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An intervention to promote walking amongst the general population based on an ‘extended’ theory of planned behaviour: A waiting list randomised controlled trial

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Theory of planned behaviour (TPB) studies have identified perceived behavioural control (PBC) as the key determinant of walking intentions. The present study investigated whether an intervention designed to alter PBC and create walking plans increased TPB measures concerning walking more, planning and objectively measured walking. One hundred and thirty UK adults participated in a waiting-list randomised controlled trial. The intervention consisted of strategies to boost PBC, plus volitional strategies to enact walking intentions. All TPB constructs were measured, along with self-reported measures of action planning and walking, and an objective pedometer measure of time spent walking. The intervention increased PBC, attitudes, intentions and objectively measured walking from 20 to 32 min a day. The effects of the intervention on intentions and behaviour were mediated by PBC, although the effects on PBC were not mediated by control beliefs. At 6 weeks follow-up, participants maintained their increases in walking. The findings of this study partially support the proposed causal nature of the extended TPB as a framework for developing and evaluating health behaviour change interventions. This is the first study using the TPB to develop, design and evaluate the components of an intervention which increased objectively measured behaviour, with effects mediated by TPB variables.

Keywords: theory of planned behaviour; walking; physical activity; intervention

Introduction

The current England and Wales (Department of Health, 2004) and United States (Department of Health and Human Services, 1996) governmental guidelines are for adults to accumulate at least 30 min of moderate or vigorous physical activity on at least 5 days in every week. However, 60% of males and 70% of females in England do not reach this level of physical activity required to benefit their health (Department of Health, 2005). The US Surgeon General’s office estimates that 25% of American adults are ‘completely sedentary’, and that less than 40% maintain regular physical activity at the recommended

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levels of 30 min or more per day (Department of Health and Human Services, 2000). In a recent report, the Chief Medical Officer for England recognised the difficulty many people have in translating a physical activity recommendation into a meaningful behaviour pattern that can fit into daily life (Department of Health, 2005).

Walking is especially promising as a focus of public health interventions to increase physical activity. A meta-analysis found that increases in walking led to increased fitness, decreased body weight, BMI, percentage body fat and resting diastolic blood pressure in previously sedentary adults (Murphy, Nevill, Murtagh, & Holder, 2007). Walking is the most common form of lifestyle physical activity that adults perform. Most importantly, walking is acceptable and accessible, particularly among populations who are the most physically inactive (Morris & Hardman, 1997).

The efficacy of walking interventions was supported by a recent systematic review and meta-analysis of 19 randomised controlled trials and 29 non-randomised controlled studies (Ogilvie et al., 2007). However, the Ogilvie et al. (2007) review included a mix of different types of interventions targeted at different populations, utilising different modes of delivery and different assessments of change in walking, making interpretation in terms of policy difficult. In particular, more work is needed to identify the components of interventions that are effective in increasing walking. This task would be facilitated by developing and evaluating interventions in terms of explicit theory (Michie & Abraham, 2004). Theory-based interventions can provide an explanation of how an intervention works, developing an understanding of the causal processes and mechanisms which account for any observed behaviour change.

One theory which has been used extensively in health psychology research to predict intentions and behaviour is the theory of planned behaviour (TPB) (Ajzen, 1991). There are several reasons why the TPB is a promising theory on which to base interventions to alter health-related behaviour. First, it can be used to predict and explain any behaviour in terms of a few constructs. Second, it has been frequently used to study a variety of health behaviours (Conner & Sparks, 2005), and is probably the social cognition model that is most commonly used in health psychology (M. Johnston, French, Bonetti, & Johnston, D.W., 2004; Ogden, 2003). Third, meta-analytic reviews of the TPB have provided empirical support in terms of its capacity to predict many health behaviours (Conner & Sparks, 2005). The TPB has also been successfully used several times to predict walking behaviour (described below).

The TPB suggests that the proximal determinants of behaviour are a persons' intention to engage in that behaviour, i.e. their motivation to perform the behaviour, and perceived behavioural control (PBC), i.e. the extent to which a person feels that the behaviour is easy to perform and/or under their control. In turn, intentions are determined by attitude towards the behaviour (global evaluation of the consequences of performing that behaviour), subjective norm (the perceived social pressure to perform the behaviour) and PBC. The basis of attitude, subjective norm and PBC are posited to be behavioural, normative and control beliefs. Attitude is determined by behavioural beliefs, i.e. the perceived consequences of engaging in that behaviour, weighted by the evaluation of these consequences (Ajzen & Fishbein, 1980). Subjective norms are determined by normative beliefs, i.e. perceptions of whether important others think a person should or should not engage in a behaviour, weighted by a person's motivation to comply with that salient referents expectations (Ajzen & Fishbein, 1980). PBC is determined by control beliefs, i.e. factors or conditions that make it difficult or easy to perform the behaviour, weighted by the perceived power of these factors or conditions to facilitate or inhibit the behaviour (Ajzen, 1991).

