Running Head: Walking-based interventions

Can implementation intentions and text messages promote brisk walking? A randomized trial.

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Abstract

Objective: To test the efficacy in promoting brisk walking of two theory-based interventions that incorporate implementation intentions and text message (SMS) reminders directed at either one's walking related plans or goals. ***Design:*** Participants (*N*=149) were randomized to one of three conditions (implementation intentions + SMS plan reminder; implementation intention + SMS goal reminder; control) before completing measures at baseline and follow-up four weeks later. At follow-up, the experimental groups were given a surprise recall task concerning their plans. All participants took an equivalent goal recall task. ***Outcome Measures:*** Validated self-report measures of physical activity and measures of implementation intention and goal recall, weight and waist-to-hip ratio. ***Results:*** Both intervention groups increased their brisk walking relative to the control group, without reducing other physical activity. The goal reminder group lost most weight. The plan reminder group recalled more of their plans than the goal reminder group but the latter were more successful in goal recall. ***Conclusion:*** Both interventions can promote brisk walking in sedentary populations. Text messages aid the recall of, and could enhance interventions that target, implementation intentions and goals.

Keywords: UK, implementation intentions, text messages, randomized controlled trial, physical activity, walking

Introduction

Being physically active through behaviors that include brisk walking (Manson et al., 2002), is associated with potential health (e.g., Kohl, 2001) and psychological (e.g., Brownley et al., 2003) benefits. Consequently guidelines across the world tend to recommend at least 30 minutes of moderate physical activity on most days of the week (e.g., Department of Health UK, 2004). However, many adults in Europe (Office for National Statistics, 2006a) and the US (USDHHS, 1996) have sedentary lifestyles failing to meet these or similar guidelines. There is a need, therefore, to develop effective interventions that can be delivered efficiently across large populations. Within this contribution, we present a test of two technology-based minimal interventions that attempt to promote brisk walking in individuals that were not meeting physical activity guidelines prior to intervention.

Theoretical Basis

Ample literature has shown the so-called "intention-behavior gap" whereby individuals fail to enact behaviors despite holding positive intentions (e.g., Sheeran, 2002). Sheeran, Milne, Webb, and Gollwitzer (2005) argue that failing to supplement one's intentions (e.g., to walk briskly) along with details regarding when, where and how the intention can be fulfilled (e.g., 'Every weekday morning at 8.30am I will leave my house and walk briskly to work') contributes to intention-behavior discrepancies. Gollwitzer's (1993) implementation intentions deal directly with this issue by requiring individuals to decide in advance of action, when and where they will act. They have been proposed to influence behavior by, first, increasing the accessibility of the mental representation of the anticipated environmental cue (leaving the house on weekday mornings at 8.30am) so that fewer good opportunities to act pass by unnoticed (see Aarts, Dijksterhuis, & Midden, 1999). Second, implementation intentions strengthen the link between

the planned situation (leaving the house) and the goal-directed response (walking to work) such that behavior is more likely to be initiated upon encountering the planned situation (see Webb & Sheeran, 2007).

As some studies have reported null effects of implementation intentions, strategies to enhance their efficacy need to be tested. Prestwich, Perugini, and Hurling (2008a) have demonstrated that pairing implementation intentions with text messages strengthen their effects on physical activity but as the type of text message (plan versus goal reminders) that participants received was not manipulated it is not clear which type of reminder would be the most effective. It is likely that, when paired with implementation intentions, reminders of one's plans or goals that underlie the particular behavior are likely to both be effective in changing behavior.

Plan reminders should further increase the accessibility of the environmental cue (as the individual is reminded of this cue) or prompt an individual to implement their plan (as the individual is reminded of the association between the cue and their desired action), or both. This is consistent with the role of cues to action in the Health Belief Model (e.g., Strecher & Rosenstock, 1997) as an important modifying factor influencing the likelihood of enacting health behaviors. Literature on automaticity (e.g., Aarts, & Dijksterhuis, 2003) would suggest that text message reminders of one's goals can also facilitate action via environmental cues. Within Kruglanski et al. (2002, p.333) Theory of Goal Systems, "goal systems consist of mentally represented networks wherein goals may be cognitively associated to their corresponding means of attainment and to alternative goals" and "typically, facilitative links may exist…between goals and their corresponding means". Text message reminders of one's reasons (goals) for performing a behavior should strengthen the link between goals and behavioral intentions (and their associated plans) within a mental hierarchy (see Kruglanski et al., 2002; Prestwich et al., 2008b).

Thus, text reminders of one's goals, following implementation intention formation, should prompt intention activation and their associated plans via the cognitive hierarchical structure. When brought to mind at an opportune moment, intentions should be particularly predictive of behavior (e.g., Cooke & Sheeran, 2004). Moreover, activating one's goals in conjunction with an implementation intention has been shown to be useful in changing health behavior (Prestwich, Ayres, & Lawton, 2008). Interestingly, recent evidence has shown that the mechanisms underlying the influence of implementation intentions and goal activation are separable and both contribute additively to action execution (Miles & Proctor, 2008). In the present context, this might suggest that reminder cues of one's own plans and of one's underlying goals can both increase the likelihood of action execution and do so via relatively independent mechanisms.

Technology and Health Behavior Change

Using technology such as the internet or mobile phones to deliver behavioral interventions has a number of benefits. The use of mobile phones in young adults is widespread (Office for National Statistics, 2006b) and represents a means through which health behavior can be influenced at any time without the need for face-to-face interaction.

Recently, van den Berg, Schoones and Vliet Vlieland (2007) identified 10 randomized controlled trials that used the internet to try to change physical activity. Of these studies, 3 tested the efficacy of an internet-based intervention against a waiting list or attention-control group and 2 of these 3 studies achieved greater behavior change with the internet-based strategy.

