

Improving Affective Associations with Physical Activity via Message-Based Mobile Health Interventions: A Proof-of-Concept Trial of the WalkToJoy Intervention

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Submitted to: Journal of Medical Internet Research
on: April 10, 2025

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Abstract

Background: Traditional mobile health (mHealth) interventions for physical activity (PA) primarily rely on reflective self-regulatory processes, often neglecting the role of affective associations in sustaining long-term engagement. The WalkToJoy intervention addresses this gap by applying the Affective–Reflective Theory (ART) to enhance intrinsic motivation for PA among adults 40 and older through affective message framing, evaluative conditioning, and belief updating.

Objective: This proof-of-concept study evaluated the feasibility of the message-based WalkToJoy intervention package and examined the impact of its three components—walking suggestion prompts, salience messages, and planning prompts—on affective and behavioral outcomes related to walking.

Methods: We conducted a 6-week full factorial experiment with an embedded micro-randomized trial (MRT) involving 49 adults aged 40 and older. Statistical analyses, including paired t-tests and generalized estimating equations (GEE), assessed pre-post changes and the effects of smile-inducing walking suggestion prompts with short, animated images in Graphics Interchange Format (GIF), salience messages, and planning prompts on weekly affective measures and daily step counts. Additionally, MRT analyses evaluated the proximal effects of these components. Post-study interviews were thematically analyzed to contextualize participants' experiences and engagement with the intervention.

Results: Significant pre-post improvements were observed across affective outcomes on a 7-point Likert scale: affective attitude increased by 0.547 points ($p = .0002$), affective valuation by 0.718 points ($p = .00001$), affective reflection by 0.692 points ($p = .00028$), and anticipated affect by 0.692 points ($p = .000079$). While the average daily steps showed a nonsignificant increase of 80 steps ($p = .79$), further analysis revealed a significant increase of 506 steps ($p = .07$) at the 10% significance level when comparing baseline to the average of weeks 4–6. Among the intervention components, GIF prompts significantly increased anticipated affect by 0.345 points ($p = .046$) and average daily step count by 1,834 steps ($p = .05$) compared to identical text-only prompts, supporting the effectiveness of evaluative conditioning. However, MRT analysis found no significant increase in 4-hour step counts following the walking suggestion prompts ($p = .55$), which was explained by qualitative findings suggesting that participants interpreted messages as flexible, day-long reminders rather than immediate calls to action. Salience and planning prompts did not yield statistically significant effects but were positively received by participants for promoting mindfulness and personalized engagement.

Conclusions: The WalkToJoy intervention is a feasible and promising approach for increasing affective associations with walking. Walking suggestion prompts were particularly effective in boosting engagement and mitigating message fatigue, highlighting the potential of affect-driven interventions to enhance PA motivation and adherence.

(JMIR Preprints 10/04/2025:75792)

DOI: <https://doi.org/10.2196/preprints.75792>

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Original Manuscript

Original Paper

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Abstract

Background: Traditional mobile health (mHealth) interventions for physical activity (PA) primarily rely on reflective self-regulatory processes, often neglecting the role of affective associations in sustaining long-term engagement. The WalkToJoy intervention addresses this gap by applying the Affective–Reflective Theory (ART) to enhance intrinsic motivation for PA among adults 40 and older through affective message framing, evaluative conditioning, and belief updating.

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Results: Significant pre-post improvements were observed across affective outcomes on a 7-point Likert scale: affective attitude increased by 0.547 points ($P<.001$), affective valuation by 0.718 points ($P<.001$), affective reflection by 0.692 points ($P<.001$), and anticipated affect by 0.692 points ($P<.001$). While the average daily steps showed a nonsignificant increase of 80 steps ($P=.79$), further analysis revealed a significant increase of 506 steps ($P=.07$) at the 10% significance level when comparing baseline to the average of weeks 4–6. Among the intervention components, GIF prompts significantly increased anticipated affect by 0.345 points ($P=.046$) and average daily step count by 1,834 steps ($P=.05$) compared to identical text-only prompts, supporting the effectiveness of evaluative conditioning. However, MRT analysis found no significant increase in 4-hour step counts following the walking suggestion prompts ($P=.55$), which was explained by qualitative findings suggesting that participants interpreted messages as flexible, day-long reminders rather than immediate calls to action. Salience and planning prompts did not yield statistically significant effects but were positively received by participants for promoting mindfulness and personalized engagement.

Conclusions: The WalkToJoy intervention is a feasible and promising approach for increasing affective associations with walking. Walking suggestion prompts were particularly effective in

boosting engagement and mitigating message fatigue, highlighting the potential of affect-driven interventions to enhance PA motivation and adherence.

Keywords: mobile health; behavior change; physical activity; intrinsic motivation; affective association; proof-of-concept

Introduction

Physical activity promotes long-term health and wellness by providing physiological benefits such as weight management, blood glucose and blood pressure control, and reducing the risk of chronic diseases like heart disease and diabetes. Additionally, it enhances cognitive functions (e.g., improved alertness, attention, and memory) and emotional well-being (e.g., elevated mood and confidence, reduced anxiety and stress) [1–5]. Despite the many documented benefits of physical activity for health and wellness, increasing physical activity on a population level remains a challenge. Research shows that in 2020, only 24.2% of American adults met the recommended levels of physical activity (i.e., 150 minutes of moderate-intensity physical activity and 2 days of muscle strengthening activity) [6]. Additionally, with increasing age, the level of physical activity tends to decrease significantly over time [6]. With the extended life expectancy and a growing proportion of older adults, the lack of physical activity among middle-aged and older adults suggests an increasingly significant public health problem.

With a high penetration of smartphones and wearables across a broad range of population, there have been many interventions that have attempted to provide support for physical activity through mobile health (mHealth) applications [7]. Compared to the more traditional modes of intervention such as an in-person cognitive behavioral therapy, the key benefits of mHealth applications are high accessibility, low cost, support for user autonomy [8–10], trackability of progress over time with continued intervention support in daily settings, as well as the potential for adaptability and tailoring to the individual needs [11–13].

Traditional Theory-based mHealth Interventions and their Limitations

Scholars in the mHealth space have relied on behavior change theories and models such as the Self-Determination Theory (SDT), Health Belief Model (HBM), Theory of Planned Behavior (TPB), and Social Cognitive Theory (SCT) to understand the determinants of health behaviors and guide the design of intervention strategies. These theories provide valuable insights into the psychological factors that drive intention and motivation for behavior change, such as perceived benefits, self-efficacy, and autonomy. By identifying the "why" behind behavior, these frameworks have informed the development of theory-based strategies to create mHealth interventions tailored to psychological and behavioral needs.

However, despite their theoretical rigor, many mHealth studies face persistent challenges in sustaining user engagement, often reporting high attrition rates [14,15]. Attig and Franke [14] highlighted several barriers to continued use of activity wearables, including declines in intrinsic motivation, disruptions to tracking routines, and shifts in life priorities. These findings suggest that traditional mHealth strategies may struggle to accommodate the dynamic and fluctuating nature of user motivation and needs over time, especially in long-term interventions.

A key limitation of these traditional models is their heavy reliance on self-regulatory strategies, like goal setting and planning, that assume that health behaviors are primarily driven by reflective cognitive processes. More recent research has shown that health behaviors are heavily influenced by subconscious and automatic processes, such as implicit attitudes, emotions, and habits [16–18].

Implicit mechanisms operate below the level of conscious thought, shaping perceptions and responses through repeated experiences and associations [19]. In recognition of these limitations, the field of health psychology has seen a shift from the predominantly social cognitive approach toward dual-process theories of behavior, which integrate both reflective and automatic cognitive processes. This shift acknowledges the critical role of implicit factors in shaping health behaviors and underscores the importance of addressing a fuller range of self-regulatory processes in mHealth intervention design.

An affect-based theoretical framework

Several psychological barriers to exercise initiation and adherence stand in the way of sustaining physical activity, particularly among sedentary adults. These barriers include lack of sustained motivation, low perceived self-efficacy, negative exercise attitudes, low expectations of benefits, and lack of enjoyment or prior unpleasant exercise experiences [14, 15]. Such challenges are particularly influential in the elderly population, where adherence to a regular exercise routine is further complicated by age-related changes in priorities and physical capacity [20].

One critical determinant of exercise adherence is the type of motivation driving physical activity. Research shows that adults who rely on external motivations (e.g., improving appearance, peer acceptance) often struggle to sustain their exercise behavior over time. In contrast, those with intrinsic motivations (e.g., enjoyment) demonstrate greater long-term adherence [22,23]. This underscores the importance of fostering strong, intrinsically motivated intentions to support sustained behavior change.

Central to the nature of motivation is the role of affective states—feelings of pleasure or displeasure, mood, and emotion—which have been identified as key determinants of intrinsic motivation [19, 20]. Affective states influence the flow of information processing in the brain, either enhancing or inhibiting behaviors, through subconscious mechanisms that operate beyond conscious deliberation [18, 19]. Facilitating positive emotions toward physical activity has shown particular promise in increasing intrinsic motivation, especially among sedentary individuals, by making the behavior more rewarding and enjoyable [26].

The Affective–Reflective Theory of physical inactivity and exercise (ART) provides a theoretical framework for explaining the interplay between the cognitive and automatic processes of affective association formation. This dual-process theory describes the role of affective valuation—momentary emotional response towards exercise behavior based on our previous exposures and experiences—in exercise motivation and behavior change [17,27]. The theory explains the relationship between our brain's automatic affective processing, which occurs quickly and automatically with minimal cognitive resources or effort, and reflective processing, which occurs slowly and requires cognitive reasoning through working memory [17,27–29]. The interplay of the two processes dictates an individual's exercise behavior, with the automatic affective valuation acting as the basis for the reflective process. According to ART, positive or negative experiences with a behavior such as exercise over the course of an individual's learning history result in the formation of affective valuations of the behavior—fast, momentary reactions of attraction or aversion triggered by thinking about the behavior or the need to engage in the behavior. Repeated affective valuations, coupled with conscious reflection on positive and negative experiences with exercise, result in the formation of affective attitudes, which are an individual's overall emotional evaluations of a behavior encompassing feelings of like or dislike [19]. Affective valuations and attitudes—collectively called affective associations—have been found to dictate one's exercise behavior, performance, and exercise decision preference [29–32]. As such, having sustainable, positive affective associations (i.e., positive affective responses to physical activity, such as enjoyment of activity) is an important

factor for increasing intrinsic motivation and intention for physical activity [20, 28, 29].

However, despite the close relationship between affective associations and the motivation and intention to engage in physical activity, many mHealth interventions overlook this critical determinant of physical activity. While recent interventions have attempted to track and monitor affective states, they fall short of directly influencing the core affective association processes that underpin the intrinsic motivation for engaging in physical activity [30, 31]. Furthermore, there is a notable lack of research regarding how the design of mHealth interventions can influence affective processes towards physical activity among middle-aged to older adults. Addressing this gap, this study introduces the WalkToJoy mHealth intervention. Grounded in ART, this message-based mHealth intervention employs three intervention strategies designed to positively revise and update middle-aged to older adults' affective valuations of and affective attitude towards walking (i.e., a moderate physical activity).