Meta-analytic reviews of correlational studies using the TPB have provided empirical support in terms of its capacity to predict many behaviours (Armitage & Conner, 2001) including physical activity (Hagger, Chatzisarantis, & Biddle, 2002). To date, the TPB has been mainly used to operationalise variables in the theory and to predict intention and behaviour. It has less commonly been used to develop interventions to change behaviour. One potential reason for this is that although the TPB can help to identify key beliefs that interventions could focus on, however it does not provide guidelines about how to change beliefs (Norman & Conner, 2005). A systematic review of interventions based on the TPB (Hardeman et al., 2002) identified 12 studies that used the TPB to develop a behaviour change intervention. Seven of these studies were found to change self-reported behaviour, but only two conducted mediation analysis to establish whether the effects of the intervention on behaviour was mediated by TPB constructs. Since the Hardeman et al. (2002) review, only one study has been published, to our knowledge, examining whether the TPB constructs mediate the effects of interventions on behaviour (Chatzisarantis & Hagger, 2005). However, as with the studies included in the Hardeman et al. (2002) review, these studies that conducted mediation analyses did not assess objectively measured behaviour. So, critically the TPB has rarely been used to develop, design or evaluate interventions and no study has demonstrated an effect of an intervention on objectively measured behaviour that was shown to be mediated by TPB constructs. Thus, none of these studies adequately test whether the TPB describes causal relationships, whereby altering TPB constructs brings about changes in objectively measured behaviour, via the causal pathways proposed by the model (Sutton, 2002).

We therefore designed an intervention with the aim of improving and expanding our understanding of the utility of the TPB as a framework on which to base interventions to encourage members of the general public to walk more, and to assess the extent to which changes in walking are mediated by TPB measures. To our knowledge, seven studies have used the TPB to predict intentions or actual walking behaviour, and with the exception of one study (Rhodes, Brown, & McIntyre, 2006) all have found that PBC was the strongest predictor of intention (Darker & French, submitted; Darker & French, unpublished; Eves, Hoppé, & McLaren, 2003; Galea & Bray, 2006; Scott, Eves, French, & Hoppé, 2007 [two studies]). These studies include samples as diverse as students (Darker & French, unpublished; Eves et al., 2003; Scott et al., 2007 [study one]), military personnel (Scott et al., 2007 [study two]), the general public (Darker & French, submitted) and patients with intermittent claudication (Galea & Bray, 2006). PBC therefore appears to be the construct that behaviour change interventions should aim to alter in order to increase intentions to walk more.

Altering intentions may not be sufficient to alter actual walking behaviour as there is a 'gap' between intentions and actions for many behaviours (Orbell & Sheeran, 1998). Relatedly, Scott et al. (2007) found that the TPB predicted self-reported intention to walk but failed to predict objectively measured behaviour. Thus, motivating people to walk more may be a necessary but probably not a sufficient condition for behaviour change. In addition, it has been suggested that facilitating planning may help individuals to bridge the gap between having a 'good intention' and actually translating that into behaviour (Heckhausen, 1991). Indeed there is considerable evidence showing that simple planning interventions are effective in increasing levels of physical activity in individuals motivated to change (Gollwitzer & Sheeran, 2006). For example, Sniehotta, Scholz and Schwarzer (2006) found a combination of action planning and coping planning to be effective in promoting physical activity amongst cardiac rehabilitation patients, who were highly motivated to change.

Planning can have several strategic purposes in self-regulation of behaviour, e.g. specifying when, where, how and whom to act (action planning), identifying situations which would facilitate the performance of difficult goal related behaviours (facilitative planning) or identifying strategies to overcome obstacles and to cope with barriers to performing the target behaviour (coping planning). While these planning processes usually presume a behavioural intention and are theorised to be post-intentional and volitional, planning to bring about factors which support walking and anticipating how to overcome barriers explicitly address perceptions of barriers and facilitation – or negative and positive control beliefs – the precursors of PBC. It is therefore possible, that interventions including these kinds of planning have an effect on PBC which may mediate some of their effect on behaviour.