Further evidence has shown that a combined internet and mobile phone-based intervention, comprising tailored feedback, tailored solutions to perceived barriers, motivational tips, self-monitoring and implementation intentions with SMS text message reminders, significantly increased physical activity relative to a control group (Hurling et al., 2007). While

effective, the number of techniques utilized within the intervention made it unclear which components are effective. A study by Prestwich et al. (2008a) suggested that pairing implementation intentions with text messages represents a key intervention component and consequently that SMS text messages could be useful reminders when paired with plans.

Prestwich et al. (2008a) randomly allocated participants to one of five conditions (implementation intentions + SMS, implementation intention only, SMS only, or one of two control groups). The implementation intention + SMS condition reported the greatest increases in exercise behavior, whereas neither implementation intention only nor SMS only were effective. Within the SMS groups, participants were required to receive text messages but they were free to choose their own message content. However, it was suggested that they might choose reminders of their plans. The participants that received these text reminders of their plans increased their exercise more than those that chose different messages. However, without a direct experimental manipulation of the type of message received by those forming implementation intentions, it is difficult to make firm conclusions. First, the participants that followed the request to have texts reminding them of their plans might have been different (e.g., more motivated) than those that did not. Second, text messages cueing implementation intentions were compared against any other type of text messages, not just those cueing one's exercise goals. It is not clear, therefore, whether text messages cueing one's plans are more effective than texts cueing one's goals. A third limitation, like many of the studies included in Gollwitzer and Sheeran's (2006) review of implementation intentions, key study personnel were not blinded to condition using mechanisms such as sealed envelopes. Methodological limitations regarding blinding, along with insufficient details regarding randomization and concealment methods compromise any conclusions regarding implementation intention effectiveness and some recent rigorous trials have reported

null effects (e.g., Rutter et al., 2006). Further rigorous tests are needed. Here, we address these issues through a methodologically rigorous test of implementation intention-based interventions. This trial compared interventions incorporating implementation intentions and either text message reminders of plans or brisk walking goals against a control group that were simply asked to try to meet governmental physical activity guidelines.

Summary & Objectives

Recent evidence suggests that pairing an implementation intention with reminders delivered using text messages (SMS) is more effective than either implementation intentions or SMS alone, or no intervention (Prestwich et al. 2008a) but it is unclear whether the benefits of these interventions vary due to the specific content of the SMS (plans vs. goals). Reminders of implementation intentions might ease the likelihood that the plan is mentally accessible and thus useable (Prestwich et al., 2008a). Due to the fusion of goals and means within a mental represented network (Kruglanski et al., 2002), reminders of goals should activate the means through which they can be achieved (i.e., behavioral intentions and/or implementation intentions).

The primary objective was to test whether interventions that paired implementation intentions with text messages cueing plans or goals increased brisk walking in a student-based sample. Effective strategies promoting physical activity in university students are important because at this stage of life, most students have often just moved from a period of structured and supervised exercise in the form of physical education classes at school. A secondary objective was to check that any increase in walking arising from the manipulation did not have a negative compensatory effect on other physical activity. Additionally, we tested whether text reminders of plans and goals aided their recall in a surprise recall task at follow-up. If text reminders

strengthen the mentally represented association between the stimulus and response, those receiving text reminders of one's plans should be more successful in their recall of plans.

Participants that formed implementation intentions and were reminded either of their plans or goals should increase their brisk/fast walking (hypothesis 1) and physical activity (of at least moderate intensity, hypothesis 2), lose weight (hypothesis 3a) and reduce their waist-to-hip ratio (hypothesis 3b) significantly more than those in the control group. Moreover, those in the plan reminder condition should recall their plans significantly more than those in the goal reminder condition (hypothesis 4) and those in the goal reminder condition should recall their goals significantly more than those in the plan reminder or control groups (hypothesis 5). While we did not hypothesize differences between the plan reminder and goal reminders in brisk walking/physical activity such differences were explored.

Methods

Recruitment

Participants were recruited between 15th January 2007 and 2nd February 2007 and completed follow-up measures 4-weeks after baseline. All participants were recruited using an email distributed to a participant database that outlined the eligibility criteria and described the study as concerning attitudes and behavior relating to walking.' Participants were required to exercise less than three times per week (including brisk walking), not have a medical condition that prevents them from walking briskly, own a mobile phone and be able to attend a second (follow-up) session exactly four weeks after their first session. Research staff member 4 screened the participants. The list of eligible participants was then forwarded to another research staff member (number 3). Participants received £15 each or course credit.

Sample

Required sample sizes were calculated a-priori to detect a difference in activity between a group forming implementation intentions benefiting from SMS and a group forming implementation intentions not benefiting from SMS (*d*=.59; see Prestwich et al., 2008a) at $p < .05$, with 80% power and, based on our experience with similar trials, allowing 5-10% drop-out. One hundred and forty-nine volunteers (144 students, 4 non-students, 1 missing data; 54 men, 95 women; mean age=23.44 years, *SD*=5.63 years) were thus recruited.

Randomization

Participants were randomized to one of three groups (implementation intention + SMS plan, implementation intention + SMS goal, control) and completed measures of walking at baseline and four weeks follow-up. An allocation sequence, based on complete randomization (non-blocked, non-stratified) with no restrictions, was prepared by research staff member 1 using a computer-generated randomization program. On the basis of this allocation sequence, research staff member 2 placed the relevant study materials in a series of numbered and sealed envelopes. These envelopes were passed to research staff member 3 who met the participants. Participants opened the envelopes in individual cubicles away from research staff. Upon completion of the study materials, participants sealed their completed measures in other envelopes. Consequently, research staff member 3 was blinded to condition during the testing phase.

