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Time for Change: Using Implementation Intentions to Promote Physical Activity in a Randomised Pilot Trial

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Abstract

Objective: A common barrier to exercise is a perceived lack of time. The current pilot study examined the effects of an implementation intention intervention to enhance exercise self-efficacy, increase confidence to exercise when facing time constraints, and increase physical activity in middle-aged adults (n=63, aged 35-69).

Design: Participants received a pedometer (Fitbit) to objectively measure activity and were randomly assigned to either a control or intervention condition. After a one-week baseline, the intervention condition received instructions to plan how, where, and when they would add steps to their daily routine to meet their step goal, using personalized schedules and maps. Both groups were contacted nightly via email.

Main Outcome Measures: Physical activity (steps and time spent in moderate-to-vigorous activity), goal achievement, exercise self-efficacy, time-relevant exercise self-efficacy, and affect.

Results: Compared to the control, the intervention condition significantly increased in steps, time spent in moderate-to-vigorous activity, and time-relevant exercise self-efficacy. Goal achievement was related to greater time-relevant exercise self-efficacy and more positive affect at the daily level.

Conclusion: Findings suggest that the personalized planning intervention increased physical activity and confidence in achieving physical activity goals under time constraints. Avenues for future directions, especially for producing more sustained effects, are discussed.

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Disclosure Statement

The authors have no conflict of interest and no financial interest or benefit.

Keywords

physical activity; intervention; self-efficacy; adults; randomised controlled trial

Introduction

Although the benefits of regular physical exercise are well known, the U.S. National Center for Health Statistics reports that only about 20% of adults meet the federal physical activity guidelines, and the percentage decreases as age increases (Clarke, Norris and Schiller, 2017). Inactivity is a global problem; the World Health Organization recently reported that 1 in 4 adults were not sufficiently active (World Health Organization; 2017). A sedentary lifestyle is not only detrimental to one's physical activity, but can also have psychological consequences, such as negative affect or depression (Reed & Buck, 2009). Given the negative health consequences of an inactive lifestyle (Kohl et al., 2012), there is interest in developing effective interventions to promote physical activity. Recent meta-analyses of physical activity interventions have highlighted the need for more theoretically-based programs (Chase, 2014; Taylor, Conner, & Lawton, 2011) and more objective assessments of activity (Bélanger-Gravel, Godin, & Amireault, 2013). It is also important that the interventions are designed to address the perceived barriers that are unique to the population. Middle-aged adults, an often under-studied population, are at a pivotal point in their lifespan as they may be setting up behaviours that will endure into older age, when physical health problems may increase and physical activity tends to decrease (Lachman, 2015; Clarke et al., 2017). Midlife is also a challenging population for interventions, as this age-range tends to be busy, has limited time, and can be difficult to recruit (Lachman, 2015). The primary aim of this study was to develop a theoretically-based intervention to increase objective physical activity in middle-aged adults who thought they did not have enough time to exercise.

One empirically-supported strategy for behaviour change applies the concept of implementation intentions (Gollwitzer, 1993). Implementation intentions involve specifying the conditions under which one will engage in goal-directed behaviours (Gollwitzer & Sheeran, 2006), such as when, where, and how one will act on a goal. However, the exact mechanisms as to how implementation intentions might increase one's commitment to respective goal intentions remain unclear. One possibility is that planning could influence intention strength via enhanced self-efficacy (Ajzen, 1991). That is, the process of planning out future goals could make accomplishing said goals seem more achievable, and therefore help solidify respective goal intentions. Implementation intentions may also increase self-efficacy because they reduce perceived susceptibility to potential barriers of one's goal, such as a perceived lack of time (Gollwitzer, Fujita, & Oettingen, 2004). Given that self-efficacy is an essential factor of physical activity engagement (Bandura, 1997), the secondary aim of this study was to focus on the role of self-efficacy and time constraints as specific barriers in an implementation intention intervention in a less-frequently studied and challenging population - middle-aged adults.

Physical Activity

Pedometers and activity monitors (Fitbit, Jawbone, etc.) have become popular for monitoring daily steps, and providing people with goals to increase the number of steps they walk per day (Bassett, Wyatt, Thompson, Peters, & Hill, 2010; Powel, Paluch, & Blair, 2011). However, solely providing a step counter with a goal to become more active is not always effective for behaviour change (Sullivan & Lachman, 2017; Patel, Asch, & Volpp, 2015). This may, in part, be because adults have often reported negative and inaccurate outlooks and expectations that interfere with exercise (Lachman et al., 1997). Therefore, when designing strategies to promote activity, it is critical to consider the barriers preventing people from engaging in physical activity.

Time perceptions—One of the most common barriers to behaviour change such as increasing physical activity reported by middle-aged adults is a perceived lack of time (Ebrahim & Rowland, 1996; AARP, 2004). Time constraints are likely to be an ongoing obstacle to engaging in physical activity, particularly for those who feel a conflict between the many goals or tasks one must achieve throughout the day (e.g., finishing work, picking up children, eating healthily, etc.). This perceived conflict between time and goals contributes to the perception of less time and can negatively impact psychological well-being (Etkin, Evangelidis, & Aaker, 2014). Those who feel better equipped to cope with these constraints are more likely to maintain an active lifestyle over time. The current pilot study tested the effectiveness of an intervention using implementation intentions to reduce time as a perceived barrier and increase daily physical activity via walking. Participants were asked to specify when and for how long they could exercise, along with calculating how they could meet their step goals within their designated timeframe.

Self-efficacy—Consistent with the social-cognitive model of physical activity (Bandura, 1997), self-efficacy beliefs are also critical to consider in relation to exercise and a principal determinant of regular, health-promoting levels of physical activity (e.g., McAuley & Blissmer, 2000; McAuley, 1992; Neupert, Lachman, & Whitbourne, 2009; White Wójcicki, & McAuley, 2011). The confidence that one can exercise, even when faced with constraints and obstacles such as feeling tired or busy, is associated with a greater likelihood of accomplishing the activity goal (Bandura, 1997). Most of the work on exercise self-efficacy and physical activity has been in college students and older adults, with less attention to middle-aged adults. At the precipice of growth and decline, midlife offers a critical period in the life course (Lachman, 2015). The findings from studying this age group can inform interventions to promote well-being among the middle-aged and may have benefits that spill over into later life. Self-efficacy is linked to performance in multiple domains, and can buffer some of the deleterious effects of aging. This important role in health and well-being across the lifespan provides a rationale for the investigation of methods to maintain and/or enhance these beliefs in midlife.