The present study provides a rigorous test of an intervention to promote objectively measured walking behaviour, with a focus on using mediation analyses to test the hypothesised causal processes of the TPB. The intervention was based on the TPB, extended to include post-intentional volitional process. As the intervention consisted of strategies to increase PBC and planning, in line with Ajzen (1991), we hypothesize that (i) the intervention will lead to a change in control beliefs; (ii) the intervention will result in an increase in PBC, mediated by a change in control beliefs; (iii) the intervention will result in an increase in intention to walk, mediated by a change in PBC and that (iv) the intervention will lead to an increase in the number of minutes spent briskly walking assessed by pedometers, mediated by a change in intention and/or PBC.

Method

Participants

This study was publicised via newspapers and radio station interviews local to Birmingham, England where the intervention took place. Participants were recruited from September 2006 to April 2007. This resulted in 176 people expressing interest and being given information about the study. The inclusion criteria were that participants must be between the ages of 16–65 years, and not walk more than 90 min a day in a usual week (as assessed by self-report). These criteria were to ensure that the study recruited a sample of fairly sedentary adults of working age who were able to consent to participate in the study. All participants who wished to participate were screened, by C.D. Darker, using a general health questionnaire, to assess for any medical reasons why they could not engage in moderate physical activity, i.e. brisk walking in the present study. Twelve people were excluded for not being within the age range or for diverse medical reasons. Power analysis indicated a need to recruit and retain 130 participants, giving 80% power to detect a medium effect size of Cohen's $d=0.5$ with an alpha error level of $p < 0.05$. After 42 people decided not to take part in the study, the final sample ($N=130$) included 92 females (70.8%) and 38 males (29.2%) with a mean age of 40.60 years ($SD=10.84$). A CONSORT diagram (Moher, Schulz, & Altman, 2001) is used to show the flow of participants through the study (Figure 1).

Design

The study used a 'waiting-list control' form of randomised controlled trial, where participants in the control group receive the intervention, but at a later time than the experimental group. This was employed in order to increase acceptability of the research

Figure 1. CONSORT flow diagram of participants through the intervention.

protocol to the participants in the control group, and thereby to decrease attrition effects. Participants were individually randomly allocated to one of two experimental conditions via a random number generator. Half of the participants received the intervention immediately (at t_1) and the filler task 1 week later (at t_2) and half received the filler task at t_1 and the intervention at t_2 . All participants received two face-to-face sessions and two postal follow-ups (t_3 and t_4). The main outcome measure was number of minutes spent briskly walking, as assessed by pedometers.

Procedures

All sessions took place in a laboratory. At the beginning of the first session (*t1*), informed consent was obtained from all participants. Respondents completed the Neighbourhood Physical Activity (NPA) questionnaire (Giles-Corti et al., 2006), a self-reported measure of walking, along with a full TPB questionnaire. The participants were then randomly allocated to either the intervention group or the waiting-list control group. The experimental group received the intervention at that session. The control group received a filler task, which elicited their beliefs in relation to recycling. At the end of the session all participants completed the brief version of the TPB questionnaire. All participants were given a pedometer, were instructed on its use and asked to wear it over the next week.

One week later (*t2*) all participants again completed the NPA and the full TPB questionnaire. Those participants who had previously received the intervention now received the filler task and the previous control participants received the intervention. Participants were given another pedometer to wear for a further week, which they were asked to return via the post using a stamped addressed envelope provided along with the NPA. The return of these items constituted *t3*. One month later (*t4*) all participants received another follow-up measure comprising the NPA.

Intervention development and contents

The behavioural change intervention had several components that aimed to alter PBC concerning walking and to develop plans to enact intentions to walk. The intervention itself was developed during an extended period of formative research (described in detail by French, Darker, Eves, & Sniehotta, submitted). This research included a review of TPB walking studies (summarised above) to identify PBC as the construct which should be targeted, a TPB belief elicitation study to identify salient control beliefs (Darker, French, Longdon, Morris, & Eves, 2007a), an interpretative phenomenological analysis on walking behaviour (Darker, Larkin, & French, 2007b), and a piloting of intervention components and TPB measures (Darker & French, submitted).

As the literature reviewed earlier on TPB walking studies shows, PBC was consistently the strongest predictor of intentions to walk more in several studies, so the motivational component of the intervention aimed to increase participants' sense of control over walking. Following Ajzen (1991), the current intervention targeted control beliefs in order to bring about a change in PBC, which should then evoke a change in intention, leading to a subsequent change in actual behaviour.