WalkToJoy's Affective-Based Approach to Supporting Walking

SMS text messaging has become a prevalent method for promoting physical activity in mHealth interventions due to the widespread ownership of mobile phones among American adults, with over 95% capable of sending and receiving SMS and Multimedia Messaging Service (MMS) texts [37]. Message-based interventions for physical activity have shown that message framing is an effective strategy for shaping people's perceptions to motivate healthy behaviors such as physical activity [38–41]. Additionally, a study employing affective message framing have demonstrated promising results in influencing exercise behavior and in shifting attitudes toward physical activity [42]. Based on these results, WalkToJoy aims to use specifically framed SMS and MMS messages to positively alter individuals' affective associations with walking in order to increase their intrinsic motivation for physical activity.

Theoretically, the overarching strategy behind WalkToJoy messages involves evaluative conditioning [39, 40] and belief updating [45]. WalkToJoy employs evaluative conditioning [39, 40] to modify individuals' affective valuations of walking by pairing a neutral stimulus with a unconditioned, positively valenced stimulus. Specifically, we hypothesized that repeatedly pairing suggestions to go for a walk via “push” message with a positively valenced experience—smiling induced via an animated images of cute animals in Graphics Interchange Format (GIF)—will, over time, create associations between positive emotions and the thought of walking. Supporting this approach, long-standing research shows that emotional imagery enhances affective arousal, valence, and attention [46,47]. This associative process targets the brain's automatic affective processing by subconsciously triggering positive emotional reactions via the GIF when participants are prompted to go for a walk.

Belief updating is a strategy that aims to update people's existing expectations and prior beliefs about a behavior [45]. These prior beliefs, which can be captured by measuring a person's attitudes toward the behavior, reflect individual's overall assessment of engaging in the target behavior [37, 38]. As explained by ART, beliefs and expectations towards physical activity are shaped and solidified over time through individuals' experiences with physical activity over the course of their learning history. If these beliefs are negative, they can be updated by repeatedly nudging participants to pay attention to and reflect upon the enjoyable aspects of being active [50]. Increasing salience of positive aspects of walking has been shown to be effective in increasing walking behavior among older adults [39]. Therefore, by making enjoyable aspects and benefits of walking experience more cognitively accessible and encouraging participants to positively modify their affective valuation of the walking behavior, WalkToJoy aims to make choosing to go for a walk more effortless each time, where the choice will be driven by a revised expectation that walking will be a pleasant and fulfilling experience.

To assess the feasibility of this approach, we conducted a proof-of-concept study of WalkToJoy. The study employed a hybrid experimental design that combines a factorial experiment with a micro-randomized trial in order to investigate the potential of each of WalkToJoy's three experimental components to influence affective association and walking behavior. In addition, we interviewed a subset of participants to understand their experiences with the intervention, how they incorporated walking into their daily lives, and how they subjectively experienced the impact of using WalkToJoy.

Methods

Overview

A proof-of-concept study of the WalkToJoy intervention was conducted as a 6-week full factorial experiment with 3 factors (i.e., for a total of 8 conditions) and an embedded micro-randomized trial (MRT) [11, 13, 43]. The primary aim of the study was to assess the feasibility of the WalkToJoy intervention package as a whole for improving affective associations with walking. The secondary aim was to assess how each of the three components contributed to an improvement in affective associations with walking and the walking behavior itself. Additionally, the study investigated the impact of the micro-randomized components on their respective proximal outcomes in order to inform the decision rules (e.g., timing and context) for the delivery of those components.

Recruitment

The target study population consisted of adults aged 40 and above residing in the United States with access to a smartphone and a Fitbit activity tracker. Recruiting was done through MHealthy and UMHealthResearch, two online platforms at our university focused on wellness and health research, respectively. Recruitment emails containing a detailed study description, contact information, and a link to the Qualtrics eligibility screener were sent to potential participants who expressed interest in the study.

The eligibility screening involved a conditional two-item self-report measure assessing participants' satisfaction with their current activity levels. The first question asked, "I want to be more physically active," with responses on a 5-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5). Participants who scored 3 or higher were then shown the second question: "To be more active, I want to increase how much I walk," also rated on the same 5-point scale. Participants who scored 3 or higher on both items (i.e., indicating low satisfaction with their current activity level and strong motivation to increase physical activity through walking) were invited to participate.

This proof-of-concept study intentionally included participants across a wide range of baseline activity levels, rather than restricting recruitment to sedentary individuals, to assess the feasibility of WalkToJoy broadly. Eligible participants were subsequently asked to confirm their intent to participate and complete an informed consent form. Upon completion, they provided their email address and phone number to receive further instructions for study enrollment. The inclusion criteria are summarized in Textbox 1.

Textbox 1. Inclusion Criteria

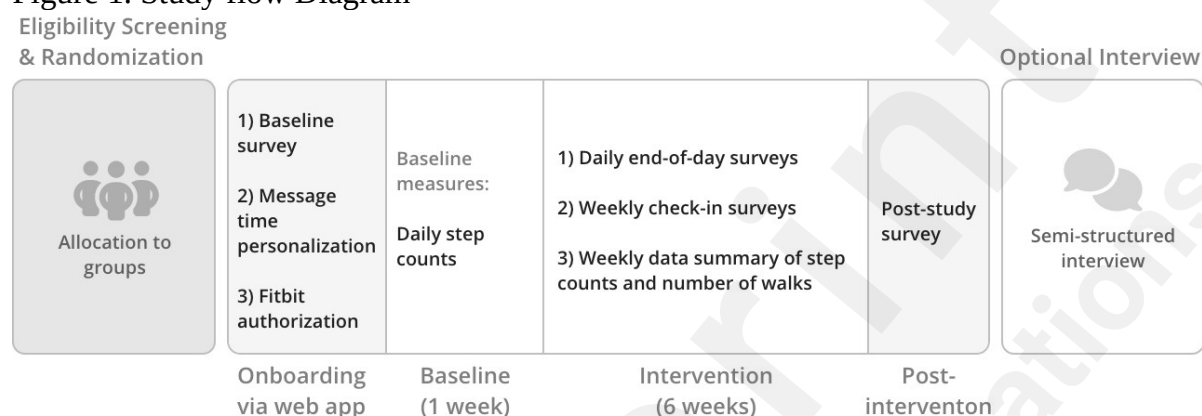
- Adults 40 years or older living in the U.S.
- Have no medical condition that would prevent them from safely engaging in a moderate physical activity (i.e., walking).
- Have access to a smartphone that can run the Fitbit app.
- Have and is willing to use a Fitbit daily for the duration of the study.
- Have a safe and easily accessible place to walk.

- Have low satisfaction with current physical activity level and want to increase activity by walking more.

Study Procedures

Participation in the study involved several steps: onboarding through the WalkToJoy mobile application, a one-week baseline assessment, a six-week intervention period, a post-intervention assessment, and an optional semi-structured interview. The overall study flow is illustrated in Figure 1.

Figure 1. Study flow Diagram



Given the limitations imposed by COVID-19, the entire study was conducted in a contact-free manner. Upon providing consent, eligible participants received their participant ID and an 8-character token, along with onboarding instructions via email. These credentials were used to sign into the WalkToJoy web application on their smartphones to complete the onboarding tasks and the baseline survey. At this stage, participants were also randomly assigned to one of eight study conditions.

Upon signing into the WalkToJoy web application (see Figure 2), participants completed the onboarding process, which included personalizing their intervention experience by setting normal waking hours, authorizing their Fitbit account, and configuring phone and Fitbit application settings. The overall application architecture of the WalkToJoy intervention is depicted in Figure 3.

Figure 2. Onboarding Application Interaction Map

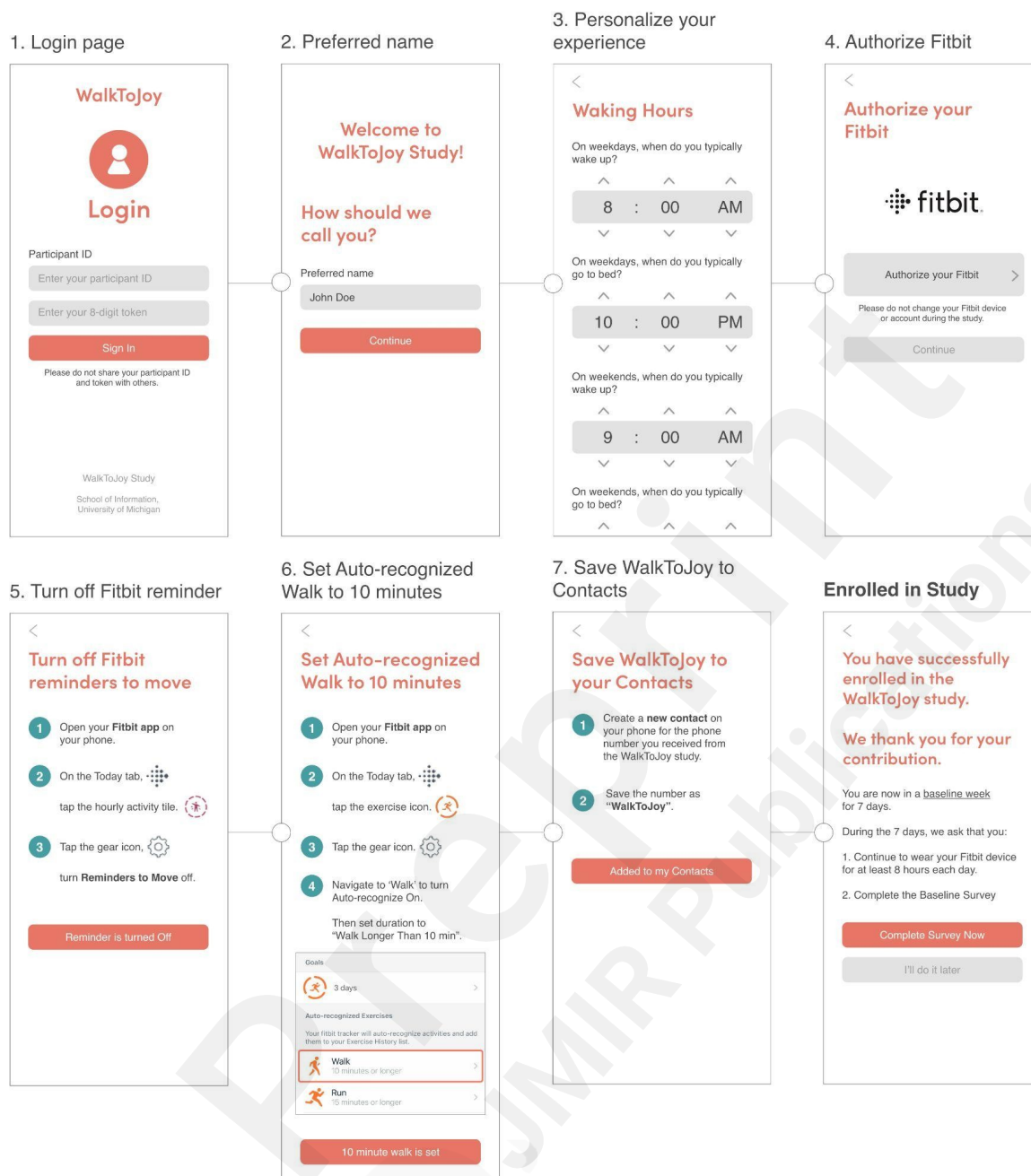
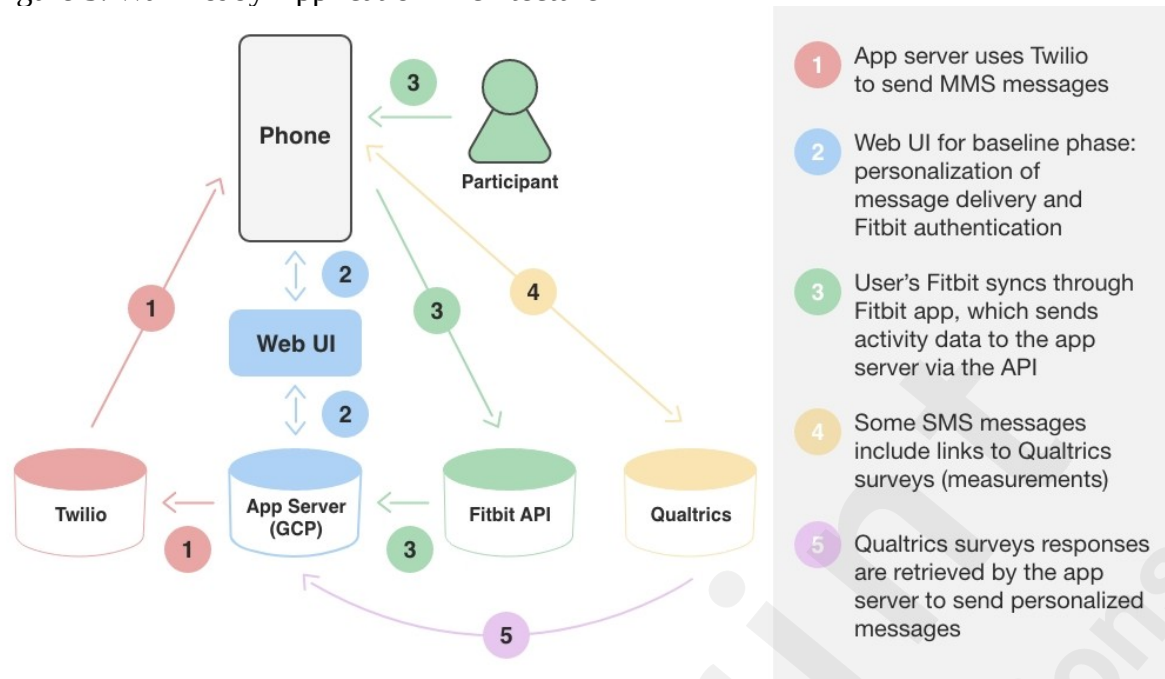