All participants were asked, in writing, to try to be active (as defined by governmental guidelines). Furthermore, to minimize the risk of contaminating the experimental manipulations, the need to refrain from communicating with other people about the study was stressed to all participants. Participants (by not discussing the trial with others), the persons entering the data (research staff members 5 and 6, by receiving only the dependent measures), and the data analyst

(research staff member 7, by receiving information regarding the study groups coded by number rather than name), were blinded to condition.

Manipulations (Interventions)

Each manipulation (and the information given to the control group) was presented as written text following the baseline measures. The control group received no text messages and was not required to form implementation intentions. However, as with all other participants, they provided their mobile phone number and were informed of the current governmental guidelines for physical activity (30 minutes a day of at least moderate intensity physical activity of five or more days of the week) and the benefits of meeting these guidelines. Furthermore, they were told they did not meet these guidelines. It was suggested that brisk walking was a good means to help them reach these targets and they were then explicitly asked to try to walk for at least 30 minutes on 5 or more days per week (in bouts of at least 10 minutes).

Implementation Intentions + Plan Reminders

Participants in this condition received the same text as the control group. Additionally, they were informed that it can be 'helpful to *make very specific plans* regarding how you will walk briskly five times per week *and receive text message reminders of these plans*.' They were also told that they were free to choose the situations in which to walk that will be easy, convenient and/or enjoyable for them and were able to decide when they would receive text message reminders of these plans.

They were then required to complete a task to help them form plans to help them to walk five times per week. They were required to think about when and where would be the most convenient and/or enjoyable for them to walk 30mins per day for 5 days per week in bouts of at least 10mins, provided with suitable examples, and asked to write this plan in the form, 'When

I'm in situation X then I will do Y'. Participants were asked whether their plans identified enough situations to enable them to walk five times per week (30 mins/day in bouts of at least 10 mins). If they answered 'no', they were requested to formulate additional plans and were provided with space to do so. They then stated the day(s) and time(s) that they would like to receive text message reminders of these plans. They were required to receive at least one text message reminder of each plan. Finally, participants had to note down a username and password that would enable them, if they desired, to log onto a website to change the content of the text message reminders, the number of text message reminders that they receive or when these text messages are delivered. They also wrote down their username and password on a tear-off slip of paper that noted the website address and kept this sheet of paper. Unless the participant logged in to stop their text message reminders, they were sent text messages over each of the four weeks.

Implementation Intentions + Goal Reminders

The manipulation received by this group was exactly the same as that presented to the implementation intention + plan reminder condition with the following difference. Although participants were requested to formulate implementation intentions, they did not receive reminders of these plans. Instead, they were informed that it would be helpful to receive reminders of their brisk walking goal. They were subsequently required to decide the days and times that they would receive these text message reminders. The participants in this condition could also log into the system to change the content of the text message reminders, the number of text message reminders that they received or when these text messages were delivered, and received text messages for the full 4 week period.

Measurement of Outcomes

All self-report measures were completed within individual cubicles in the laboratory. Participants' physiological measures were taken in the laboratory. Participants in each condition completed the behavior measure pre-manipulation and at 4-weeks follow-up. The physiological measures were also taken at baseline and follow-up. Participants also completed a range of psychosocial measures from the Extended Model of Goal-Directed Behavior (EMGB; Perugini & Conner, 2000). Within these measures, all participants were required to identify one goal that would best explain their walking briskly for 5 days/week over the next 4 weeks. These measures are not discussed further.

Primary Outcome Measure. A self-report index of walking was taken from Prestwich, Perugini, and Hurling's (2008c) validated Self-report Walking and Exercise Tables (SWET) measure. The SWET demonstrated the best predictive validity (r = .52 distance traveled; r = .48 number of steps recorded), in relation to physical activity recorded by a validated pedometer (Yamax SW-200), out of nine measures of physical activity such as the Godin scale (Godin & Shepherd, 1985; average r = .42 across the two criterion outcomes), short-version IPAQ (Craig et al., 2003; average r = .43) and 7-day PAR (Sallis et al., 1985; average r = .07). The Yamax pedometer range has consistently performed favourably against other available pedometers (e.g., Schneider et al., 2003; Schneider et al., 2004) and has been used to validate other pedometers (De Cocker, Cardon, & Bourdeaudhuij, 2006). The SWET was also less likely that some alternatives (e.g., LWQ, Stovitz, Van Wormer, Center & Bremer, 2005) to produce missing data.

The walking sub-scale of the SWET requires participants to note in a table the journeys that they had walked during the last week; the days in which they made these journeys, the duration of *each* journey, and the speed of each walk (categorised as: a=slow pace (i.e. less than 3mph); b=steady average pace; c=brisk pace; d= fast pace (i.e. over 4mph)). In line with the

main aim of the research, the frequency of brisk walking was added to the frequency of fast walking to generate an index of walking frequency. In line with government guidelines and the aims of the study, from this table the number of days in a week where a participant did brisk or fast walking for 30 minutes or more (in bouts of at least 10 minutes) was calculated and represented the primary outcome. In the same validation study described above (Prestwich et al., 2008c), the walking sub-scale of the SWET also demonstrated predictive validity (being significantly correlated with distance traveled $r = .44$ and number of steps recorded $r = .39$).

Secondary Outcome Measures. Total physical activity was assessed using the full-version of the SWET. The full version involves both the walking sub-measure and a second table pertaining to non-walking physical activity. Within this table, participants were required to note the exercise, the days in which they did this exercise, and the duration of each exercise session (in minutes) during the last week. Similar to the primary outcome, the secondary outcome reflected the number of days in which participants exercised (including brisk and fast walking) for at least 30 minutes (in bouts of at least 10 minutes). By measuring this, we could determine whether any increase in brisk/fast walking occurred at the expense of other exercise.