In line with Ajzen's (2002a) recommendations, Hardeman et al. (2002) found that the behaviour change methods most commonly used in TPB intervention studies were persuasion and providing information. By contrast, Bandura (1997) has argued that these techniques are limited in their power to create enduring increases in perceived self efficacy. Ajzen has commented that PBC 'owes its greatest debt to Bandura's work on self-efficacy' (Ajzen, 2002b, p. 3). Enactive mastery experiences are considered the most influential source of self-efficacy information because they provide the most credible evidence of whether a person can gather what it takes to succeed at performing the behaviour (Bandura, 1997). The motivational stage of the intervention was consequently based on techniques to alter control beliefs and thereby PBC that were derived from the overall philosophy of motivational interviewing (Miller & Rollnick, 2002). According to motivational interviewing, behavioural change is facilitated by communicating in a way that elicits the person's own ideas about how they can bring about change.

This motivational phase therefore focused on recall of prior instances of success towards the external and internal factors that may surround walking.

The motivational component of the intervention consisted of three activities. First, a warm up task was used, whereby the participants were shown 10 statements about what would make it easier for them to walk more, i.e. 'when I felt like I have enough time to walk'; 'when I can walk in pleasant surroundings'. They then had to use a scale to indicate how confident they would be that they could bring about their walking in that specific situation. The researcher asked them to elaborate on why they indicated a high level of confidence for any of the instances (Miller & Rollnick, 2002). Second, the participants were then asked to recall an occasion where they felt like they had personal control over their walking and explicitly state what they felt was the helpful factor in that situation (Fisher & Johnston, 1996). Conversely, the participants were asked to recall an occasion when they felt like they had no control over their walking and state the unhelpful factor. Finally, the participants then used this information to develop a facilitative plan. This plan consisted of the participants generating three helpful factors that would make it easier for them to implement their physical activity plans. They also produced ideas for how they could successfully bring about these factors.

The volitional phase of the current intervention used goal setting, action planning and coping planning. These have been shown to be effective in promoting physical activity interventions with cardiac rehabilitation patients (Sniehotta et al., 2006). At the start of the volitional phase of the intervention, participants were informed of the average amount of walking that they currently did during a usual day, based on estimates derived from the NPA. Following discussion with the researcher, they were then asked to decide whether to increase their walking by an additional 10 min a day or an additional 20 min a day. Participants were given a choice of goals because goal theories have indicated that participants given a certain amount of choice are more likely to be successful in implementing their goals (Strecher et al., 1995).

Participants were required to develop up to three action plans to incorporate their additional walking into the next seven day period. Action planning asks participants to specify when, where, how and with whom to act, and can help initiate behaviour (Gollwitzer & Brandstatter, 1997; Sniehotta, Schwarzer, Scholz, & Schüz, 2005). The participants were asked to think about what potential barriers or obstacles that they could anticipate occurring and if necessary revise their action plan. Coping plans (Sniehotta et al., 2006) ask participants to anticipate potential barriers to performing this behaviour, i.e. feeling too tired to walk or bad weather, and specify how they would overcome these barriers if they were to arise. Coping plans can help with maintenance of behaviour.

Throughout the session it was emphasised that all of the plans were for the participants own benefit and that the additional walking goal chosen was entirely a personal choice, with the emphasis on the feasibility of goals and plans. Participants were asked to make a commitment to act as they had planned to over the next 7 days. They also received copies of all of their plans at the end of the intervention session to take home with them.

Measures

The NL-1000 pedometer (New Lifestyles Inc., USA) provided an objective measure of walking and records both step count and the number of minutes activity at a set intensity. The pedometer was set to record moderate activity (i.e. brisk walking) and above to the exclusion of light or low-intensity activity, i.e. at least four or above on its nine settings.

Pedometer data were cleaned (Rowe, Mahar, Raedeke & Lore, 2004), all pedometer scores below 1000 steps and above 30,000 were treated as missing data and mean scores for the same participant on other days were substituted.

Self-reported walking was assessed via the NPA questionnaire (Giles-Corti et al., 2006), which assesses the frequency and duration of recreational and transport related walking within and outside the participants' neighbourhood. It is a 14-item measure that uses prompted recall to estimate how many minutes were spent for walking in the past 7 days in all locations. Reliability estimates for the NPA are comparable with other traditional self-report physical activity instruments (Brown, Bauman, Chey, Trost, & Mummery, 2004; Sallis & Saelens, 2000).

A full TPB questionnaire on walking behaviour was modelled on the recommendations of Ajzen (1991, 2002a) and Ajzen and Fishbein (1980). There were 52 items, with 10 behavioural beliefs, three normative beliefs and five control beliefs, and their associated paired variables used to weight each belief (Ajzen, 2002a). There were five attitude questions (Cronbach's $\alpha = 0.85$), four subjective norm questions (Cronbach's $\alpha = 0.75$), four PBC questions (Cronbach's $\alpha = 0.85$) and three intention questions (Cronbach's $\alpha = 0.80$). Belief items were based on the most frequent responses to open-ended responses in a TPB belief elicitation study with 180 members of the general public (Darker et al., 2007a). All responses were made on a seven point rating scale.