Figure 3. WalkToJoy Application Architecture



As part of the baseline survey, participants provided information on their gender, motivation for physical activity, preferred hours for receiving walking prompts (i.e., waking hours), and baseline measures, including affective attitudes toward and affective valuations of walking, exercise self-efficacy, and body awareness. Following the completion of the baseline survey and onboarding tasks, participants were fully enrolled in the study and began a one-week baseline phase. During this phase, participants' daily step counts were recorded for a minimum of seven days to establish baseline activity levels. Participants transitioned to the intervention phase the following Monday if they had worn their Fitbit for at least three days for a minimum of eight hours per day during the baseline week. Those who did not meet the three-day adherence requirement received reminders and were given up to seven additional days to fulfill the baseline criteria.

Interventions

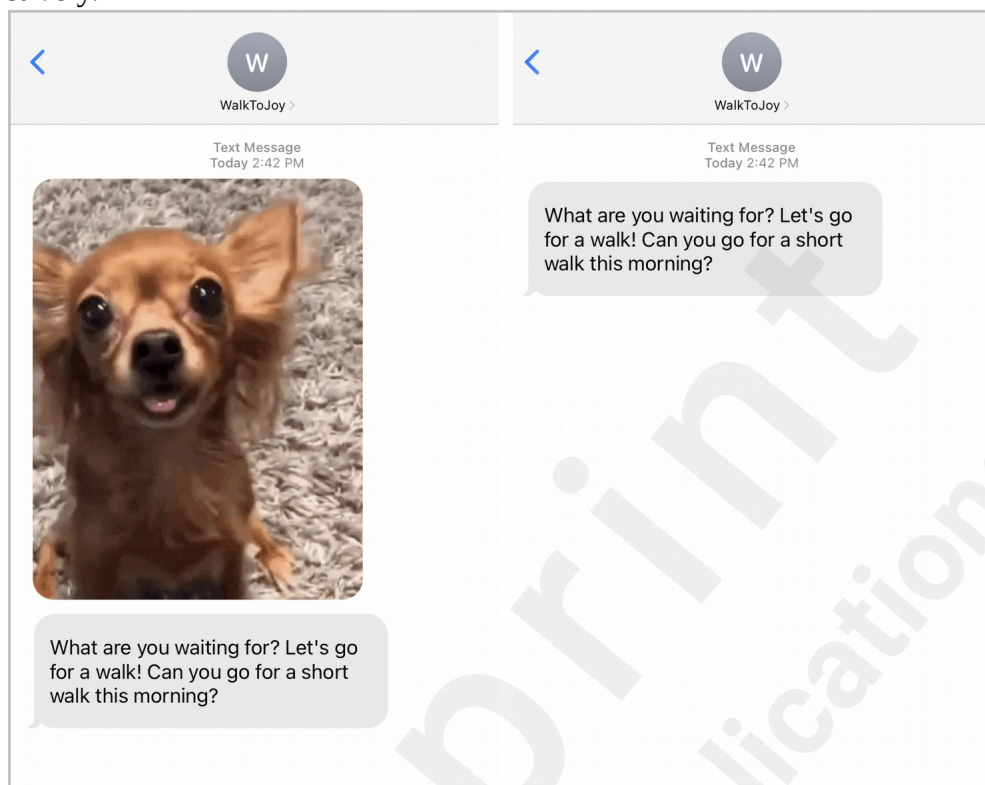
The intervention consisted of text messages targeting positive affective valuations and attitudes toward walking along with a real-time activity tracking wearable device. Specifically, the study assessed three intervention components as part of the WalkToJoy intervention package.

Positive conditioning via walking suggestion GIF prompts

The first intervention component involved sending participants smile-inducing messages suggesting they go for a walk within the next few hours (see Figure 4). These text messages were either accompanied by an animated image in GIF designed to elicit automatic positive affect (GIF group) or sent without a GIF (Non-GIF group). The goal was to test whether repeated pairing of acute smile-inducing stimuli in the form of GIFs with walking suggestion prompts could help participants associate walking with positive emotions. This approach is based on evaluative conditioning [43,52], where the GIF (unconditioned stimulus) is paired with the walking suggestion prompt (neutral stimulus) to create a conditioned positive emotional response toward walking. The GIF-enhanced prompts served two purposes: reminding participants to walk and fostering positive emotions toward walking, thus addressing barriers of forgetfulness and negative affective valuation (i.e., the automatic emotional response when thinking about walking). The intended immediate outcome (proximal outcome) was for participants to take a walk within four hours of receiving the prompt. Over time, repeated exposure was expected to enhance affective attitudes and valuations toward walking and

increase overall step counts (distal outcomes).

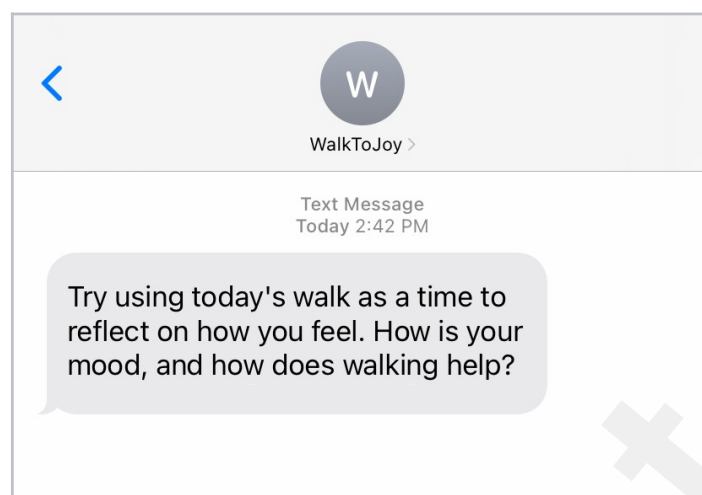
Figure 4. An example walking suggestion prompt for the GIF group (left) and Non-GIF group (right), respectively.



Salience messages about positive aspects of walking

The second intervention component involved sending salience messages (see Figure 5) that directed participants' attention to the positive aspects of walking. The message content was randomly selected from topics such as observing the environment, focusing on the body, noticing affective states, or engaging in an enjoyable activity while walking. The goal was to test whether heightened awareness of positive aspects of walking could help participants associate enjoyment with the walking experience. This approach uses salience to enhance the reward value of walking, which, we hoped, would update participants' beliefs about walking toward more positive beliefs and attitudes [50]. We hypothesized that the salience prompts will improve participants' affective attitudes toward walking by making the enjoyable aspects of walking more cognitively accessible. This approach addresses the barrier of negative affective attitudes and encourages participants to update their existing attitudes toward walking through positive reflections on their experiences. The immediate goal (proximal outcome) is for participants to report increased positive experience with their daily walks, with repeated exposure over time resulting in more positive affective attitudes towards walking and greater step counts (distal outcomes).

Figure 5. Example salience message



Planning prompt to reflect on and plan enjoyable walks

The third intervention component involved sending a weekly reflection prompt on Monday mornings, asking participants to reflect on the previous week's walking experience and create an actionable plan to make future walks more enjoyable. The prompt provided examples of strategies such as listening to a favorite album or podcast, walking with a pet or family member, or trying a new route. Participants were randomly prompted to either try a new planning strategy or continue the one from the previous week. After completing the reflection, participants received reminders twice a week (Tuesdays and Thursdays) to follow through with their plans. This component aimed to enhance the reward value of walking by making each walk more enjoyable, ultimately improving participants' affective valuations and attitudes toward walking over time. The repeated reflection and planning process also fostered greater awareness and curiosity about ways to make walking experiences more enjoyable before, during, and after the activity. The immediate goal (proximal outcome) was for participants to report increased positive reflections on their weekly walks, while repeated activation of these mechanisms over time was expected to enhance affective valuations and attitudes towards walking and increase step counts (distal outcomes).

Randomization

The WalkToJoy intervention package was evaluated for feasibility and adherence using a pre-post study design. To maximize what we could learn from this study and to assess the preliminary efficacy of each intervention component for improving participants' affective valuations and attitudes toward walking over the six-week study, a 3×2 factorial design was implemented (see Table 1). Upon enrollment, participants were randomized across the three intervention components, resulting in assignment to one of eight unique conditions representing combinations of the factors. Additionally, the study included micro-randomization of the walking suggestion prompts and salience messages to evaluate their immediate impact on step counts within a four-hour window of receiving the messages and on daily affective reflection on their recent walks, respectively.

Table 1. Intervention Conditions

Conditions	Walk Prompt	Salience	Planning
1	ON*	ON*	ON
2	ON*	OFF	ON
3	ON*	ON*	OFF
4	ON*	OFF	OFF
5	OFF*	OFF	OFF
6	OFF*	ON*	ON

Conditions	Walk Prompt	Saliency	Planning
7	OFF*	ON*	OFF
8	OFF*	OFF	ON

* Embedded micro-randomized trials

The WalkToJoy system micro-randomized the delivery of GIF and text-only walking suggestion prompts at two decision points per day (i.e., morning and afternoon), determined by participants' wake-up times and time zones, with a 50% probability of activation at each decision point. This meant participants could receive up to two prompts per day but were expected to get on average one prompt per day. Randomization at each decision point was independent of intervention provision at previous decision points. Given the study duration of 42 days, each participant could be randomized up to 84 times.

