automaticity (Lally et al., 2010); perhaps a similar approach focused on promoting ‘utility’ walking and cycling (e.g. walking part or all of the way to work each day) could be incorporated into future intervention design.

The visibility of cycling was also shown to predict changes in time spent cycling for recreation. Individuals reporting that they did not see people in their neighbourhood cycling for recreation were more likely to reduce their time spent engaging in that behaviour. Perceptions of cycling for recreation may represent a barrier to changing behaviour. Increasing the visibility of cycling for recreation, through promotional media and visual exposure, may create opportunities for social comparison, improve people's confidence to cycle, and contribute to the normalisation of cycling (Sahlqvist et al., 2015).

Findings indicated that increases and decreases in time spent walking and cycling were associated with baseline time spent engaged in those behaviours. However, the risk ratios were small, with an additional minute per week spent walking and cycling at baseline increasing the likelihood of increasing or decreasing walking and cycling behaviour by only 1–6%, relative to those reporting no change in walking and cycling. Results for each behavioural outcome, with and without adjustment for baseline walking and cycling behaviour, were broadly similar in terms of magnitude and effect size. This suggests that even after allowing for differences in baseline levels of walking and cycling, eTPB constructs were positively associated with change in at least one of the four walking and cycling outcomes examined in this study.

4.1. Study strengths and limitations

Important strengths of the study include its large population based sample (Goodman et al., 2014) and its cohort design allowing for assessment of changes in four distinct walking and cycling outcomes over time. Our analyses used eTPB constructs that were assessed as they related specifically to walking and cycling for recreation and transport. The response rate to the survey was low, but comparable to that of a similar postal survey of the general population (du Toit et al., 2005). However, while the sample was population-based, it was largely Caucasian and more than 30% of respondents were retired, which may restrict the generalisability of our findings to other populations.

In our study change in each of the four behavioural outcomes was derived by subtracting baseline walking or cycling for transport or recreation from time spent walking or cycling for transport or recreation at 1- and 2-year follow-up. This definition therefore incorporated those people walking or cycling slightly more or less than they did at baseline with those that may have newly adopted walking or cycling behaviours from zero at baseline. It is possible that the psychological factors influencing change in walking and cycling behaviours differ for these two groups and this warrants further examination.

The eTPB framework applied in this study was one small part of a larger conceptual model designed to investigate changes in walking and cycling (Ogilvie et al., 2011; Ogilvie et al., 2012). To reduce the burden on participants, the study questionnaire included only single-item and two-item measures to measure eTPB constructs. It is therefore questionable whether those items were able to fully capture each of the constructs relating to walking and cycling for travel or recreation. Furthermore, we did not examine the wider socio-ecological influences on behaviour change as this was outside the remit of the analysis reported in this paper. Other analyses from this project report that environmental perceptions did not appear to mediate the effect of exposure to the new infrastructure on behaviour; only use of new infrastructure was found to be a significant mediator (Panter and Ogilvie, 2015). Another similar recent evaluative study found that no TPB constructs were significantly associated with changes in active commuting; again only use of new infrastructure was found to be a significant mediator (Prins et al., 2016). Future path analyses, qualitative or mixed methods investigations may be able to investigate the interplay between psychological and socio-ecological constructs in influencing physical activity behaviour change.

5. Conclusions

This is one of the first known studies to examine psychological predictors of change in walking and cycling for transport and recreation using an extended version of the Theory of Planned Behaviour. Despite finding limited support for the extended model as a whole, all eTPB model constructs, with the exception of subjective norm, were found to be positively associated with change in at least one of the four walking and cycling outcomes examined in this study. The findings highlight strategies to be explored in future development of interventions to promote walking and cycling.

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Conlict of interest

The authors report that they have no conflicts of interest.

Availability of data and material

The data set used in this study is managed by the MRC Epidemiology Unit at the University of Cambridge. The access policy for sharing is based on the MRC Policy and Guidance on Sharing of Research Data from Population and Patient Studies. All data sharing must meet the terms of existing participants' consent and study ethical approvals. The authors' Data Access and Sharing Policy defines the principles and processes for accessing and sharing our data. They welcome proposals for projects and aim to make dataas widely available as possible while safeguarding the privacy of our participants, protecting confidential data and maintaining the reputations of our studies and participants. All data sharing is dependent on the project being approved by the study team, a data sharing agreement being in place with the University of Cambridge and resources being available to support the request. For further information please refer to the MRC Epidemiology Unit datasharing portal at http://epi-meta.medschl.cam.ac.uk.

Authors' contributions

The analysis plan was conceived by ELB, JP, GB and DO. ELB analysed the data and discussed findings with co-authors. ELB drafted the first version of the manuscript. All authors provided critical edits and revisions to the paper and have reviewed and approved the final version of the paper.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jth.2018.05.014.

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