Physiological outcomes, while not necessarily indicative of physical activity, were recorded due to their association with health outcomes. Participants' height, weight, waist size and hip size were measured by a researcher (number 3) blinded to condition. From these measures, body mass index (BMI) and waist-to-hip ratio (WHR) were calculated. To measure participants' height, participants removed their shoes and stood straight, feet together, flush against a wall-chart. A pen was then placed horizontally on the participants' head to obtain the height reading. Participants then emptied their pockets, removed any excess clothing (e.g., sweatshirt), for their weight and waist/hip size measures. With their shoes still removed,

participants stood still on an electronic scale, until a steady reading was shown, to assess their weight. Their waist and hip size were then recorded using a tailors' tape measure while the participants stood, feet together, with the readings taken at the narrowest (waist) and widest (hips) points. All measures were taken once by a researcher trained beforehand by a researcher experienced in taking these physiological measures. No steps were taken to verify the accuracy of the measures (e.g., a percentage of measures taken by a second researcher and the results compared). However, the researcher was blinded to condition and thus any error in the measures should not have differed across the three conditions.

At 4-weeks follow-up, participants were given a surprise recall task. Participants in the implementation intention groups were required to list all of the implementation intentions that they had formed 4-weeks ago. Written instructions informed the participants that they should do this without looking at their phone. For each plan that they formed, up to 0.50 points were awarded for correctly recalling the planned situation and 0.50 points for correctly recalling the planned response (0.25 points were awarded where the response was partly correct- e.g., Monday morning in my house vs. Monday morning at work). Failing to recall the plan entirely, or writing new plans at 4-weeks follow-up (time 2), were each scored as zero for that particular plan. These series of scores for each plan were then mean averaged to produce an index reflecting the degree of implementation intention recall. This ranged from 0 (no recall of any plan) to 1 (full recall of all plan/s). This points system was chosen as it was more precise, and thus more powerful, than the alternatives (1. dropping the .25 points aspect; 2. coding each plan simply in terms of whether the participants successfully recalled the full plan (situation *and* response, or not)). All participants were asked to try to recall their brisk walking goal. For each participant, their goal recall was scored as 0 (did not recall their goal) or 1 (did recall their goal). Two independent

raters showed almost perfect agreement on both measures (goal recall: $\kappa = .95$; plan recall: $r = .93$) and any discrepancies were resolved prior to analysis.

Statistical Methods

All of the analyses conducted are reported henceforth. ANOVA and chi-square examined differences between those completing the study and those who did not and baseline differences between the three conditions. ANCOVA tested the effects of the interventions on increasing brisk/fast walking during the intervention period, using condition (implementation intention + plan reminder, implementation intention + goal reminder, control) as the between-subjects independent variable, and brisk/fast walking at baseline as the covariate. This analysis was repeated with the secondary outcomes (number of days meeting physical activity guidelines; weight; WHR). T-tests and chi-square compared the groups on implementation intention and goal recall, respectively. Effect sizes (d or φ) are reported for significant primary and secondary outcomes. Within-groups t-tests reflecting change in the outcomes between time 1 (T1) and time 2 (T2) are denoted in Table 2 (see Δt columns).

Results

There was no investigator-determined exclusion of participants through withdrawal from treatment or poor adherence to trial protocol. Concerning the last point, of the 99 participants required to form implementation intentions, 6 participants deviated from the protocol incorrectly forming at least one implementation intention (i.e. identifying a situation and relevant action) but were still included in the main analyses. Of these, three failed to correctly form any implementation intention concerning their brisk walking (consequently these three participants were omitted from analysis concerning implementation intention recall but were included in all other analyses). Four participants failed to specify a day and time to receive their text message

reminders but were still included in the analysis. On each dependent variable, six participants' responses could not be coded into the number of days that they walked/exercised for at least 30 minutes due to incomplete data. Nine participants were lost to follow-up reflecting a dropout rate of 6%. Two-tailed *p* values are reported throughout.

There were no differences between those remaining in the study and those that dropped out in terms of their BMI, $F(1,146)=1.52$, $p = .22$, and WHR, $F(1,146)=1.57$, $p = .21$, nor was there differential dropout across sexes, $\chi^2(1)= 0.82$, $p = .37$. However, the participants that dropped out of the study walked marginally more (primary outcome: $F(1,145)=2.75$, $p = .099$, $M = 1.33$ vs. $M = 0.63$) and exercised more (secondary outcome: $F(1,145)=4.40$, $p = .04$, $M = 2.33$ vs. $M = 1.21$), at baseline, than those that remained in the study. Non-smokers (7.9% dropout) were marginally more likely to dropout than smokers (0% dropout), $\chi^2(1)= 2.94$, $p = .09$.

The rate of dropout, $\chi^2(2)= 3.20$, $p = .20$, did not vary across the three conditions (implementation intention + plan reminder = 10.6%; implementation intention + goal reminder = 5.8%; control = 2.0%). The flow of the participants through each stage of the study is illustrated in Figure 1.

Insert Figure 1 about here

Baseline characteristics of the sample

The baseline characteristics of the participants are summarized in Table 1. Across the three conditions, there were no differences in the primary ($F = .05$) or secondary behavioral ($F = .55$) outcome variables, BMI ($F = .62$), WHR ($F = .15$), or age ($F = 1.94$) at baseline (all $p > .14$) or in the proportion of men and women, $\chi^2(2) = .75$, $p = .69$, smokers, $\chi^2(2)= 3.19$, $p = .20$, and those receiving financial payment rather than course credit, $\chi^2(2)= 2.20$, $p = .33$.