For the Saliency group, saliency messages were micro-randomized with a 50% probability once per day at 12:00 PM, based on participants' time zone. As a result, participants would receive, on average, a saliency message every two days. Participants in the non-saliency group did not receive any saliency messages.

There was no embedded micro-randomized trial for the planning component. Participants in the Planning group received a planning prompt each Monday morning once a week with an activation chance of 100%, but randomly received one of the two types of a planning prompt with 50% probability: a prompt to try a new planning strategy or a prompt to keep the same strategy as the previous week. When participants completed the planning prompt, they received a reminder twice during the week (i.e., Tuesdays and Thursdays) on how they planned to modify their walks. Participants in the non-planning group did not receive any planning prompts nor the reminder messages.

Outcome Measures

Table 2. Summary of the outcome measures and assessment times

Outcome measure	Baseline Phase	Intervention Phase						Post-study
		Wk1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	
Affective Attitude	X	collected weekly						X
Affective Valuations	X	collected weekly						X
Affective Reflection		collected daily and weekly						
Anticipated Affect		collected daily and weekly						
Step Counts	X	collected daily, and at a minute level						
Exercise self-efficacy	X							X
Body Awareness	X							X
Post-study Intervention Evaluation and Barriers								X

Primary outcome measure: Affective attitudes

See Table 2 for a summary of the outcome measures and assessment times. The primary outcome measure consists of a modified 7-point scale, semantic differential 3-item measure of affective attitude [53–56] towards walking administered through the weekly check-in survey. The specific items are shown in Textbox 2.

Textbox 2. Affective attitude scale

- “For me, walking is...” very unpleasant (1) to very pleasant (7)
- “For me, walking is...” unenjoyable (1) to enjoyable (7)
- “For me, walking is...” boring (1) to interesting (7)

By measuring affective attitude on a weekly basis, the items capture the changes in participants’ affective experience of walking over the course of the study. The measure was selected as the primary outcome because (a) it would be impacted if the intervention is effective, and (b) it is a key mechanism of change postulated by ART.

Secondary outcome measure: Affective valuations

The secondary outcome measure consists of a modified 7-point scale, semantic differential 1-item measure of affective valuations [53,56] administered via the weekly check-in survey. The item was

phrased as follows: “*When I think about walking...*” with response options anchored in “I cringe” (1) and “I smile” (7).

Exploratory outcome measures

In addition to the primary and secondary outcome measures, the study assessed daily step counts via Fitbit-measured steps, as well as affective reflection and anticipated affect on a daily and weekly basis to assess daily and weekly changes in participants’ views of previous and upcoming walks. Affective reflection item for the weekly measure consists of a 7-point scale, semantic differential 1-item measure of “How did you feel overall when walking this last week?” with answers anchored in “I couldn’t wait for it to end” (1) and “Loved every second of it!” (7). Affective reflection item for the daily measure consists of a 7-point scale, semantic differential 1-item measure of “How did you feel overall when walking today?” “I couldn’t wait for it to end” (1) to “Loved every second of it!” (7). Anticipated affect item [54,55] for the weekly measure consists of a modified 7-point scale, semantic differential 1-item measure of “This coming week, I expect walking will feel...” Awful! (1) to Great! (7). Anticipated affect item for the daily measure consists of a modified 7-point scale, semantic differential 1-item measure of “Next time you take a walk for 5 minutes or longer, what will that be like for you?” Awful! (1) to Great! (7).

Proximal outcome measures for micro-randomized factors

The proximal outcome measures for MRT of the walking suggestions (i.e., GIF and Non-GIF groups) was the number of steps taken within 4 hours following each randomization. Our expectation was that participants would have more steps within 4 hours after receiving a walk prompt compared to when they did not receive one. The proximal outcome for salience messages was participants’ affective reflections about their walks that day and anticipated affect for upcoming walks, measured at the end of each day.

Additional measures of potential effect modifiers

The Exercise Self-Efficacy scale was administered before and after the intervention to evaluate participants’ self-efficacy towards exercise behavior as a potential moderator of study outcomes. The Exercise Self-Efficacy scale [57] includes 9 self-reported items measured on a 4-point response scale from Not at all sure (1) to Very sure (4).

Additionally, a reduced version of the Revised Body Awareness Rating Questionnaire (BARQ-R) was administered before and after the intervention to evaluate participants’ awareness of their own bodies. The reduced BARQ-R [58,59] includes 7 self-reported items measured on a 4-point response scale from Completely disagree (0) to Completely agree (3).

Post-study measures

At the end of each intervention week, participants were prompted to complete a post-study survey to evaluate their experience with the intervention and barriers to participation. The measures consisted of questionnaires covering the following topics: 1) general attitude toward the intervention, 2) participants’ subjective evaluation of the intervention (i.e., whether it was beneficial and improved affective attitude towards walking), 3) participants’ subjective evaluation of the intervention’s usability (i.e., whether it was easy to incorporate into their daily lives, were there too many messages, and were the guidelines clear), and 4) any barriers to participating in walks and surveys.

Adherence protocol

All participants received a minimum of \$10 to a maximum of \$52 via check for participating in the study based on their adherence to study assessments and Fitbit wear time. To ensure the reliability of

study data and participant engagement throughout the intervention, adherence protocols were implemented for the baseline survey, daily and weekly outcome surveys, and activity data monitoring.

For the baseline survey, participants received reminder messages 24 and 48 hours after enrolling if the survey was not completed. Participants were dropped from the study if they failed to respond within the seven-day baseline period. Weekly surveys were sent every Sunday at 8:00 PM, with up to two daily reminders for non-completion. Daily end-of-day surveys were sent at 8:00 PM (excluding Sundays), with reminders sent after two consecutive missed days. If surveys remained incomplete, a phone call from a study coordinator was made on the fifth day. Activity adherence was monitored by tracking Fitbit usage. Participants received up to three reminders for two consecutive non-wear days. After six consecutive non-wear days, a study coordinator contacted the participant by phone.

Semi-structured Interviews

The multifaceted design of the intervention study, incorporating both factorial and micro-randomized approaches, enabled the assessment of participants' varied experiences with different combinations of intervention components. These components differed in the frequency of notifications, prompts, and tasks delivered to participants' phones. At the end of the study, one participant from each intervention group was randomly selected to participate in an optional semi-structured interview that lasted 45 to 60 minutes, gathering qualitative data on their experiences with incorporating walking into daily life, perceptions of the value of intervention components, and barriers to participation (see Appendix 1 for interview questions). Using purposive sampling, participants were selected based on their allocation to one of the eight intervention arms and their recent completion (within 30 days) of the six-week study. If a selected participant declined, another was randomly chosen as a replacement. These interviews were audio recorded through the video conference software (Zoom). The recordings were transcribed to text and deidentified for further analysis.

Statistical power

In line with ORBIT recommendations for proof-of-concept studies [60], our primary goal for this deployment of WalkToJoy was to assess if the WalkToJoy package could produce a clinically significant outcome—in this case, a shift in participants' affective attitudes toward physical activity. At the time we were planning the study, there was no clear empirical evidence for what kind of impact on affective attitudes should be considered clinically meaningful. As a result, we relied on an observation that a half a standard deviation change constitutes a meaningful impact across a range of health measures [61,62]. Starting with the standard deviation for affective attitudes of 1.21 reported by Kiviniemi et al. [56], we calculated that a half of standard deviation impact would correspond to a moderate standardized effect size of .5. To detect this effect size with 90% power and type I error rate of .05, we calculated that we needed a minimum of 36 participants. A recently published paper by Dunton, Crosley-Lyons, & Rhodes [63] has since provided further support for these assumptions by finding that even a third of a standard deviation change in affective response to exercise can meaningfully improve exercise behavior. Assuming a 10% attrition, as in our recent mHealth studies, the minimum required sample size was 40 participants. We note that this sample size would have also enabled us to detect a small, standardized effect of .12 on the proximal outcome of the micro-randomized walking suggestions, as well as a standardized effect of .17 on the proximal outcome of the micro-randomized salience messages, both with 90% power at the alpha level of .05.

Statistical analyses

To examine changes in affective attitudes (primary outcome), affective valuations (secondary

outcome), and step counts (exploratory outcome) between the start and end of the study, we used descriptive statistics and paired t-tests. Additionally, to assess the main effects of each of the three baseline-randomized factors on the weekly assessments of the affective measures as well as daily measures of step count, we used the Generalized estimating equation model (GEE). This allowed us to assess the overall (average, across all time points) effect of delivering a GIF version of the walking suggestions versus delivering a non-GIF, text-only version of the suggestions; the overall effect of delivering salience messages about positive aspects of walking versus not delivering salience messages; and the overall effect of prompting weekly planning of enjoyable walks versus not prompting planning. To decrease noise, covariates in our analyses included time in study and baseline values of the outcome variables (affective measures and step counts, respectively).

The analyses of micro-randomized components examined their impact on their respective proximal outcomes. For walking suggestions, our primary interest was the average effect of sending a prompt versus not sending the prompt on the subsequent 4-hour step count. For the salience messages, our primary interest was the average effect across time of sending a salience message versus not sending a salience message on the daily affective reflection (i.e., enjoyment) of the day's walking experience and anticipated affect towards upcoming walks (measured at 8PM daily). To assess these effects, we employed the centered and weighted least square method [13,64], the standard statistical approach for examining data from micro-randomized trials. This approach enables robust estimation of causal treatment effects while accommodating longitudinal data correlations through the nesting of outcomes within participants [64]. To reduce noise, the analyses of the walking suggestions included a covariate of the 1-hour pre-randomization step count.

In addition to the statistical analyses, the data from the post-intervention interviews was thematically analyzed. The interviews, conducted individually via Zoom, lasted 45 to 60 minutes and were audio-recorded. Transcriptions were made verbatim, with all identifying information removed to ensure anonymity. A thematic analysis was conducted using an inductive approach, beginning with a detailed review of each transcript to identify patterns and assign unique codes. Emergent themes and sub-themes were synthesized through systematic re-reading and joint discussions among the research team to ensure rigor and resolve discrepancies. The analysis concluded when data saturation was reached, indicated by the absence of new themes or variations.

Results

Participant Sample

Participant recruitment began in May 2023, with 77 individuals initially recruited. Of these, 56 provided consent; however, 7 were lost to follow-up during onboarding with the WalkToJoy app and they never progressed to the intervention phase. Ultimately, 49 participants began the intervention, but 4 were withdrawn due to non-adherence for wearing the Fitbit activity tracker (i.e., 10 consecutive days of no activity data despite reminder messages and emails). A total of 45 participants successfully completed the study. Data collection concluded in September 2023, and the demographic characteristics of the 49 participants are summarized in Table 3.

Table 3. Demographic characteristics of the WalkToJoy participants

Variable (Categorical)	<i>n</i>	%
Gender		
Woman	40	81.6
Man	9	18.4
Age range		

Variable (Categorical)	<i>n</i>	%
40 - 49 years	24	49
50 - 59 years	12	24.5
60 - 69 years	8	16.3
70 years and above	5	10.2

The recruitment for exit interviews involved a purposive sampling strategy to select participants who: 1) were each allocated to one of the eight intervention arms, and 2) had recently (within the past 30 days) finished participating in the 6-week WalkToJoy study. Out of 14 participants invited, 9 completed the interview process. Notably, an additional participant was invited from the subgroup that received the comprehensive intervention package comprising all three components, thereby enriching the data obtained from the interviews. The demographic details of the interview participants are summarized in Appendix 2.