The Intention-behaviour Gap

In a recent review, Prestwich, Sheeran, Webb, and Gollwitzer (2015) hypothesized that three processes - *intention viability*, *activation*, and *elaboration* - may underlie the discrepancy between intent to exercise and actual exercise behaviour, or the ‘intention-behaviour gap’.

Intention viability may become problematic if the specified intentions can only be translated into actions if the necessary abilities, resources, and opportunities exist. This issue can be a particularly challenging issue in a busy population, such as working, middle-aged adults. Issues pertaining to intention viability can be overcome with implementation intentions that specify when, where, and how a goal will be achieved (Prentice et al., 2015). Intention activation refers to the extent to which contextual demands can influence the salience, direction, or intensity of the intention. A lack of activation, or salience of the intention, can lead to prospective memory failures, such as forgetting to do the behaviour to reach a goal, and goal reprioritization, such as perceiving oneself as too busy to accomplish that goal. These consequences are particularly relevant for populations that perceive there is not enough time in their day to exercise. Finally, intention elaboration may contribute to the intention-behaviour gap if there is a lack of elaboration on the specifics of the intention. Therefore, it is necessary that implementation intention interventions have participants denote the specifics of the intended behaviour, such as the when, where, and how.

Implementation Intentions

As suggested by Gollwitzer (1993), motivation in and of itself does not seem to be sufficient for behaviour change. Rather, it is suggested that behaviour change is most likely to occur when the individual is both motivated to act and has developed strategies and plans that promote behavioural enactment. Implementation intentions, grounded in the Theory of Self-Regulation (Leventhal, Leventhal, & Contrada, 1998), have been effectively used to change a variety of health behaviours, such as getting flu shots (Milkman, Beshears, Choi, Laibson, & Madrian, 2011), eating healthier (Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011), and increasing exercise (Prentice, Conner, Lawton, Ward, Ayres, & McEachan, 2012). Implementation intentions establish a strong connection between a specific opportunity and a specific response (Webb & Sheeran, 2008), resulting in the initiation of a goal-directed response (Gollwitzer & Sheeran, 2006). Implementation intentions combine both reflective and automatic processes, where control of one's behaviour to previously specified situational cues is delegated with the explicit purpose of achieving one's goals (Rothman, Sheeran, & Wood, 2009).

Recent meta-analyses demonstrated support for implementation intention-based action planning and coping planning to enhance physical activity engagement (Bélanger-Gravel, Godin, & Amireault, 2013; Carraro & Gaudreau, 2013). Distinctions have been made between simple implementation intentions and a more elaborate operationalization that includes coping plans and barrier-focused strategies (Snihotta, Schwarzer, Scholz, & Shuz, 2005). Similarly, the work by Bélanger-Gravel et al. (2013) found that interventions that used components of barrier management as part of the implementation intention strategies were more effective at increasing physical activity (Bélanger-Gravel et al., 2013). A recent review suggests that personalized interventions with multiple components may be more effective in promoting physical activity as they can foster exercise skills, combat self-defeating negative attitudes and barriers, aid in goal-setting, and offer social support and incentives (see Lachman, Lipsitz, Lubben, Castaneda-Sceppa, & Jette, 2018).

Implementation intentions and self-efficacy—There are inconsistencies regarding the role of self-efficacy and implementation intentions. Implementation intentions are argued to influence behaviour not through motivation, but through psychological processes that are analogous to automaticity and habituation (Gollwitzer, 1999; Sheeran, Milne, Webb, & Gollwitzer, 2005). Some previous work has found limited evidence that implementation intentions enhance motivation for exercise and self-efficacy (Sheeran et al., 2005; Milne, Orbell, & Sheeran, 2002; Orbell, Hodgkins, & Sheeran, 1997). However, other work has found that forming implementation intentions do, indeed, increase self-efficacy (e.g., Latimer, Ginis, & Arbour, 2006; Murray, Rodgers, & Fraser, 2009). A possible reason for the inconsistent findings concerning self-efficacy and implementation intentions may be related to the different methods in which self-efficacy was assessed. In Milne et al.'s (2002) study, overall self-efficacy was examined, as opposed to Latimer et al.'s (2006) and Murray et al.'s (2009) use of domain-specific self-efficacy (scheduling self-efficacy). Another possible reason may be the difficulty of the behaviour-of-interest. That is, goal difficulty may moderate success of the implementation intention (Gollwitzer & Sheeran, 2006). For example, Milne et al. (2002) asked participants to form an implementation intention to exercise once a week over a 2-week period, whereas Latimer et al. (2006) asked participants to form implementation intentions three times per week every 4 weeks over an 8-week period, and Murray et al. (2009) had participants enrol in an 11-week resistance training program. The goals to exercise 3 times per week over an 8-week period (Latimer et al., 2006), or complete an 11-week resistance training program (Murray et al., 2009) are arguably more difficult goals compared to trying to exercise once a week for two weeks (Milne et al., 2002). If the goals are more complex, it might be necessary to not only form implementation intentions, but also to believe that they are able achieve their goal (i.e., self-efficacy; Murray et al., 2009).