Insert Table 1 about here

Based on those that specified at least one day and time to receive their text message, 5.1 texts per week were requested on average. The average number of texts requested did not differ across the experimental groups, $t(93) = 1.30$, $p = .20$. Within the implementation intention condition, 83.4% of the text messages were requested for the same time as the planned behavior (e.g., planned to walk on Monday morning and requested text message reminders on Mondays at 8am; planned to walk on Tuesdays at 9pm and requested text message reminders on Tuesdays at 9pm) and 90.5% of the text messages were requested within 1 hour of the planned walk (e.g., planned to walk on Mondays at 8am and requested reminders on Mondays at 7.30am).

Change in brisk/fast walking (primary outcome)

There was a differential change across groups on the primary outcome, $F(2, 130)=3.12$, $p=.048$.[1] Post-hoc tests revealed that the implementation intention + plan reminder (*vs.* control: $p = .04$; $d = .49$; 95% CI, $d = .05$ - $.94$) and the implementation intention + goal reminder (*vs.* control: $p = .03$; $d = .45$; 95% CI, $d = .04$ - $.88$) conditions increased the number of days that they met the physical activity daily guidelines, through brisk and fast walking, significantly more than the control group. Hypothesis 1 was thus supported. Forty-two percent in the goal reminder condition and 45% in the plan reminder condition benefited by at least an increase of 2 days per week (compared to 22% in the control group).

Insert Table 2 about here

Change in total exercise (secondary outcome)

The benefits on the amount of brisk or fast walking accrued through implementation intentions paired with text messages did not particularly impact negatively on other physical activity. Specifically, there was a marginal difference in total physical activity across the three conditions, $F(2, 130)=2.63$, $p=.076$.[2] Post-hoc tests indicated that the participants in the

implementation intention + plan reminder condition exercised more than those in the control group (p = .03, d = .55; 95% CI, d = .12 – 1.01). There were no differences between the other conditions (both p > .12). There was, therefore, partial support for hypothesis 2.

Change in Weight and WHR

There was a marginal difference, in the change in weight from time 1 to time 2, across the three conditions, $F(2, 136)=2.42$, p=.09. The implementation intention + goal reminder group lost more weight than the implementation intention + plan reminder condition (p = .03, d = .47; 95% CI, d = .04 – .91). The main effect was significant when the implementation intention + goal reminder was compared against the implementation intention + plan reminder and control groups *combined*, $F(1, 137)=4.07$, p=.046 (d = .37; 95% CI, d = .03 – .72). The implementation intention + goal reminder group lost most weight (on average, 0.53kgs) compared to the other conditions (implementation intention + plan reminder: gained 0.10kg; control: lost 0.14kg). There was, therefore, partial support for hypothesis 3a. There was no differential change across the three conditions in WHR, $F(2, 136)=0.02$, p=.98. Hypothesis 3b was thus rejected.

Recall of Implementation Intentions and Goals

In a surprise recall task at time 2, those in the implementation intention + plan reminder condition showed greater plan recall than those in the implementation intention + goal reminder condition, $t(84) = 5.09$, $p < .001$ (d = 1.10; 95% CI, d = .63 – 1.62), supporting hypothesis 4.[3] There were also differences across the three conditions in recall of the goals specified at time 1, $\chi^2(2)= 13.50$, p = .001, φ = .32. Goal recall was significantly greater in the implementation intention + goal condition than those in the control, $\chi^2(1)= 4.07$, p = .04, φ = .21, and implementation intention + plan reminder, $\chi^2(1)= 13.54$, $p < .001$, φ = .40, groups, supporting hypothesis 5. The control group reported marginally greater recall of goals than those in the

implementation intention + plan reminder condition, $\chi^2(1)= 3.19$, $p = .07$, $\varphi = .19$. No adverse events were reported by any member of any of the three groups. There was a significant partial correlation between the implementation intention recall and brisk/fast walking at time 2 (controlling for brisk/fast walking at time 1), $r = .22$, $p = .047$, but no relationship between goal recall and the same outcome measure, $r = -.02$, $p = .83$, or any of the secondary outcomes.

Discussion

This study provides preliminary evidence that an intervention using physical activity-based text messages and implementation intentions can increase physical activity. Specifically, implementation intentions paired with SMS that either reminded the individual of their brisk walking plans or their reasons for brisk walking significantly increased, relative to a control group, the number of days that an individual self-reported brisk/fast walking for 30 minutes in bouts of at least 10 minutes (supporting hypothesis 1). This was achieved without significant reductions to other types of physical activity of at least moderate intensity (supporting hypothesis 2). Those receiving text message reminders of their plans did not lose more weight than those in the control group but those receiving goal reminders did lose more weight (reflecting partial support for hypothesis 3a). There were no differences across condition in waist-to-hip ratio (thus hypothesis 3b was rejected). Text messages targeting plans or goals aided the recall of plans and goals respectively (supporting hypotheses 4 and 5).

The study provides some suggestive evidence that implementation intentions might be incorporated within interventions that significantly change health behavior (Gollwitzer & Sheeran, 2006). Moreover, by blinding the experimenter and data analyst to condition, the risk of experimenter or interpretational biases are minimized. The significant effect of an implementation intention-based intervention conflicts in some ways with recent studies, of

similar methodological rigor, which conferred no benefit of implementation intentions for health behavior change (e.g., Rutter et al., 2006). However, it should be noted that the plans were paired with SMS and the primary outcome was based on a (validated) self-report measure. More research concerning efficacy and mechanisms is needed to build on these preliminary findings.

Implementation intention and relapse prevention interventions (Marlatt & Gordon, 1985), also shown to promote physical activity (Belisle, Roskies & Levesque, 1987), are similar. Both establish action plans that are conditional on anticipated situational events. However, relapse prevention typically focuses on the maintenance of behavior change via action plans contingent on high-risk situations that could *disrupt* the desired behavior (problem-solving solutions). Implementation intentions typically focus on initiation of change via action plans contingent on critical situations that could *enhance* the likelihood of enacting the desired action. Future research could test whether combining these two approaches produces an additive change effect.