As the full TPB questionnaire had 52 items, to reduce participant attrition from fatigue due to completing lengthy questionnaires, a brief eight item TPB questionnaire was also developed. The brief TPB questionnaire had one attitude, one subjective norm, four PBC and two intention items, which were derived from the full TPB questionnaire. The four item PBC scale utilised the same PBC items which appeared in the full TPB questionnaire.

Action planning was measured by four items (Cronbach's $\alpha = .99$), for example, 'I have made a detailed plan regarding when to walk' and 'I have made a detailed plan of where I am going to walk' (Sniehotta et al., 2005).

Analysis

Analyses were conducted to compare those that received the intervention *versus* those participants allocated to the control group. A series of 2×2 mixed design ANOVAs were conducted to evaluate the effects of the intervention on the constructs within the TPB. The repeated measure factor was measurements at $t1$ and $t2$ and the between subject factor was the experimental condition, i.e. the control or intervention group.

Given the absence of baseline pedometer measures, independent samples t -tests were conducted at $t2$ to examine whether the objective measure of pedometer walking of the participants had increased after the experimental group had received the intervention but the waiting list control group had not.

Mediation analyses were conducted to test the causal hypotheses derived from Ajzen (1991). Mediation implies a relationship whereby an independent variable causes a change in a mediator variable, which in turn causes a dependent variable. Mediation analyses of the effects of attitude, subjective norm and PBC on intention were conducted on the brief TPB measures taken at end of $t1$, as were the effects of intention, PBC and action planning on pedometer scores. The effects of beliefs on direct TPB measures were based on full TPB measure taken at the beginning of $t2$.

Mediation analyses were conducted using the bootstrapped sampling distribution model (Preacher & Hayes, 2004). Bootstrapping is neither a nonparametric approach to

effect-size estimation and hypothesis testing that makes no assumptions about the shape of the distribution of variables, nor about the sampling distribution of the statistics. The Preacher and Hayes (2004) bootstrapping method was preferred to the more usual Baron and Kenny (1986) method, following a recent review of mediational analysis (MacKinnon, Fairchild, & Fritz, 2007). There is evidence that methods of mediation such as the steps outlined by Baron and Kenny (1986) have a very low power to detect mediated effects, especially in the case of complete mediation (i.e. direct effect is zero) and are more likely to produce spurious results (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Bootstrap tests, such as those of Preacher and Hayes are most likely to yield more accurate probability estimates (MacKinnon et al., 2007; Shrout & Bolger, 2002).

Maintenance of walking was assessed by a 2×4 mixed factor ANOVA. The repeated measures factor was NPA scores throughout t_1 , t_2 , t_3 and t_4 ; the between subjects factor was the experimental condition. *Post hoc* repeated measures *t*-tests were used to assess where changes in walking behaviour had occurred and for how long these changes were maintained. These analyses were conducted for the intervention group and waiting list control group separately.

Results

Was randomisation successful?

The two experimental groups were compared at baseline on the following variables: age, gender, all TPB variables, including beliefs and NPA estimates of time spent walking. There were no significant differences in mean scores on any of these variables (all $p > 0.42$). Randomisation was therefore successful in producing broadly equivalent groups.

Did the intervention change behavioural, normative and control beliefs?

Behavioural and normative beliefs did not change as a result of the intervention (Table 1). However, control beliefs increased as a result of the intervention with a medium effect size of Cohen's $d = 0.49$.

Did the intervention change attitude, subjective norm, PBC and intention?

Attitude increased as a result of the intervention with a large effect size of Cohen's $d = 0.98$ (Table 1). There were no significant effects for subjective norms. PBC scores increased as a result of the intervention with a large effect size of Cohen's $d = 1.86$. Changes in intention scores increased as a result of the intervention, with a large effect size of Cohen's $d = 1.55$.

Did the intervention change behaviour?

There was a significant difference [$t(116) = 4.86, p < 0.001$] in the number of minutes spent walking, as assessed by pedometers, in the week up to t_2 between the control group ($M = 138.7, SD = 93.9$) and the intervention group ($M = 225.7, SD = 100.3$). The increase in walking was from a mean of 19.8 min to a mean of 32.2 min a day, an increase of over 60% in objectively measured time spent walking, a large effect with Cohen's $d = 0.90$. There was also a significant difference [$t(116) = 5.850, p < 0.001$] in the number of steps, as assessed by pedometers, in the week up to t_2 between the control group

Table 1. Mean scores of direct and indirect TPB measures during time 1 and time 2 of the intervention and significance of 2×2 ANOVA's.