Current Study

The current pilot study tested the efficacy of using a multi-component, personalized implementation intention intervention to increase middle-aged adults' physical activity and confidence in their ability to exercise given time constraints. This study can be classified as a Stage 1 intervention that includes generation and pilot testing of the intervention, as defined by the U.S. National Institutes of Health's stage model for behavioural intervention development (Onken, Carroll, Shoham, Cuthbert, & Riddle; 2014). As noted, establishing evidence for effective interventions to promote physical activity is particularly important in sedentary, busy middle-aged adults. A previous meta-analysis of implementation intentions found a relatively small effect size compared to other health promotion interventions (Bélanger-Gravel et al., 2013). This small effect size in past research befits the design of an intervention that will potentially maximize the effect of the treatment by combining several personalized components, rather than examining effects of separate parts of the manipulation. In the context of physical activity, the current study focused on walking. Recently, walking has increased in popularity as a practical strategy to increase physical activity as it is a free, low-impact way to meet the recommended amount of moderate-intensity exercise per week and improve health outcomes (Lee & Buchner, 2008). Unlike setting aside 30 to 60 minutes at a time on a regular basis to exercise or go to the gym, which may be difficult for busy, working adults, walking can be done practically anywhere

at any time, can be spread throughout the day, and does not require equipment or a gym membership (Sullivan & Lachman, 2017). Therefore, focusing exercise goals on walking, and breaking these goals into smaller chunks and incorporating them into personal daily schedules is expected to be a more realistic and successful approach for long-term behaviour change. This technique can be used to increase daily walking in the context of work schedules. Moreover, behavioural change can be facilitated further by providing resources and contextual, personalized information tied to the setting (Lachman et al., 2018; McAlister, Perry, & Parcel, 2008). In the current context, providing personalized maps of the participants' neighbourhood and workplaces including walking time and distance information may facilitate planning the routes for walking.

Based on the classifications developed by Prestwich, Sheeran, Webb, and Gollwitzer (2015), the intervention used in the present study can be categorized as repeated, individually self-generated implementation intentions that utilize external cues to facilitate a behaviour (walking). The study employed repeated implementation intentions, in which participants reviewed their schedules each night and identified when, how, and where they would add steps throughout their day over the course of four weeks. Other studies have employed repeated implementation intentions to increase physical activity. For example, de Vet and colleagues (2009) had participants form new implementation intentions three times throughout the study, although they did not find any significant changes in self-reported physical activity. The current study utilized a repeated paradigm for implementation intentions that considered the daily variability and time constraints that can prevent one from fitting physical activity into their schedules and investigated the effects on objective physical activity. We hypothesized that the intervention group would show greater increases and higher maintenance of daily steps and active time in comparison to a control group who were not given the implementation intention intervention. We expected that the use of personalized implementation intentions would lead to greater exercise self-efficacy and a decreased perception of time as a barrier to exercise. Additionally, we predicted that exercise goal achievement would predict an increase in exercise self-efficacy and confidence in one's ability to exercise under time constraints, and that on days with higher goal achievement there would be reports of more positive affect, as positive affect is a critical factor in promoting and sustaining behaviour change and health (Notthoff & Carstensen, 2014; Lachman et al., 2018).

Method

Participants

Eligibility—Participants were deemed eligible if they were inactive, healthy, working at least 35 hours a week, between 35 and 69 years of age, and had access to a computer and/or smart phone or tablet. Participants' physical activity level was measured by the International Physical Activity Questionnaire Short Form (IPAQ-short; Craig et al., 2003) which categorized participants into three categories of activity levels: low, moderate, or high. All participants categorized as 'low' were eligible, and all participants that were categorized as 'high' were not. For participants that were categorized as 'moderate', they were determined to be eligible if they self-reported that they walked a total of 60 minutes or less throughout

the day. To assess that participants' functional health was at a level that would allow them to safely engage in brisk walking, they were administered a modified version of the Physical Activity Readiness Questionnaire (PAR-Q). Questions on this measure were adapted to specifically ask for health issues related to walking, as opposed to more strenuous exercise programs. For example, one original question read 'Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?', this question was changed to ask 'Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your walking?'. Participants that answered 'yes' to any of the questions that were not eligible.

Sample—An effect size for the current study was estimated to compare the multicomponent implementation intention intervention against a control group for physical activity based on the previously reported benefit of collaborative implementation intentions compared to a control group for physical activity in working adults ($d=.63$; Prestwich et al., 2012). Given the estimated effect size of $d=.63$, an *a priori* power analysis indicated that the required sample size in each condition, with 80% power at $p=.05$, was 32 per group (64 total). Participants were recruited via flyers, community events, and online advertisements in the greater Boston-area. Flyers advertised that the study was for those who 'did not feel they had enough time to exercise' and were 'interested in using a step counter to help become more active'. Of the 340 adults who filled out our eligibility questionnaire online, 252 were not eligible; 79 did not meet the age requirement, 46 were too active, 9 responded 'yes' to one or more questions on the adapted version of the PAR-Q, indicating participating in a walking intervention would be a potential health risk, and 2 already owned a Fitbit. 116 participants were not eligible because they were not working ($n=87$) or were only working part-time ($n=29$). 26 potential participants that were eligible did not respond when we notified them that they were eligible and were ready to begin the study. Recruitment took place from October 2015 to August 2016, with primary data collection completed in September 2016 and follow-up data collection completed in December 2016. A total of 62 adults were recruited and randomly assigned to either the control condition ($n=32$) or the intervention condition ($n=30$). Participants ranged in age from 35 to 69 years of age ($M=49.37$, $SD=8.33$). 71.4 % were female and the mean level of educational attainment was 16.39 years ($SD=2.01$). Three dropped out before the end of the study, resulting in a total of 59 participants (control condition, $n=30$; intervention condition, $n=29$).

Randomisation was checked by comparing age, gender, education, and functional health between conditions with a series of independent t-tests. Conditions did not differ by education, gender, or functional health, however the intervention condition was significantly younger ($M=46.33$, $SD=8.03$) than our control condition ($M=52.22$, $SD=7.68$). See Table 1 for more details, including the means and standard deviations for study variables at pre- and post-test and Figure 1 for more details on enrolment and retention. See Table 2 for correlations between study variables.