Without the inclusion of conditions that received only SMS text messages or were only asked to form implementation intentions, it is not possible to determine, solely on the basis of this study, the components of the intervention that caused the significant increase in physical activity. This is a common problem with randomized controlled trials. Health behavior change studies often comprise multiple techniques and are compared against interventions that lack at least two of the intervention techniques (see Michie et al., 2008). However, previous research has already suggested that both implementation intention and SMS components contribute to experimental effects (Prestwich et al., 2008a). This study reinforces the finding that this combined intervention is effective relative to a control using more methodologically robust controls. Moreover, benefits from combining SMS and planning manipulations can be achieved equally by reminding the individual of their specific plans or the goals underlying the behavior.

Prestwich et al. (2008a) suggested, but did not provide evidence, that text message reminders of implementation intentions might enhance the mechanisms through which implementation intentions change behavior (i.e. the accessibility of the mental representation of the planned situation and the association between the planned situation and response). In the study presented here, text messages aided the recall of implementation intentions. This might reflect that they strengthened implementation intentions by improving the accessibility of the plan and/or strengthening the stimulus-response link. The results are compatible also with additional theoretical mechanisms. Text reminders might act by increasing the likelihood of self-generated thoughts concerning the individual plans or goals (Petty, Ostrom, & Brock, 1981) that in turn could make them more salient and consequently cognitively accessible.

It is important to note that the level of plan recall was significantly correlated with changes in self-reported brisk/fast walking suggesting that being able to recall one's plan has some importance for behavior change. In this sense, the relatively low-rate of recall in the implementation intention + goal condition (i.e. the group without plan reminders) might explain why implementation intentions sometimes do not work. It could also undermine, somewhat, the mechanisms through which implementation intentions change behavior in real-life settings. The studies that have focused on implementation intention mechanisms have been conducted in the laboratory (e.g., Aarts et al., 1999; Webb & Sheeran, 2007) and thus the generalizability within more real-life settings is not clear. If implementation intentions do increase the accessibility of the planned situation and the link between the stimulus and response to the point that it reflects features of automaticity such as immediacy and efficiency (e.g., Brandstätter, Lengfelder, & Gollwitzer, 1997) then people should consistently respond in the same way when encountering the same situational cues. Consequently, recall of their plans should be sound. This does not

appear to be necessarily the case. The association between the planned stimulus and response can be strengthened, as indexed by superior recall following relevant reminders.

The effects of pairing implementation intentions with goal reminders also warrant discussion. Participants in this condition reported walking more than the control group and reduced their weight significantly more than the implementation intention + plan reminder condition. In light of the latter finding, the consequences of the interventions are unlikely to be determined purely by the formation of implementation intentions. Studies suggest that goals and intentions are linked (e.g., Kruglanski et al., 2002) and that goals can moderate intention-behavior relations (Prestwich et al., 2008b). Sending text reminders of one's goals at opportune moments should ensure the activation of behavioral intentions and also consequently moderate the likelihood of action (cf. Cooke & Sheeran, 2004). As well as activating intentions to walk briskly, text messages by reminding individuals of their goals might also have activated other behavioral intentions (e.g., to do vigorous activity; to avoid snacks) that promote actions that indirectly influence weight. Further, activating behavioral intentions can also benefit the impact of implementation intentions as research has shown that for them to effect behavior change they should be supplemented by positive intentions (e.g., Prestwich et al., 2003; Sheeran et al., 2005).

There are some limitations that should be noted. The study primarily used self-reports. However, to reduce the risk of social desirability or demand effects, all participants were asked to try to meet physical activity guidelines. Furthermore, the behavioral measure has been validated against an objective behavioral measure (i.e., pedometer) in a largely inactive sample that was comparable to the sample recruited in this study. Moreover, Gollwitzer and Sheeran (2006) reported that the effects of implementation intentions are similar when self-report or objective measures are employed. We also incorporated physiological measures and achieved

significant change in weight though the effect sizes were only small-to-moderate. The data should be viewed as providing only preliminary evidence for the efficacy of this strategy in changing objectively-measured behavior. Although the study was appropriately powered to detect significant differences between groups, the sample size was quite small and consequently the 95% confidence intervals were quite broad. However, the effect size was similar to that obtained by previous research (Prestwich et al., 2008a) and employed a rigorous methodology. The study was powered to detect significant effects rather than to make strong conclusions regarding null effects. Consequently, the non-significant difference between the two types of text messages should be considered in light of how the study was powered. The sample was mainly students thus the generalizability of findings to the general population is unknown.

Promoting brisk walking produces important physiological benefit (e.g., Manson et al., 2002) thus identifying effective interventions, delivered on a wide scale to increase brisk walking, is important. Some of the behavioral changes achieved from our interventions might require further maintenance to accrue measurable physiological change. However, they require fairly minimal intervention and are potentially deliverable without face-to-face interaction.

To summarize, we present a methodologically rigorous test of whether combining implementation intentions with text messages cueing plans or goals can significantly increase brisk walking. This study provides preliminary data supporting the efficacy of both strategies as indexed by a validated, self-report measure, relative to a control group. These interventions were quick to administer. These factors, in combination with widespread use of mobile phones, suggest that this approach could be effective and efficiently administered to a wider population of inactive adults.

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Footnotes

[1] The primary outcome was also refined in a second measure where participants were requested to complete the SWET table on the basis of a *typical* 7-day period over the last 4 weeks. The results were very similar, $F(2, 121)=4.01$, $p = .02$. Both intervention groups reported more change in brisk walking than the control group (both $p < .05$).

[2] When these analyses were repeated in regard to the typical 7-day period over the 4-weeks of the intervention period, the effects of the intervention were marginal, $F(2, 117)=2.30$, $p=.10$ (implementation intention + plan reminder vs. control- $p = .11$; implementation intention + goal reminder vs. control- $p = .05$).