Adherence and data missingness

Of the 45 participants who completed the study, 40 participants completed the affective measures for primary and secondary outcomes (affective attitude and affective valuations) at both baseline and the final intervention week; pre-post statistics are reported for this subset. Additionally, 42 participants provided valid Fitbit wear data—defined as at least 3 days per week with ≥ 8 hours/day of wear, confirmed via heart rate minute data—at both baseline and the final intervention week (week 6). Pre-post analysis for average daily step count is reported for this subset.

Of the 45 participants enrolled in the study, adherence to the weekly outcome assessments varied across the six-week intervention period. A total of 270 weekly assessments were expected across all participants ($45 \text{ participants} \times 6 \text{ weeks} = 270 \text{ total assessments}$). Overall, 94% ($n = 254$) of the expected assessments were completed, indicating a high level of adherence. The percentage of participants who completed all six assessments was 75.6% ($n = 34$), while 97.8% ($n = 44$) completed at least 4 out of 6 assessments.

The total possible decision points for the micro-randomized GIF and text-only walking prompts were 3240 ($45 \text{ participants} \times 36 \text{ days} \times 2 \text{ per day}$), where participants were randomized two times per day, excluding Sundays. Of these, 25 decision points were not randomized due to technical issues, resulting in a total of 3,215 decision points randomized. Across the 3,215 decision points, both heart rate data for wear adherence monitoring and step count data for the proximal outcome were completely missing in 217 decision points (6.75%). These missingness likely resulted from device non-wear during the entire decision timeframe (i.e., a 4-hour window). To address wear adherence missingness, an imputation method was applied for the MRT analyses of the walking suggestions. For each minute within the 4-hour proximal-outcome window following a decision point, heart rate data was assessed within a 5-minute radius. If data were detected within this window, the minute was classified as an "adherent minute", even if no heart rate data were available for the exact minute.

The total possible decision points for the micro-randomized salience messages were 792 ($22 \text{ participants} \times 36 \text{ days} \times 1 \text{ per day}$), where the 22 participants randomized to the Salience group were randomized once per day, excluding Sundays. Of these, 46 decision points (5.8%) were not randomized where no decision could be made, likely due to technical issues (e.g., server instability), resulting in a total of 746 decision points randomized. For the remaining 746 decision points, 381 (51%) points were randomized to send salience messages, and 365 (49%) were randomized to not send any salience message that day. Among the 381 activated salience messages, one message failed to deliver due to mobile carrier's network issues. Additionally, across these 745 decision points,

missingness occurred in 103 decision points (13.8%) for the measure of affective reflection and anticipated affect when participants failed to complete the daily end-of-day survey for that day. Therefore, the MRT analysis of the salience factor was conducted on the 642 valid decision points.

Changes over time for all participants

Pre-post differences in affective measures and step count

The average for affective attitude (primary outcome) significantly increased by 0.547 points on a 7-point scale from baseline to the final week of the study ($P<.001$) with a gradual trend on a weekly basis (See Table 4). The average for affective valuations (secondary outcome) showed an even greater improvement, increasing by 0.718 points on a 7-point scale ($P<.001$). Additionally, the exploratory outcome measures of affective reflection and anticipated affect both showed a significant increase of 0.692 points on a 7-point scale, respectively ($P<.001$ for both).

Table 4: WalkToJoy pre-post measurements

	T-Value	P-Value	95% Lower	CI Upper	Mean Difference
Affective Attitude	4.139	.0002	0.279	0.815	0.547
Affective Valuations	5.233	.00001	0.440	0.996	0.718
Affective Reflection	4.004	.00028	0.342	1.042	0.692
Anticipated Affect	4.423	.000079	0.375	1.009	0.692

In addition to the affective measures, we assessed changes in valid average daily steps (exploratory outcome). From baseline to the end of the study, there was a nonsignificant increase of 80 steps ($P=.79$), which was influenced by a sharp peak in week 5 followed by a decline in week 6 due to outliers. Given this unexpected pattern, further analysis was conducted to identify trends from baseline to the average steps of week 4 to week 6, which showed a statistically significant increase of 506 average daily steps ($P=.07$).

Participant perceptions of the impact of the intervention on affective associations with walking

Thematic analysis of exit interviews corroborated significant increases in pre-post affective measures and step count, indicating that the intervention successfully reshaped participants' affective associations and engagement with walking. Across varying intervention exposures, participants consistently reported heightened awareness of the benefits of walking, fostering positivity, confidence, and motivation. P24 explained, "*I got to be more aware... I was kind of looking forward to the opportunity. Okay, I'm out of my desk. I'm gone. Let's go... I was just feeling content and comfortable with it.*" Even participants who received minimal intervention, such as P33, recognized the impact of study participation on their intention to walk: "*... being reminded to try to keep up with walking was helpful... it's just a helpful reminder to keep putting it in my head.*"

This increased awareness and intention led to habitual integration of walking into daily routines. P7 described, “... *it's been a couple of weeks since I stopped the study... and I still feel that routine. I'm more amenable to doing actual walks for exercise.*” As walking became more of a routine, participants' attitudes shifted, transforming walking from a task to an anticipated and enjoyable experience. Psychological barriers diminished over time, making walks feel more accessible. P24 illustrated this shift: “... *as I progressed... I started looking forward to it. And then as I'm walking, I'm like, la-di-da.*” Overall, the intervention fostered cognitive and emotional alignment with walking's benefits, reinforcing habit formation, increasing enjoyment, and strengthening participants' intention to walk regularly despite potential obstacles.

Effects of individual intervention components

Since walking prompts, salience messages, and planning were baseline-randomized in a factorial experiment, we examined the effects of each of the three intervention components on both affective measures and steps. A Generalized Estimating Equations (GEE) model was used to account for within-subject correlations over the six-week intervention period. This approach was selected for its ability to handle repeated measures data and provide robust population-averaged estimates of intervention causal effects. All p-values reported were one-sided, reflecting the directional hypothesis that the intervention components would lead to improvements in affective measures and physical activity. This approach enhances sensitivity to detect intervention effects consistent with the goals of proof-of-concept studies, while maintaining methodological rigor.

GIF prompts versus text-only prompts

From baseline to the end of study, the delivery of smile-inducing GIF walking prompts resulted in a non-significant increase of 0.099 points in affective attitudes ($P=.37$) and 0.117 points in affective valuations ($P=.33$) compared to text-only prompts. Although these results did not reach statistical significance, the direction of the estimates suggests potential benefits that may emerge with increased exposure or in larger samples. Notably, the anticipated affect toward future walks (an exploratory outcome) showed a statistically significant increase of 0.345 points ($P=.046$) from baseline to the end of study for the GIF group compared to the text-only prompt group. This increase accounts for approximately half of the total pre-post improvement in anticipated affect (0.692 points). These findings suggest that GIF prompts were a key driver of the positive shift in participants' positive anticipation of walking, likely mediated by the evaluative conditioning effects of smile-inducing stimuli. Additionally, GIF prompts significantly influenced physical activity. Participants in the GIF group exhibited an 1,834-step increase in valid average daily steps ($P=.05$) from baseline week to week 6 compared to those in the text-only group, where "valid" was defined as wearing the Fitbit for at least three days per week with ≥ 8 hours of wear per day.

Salience messages and planning

No meaningful increases were observed in affective measures or step counts when comparing the salience group to the non-salience group or the planning group to the non-planning group. This may indicate the need for further refinement of these components, longer intervention periods, or larger sample sizes to better assess their independent effects.

Participant perceptions of GIF walking prompts as drivers of engagement

In alignment with the factorial analysis, the thematic analysis of participant interviews revealed a notable difference in the perception and reception of smile-inducing GIF versus text-only walking suggestion prompts. Participants in the non-GIF group acknowledged the text-only walking prompts

as helpful reminders but reported message fatigue over time, particularly when compounded by multiple reminders and other notifications. P42 noted, *“The daily reminders and encouragement weren't really encouraging to me and I'll tell you why. ... it just becomes old news.”* Similarly, P33 explained, *“They were just good gentle reminders that, you know, let's go for a walk today. [...] I think what I found a little bit annoying is when I was getting multiple reminders in a day. I mean, I don't want to turn off the texts completely. I still wanted to get texts, but I think sometimes it just felt like too many in a day.”*

In contrast, participants in the GIF group consistently described the prompts as enjoyable, highlighting their humor and visual appeal. P32 shared, *“It made me happy and brought my mood up and it made everything a lot easier to do because it was funny.”* P5 echoed this sentiment, *“I have to say the texts helped a whole lot. It definitely wasn't stressful to receive the prompt, and it helped that it had something visually appealing to look at, whether it was funny or motivating, you know, you can't really get upset at a text like that... it's entertaining for the 30 seconds and I'm like, okay, I gotta walk.”*

Additionally, the smile-inducing GIF prompts appeared to foster a sense of positive anticipation that sustained engagement throughout the study. P6 reflected, *“Yes, the little dogs [chuckles]. ... it's just that little nudge that you need sometimes when you're like, I don't really feel like it, but I know I should. So, getting the message made it nice. [...] it was just a fun way to get going in the morning.”* This sense of expectancy contributed to the intervention's ability to sustain motivation and engagement, even on days when prompts were not delivered due to the micro-randomization process. Several participants described an evolving relationship with the prompts, initially dismissing their relevance but later expressing appreciation for their impact. P7 recounted, *“Like initially I was kind of like, oh, how silly... it's like this little animal or whatever. [...] But I have to admit [chuckles], by the end of the study, I was always kind of curious to see the next one. ... There was one that was just great, it was like this dog that was jumping on all fours, up and down, ready to go for a walk, right [chuckles]. I liked it so much.”*

Participants also indicated that the GIFs prompted mindfulness around walking and subtly integrated it into their daily routines. P5 explained, *“I've internalized your memes and your messages. I do try to get more walks in. I know that I'm a little bit more conscientious about the time. So around 11 o'clock, I'll look at my phone, or I'll look at where I'm at, and be like, you know, this is a good time to take a break. You know, and I'll go out and do something.”*

Participant perceptions of salience messages as catalysts for attitudinal change

Despite the non-statistically significant quantitative results, the thematic analysis revealed that salience messages may have served as a catalyst for attitudinal change by shifting participants' perceptions and experience of walking from obligation to opportunity. In the group who received salience messages (i.e., Salience group), participants reported a positive shift in attitude towards and experience of walking. Several participants distinctly recalled specific messages that impacted them. For instance, P33 noted: *“I like the ones especially about, the one that has stuck with me the most, is the one that you just said about giving you more energy. Like, are you tired? Go for a walk. It will give you more energy.”* When asked about their change in experience of walking as a result of reading the salience messages, P3 explained: *“... we were truly walking around and like looking at different things and enjoying the outdoors. ... like I tried to be more aware of how it impacted me.”* P7 echoed this sentiment, *“One of the messages, you know, kind of suggested, slowing down, you know, and it's so counterintuitive. That one, it was a very positive message, and it, for me, personally, it worked. I was approaching walking a little bit weird, it was always like this mad dash*

rush, a thing to get it done and whatever, but... ever since I read the message, it sort of resonated with me... And I remember, just a change in how I was approaching the whole thing a little bit and taking my time with it. It's something I'll probably keep going forward with having that in mind." For P7, the salience messages reframed the expectation of walking from a chore to an opportunity for stress relief and a step away from the hustle of daily life by fostering a sense of mindfulness and introspection about their walking experiences. Similarly, P32 noted an increased awareness of the physical and mental benefits experienced after walking, suggesting a heightened appreciation for its value: *"It really made me pay attention to my body and how it functions. [...] I think a lot of times in life we forget about, you know, the important things in life and the fresh air and the flowers and all that stuff really helps, you know. And it increases your mood as well, you know."*