Measures

Covariates

Age, gender, education, and functional health were used as covariates in our analyses. Functional health was assessed at pre-test with eight items from the Physical Functioning subscale from the SF-36 Health Survey (Ware & Sherbourne, 1992). Two items from the original scale were omitted as they directly referred to physical exercise, one of our predictors ($\alpha=.79$; see Lachman & Agrigoroaei, 2010). The eight items capture the extent to which the participants' health level limits them in doing different activities (e.g., lifting or carrying groceries, climbing several flights of stairs). The scores ranged from 1 (a lot) to 4 (not at all) and were averaged so that a higher score indicated better functional health.

Study outcomes

Physical activity.—Physical activity was operationalized in two ways: 1) daily steps and 2) time spent in moderate-to-vigorous physical activity (MVPA). While daily steps and MVPA can be correlated, active minutes can pick up on activity that is more strenuous than regular walking (e.g., brisk walk, cardio workout, run, etc.). These two physical activity variables were measured with the Fitbit Zip wireless activity tracker. Every day throughout the five-week study, participants were asked to wear the Fitbit to track their physical activity. To validate that the participants wore the Fitbit on each day we examined the hourly step data. Participants were asked to synchronize their Fitbit daily to their computer and/or smartphone or tablet. Daily estimated activity data were aggregated via the Fitabase API. Fitbit categorizes active time into four categories: sedentary, lightly active, fairly active, and very active. MVPA was calculated by adding fairly active and very active minutes each day.

Goal achievement.

Goal achievement was measured by calculating the percentage of steps taken compared to the step goal that day (e.g., if the goal was 10,000 steps and the participants walked 8,000, goal achievement would be 80%). As only the intervention condition received step goals, goal achievement was only calculated for this condition.

Exercise self-efficacy.—Exercise self-efficacy (ESE) was assessed before the start of the study (pre-test) and after the end of the 5-week study (post-test) from a modified self-efficacy scale (Neupert, Lachman, & Whitbourne, 2009). Participants indicated on a scale of 1 (very sure) to 4 (not sure at all) across 9 items how sure they were that they would perform exercise under different conditions or constraints, including when they were tired and when they were feeling under pressure to get things done. Scores were reverse coded and averaged across items so that a higher number indicated greater self-efficacy. Reliability was high ($\alpha=.95$).

Time-relevant exercise self-efficacy.

A subscale from the aforementioned ESE measure was formed with three items germane to time-relevant restraints (Time ESE): 'Exercise when you are feeling under pressure to get things done', 'Exercise when you have too much work to do at home', and 'Exercise when you are away from home (e.g. traveling, visiting, on vacation)'. This last item represented

how likely participants were to exercise when a disruption occurred to their daily life and/or schedule. Scores were reverse coded and averaged across items so that a higher number indicated greater confidence that they would exercise under time-relevant constraints. This subscale was found to be highly reliable ($\alpha=.85$).

Barriers to being active.—The Barriers to Being Active Questionnaire (BBAQ; CDC, 2017) assessed potential reasons that prevent a person from physical activity with a 21-item self-report questionnaire. It can be scored into seven subscales/domains; of interest were the composite score and perceived lack of time subscale. The composite was formed by averaging across all 21 items ($\alpha=.89$). The perceived lack of time subscale was formed by summing 3 items: ‘I’m just too tired after work to get any exercise’, ‘Physical activity takes too much time away from other commitments - time, work, family, etc.’, and ‘My free times during the day are too short to include exercise’ ($\alpha=.83$). Participants reported how likely they were to agree with each item on a scale from 0 (very unlikely) to 3 (very likely). A higher score indicated greater perception of barriers.

Affect.—After a baseline of one-week, participants in both conditions were emailed daily to report their affect for that day. Affect was measured with an abbreviated version of the Positive and Negative Affect Schedule (PANAS; Brim, Ryff, & Kessler, 2004). This measure had 12 items that had participants report their positive affect (6 items; e.g., in good spirits; $\alpha=.83$) and negative affect (6 items; e.g., hopeless; $\alpha=.61$) for that day.

Design and Procedures

After participants were deemed eligible to participate in the study, the study investigator randomly assigned participants to either a control or intervention condition using computer-generated random numbers. During the 5-week study, participants and research staff that interacted with the participants were blinded to participant condition. Data collection was blinded, as our survey and physical activity data were collected through online platforms (Qualtrics and Fitabase, respectively). The study was approved by the University’s Institutional Review Board. The clinical trial was registered at the US National Institutes of Health ([ClinicalTrials.gov](https://clinicaltrials.gov)) # NCT03124563. After pre-test assessments of self-efficacy and barriers to being active, both conditions participated in a one-week baseline measurement of activity level and familiarization with the Fitbit to obtain an objective measurement of physical activity pre-intervention. Participants were instructed to wear the Fitbit each day, from when they woke up in the morning to when they went to bed at night. Participants were given the Fitbit as compensation for their participation. If participants decided to stop participating in the study, or they decided they did not want to keep the Fitbit at the end, they received monetary compensation relative to their time in the study (\$10 for pretest assessment and \$1 for each of the 35 study days, totalling to a possible \$45 dollars). Participants that kept the Fitbit were contacted one month after post-test to participate in an optional follow-up where they were asked to report their steps from the past week.

Intervention condition

Participants in the intervention condition were provided with resources to form implementation intentions to help them take control of their daily schedule, manage time-