	Time 1		Time 2		Probabilities			Interaction effect size Cohen's (<i>d</i>)
	Intervention mean (SD)	Control mean (SD)	Intervention mean (SD)	Control mean (SD)	Time	Group	Interaction	
Behavioural beliefs	246.60(48.99)	241.32(49.59)	255.87(47.24)	243.29(49.70)	0.16	0.27	0.16	0.25
Normative beliefs	70.47(23.51)	69.23(22.44)	73.61(27.17)	69.18(22.34)	0.09	0.49	0.09	0.17
Control beliefs	66.99(23.25)	71.09(23.24)	79.20(25.72)	71.02(25.72)	0.01	0.63	0.01	0.49
Attitude	29.56(4.35)	29.18(3.89)	32.63(3.43)	29.14(3.65)	0.01	0.01	0.01	0.98
Subjective norm	20.82(4.21)	21.10(3.90)	21.04(4.06)	21.07(3.67)	0.56	0.81	0.44	0
PBC	19.89(4.57)	19.56(4.36)	26.09(3.00)	19.46(4.03)	0.01	0.01	0.01	1.86
Intention	15.72(2.98)	15.28(2.96)	19.70(2.57)	15.43(2.91)	0.01	0.01	0.01	1.55

($M = 48643.3$, $SD = 11515.7$) and the intervention group ($M = 62751.7$, $SD = 14555.5$), with a large effect size of Cohen's $d = 1.07$.

Did beliefs mediate the effects of the intervention on PBC, attitude and subjective norm?

Mediation analyses were conducted to assess whether the effects of the intervention on attitude, subjective norm and PBC were mediated by respectively behavioural, normative and control beliefs in line with the TPB theoretical framework (Table 2). The effect on attitude was not mediated by behavioural beliefs, the effect on PBC was not mediated by control beliefs and there was no effect of the intervention on subjective norm. In all cases, the amount of variance accounted for by the indirect (mediation) path in all cases was not significant.

Did PBC and attitude mediate the effects of the intervention on intentions?

The effect of the intervention on intention was partially mediated by PBC and by attitude, but not by subjective norm, which was not altered by the intervention (Table 2). A statistically significant amount of the effects of the intervention on intention was accounted for via the indirect effects of the intervention on PBC ($p < 0.01$) and on attitude ($p < 0.01$).

What mediated the effects of the intervention on behaviour?

Mediation analyses were conducted to determine the potential mediating effects of intention, PBC and action planning (Table 2). There was no significant mediation of the intervention effects by either intention scores or action planning scores on pedometer scores. By contrast, the amount of variance accounted for by the indirect PBC pathway was significant ($p < 0.05$), indicating significant mediation by PBC of the effects of the intervention on objectively measured walking behaviour.

Were these effects maintained?

Maintenance of walking was assessed using NPA scores (Giles-Corti et al., 2006) (Figure 2). Minutes spent walking as assessed by pedometers over the first week of

Table 2. Tests of the mediated effects of the intervention on TPB and behaviour dependent variables as assessed by the Preacher and Hayes (2004) method.

Mediator	Dependent variable	<i>N</i>	Mean	Significance of mediated effect
Behavioural beliefs	Attitude	129	0.52	n.s.
Normative beliefs	Subjective norm	129	0.39	n.s.
Control beliefs	PBC	129	0.28	n.s.
Attitude	Intention	125	0.42	$p < 0.01$
Subjective norm	Intention	129	0.00	n.s.
PBC	Intention	128	1.70	$p < 0.01$
Intention	Pedometer minutes	117	30.44	n.s.
PBC	Pedometer minutes	116	37.64	$p < 0.05$
Action plan	Pedometer minutes	116	84.44	n.s.

Figure 2. Self-reported maintenance of walking across all four time points for the intervention group ($N = 47$) and the control group ($N = 51$).

measurement correlated strongly with this self-report measure ($r = 0.58$), supporting its validity. The intervention had a significant interaction effect between experimental condition and time on self-reported walking [$F(3, 94) = 33.88, p < 0.001$].

Post hoc paired sample *t*-tests for the intervention group indicated that there was a significant increase in number of minutes spent walking per week between t_1 (mean = 139.6, $SD = 126.5$) and t_2 (mean = 313.6) [$t(46) = 11.38, p < 0.001$], between t_1 and t_3 (mean = 305.0, $SD = 139.6$) [$t(46) = 8.12, p < 0.001$], between t_1 and t_4 (mean = 287.3, $SD = 129.4$) [$t(46) = 6.53, p < 0.001$]. There was no observed difference between t_2 and t_3 for the intervention group [$t(46) = 0.46, p = 0.643$] but there was a significant decrease between t_2 and t_4 for the intervention group [$t(46) = 1.96, p < 0.05$].