Participant perceptions of planning as a way to foster enjoyable walking experiences

Despite the non-statistically significant results, the interview findings revealed that participants who received planning prompts and reminders found them helpful to reflect on ways to make walking more enjoyable, making the experience more interactive and engaging. As noted by P6, the process of planning allowed participants to personally tailor their walking experiences, fostering an interactive and pleasurable engagement with walking: *"I really like to listen to music when I walk, so I made sure that I have my headphones charged and I had my, you know, my phone charged up, so I could just be kind of by myself listening to my music. That was nice, that was really nice."* This not only enhanced the enjoyment of their walks but also boosted their motivation and overall mood post-walk, as noted by P32: *"I tried the different ones and I think the best one would be, well, I tried to listen to an album and that help with the motivation and make my steps a little bit faster. ... And I also enjoyed one, you know, just to be mindful and have a lot of awareness of my environment. And those definitely increased my mood and motivation."*

This selection process was complemented by customized reminder messages, which kept their weekly chosen strategies on top of participants' minds, thereby supporting sustained engagement and motivation throughout the study. P42 explained, *"... what was motivating for me is when it was personalized. And even at the end of the week, even though it was simple, "you said last week you were going to do this". It engaged me more."* Additionally, P42 noted how they desired an even more personalized interaction based on their chosen strategy for each week via the messaging system. P42 added, *"But, if you're able to customize it to, "what plant did you see today?" You know, on Wednesday, send me a message, but not overdo it. Find a balance."*

Effects of micro-randomized intervention components

The MRT analyses of walking suggestions did not observe a significant difference in step counts in the 4-hour window following the decision points, either between providing any kind of a walking prompt and no prompt, or between sending a GIF prompt versus a text-only walking prompt ($P=.55$). For the salience group, the MRT analysis revealed a non-significant increase in daily affective reflection scores of 0.142 points when salience messages were sent compared to when no message was sent ($P=.26$). Similarly, there was a moderate but non-significant increase in daily anticipated affect towards upcoming walks of 0.16 points ($P=.145$).

Discussion

The primary aims of this proof-of-concept study were to evaluate the feasibility of the WalkToJoy intervention for promoting physical activity among middle-aged to older adults and to gather initial evidence for its ability to have clinically meaningful impact on affective mechanisms and steps. The intervention package was grounded in the Affective-Reflective Theory (ART) of physical inactivity

and exercise, and it leveraged both automatic and reflective affective processes to foster intrinsic motivation [17,27]. Our secondary aim was to gather preliminary evidence for the efficacy of each of WalkToJoy's three intervention components—smile-inducing walking suggestions, salience messages, and planning prompts—to inform optimization decisions for their use in future versions of the WalkToJoy intervention. Overall, the results suggest that WalkToJoy is both feasible and promising for fostering positive affective associations with walking and promoting engagement in walking.

The intervention package as a whole demonstrated robust pre-post improvements in affective outcomes. Affective attitude, the primary outcome, significantly increased by 0.547 points ($P<.001$), while affective valuations, the secondary outcome, showed an even greater improvement of 0.718 points ($P<.001$). Both of these impacts are over half a standard deviation in magnitude, suggesting—based on recent findings [63]—that they may have a meaningful impact on engagement in physical activity itself. Exploratory measures, including affective reflection and anticipated affect, also demonstrated substantial gains, both increasing by 0.692 points, respectively ($P<.001$ for both). These findings underscore the intervention's success in reshaping participants' affective associations with walking, consistent with ART's explanation that repeated positive affective exposures can reinforce intrinsic motivation (i.e., enjoyment) for PA. Behaviorally, while the pre-post analysis of valid average daily steps showed a nonsignificant increase of 80 steps ($P=.79$), additional analysis revealed an improvement of 506 steps ($P=.07$) from baseline to the average steps of week 4 to week 6. Qualitative data supported the impact on affective mechanisms as well. Participants described heightened awareness of walking's benefits, increased positivity, confidence, and motivation, and a diminished perception of psychological barriers. These qualitative insights reinforce the cumulative impact of the intervention package on fostering both affective and behavioral engagement with walking.

Among the intervention components, the GIF walking suggestion prompts emerged as the most impactful driver of affective and behavioral outcomes. While GEE revealed nonsignificant results for affective attitude and affective valuations, GIF prompts significantly increased anticipated affect toward future walks by 0.345 points ($P=.046$) compared to text-only prompts, accounting for approximately half of the total pre-post improvement in anticipated affect (0.692 points). These findings provide initial support for our hypothesis that evaluative conditioning—pairing a neutral stimulus (e.g., a walking prompt) with a positively valenced stimulus (e.g., smile-inducing GIF)—fosters positive emotional associations over time through automatic affective processing [27,43,44]. This conditioning mechanism likely contributed to the observed increases in participants' positive anticipation and motivation to walk. Additionally, GIF prompts significantly boosted average daily steps between the start and end of the study by 1,834 steps ($P=.05$) compared to text-only prompts, highlighting their role as engaging and burden-resistant reminders that can impact physical activity behavior itself.

Despite not seeing statistically significant differences between GIF and text-only prompts in measures of affective attitudes and valuations, the significant increase in anticipated affect toward future walks and step count in the GIF group provides evidence of the prompts' unique impact. These results align with the qualitative insights, where participants showed a clear preference for the smile-inducing GIF walk prompts over text-only prompts in maintaining participant engagement and motivation. While text prompts were initially effective as reminders to walk, they became burdensome over time. In contrast, participants consistently described the GIFs as humorous, visually engaging, emotionally uplifting, and even evoking a sense of anticipation. These qualities helped sustain engagement and mitigate message fatigue. A recurring challenge in current mHealth interventions is maintaining sustained user engagement, which is often corroded by treatment fatigue

[15,65,66]. High user burden from repeated treatment delivery frequently results in low intervention adherence, thereby limiting the long-term effectiveness of such interventions. Our findings suggest that evaluative conditioning provides a promising framework for designing fatigue-resistant and positively valenced message delivery strategies. This approach has the potential to mitigate message fatigue and sustain engagement, especially in interventions requiring long-term adherence. Moreover, this affect-based approach can be extended to other components of mHealth interventions, such as planning, goal setting, and monitoring behaviors. Future studies should explore ways to integrate affective strategies into interventions that have traditionally relied on reflective cognitive processes to further enhance intervention effectiveness. Collectively, these results highlight the potential of affective-based interventions to reinforce behavioral adherence and foster intrinsic motivation for physical activity. By delivering prompts that are both emotionally engaging and resistant to treatment fatigue, such interventions can significantly enhance the user experience, drive long-term behavior change, and promote active lifestyles.

Interestingly, the MRT analysis revealed no significant increase in 4-hour step counts immediately following the delivery of GIF versus text-only prompts ($P=.55$). However, qualitative findings provided important context, indicating that participants interpreted the prompts as flexible, day-long reminders rather than immediate calls to action. This perception appeared to stem from the suggestive and non-urgent wording of the prompts (e.g., “Could you go for a short walk this afternoon?”), which allowed participants to incorporate walking into their routines on their own terms. By reducing immediate pressure, the framing used in WalkToJoy seemed to align with participants’ preferences, fostering positive engagement with the intervention while supporting their ability to make choices about when to walk. This observation highlights the nuanced role of message framing in health interventions [38,39,41], emphasizing that both directive and suggestive framings have distinct advantages and limitations depending on the context and user group. Directive messages, which emphasize immediate action (e.g., “Take a short walk now to feel energized!”), may be better suited for individuals requiring a clear prompt to overcome inertia or decision fatigue, as they provide explicit guidance and can create a sense of urgency. Such framing has been shown to be effective in other interventions, such as HeartSteps, where more assertive prompts successfully encouraged immediate walking [67]. However, directive framing can also risk inducing psychological resistance, particularly in individuals who value autonomy and flexibility. In contrast, suggestive, non-directive framing—as employed in this study—offers a more autonomy-supportive approach. By presenting walking as an open-ended opportunity rather than an immediate demand, this type of framing may reduce pressure, increase perceived control, and encourage participants to act in ways that align with their unique routines and preferences. This aligns with Self-Determination Theory (SDT), which posits that behaviors motivated by autonomy and perceived choice are more likely to be internalized and sustained over time [68]. However, the trade-off is that this framing might not elicit immediate behavioral responses, as seen in the lack of significant proximal step count increases in this study. Future mHealth interventions could benefit from leveraging both approaches, tailoring message framing to the specific goals of the intervention and the needs of diverse user groups. For instance, directive prompts could be used strategically in moments requiring immediate action, while suggestive prompts could support longer-term habit-building and user autonomy.

Our analyses found no significant impacts of salience messages and planning prompts on affective and behavioral outcomes, suggesting these components may require refinement, or that larger or longer studies would be needed to demonstrate impact. Despite the lack of statistical significance, qualitative data suggest that salience messages facilitated meaningful attitudinal shifts by reframing walking as an enriching and mindful activity. By emphasizing the positive aspects of walking via message framing [38,39,41], participants felt that salience messages transformed walking from an

obligation into an intrinsically rewarding experience. Similarly, planning prompts, though not statistically significant, were highly valued by participants for their role in enhancing the enjoyment and personalization of walking. These observations are consistent with prior research underscoring the importance of personalization in enhancing user engagement and satisfaction in health interventions [69,70].

Limitations

The current study, as a proof-of-concept investigation, faced several inherent limitations that warrant consideration for future research. First, the intervention was not fully powered for the factorial experiment, limiting the ability to detect smaller or more nuanced effects of individual intervention components. Additionally, the study's duration of six weeks was relatively short, precluding the ability to assess WalkToJoy's long-term effects on affective mechanisms and behavior change.

The study's population presented another notable limitation. Participants were generally moderately active and reported favorable attitudes toward walking at baseline. This may have been influenced by the fact that all participants owned Fitbits prior to recruitment. This relatively high baseline in affective and behavioral measures likely attenuated the effects of individual components, as participants did not have substantial room for improvement. At the same time, this population may have also been more receptive to this style of intervention than individuals who start with strongly negative affective associations with physical activity.

Conclusion

The proof-of-concept study of the WalkToJoy intervention demonstrates the feasibility and potential of affective-based strategies for promoting physical activity. The smile-inducing walking suggestion prompts, in particular, played a significant role in enhancing engagement and motivation, underscoring the value of affect-driven and visually engaging approaches as a fatigue-resistant intervention strategy. While salience and planning prompts showed promise, further refinement and extended deployments may be necessary to optimize their effects. These findings highlight the importance of integrating affective dimensions in digital health interventions to foster sustained engagement and meaningful health behavior change.

Conflicts of Interest

None declared.