[3] Three participants in the 'goal reminder' condition mistakenly listed their goal instead of a plan and a further six participants in this condition listed their goal and part of their plan during the surprise implementation intention recall task. This might have been due to participants, in the written instructions for both implementation intention conditions, being requested to not use their mobile phones during the recall tasks. Even when the first set of participants ($n = 3$) or the first and second set of participants were excluded ($n = 9$), the effect remained significant, $t(82)=4.82$, $p < .001$, $d = 1.06$, 95% CI, $d = .60$ to 1.57, and $t(76)=4.23$, $p < .001$, $d = 0.97$, 95% CI, $d = .49$ to 1.50, respectively. The effects of plan reminders were also significant on alternative indices of plan recall (see 'Secondary outcome measures' section).

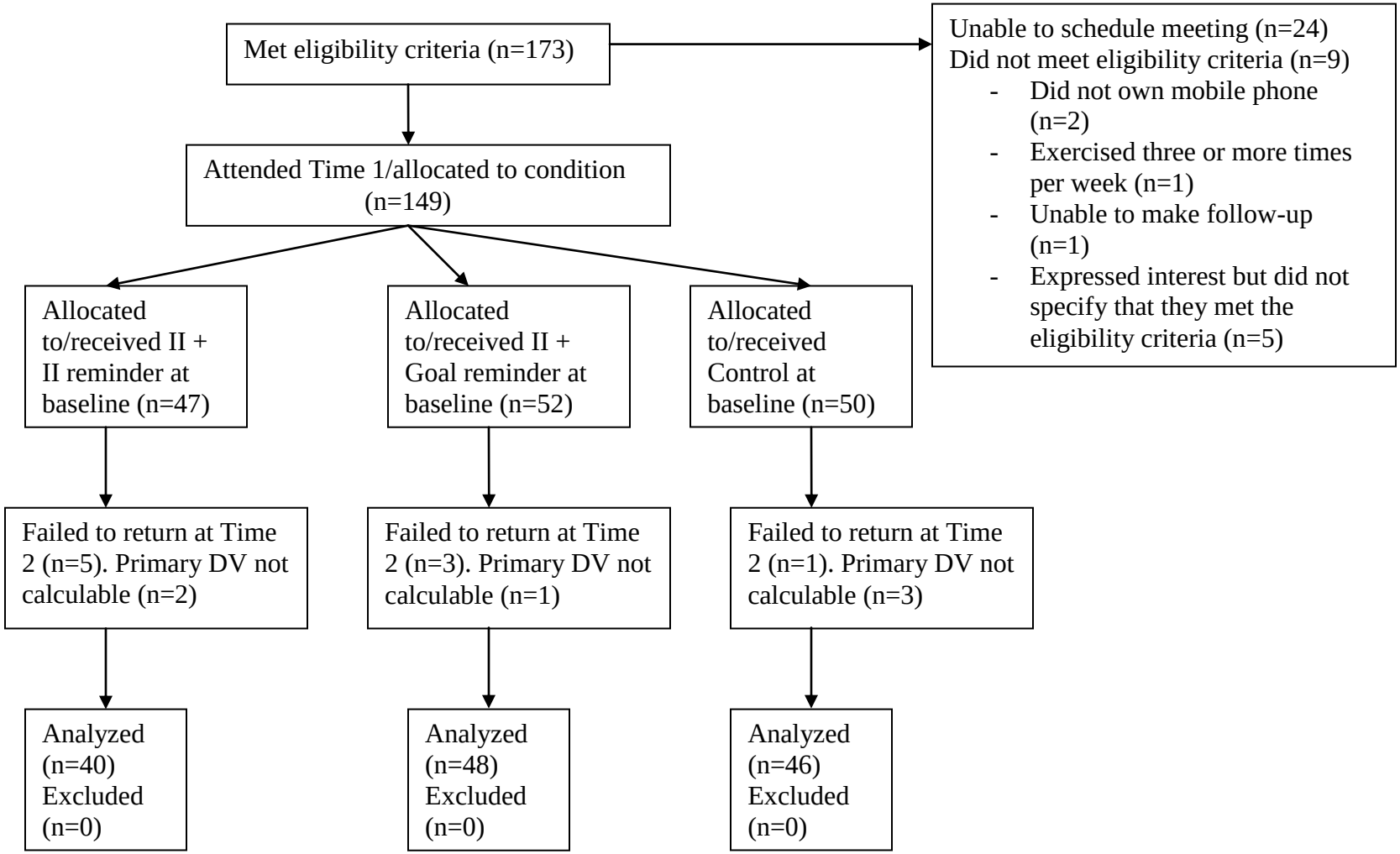
Met eligibility criteria (n=173)
Unable to schedule meeting (n=24)
Did not meet eligibility criteria (n=9)
- Did not own mobile phone (n=2)
- Exercised three or more times per week (n=1)
- Unable to make follow-up (n=1)
- Expressed interest but did not specify that they met the eligibility criteria (n=5)
Attended Time 1/allocated to condition (n=149)
Allocated to/received II + II reminder at baseline (n=47)
Allocated to/received II + Goal reminder at baseline (n=52)
Allocated to/received Control at baseline (n=50)
Failed to return at Time 2 (n=5). Primary DV not calculable (n=2)
Failed to return at Time 2 (n=3). Primary DV not calculable (n=1)
Failed to return at Time 2 (n=1). Primary DV not calculable (n=3)
Analyzed (n=40) Excluded (n=0)
Analyzed (n=48) Excluded (n=0)
Analyzed (n=46) Excluded (n=0)