Post hoc tests for the waiting list control group indicated that there was a significant increase in the number of minutes spent walking per week between t_2 (mean = 147.7, $SD = 114.4$) and t_3 (mean = 293.7, $SD = 111.8$) [$t(50) = 9.53, p < 0.001$] and between t_2 and t_4 (mean = 259.0, $SD = 158.2$) [$t(50) = 5.67, p < 0.001$] and a significant decrease between t_3 and t_4 [$t(50) = 2.07, p < 0.05$]. In sum, the intervention resulted in a large increase in the number of minutes spent walking. Although, this level of increase was not fully maintained at t_4 , it was still significantly higher than at baseline.

Discussion

The results of this study were only partially supportive of the hypotheses derived from the TPB (Ajzen, 1991). The intervention led to a change in control beliefs (Hypothesis 1 supported). The intervention resulted in a large increase in PBC but this change was not mediated by the change in control beliefs (Hypothesis 2 not supported). The intervention resulted in a large increase in intention to walk which was mediated by a change in PBC (Hypotheses 3 supported). Finally, the intervention led to an increase in the number of minutes spent briskly walking mediated by a change in PBC but not by a change in intention (Hypothesis 4 supported). The increase in walking was from a mean of 20 min to

a mean of 32 min a day, as assessed by pedometers. These differences were still apparent, albeit with a smaller effect size, 6 weeks after baseline. This is also the first study, to our knowledge, that shows an effect of an intervention on any objectively measured behaviour that has been shown to be mediated in line with the TPB, i.e. effects on intention and behaviour mediated by PBC.

There were a number of strengths to this study. First, this study had an explicit theoretical basis: An extended TPB was used in the current study as the theoretical framework to design, implement and evaluate the intervention. Second, the TPB has previously mainly been used to measure process and outcome variables and to predict intention and behaviour, but has been used less commonly to develop or evaluate interventions (Hardeman et al., 2002). By contrast, the present study provided an experimental test of an intervention which yielded large effects on behaviour. The third strength of the current study was the formative research that was conducted on walking behaviour and a review to identify PBC as the major determinant of whether members of the general public walk, and the consequent development and piloting of key intervention components to address PBC (Darker & French, submitted; French et al., submitted). Fourth, this is the only study, to our knowledge, to utilise the TPB to develop and evaluate a walking intervention in a community sample. Attrition rates were very low, indicating the acceptability of such an intervention to a community sample. The fifth strength of this study is that each participant was required to wear a pedometer over the course of the intervention to obtain an objective measure of behaviour change. This allowed us to determine whether the effects of the intervention were having an effect on actual behaviour or just affecting subjective estimates of walking.

There were also a number of limitations to the present study. First, as with all multi-component interventions, we cannot definitively attribute effects of the intervention to either motivational or volitional components of the intervention. Future research is needed, with the central components of this study delivered to separate groups in order to ascertain the principal mechanism by which walking behaviour was increased. Second, the participants within this study were healthy community volunteers, which may have resulted in a sample who were more willing to increase their walking than non-volunteers. However, this limitation does not affect the ability of this study to test the extended TPB, although it does mean that the generalisability of the effects of the intervention, are not proven. Thirdly, a waiting list control design was employed, whereby all participants entered into the study received the intervention, but half had to wait until *t*₂ to receive the intervention. The limiting factor with this type of design is that comparisons of objectively measured behaviour between experimental groups cannot be obtained after both the groups have received the intervention (at *t*₂). Finally, the follow-up data collection points in this study were conducted via self-report only. However, there was a strong correlation between the pedometer scores and self-report data suggesting that the self-report measure used is indicative of objective behaviour.

The proposed mechanism of the TPB as outlined by Ajzen (1991) suggests that behaviour change is brought about by changing behavioural, normative or control beliefs. However, in the present study, there was no mediating effect of the intervention on PBC via causal beliefs as proposed by Ajzen (1991 – see also Sutton, 2007). It is possible that individually salient beliefs were affected, but not the five modally salient beliefs we assessed. However, these belief items were derived from a belief elicitation study conducted with a community sample in the same city (Darker et al., 2007a), and these five items covered over 80% (375/466) of the beliefs thereby elicited, so we think this is unlikely. The findings of the present study therefore do not support this part of the proposed causal

pathway of the TPB. These results are therefore inconsistent with Ajzen's (1991) view that changing beliefs is a necessary condition to bring about behaviour change, but instead support the position of Bandura (1997) on the sources of self-efficacy, where mastery experiences are a more powerful method of altering self-efficacy and thereby behaviour, without the necessity of altering beliefs.