Abbreviations

ART: Affective–Reflective Theory of physical inactivity and exercise

BARQ-R: Revised Body Awareness Rating Questionnaire

GEE: Generalized Estimating Equations model

GIF: Graphics Interchange Format

mHealth: mobile health

MMS: Multimedia Messaging Service

MRT: Micro-randomized Trial

PA: physical activity

SDT: Self-Determination Theory

Appendix

A1. Semi-structured Interview Protocol

Integration to daily life

- During the study, what did your schedule look like on a daily basis (How busy were you on average)?
- How did your schedule affect your ability to go for a walk?
- How did walking fit into your daily life or routine?
 - o When did you usually go for a walk?
 - o How did walking impact your mood or mindset throughout the day?
 - o Over the course of the 6-weeks, did your walks change in any way? (e.g., timing, duration or intensity of the walks)
 - Did the walks feel any different compared to before the study?
 - Did your enjoyment of walking change in any way?
 - Did you find the way you fit your walks into your daily routine different in any way?
 - How sustainable do you feel your current walking routine is?
- Reflecting on the study period, how do you feel about the way you incorporated walks into your daily routine?

General Experience with WalkToJoy study

- Overall, how was your experience with the WalkToJoy study, meaning receiving messages everyday and having to complete surveys daily and weekly?
- What did you find valuable about WalkToJoy? What was not so valuable?
- Throughout the study, you were encouraged to reflect on your walks, your feelings towards those walks and their positive benefits.
 - o Can you think of instances where the reflections change your walking behavior and attitude towards walking?
 - o In general, what did you focus on when reflecting on your walks?
 - o How did the reflections make you feel?

Barriers to Walking

- During the study, can you think of any barriers you experienced when trying to go for a walk? (e.g. weather, mood, schedule, social situations, etc.)
 - o How often did you experience these barriers?
 - o How did these barriers make you feel?
 - o How did these barriers affect your future walks?
 - o Did any part of the intervention help you deal with those barriers during the study?
 - o Are any of these barriers going to be a problem going forward? What are they, and why?

Experience with GIF & Non-GIF messages

- What did you think of the prompts to go for a walk?
 - o Were you able to notice the prompts when you received them? Can you recall any prompt that stood out to you? (provide examples of the prompt)
 - o How often did you go for a walk as a result of the prompts? What was that experience like?
 - o Do you ever think the prompts influenced your walking behavior later, even if you

didn't act on it right away?

- o How did the prompt make you feel, and did that change your walks in any way?
- o Was there ever a time where you got the message and wanted to go for a walk but were unable to? If so, what were the barriers?

GIF only

- What did you think of the GIFs that were sent along with the prompts to go for a walk?
 - o How did you feel when you saw the GIFs?
 - o Do you have any favorite GIFs that you can remember?
 - o How did you feel when you didn't receive the GIFs?
 - o How do you think the GIFs affected your walks if at all?

Salience only

- You received messages on things to pay attention to during future walks everyday at 12PM. *(provide examples of the prompt)*
 - o Were you able to notice the messages?
 - o Can you recall any of them? Can you recall any that you particularly liked or found helpful?
 - o How did you feel when you received these messages?
 - o Did you think about the content of the message throughout your day and when going for walks? How did the message impact your walks?
- Was there ever a time the message you got seemed inappropriate? (i.e., not matching your mood or situation) How did that make you feel?

Planning only

- You were asked to create, update or continue with the same strategy to enhance your walking experience every Monday.
 - o Were you able to remember your strategy throughout the week?
 - o Can you remember any strategy that you thought were particularly helpful? Any that turned out not to be helpful?
 - o Did you try these strategies for your walks?
- In what ways did your strategies impact your walks, if at all?
 - o How did the planning make you feel towards walking?
- How did you feel when you were asked to continue with the same strategy vs. when you were asked to try something new?
 - o Were there any situations where you wanted to change your strategy or stay with the same when you were prompted to do otherwise?
 - If so, how did you deal with this situation (e.g., modify slightly or entered the same strategy)?
- You were reminded of your strategies twice a week. Did you find them helpful in remembering your strategy? Or did they feel redundant?
 - o How did you feel when you received them?

Message Timing

- What did you think about the timing of the prompt messages you received?
 - o Did the timing of the messages feel appropriate for you?
 - o Can you think of any situation where the messages felt out of place in terms of timing (e.g., should be sent in the evening instead of afternoon; received while working)?
 - o Can you think of any situation where the messages came at just the right time?

- Hypothetical
 - If you could modify the timing of the messages, when would you receive them?
 - If you could snooze a message to be sent at a later time, would you use this feature? In what ways do you think it will be helpful?
 - If you could collect messages and GIFs that you like (similar to bookmarks or favorites on web browsers), would you use them? In what ways do you think it will be helpful?

Impact on walking behavior and attitude

- Now that you have completed the study, how would you describe your relationship with walking?
 - How would you describe your relationship with physical activity/exercise in general?
- How do you identify yourself in relation to exercise (walking)?
 - Did this identity change throughout the course of the study?

Closing

- Is there anything else you'd like to tell us that we haven't already covered?
- Do you have any questions for us?

A2. Demographic characteristics of the exit interview participants

Participant	Intervention group (GIF-Saliency- Planning)	Age range	Gender
P3	F-T-F	40 – 49 years	Woman
P5	T-F-F	40 – 49 years	Woman
P6	T-F-T	50 – 59 years	Woman
P7	T-T-F	40 – 49 years	Man
P12	F-T-T	40 – 49 years	Man
P24	T-T-T	60 – 69 years	Woman
P32	T-T-T	40 – 49 years	Woman
P33	F-F-F	40 – 49 years	Man
P42	F-F-T	60 – 69 years	Man

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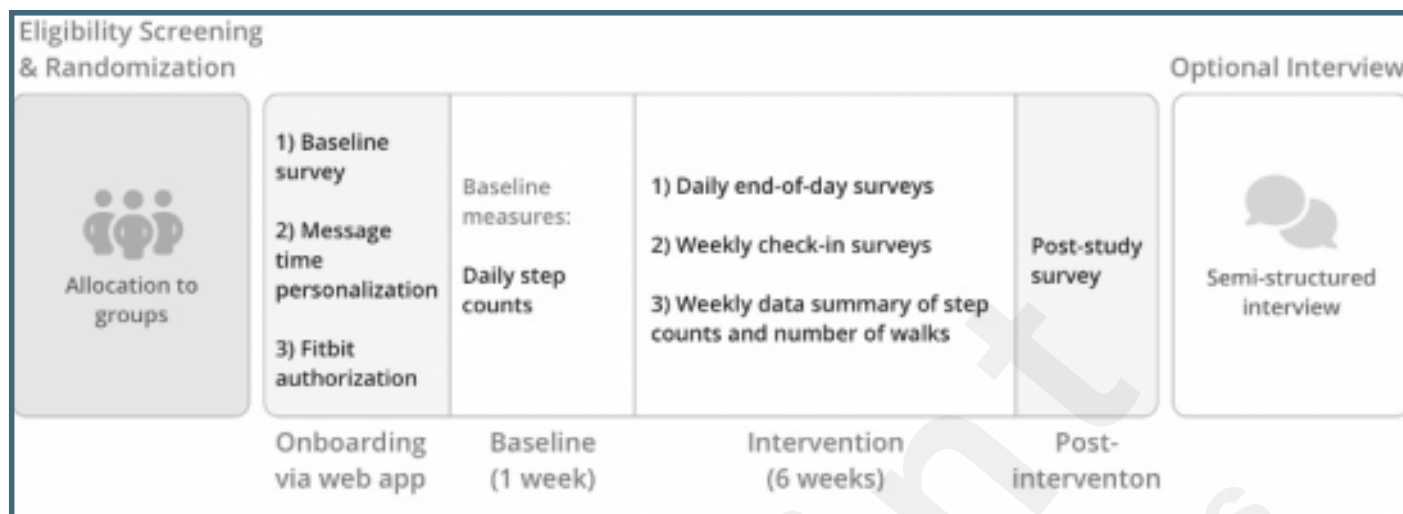
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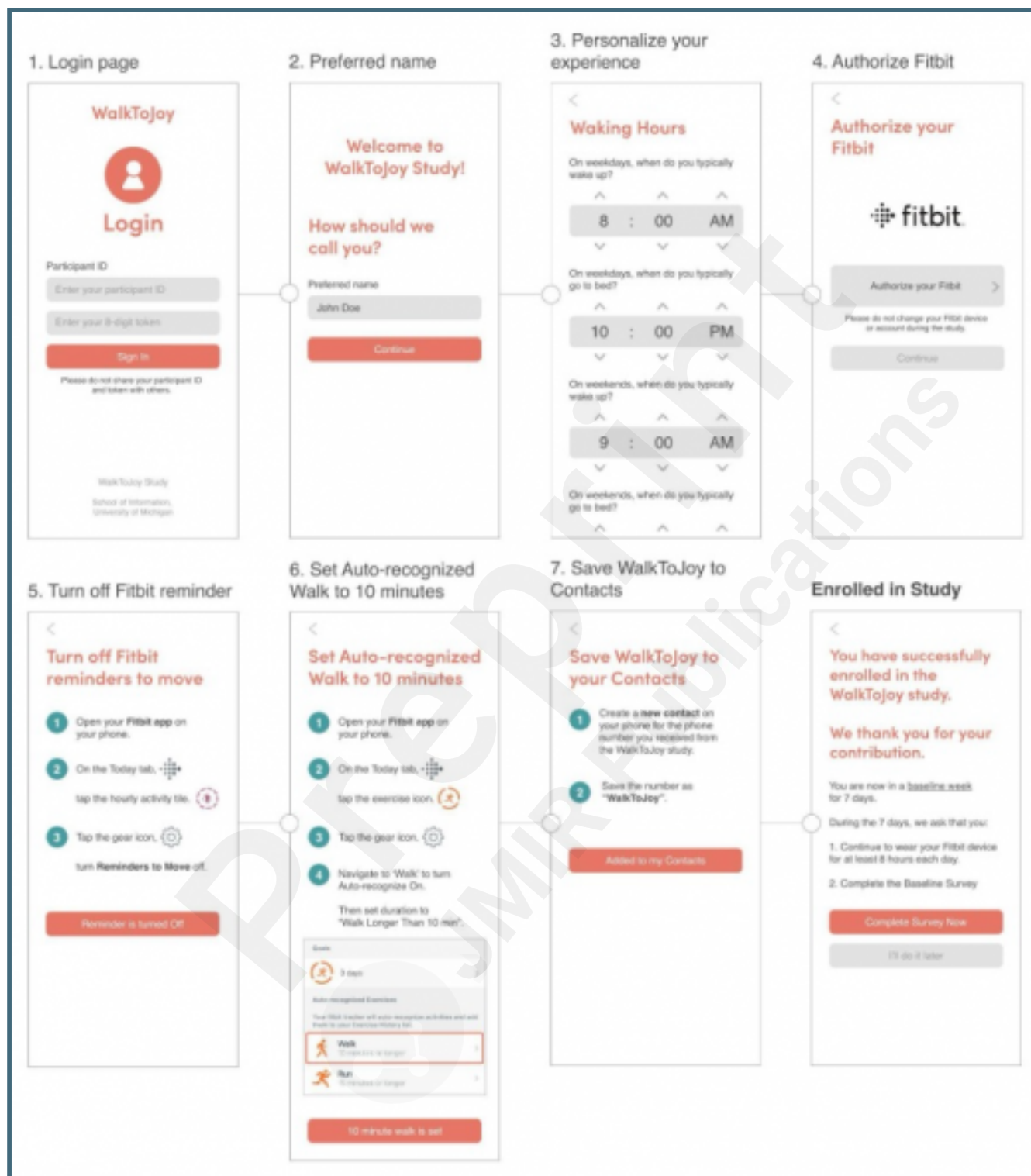
Supplementary Files