related barriers to exercise, and establish that they can incorporate physical activity in their daily life. As schedules can vary day-to-day, participants were asked to perform the intervention task each day for four weeks, as opposed to forming one implementation intention at the beginning of the intervention as is common in past implementation intention and exercise work (e.g., Latimer et al., 2006). Implementation intentions are utilized to establish habits - the specific habit for this study was the habit of identifying opportunities within a daily schedule to increase steps. Participants were given a goal to increase the number of daily steps each week, based on recommended guidelines (e.g., Hill, Wyatt, Reed, & Peters, 2003) with increments of 2,000 steps each week. Implementation intentions were formed by specifying the when, where, and how they would add steps to their day. Specifically, after the baseline week, for four weeks, participants specified the 'when' by identifying time in their schedule that they could add steps and were asked to estimate approximately how many steps they would walk during each time point. The intervention condition was prompted with an email each evening to review their schedules for the following day and identify time slots where they could add activity. They were given instructions for providing a detailed calendar of appointments and open slots for the next day using a simple daily planner. To specify the 'where' of the implementation intention, participants were given customized maps near their home and work with specific information about distances, estimated time to walk between different points, and estimated number of steps based on the participants' walking pace for specific routes to help them in planning. To help with the 'how' component of the implementation intentions, participants in the intervention condition were given a list of strategies they could use to augment their step counts throughout the day. For example, to add steps they could (1) park at a distant parking lot to add a specific number of steps at both the beginning and end of the work day, (2) walk to a colleague's office rather than talking by telephone, or take a longer route, walking stairs rather than taking an elevator, and (3) during their break they can walk to get coffee in another building. Previous work has found that similar participant-generated plans for exercise were effective at enhancing self-efficacy (Buckley, 2016). This study is distinct from Buckley (2016) in its use of specific implementation intentions throughout the participants' daily schedules, whereas Buckley had participants self-generate more general action plans (e.g., identifying exercises they enjoyed, using cognitive restructuring to combat general worries and perceived barriers to exercising, etc.). Number of steps and goal achievement were recorded daily.

Control condition

Like the intervention condition, the control condition received a Fitbit Zip to monitor their physical activity. Both conditions were matched for how much contact they had with the research staff; thus those in this condition also received daily emails asking them to record their steps and answer a few questions about their experiences that day. The only differences between the control and intervention condition is that those in the control condition did not receive the implementation intention intervention strategies (daily schedule planning instructions, goals to increase their steps, or maps). The materials and emails for both conditions are included in the supplementary materials.

Data Analysis

Mixed multilevel modelling (MLM) was used to examine between condition and within-condition variability in the relationship between the level one and level two predictor and outcome variables using SAS 9.4. MLM offers numerous advantages for daily data, including the ability to take into account intraindividual (within-person) and interindividual (between-person) processes, and examine data from a sample of participants with a varying number of measurement points (Raudenbush & Bryk, 2002). The use of empirical Bayes estimates of coefficients (vs. OLS regression estimates) in MLM improves accuracy when there is missing data (Tennen, Affleck, & Armeli, 2005). Because diary studies can be time intensive for participants, the ability to measure a varying amount of data from participants can enhance the power and feasibility of using daily data. Daily steps were measured at level one, and person-level data (e.g., condition, age, education, gender, and functional health) were measured at level two.

To examine if the intervention enhanced our other outcome variables of interest (exercise ESE, Time ESE, and perceived barriers to being active) we used SPSS (SPSS Windows, version 24.0; SPSS Inc., Chicago, IL, USA) to conduct a series of 2 (Condition) X 2 (Time; pre-test vs. post-test) mixed model ANOVAs. Percent goal achievement was examined within the intervention condition, as the control condition did not receive a daily step goal. A mean was calculated across the intervention to determine average goal achievement and a repeated measures ANOVA across weeks was conducted to examine how goal achievement varied across the intervention. Multiple regression analyses, with age, gender, education, and functional health as covariates, were used to determine if goal achievement predicted ESE and Time ESE at the end of the study. Finally, the relationship between daily goal achievement and daily positive and negative affect were examined via MLM with age, gender, education, and functional health as covariates¹.

Results

Effects of Intervention on Physical Activity

Steps—Multilevel models revealed a significant 2 (Condition; control vs. intervention) X 5 (Week; baseline - week 5) interaction on weekly steps, $F(4,1260)=3.61$, $p=.006$. We estimated a medium effect size for the intervention using the mean differences of groups with unequal sample sizes in a pre-post-control design, $d_{ppc2}=0.56$ (Morris, 2008). The intervention condition increased in steps from baseline ($M=6966.06$, $SD=2818.05$) to week 5 ($M=8900.35$, $SD=4416.04$) by 27.77%, whereas the control condition showed virtually no change (-3.60%) between baseline ($M=6337.77$, $SD=2207.44$) and week 5 (6109.46 , $SD=3308.75$) (Figure 2). Between conditions, contrasts within each week revealed no significant difference between conditions at baseline, while the intervention condition was significantly higher in average step counts compared to the control condition for the following 4 weeks. On Week 2, the control condition walked an average of 6485.54 steps ($SD=3022.37$) compared to the intervention condition ($M=8204.27$, $SD=2137.81$), $p=.046$,

¹All analyses were run with the specified covariates and without any covariates and the effects were largely similar. Therefore, there is no indication that the results were sensitive to the choice of covariates.

95% CI [-3585.14, -18.54]. During Week 3, the control condition walked on average 6050.65 steps (SD=2655.67) compared to the intervention condition (M=8253.60, SD=3678.82), $p=.015$, 95% CI [-4013.10, -443.40]. Similarly, the intervention condition was significantly higher in steps on week 4 (M=8791.24, SD=4239.44) compared to the control condition (M=5595.97, SD=1770.22), $p<.001$, 95% CI [-5405.66, -1822.14]. A similar pattern existed at week 5, where the intervention condition walked an average of 8900.35 steps (SD=4416.04) compared to the control condition (M=6109.46, SD=3308.75), $p=.003$, 95% CI [-4570.30, -968.54]. Contrasts within the intervention condition showed that there was no significant difference between baseline and week 2 or week 3. Contrasting the baseline week with week 4 there was a significant increase in weekly average count ($p=.036$), 95% CI [-3061.33, -108.10], and a trend to significant difference at week 5 ($p=.060$), 95% CI [-2908.74, 61.94]. The control condition showed no significant changes when contrasting the baseline week with weeks 2, 3, 4, or 5. See Table 3 for model statistics. To understand if the results for our primary outcome were influenced by any outliers in the sample, we reanalysed the data after removing daily step counts that were 3.0 standard deviations above or below the mean. We removed 23 days of step data (5 days between 2 control participants and 18 days between 6 intervention participants). The pattern of results from the multilevel analyses was the same with and without the outliers. Thus, the full sample was used in the final analyses.