Table 1: Means (SD) of Baseline Characteristics Across Conditions

Condition	Number of women (men)	Age	Percentage of Smokers	Number of days per week walked briskly/fast for 30 or more minutes	Number of days exercised (inc. brisk/ fast walking) for 30 or more minutes	BMI	WHR
II + Plan reminder (n=47)	28 (19)	22.19 (5.01)	25.5	.68 (.96)	1.40 (1.51)	22.40 (3.60)	.79 (.05)
II + Goal reminder (n=52)	33 (19)	24.38 (6.90)	15.4	.63 (1.52)	1.10 (1.69)	23.23 (3.67)	.79[b] (.07)
Control (n=50)	34 (16)	23.62 (4.49)	30.0	.71[a] (1.17)	1.35[a] (1.51)	23.06 (4.28)	.79 (.07)
Total	95 (54)	23.44 (5.63)	23.5	.67 (1.24)	1.28 (1.57)	22.91 (3.86)	.79 (.07)

Note: [a] n=48; [b]n=51

Table 2: Pre- and Post-Intervention Primary and Secondary Outcome Means (SD)

Condition	Number of days per week walked briskly/fast for 30 or more mins			Number of days exercised (inc. brisk/ fast walking for 30 or more mins			Weight (kg)			WHR			Recall	
	T1	T2	Δ*t*	T1	T2	Δ*t*	T1	T2	Δ*t*	T1	T2	Δ*t*	Plans	Goals
Implementation Intention + Plan reminder (n=40)	.60 (.96)	1.98 (1.75)	4.54**	1.18 (1.32)	3.13 (1.57)	5.91**	66.12[b] (12.88)	66.22[b] (12.81)	-0.51	.788[b] (.050)	.775[b] (.050)	2.70*	.72 (.25)	19/40 (48%)
Implementation Intention + Goal reminder (n=48)	.56 (1.37)	1.98 (2.04)	3.94**	1.04[a] (1.61)	2.81[a] (1.96)	4.45**	67.66[c] (14.09)	67.12[c] (13.91)	2.65*	.795[c] (.076)	.781[c] (.069)	2.90*	.39[d] (.33)	39/46 (85%)
Control (n=46)	.70 (1.17)	1.17 (1.58)	1.96† (1.52)	1.34[a] (1.99)	2.28[a] (14.25)	4.06**	66.07[c] (14.25)	65.93[c] (14.10)	0.78	.792[c] (.067)	.780[c] (.069)	2.91*	-	30/45 (67%)
Total	.62 (1.18)	1.70 (1.83)		1.19 (1.49)	2.72 (1.88)		66.64 (13.72)	66.44 (13.57)		.792 (.065)	.779 (.064)		.54 (.34)	88/131 (67%)

Note: [a] n=47; [b]n=42; [c]n=49; [d]n=46; †p<.10; *p<.05; **p<.001

CONSORT Statement 2001 - Checklist

PAPER SECTION		**Descriptor**	**Page #**
TITLE & ABSTRACT	1	How participants were allocated to interventions (*e.g.*, "random allocation", "randomized", or "randomly assigned").	Title 1, 8
INTRODUCTION Background	2	Scientific background and explanation of rationale.	2-6
METHODS Participants	3	Eligibility criteria for participants and the settings and locations where the data were collected.	7-8
Interventions	4	Precise details of the interventions intended for each group and how and when they were actually administered.	8-10
Objectives	5	Specific objectives and hypotheses.	6-7
Outcomes	6	Clearly defined primary and secondary outcome measures and, when applicable, any methods used to enhance the quality of measurements (*e.g.*, multiple observations, training of assessors).	11-13
Sample size	7	How sample size was determined and, when applicable, explanation of any interim analyses and stopping rules.	8
Randomization -- Sequence generation	8	Method used to generate the random allocation sequence, including details of any restrictions (*e.g.*, blocking, stratification)	8
Randomization -- Allocation concealment	9	Method used to implement the random allocation sequence (*e.g.*, numbered containers or central telephone), clarifying whether the sequence was concealed until interventions were assigned.	8
Randomization -- Implementation	10	Who generated the allocation sequence, who enrolled participants, and who assigned participants to their groups.	8
Blinding (masking)	11	Whether or not participants, those administering the interventions, and those assessing the outcomes were blinded to group assignment. If done, how the success of blinding was evaluated.	8-9
Statistical methods	12	Statistical methods used to compare groups for primary outcome(s); Methods for additional analyses, such as subgroup analyses and adjusted analyses.	14
RESULTS Participant flow	13	Flow of participants through each stage (a diagram is strongly recommended). Specifically, for each group report the numbers of participants randomly assigned, receiving intended treatment, completing the study protocol, and analyzed for the primary outcome. Describe protocol deviations from study as planned, together with reasons.	28
Recruitment	14	Dates defining the periods of recruitment and follow-up.	7
Baseline data	15	Baseline demographic and clinical characteristics of each group.	15, 29-30
Numbers analyzed	16	Number of participants (denominator) in each group included in each analysis and whether the analysis was by "intention-to-treat". State the results in absolute numbers when feasible (*e.g.*, 10/20, not 50%).	14 & 28-30
Outcomes and estimation	17	For each primary and secondary outcome, a summary of results for each group, and the estimated effect size and its precision (*e.g.*, 95% confidence interval).	16-18 & 30
Ancillary analyses	18	Address multiplicity by reporting any other analyses performed, including subgroup analyses and adjusted analyses, indicating those pre-specified and those exploratory.	14 & 27
Adverse events	19	All important adverse events or side effects in each intervention group.	18
DISCUSSION Interpretation	20	Interpretation of the results, taking into account study hypotheses, sources of potential bias or imprecision and the dangers associated with multiplicity of analyses and outcomes.	18-22
Generalizability	21	Generalizability (external validity) of the trial findings.	22
Overall evidence	22	General interpretation of the results in the context of current evidence.	18-22