Attitude and PBC mediated the effects of the intervention on intentions to walk, with the mediating effects being stronger for PBC than for attitude (Table 2). The intervention having an effect on attitude may be explained by evidence for the empirical and conceptual association between attitude and PBC. Kraft, Rise, Sutton, and Roysamb (2005) have demonstrated that PBC could be conceived of as consisting of three separate but inter-related factors (perceived control, perceived confidence and perceived difficulty), with perceived-difficulty items overlapping substantially with affective attitude. It may be that individuals have the greatest commitment to perform a behaviour when they hold favourable beliefs about the behaviour and they believe that they can successfully perform the behaviour. In other words, individuals like performing behaviours that they find easy. The mediating effects of the intervention on attitude and PBC on intentions to walk is in support of Ajzen's (2002a) conceptualisation of the TPB's causal mechanisms.

In the present study, there was a large effect on behaviour which was not mediated by a large effect on intentions. This is contrary to a recent meta-analysis of 47 experimental tests of intention-behaviour relations which found that a medium to large change in intention led to a small to medium change in behaviour (Webb & Sheeran, 2006). Contrary to the findings of Ziegelmann, Lippke, and Schwarzer (2006), action planning did not mediate the effects of the intervention. This may reflect the limitations of the measure of action planning to capture what may be an automatic process, although it is not clear that everyday health behaviours such as walking operate by the same automatic processes as laboratory lexical tasks (see Sniehotta, in press, for a discussion). Nonetheless, changes in PBC did mediate the effects of the intervention on objectively measured walking behaviour, so for walking, altering PBC appears to be the key ingredient for promoting walking behaviour.

Several studies (Johnston, D.W., Johnston, M., Pollard, Kinmonth, & Mant, 2004; Sniehotta et al., 2005) have previously found that motivation is not enough to alter lifestyle physical activity and that there is a need to develop methods to help individuals to increase their physical activity. The current intervention was successful in bringing about a large increase in PBC. PBC control is held to exert both a direct and interactive (with intentions) effect on behaviour. This is based on the rationale that however strongly held, the implementation of intention into action is at least partially determined by personal and environmental barriers: 'The addition of PBC should become increasingly useful as volitional control over behaviour decreases' (Ajzen, 1991, p. 185). Therefore, in situations where prediction of behaviour from intention is likely to be hindered by the level of actual (i.e. volitional) control, PBC should predict behaviour directly (Armitage & Conner, 2001). Sheeran, Trafimow, and Armitage (2003) have shown that where measures of PBC proved to be accurate proxy measures for actual control, PBC provided stronger predictions of behaviour. In the current study, behaviour was mediated by PBC but not by intention, suggesting that it was the effect of the intervention on PBC that was having a direct effect on increases in walking behaviour. PBC may have been responding to the enactive mastery technique that was utilised in the motivational component of the intervention. Perhaps in comparison to other forms of physical activity, walking is easier and individuals struggle less with implementing walking plans and more with initial motivation to walk.

This is the first study that shows an effect of an intervention on any objectively measured behaviour that has been shown to be partially mediated in line with the TPB, i.e. effects on objectively measured behaviour mediated by PBC. This contrasts with previous research that did not include an objective measure of behaviour (Chatzisarantis & Hagger, 2005). There is still a need, however, to disentangle *how* it works, specifically examining the effects of the motivational and volitional parts of the present intervention carried out separately and in combination. There is also a need for further evaluative tests of the TPB, with other objectively measured behaviours, to examine whether the TPB is a sound theoretical framework that can be used to develop other health behaviour interventions. There is also a need to examine in the future whether this type of behavioural change intervention could be generalised to a wider population of people and potential clinical samples. Objectively measured follow-up information at different time points, such as 6 months, would need to be gathered to assess longer term effectiveness.

Conclusion

We have reported a theory-based intervention, which was developed on the basis of formative research, tailored to the individual, and which has rigorously tested the efficacy of an extended TPB as a framework for use within a health behaviour change context. This extended TPB has been generally supported as a framework for developing and testing such interventions, although these results call into question the necessity of altering beliefs to bring about behaviour change. Increasing individuals' sense of personal control over aspects of their walking, leading to an increase in an intention to walk more, encouraged them to *actually* walk more. Walking continues to show promise as an avenue of intervention within public health.

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