Active time—Multilevel models revealed a significant 2 (Condition; control vs. intervention) X 5 (Week; baseline - week 5) interaction on MVPA, $F(4,1262)=2.61$, $p=.034$. The effect size was small according to the mean differences of groups with unequal sample sizes in a pre-post-control design, $d_{ppc2}=0.26$ (Morris, 2008). Between conditions, there was no significant difference at baseline, week 2, or week 5. At week 3, the intervention condition significantly ($p=.039$, 95% CI [-27.28, -0.70]) engaged in more MVPA (M=32.51, SD=28.64) compared to the control condition (M=16.61, SD=18.61). Similarly, at week 4, the intervention condition significantly ($p=.002$, 95% CI [-35.06, -8.37]) engaged in more MVPA (M=34.49, SD=32.41) compared to the control (M=14.55, SD=13.75). Contrasts within the intervention condition showed a significant increase in MVPA between week 2 (M=28.69, SD=19.15) and 4 (M=34.49, SD=32.41), $p=.039$, 95% CI [-11.89, -0.31]. The control condition showed no significant changes when contrasting the baseline week (M=18.71, SD=20.31) with weeks 2 (M=20.63, SD=19.40), 3 (M=16.61, SD=18.61), 4 (M=14.55, SD=13.75), or 5 (M=18.51, SD=25.84). See Table 3 for model statistics.

Goal achievement—Across all intervention participants and across all days of the intervention, participants walked 80.63% of their given step goal (SD=20.95%). Goal achievement was highest on the starting week of the intervention (Week 2) at 102% (SD=23.78%). A repeated measures ANOVA revealed that there was a trend towards a significant decrease to Week 3 to 79.24% (SD=31.44; $p=.065$). From Week 3 to Week 4 there was no significant change.

A series of multilevel models were conducted to see if goal achievement predicted daily positive and negative affect. Controlling for age, gender, education, and functional health, on

days in which participants were closer to achieving their goal they reported higher positive affect ($y=.002$, $SE=.001$, $p=.007$, 95% CI [0.001, 0.004]). Directionality was examined by reversing the model and seeing if days with greater positive affect predicted better goal achievement. Controlling for age, gender, education, and functional health, the model did not provide statistical evidence to support this. Negative affect was neither predicted by, nor predictive of goal achievement.

Effects of Intervention on Self-efficacy

There were no significant main effects of time or condition, nor was there a significant interaction when looking at overall ESE. For Time ESE, there were no significant main effects of condition or time; however, there was a significant condition X time (pre vs. post) interaction, $F(1,30)=5.82$, $p=.022$ (Figure 3). A small to medium effect size was estimated using the mean differences of groups with unequal sample sizes in a pre-post-control design, $d_{ppc2}=0.45$ (Morris, 2008). Contrasts revealed a significant increase in Time ESE from pre- to post-test for the intervention condition, $p=.005$, whereas the control condition showed no significant change from pre- to post-test.

Next, we examined whether change in physical activity (steps, MVPA, and goal achievement) was associated with Time ESE with a series of regression analyses. In line with the temporal order of the measures, when we examined Time ESE at pre-test we looked at it as a predictor variable and when we examined Time ESE at post-test we looked at it as an outcome variable. Controlling for age, gender, education, and functional health, Time ESE at pre-test did not significantly predict change in physical activity. Controlling for age, gender, education, and functional health, goal achievement significantly predicted Time ESE at post-test, $B=11.92$, $SE=4.83$, $p=.033$, 95% CI [0.003, 0.060], suggesting that those who were closer to meeting their step goal throughout the intervention were more likely to report higher Time ESE at the end of the intervention. Condition differences and descriptive information for ESE can be seen in Table 1. When we controlled for Time ESE at pre-test in this regression, the relationship between goal achievement and Time ESE at post-test became marginally significant ($p=.064$, 95% CI [-0.002, 0.055]).

Perceived Barriers

While perceiving time as a barrier to being active decreased in the intervention condition (Mean=-0.72, SD=3.08) and slightly increased in the control condition (Mean=0.08, SD=1.94), these changes were not statistically significant. A multiple regression analysis was conducted to see if change in time as a perceived barrier to being active was related to change in Time ESE. Controlling for age, gender, education, functional health, and condition, an increase in Time ESE significantly predicted a decrease in perceiving time as a barrier, $B=-0.62$, $SE=.18$, $p=.002$, 95% CI [-.931, -.266]. We examined if condition moderated this effect and did not see any significant condition X change in Time ESE interaction. Condition differences and descriptive information for barriers to being active can be seen in Table 1.

Follow-up

Twenty-four participants responded to our request for an optional follow-up (40.6%; 10 control and 14 intervention). Between those that did and did not respond to follow-up, there were no significant differences in age, sex, education, functional health, steps, ESE, Time ESE, or perceiving time as a barrier to being active. However, in the intervention condition, there was a trend toward a significant relationship between those that were closer to their step goal and those who responded to our request for follow-up ($p=.063$). Additionally, we ran a binomial logistic regression to see whether Time ESE predicted follow-up participation. Participants were dummy-coded as either a '0' (no follow-up) or a '1' (yes follow-up). Controlling for age, gender, education, and functional health there was no significant relationship between Time ESE (pre- or post-test) and follow-up participation.

We analysed a 2 (Condition) x 6 (Week) multilevel model with age, gender, and functional health as covariates, to examine whether the increase in step counts between conditions persisted at the 1-month follow-up. MLM analyses revealed a significant condition x week interaction ($F(5,1665)=6.14$, $p<.001$). However, contrasts revealed that the intervention condition significantly decreased in steps from the end of the study (week 5) to the follow-up ($\gamma=1303.96$, $SE=511.67$, $p=.011$, 95% CI [680.53, 2901.43]). At the follow-up, steps for the intervention condition did not significantly differ from the baseline/week 1 measurement, nor were they significantly different from the control condition.

Discussion

This Stage 1 (Onken et al., 2014) pilot study developed and tested a physical activity intervention using strategies to support implementation intentions to help middle-aged adults increase their confidence that they would engage in exercise (i.e., exercise self-efficacy; ESE) by specifying when, where, and how they would add activity to their daily routine. While overall ESE did not vary between groups or across time-points of the intervention, time-relevant ESE (Time ESE) did significantly increase from pre- to post-test for the intervention condition, while no change was found for the control group. This suggests that the intervention helped participants increase confidence in their ability to exercise under perceived time constraints. This is in line with recent work that suggests that enactive experiences at scheduling exercise into daily routines enhanced scheduling efficacy (Buckley, 2016). There was no significant interaction between conditions or across pre- and post-test regarding time as a perceived barrier to being active. However, analyses did reveal that increases in Time ESE significantly predicted a decrease in time as a barrier, suggesting that those who increased in Time ESE decreased in their perception of time as barrier to engaging in exercise.

Results revealed significant differences in physical activity between conditions at each week of the intervention. Specifically, the intervention condition increased their average daily step count and active time significantly after the first two weeks and were able to maintain this increase during the designated study period, whereas the control condition did not significantly change their daily steps throughout the study. A medium effect size was found for the implementation intention intervention on objective measures of physical activity, which supports our use of multiple components to buttress the implementation intentions.

Bélanger-Gravel et al. (2013) estimated a relatively small effect size compared to other health promotion interventions, but noted it is likely a slight underestimation as the majority of physical activity data that was collected for the meta-analysis was self-report and subject to biased estimations. The first week of the intervention (week 2) appears to be when participants were best able to meet their specified goals, and as the daily step goals increased each week, goal achievement decreased. This is likely due to the fact that goals were lowest in the first week of the intervention and perhaps more realistic and consistent with the participants' typical activity levels, or possibly the novelty of the intervention in that first week motivated the participants to achieve their goal. While time-relevant exercise self-efficacy (Time ESE) did not predict amount of physical activity, we did find that Time ESE significantly predicted participants' goal achievement. Specifically, those who were closer to meeting their step goal had higher Time ESE at post-test. Time ESE at baseline (i.e., pre-test) did not predict goal achievement. The significant relationship between goal achievement and Time ESE at the end of the study in the intervention group provides additional information as to the potential mechanisms involved in the intervention, however more work is needed to understand this relationship.

As past work has shown, a perceived lack of time is one of most commonly reported barriers to engaging in the recommended amount of physical activity (Ebrahim and Rowland, 1996; AARP, 2004). Therefore, it is promising that our intervention was effective in increasing both activity and Time ESE, especially with middle-aged adults who typically report challenges with finding time to exercise. Future intervention studies should also attempt to reduce other perceived barriers to being active. While time as a barrier was the main focus of this study, our Barriers to Being Active Questionnaire found that time was only the third most reported barrier, with lack of will-power and energy as the highest and second-highest, respectively. This order persisted at both pre-and post-test. Thus, future studies should work to develop interventions to target a lack of will-power and/or energy as barriers to being active.

Addressing the Intention-Behaviour Gap

A common occurrence, particularly regarding health behaviours such as physical activity, is the discrepancy between one's intentions and one's actions. Three proposed processes may underlie this 'intention-behaviour gap': intention viability, intention activation, and intention elaboration (Prestwich et al, 2015). The current study addressed this potential problem with intention viability by having participants find opportunities in their schedule to add a doable action, such as walking. Furthermore, it has been suggested that implementation intention interventions that enhance self-efficacy directly can help to overcome problems of intention viability. Indeed, the current study did demonstrate increased exercise self-efficacy specific to time constraints. The current study addressed the potential problem of intention activation, which can often lead to prospective memory failures or goal reprioritization, by allowing the participants to fit the intended behaviour (walking) within their previously established goals and tasks for that day. Finally, the current study was able to address problems relating to intention elaboration by having participants use implementation intentions (specifying the when, where, and how of how they would add walking throughout their day that would result in goal achievement in terms of number of steps) via doable

actions and opportunities in their everyday schedule and that were carried out at home and at work.

Limitations and Future Directions—This pilot study demonstrated the use of implementation intentions to increase physical activity in middle-aged, working adults. Results demonstrated that not only did the intervention condition increase in steps and active time, but also increased in exercise self-efficacy relevant for time constraints. However, several limitations should be noted. Despite including a one-week baseline, an objective baseline of physical activity in our participants cannot be determined, as the act of giving a Fitbit could have bolstered activity levels. Nevertheless, the intervention group did continue to increase in steps, and the control group did not. Another limitation is the absence of measuring exercise self-efficacy each week, thus, we are only able to assess pre- and post-intervention changes. More frequent measurements would be beneficial to see how this construct fluctuates with varying goal achievement. Additionally, it is possible that the participants were given goals (i.e., adding 2000 steps per week) that were too high. Goal achievement was highest at week 2, and decreased for the following 3 weeks of the study. Perhaps setting more realistic goals would have benefitted exercise self-efficacy even more so. As this study utilized multiple components to facilitate the participants' implementation intentions, it is necessary in future studies to determine if all components were necessary to achieve the same level of effectiveness. Each component was representative of the 'when, where, and how' aspects involved in implementation intentions. However, of interest is whether one component (e.g., the 'when') was more beneficial than another, or must all components work in conjunction with each other? Future studies should continue to work on parsing out the benefits of each facet to the intervention. Beyond the different components, it is also important to consider that the act of sending participants a daily email may have contributed to the effects of the implementation intentions on the outcome measures. As Prestwich and colleagues have demonstrated, implementation intentions coupled with another form of mobile communication, text messages, showed enhanced effects on physical activity over and above just implementation intentions (Prestwich, Perugini, & Hurling, 2009 & 2010). However, in the current study, as both the control and intervention groups were matched for the frequency of emails received, and the content was the same with the exception of the strategies to support implementation intentions (scheduling, maps, and daily step goals), the design of the study supports the implementation intention strategies as key for the effects on physical activity.

Due to the rolling nature of our enrolment, participants were tested across the course of approximately 1 year; seasonal differences may be linked to activity differences and future work should aim to control for these differences. Finally, at follow-up, results revealed that the significant increase in steps for the intervention condition did not persist. Previous work has found booster sessions to be helpful in maintaining behaviour change. For example, Chapman & Armitage (2010) found that having participants form a new implementation intention after 3 months was beneficial for sustained intervention effects on vegetable consumption. Similarly, previous work that utilized booster sessions after the completion of a physical activity intervention using Fitbits in middle-aged women were able to see lasting effects on physical activity (Butryn et al., 2016). It is possible that the participants stopped

employing the implementation intentions after the end of the intervention; perhaps a booster session prompting them to continue forming the implementation intentions to add steps throughout their schedule after the end of the study would have resulted in prolonged effects of the intervention. However, other work has shown that even when the intervention continued in an 11-week study, step counts were only significantly higher in the implementation intervention condition compared to the control condition during the first 6 weeks of the study, and did not persist for the remaining 5 weeks (Latimer et al., 2006). Additionally, perhaps the 4-week span of the intervention was not enough time for the intervention to become a habit, or part of the participants' everyday routines. Future studies should work to develop methods to ensure lasting intervention effects on physical activity.

Conclusion—Using an intervention with implementation intentions, this pilot study effectively increased daily walking and active time by helping participants develop concrete plans to increase activity for the next day. We found that the use of specific implementation intentions, such as planning when, where, and how to increase daily walking, also increased participant's confidence that they would engage in physical activity even under perceived time constraints. Participants that were closer to their activity goals reported greater daily positive affect and greater exercise self-efficacy at the end of the study. This is promising, as those who are more confident in their ability to exercise and who enjoy it are more likely to continue to engage in physical activity (Lachman et al., 2018). Additionally, this increase in time-relevant exercise self-efficacy from the beginning to end of the study was related to a decreased perception of time as a barrier to exercise. Though the intervention group showed greater increases in steps, this difference did not persist 1 month following the end of the intervention. Future studies should continue to explore how to encourage maintenance of activity over longer periods of time.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Consolidated Standards or Reporting Trials (CONSORT) diagram.

Figure 2. Multilevel interaction between conditions across weeks. Error bars represent the standard error of the mean.

Figure 3. Mixed model ANOVA interaction between conditions across pre- and post-test scores for exercise self-efficacy time subscale. Error bars represent the standard error of the mean.

Table 1.

Descriptive Statistics by Condition.

Variable	Control		Intervention		Total
N	32		30		62
<i>Covariates</i>					
Age	52.22* (7.68)		46.33* (8.03)		49.37 (8.33)
Education yrs.	16.27 (2.64)		15.78 (1.57)		16.39 (2.01)
Gender %	75% females		70% females		72.6% females
Functional Health	2.81 (0.28)		2.84 (0.27)		2.82 (0.27)
<i>Pre- and Post-test measures</i>					
	<i>Pre</i>	<i>Post</i>	<i>Pre</i>	<i>Post</i>	<i>Post</i>
Exercise Self-Efficacy	2.15 (0.99)	2.16 (0.86)	2.19 (0.81)	2.29 (0.92)	2.21 (.88)
Exercise Self-Efficacy Time	1.96 (1.05)	1.94 (0.89)	1.90 (0.75)*	2.30 (0.90)*	2.10 (.90)
BBAQ Composite	0.90 (0.51)	0.97 (0.70)	1.02 (.55)	0.95 (0.51)	0.96 (0.51)
BBAQ Time	3.46 (2.76)	3.81 (2.94)	4.17 (2.7)	3.73 (2.62)	3.79 (2.72)
					3.78 (2.77)

Note. BBAQ = Barriers to Being Active Quiz;

* $p < .01$.

Table 2.

Bivariate Pearson Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	--													
2. Gender	.10	--												
3. Education	.21	.05	--											
4. Health	-.01	-.17	.13	--										
5. T1 ESE	-.13	-.17	.*	.24	--									
6. T2 ESE	-.22	-.03	-.21	.02	.66	--								
7. T1 Time ESE	-.12	-.12	.*	.27	.95	.*	--							
8. T2 Time ESE	-.30	-.02	-.29	.07	.67	.95	.*	--						
9. Total Steps	-.09	-.14	-.05	.14	.15	.15	.14	.26	--					
10. Total MVPA	.02	-.19	-.19	.11	.27	.25	.26	.33	.*	.*	--			
11. T1 BBAQ	.06	.11	.24	-.23	-.53	.*	-.29	-.30	.*	-.31	.*	--		
12. T2 BBAQ	-.05	-.06	.14	-.19	-.49	.*	-.59	-.47	.*	-.37	.*	.*	--	
13. T1 BBAQ Time	.09	.09	.35	-.01	-.50	.*	-.21	-.47	.*	-.19	.*	.*	.43	--
14. T2 BBAQ Time	.07	.16	.24	-.15	-.45	.*	-.50	-.40	.*	-.35	.*	.*	.69	.*

Note. T1=Time 1, or pre-test; T2=Time 2, or post-test; MVPA=Time spent in Moderate-to-Vigorous Activity; ESE=Exercise self-efficacy; BBAQ=Barriers to being active;

* p<.05,

** p<.01

Table 3.

Unstandardized Coefficients from Multilevel Condition X Week Interaction for Physical Activity

Effect	Model df	Error df	<i>F</i>	<i>p</i> -value
<i>Steps</i>				
Age	1	45	1.17	0.285
Gender	1	45.4	1.96	0.168
Week	4	1261	1.31	0.266
Functional Health	1	45.8	0.24	0.625
Condition	1	48.9	7.78	0.008
Condition X Week	4	1261	3.60	0.006
<i>MVPA</i>				
Age	1	45	0.22	0.642
Gender	1	45.4	4.66	0.136
Week	4	1262	0.22	0.929
Functional Health	1	45.8	0.20	0.660
Condition	1	49.1	4.66	0.036
Condition X Week	4	1262	2.62	0.034

Note. MVPA=Time spent in Moderate-to-Vigorous Activity