Figures

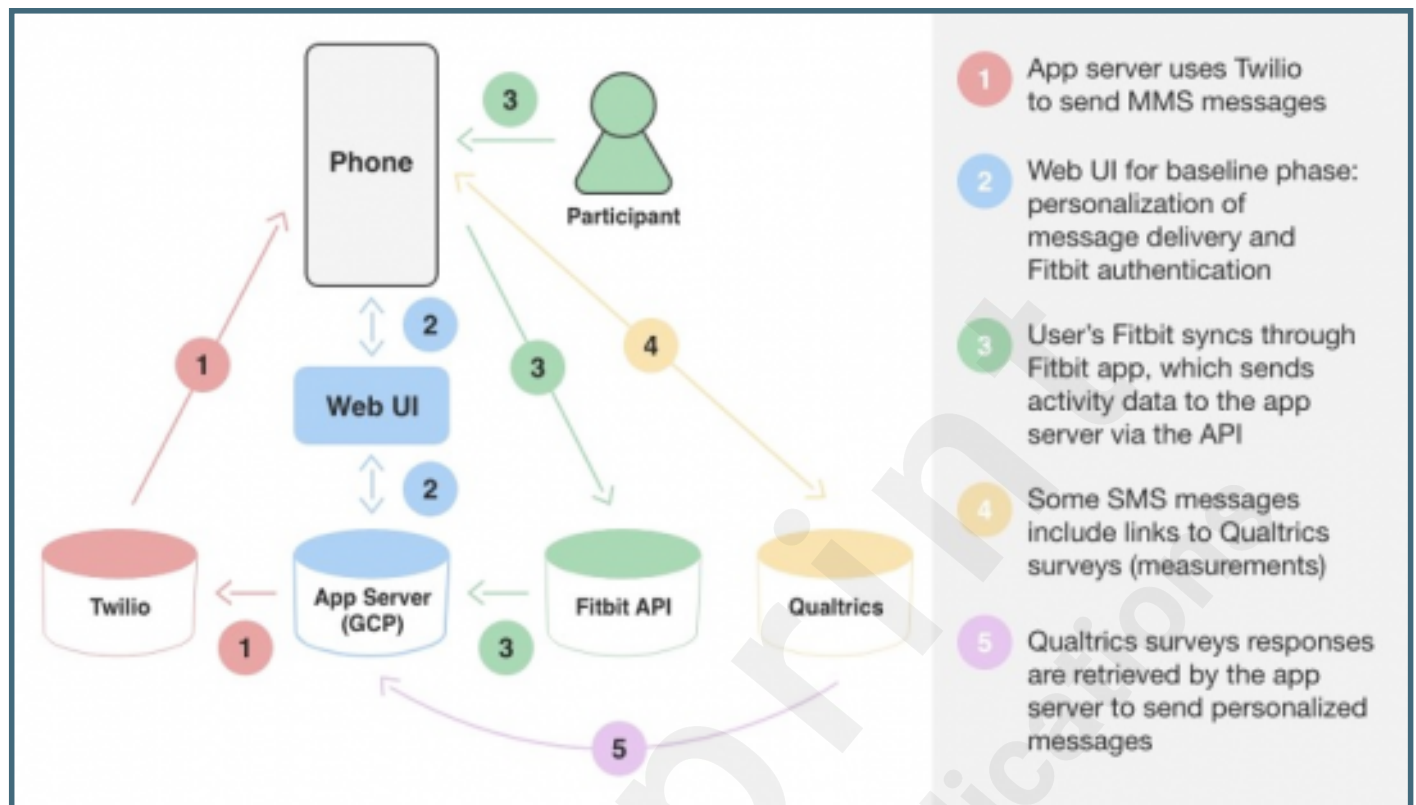
Study flow Diagram.



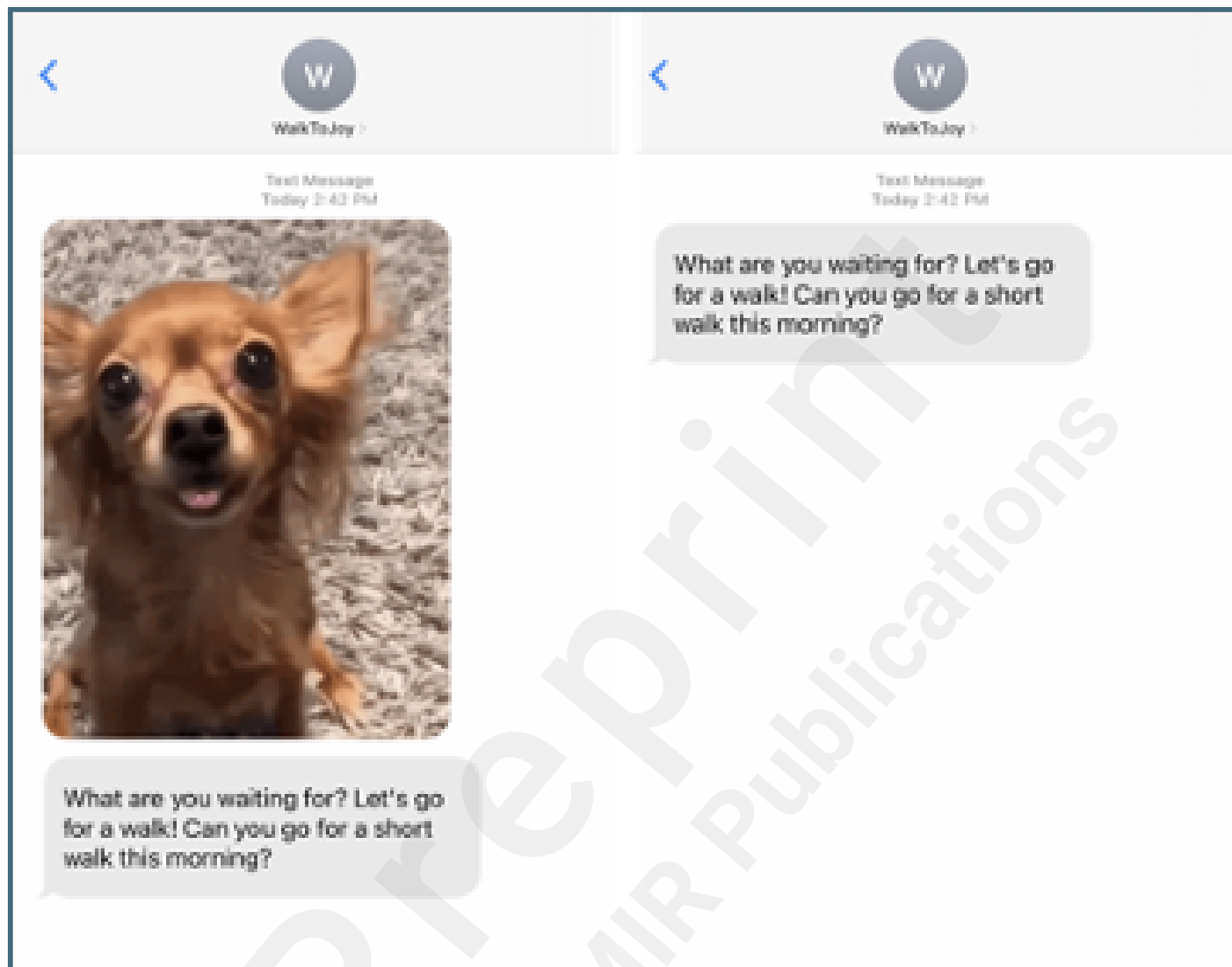
Onboarding application interaction map.



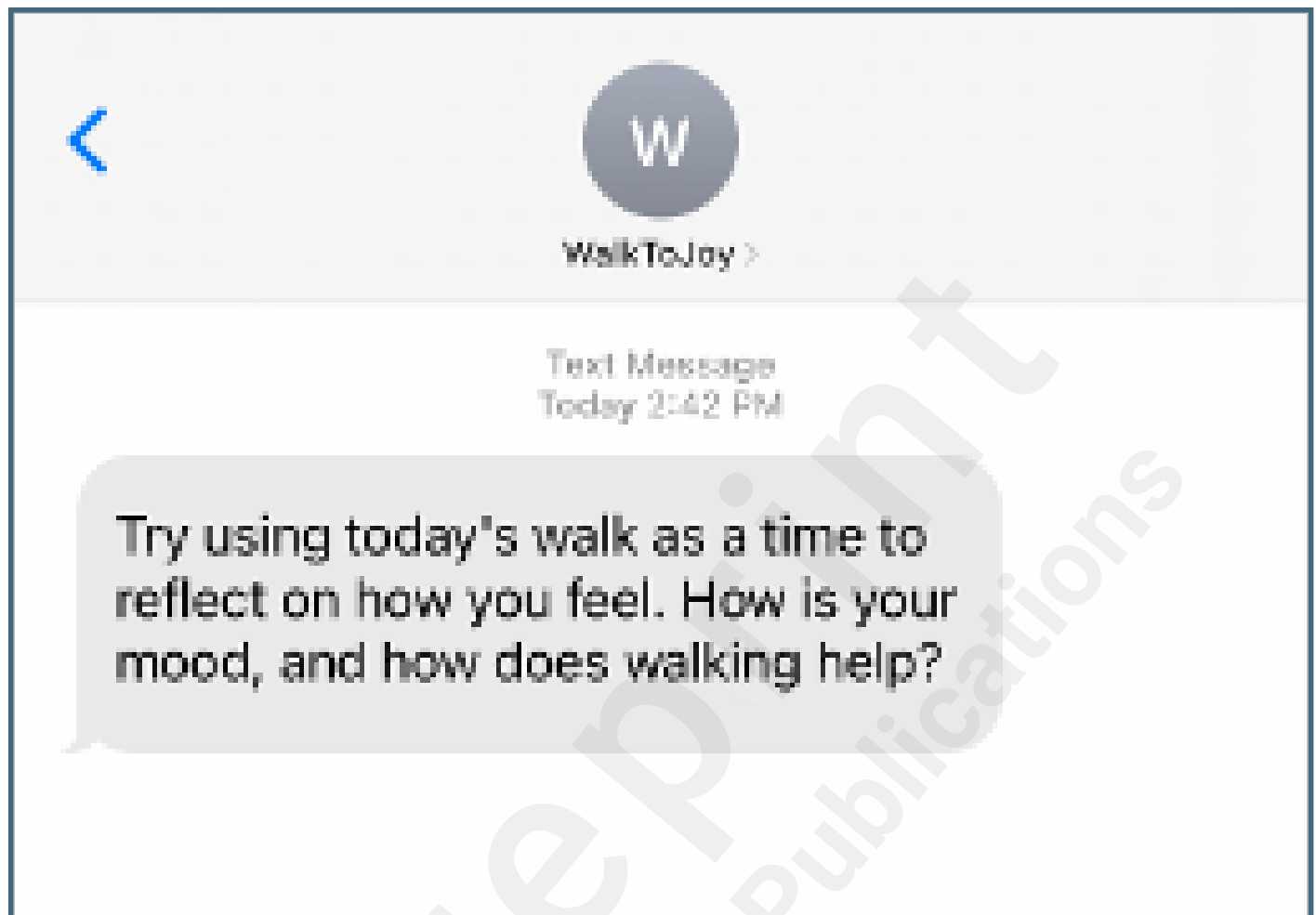
WalkToJoy application architecture.



An example walking suggestion prompt for the GIF group (left) and Non-GIF group (right), respectively.



An example salience message.



Multimedia Appendixes

Semi-structured interview protocol.

URL: <http://asset.jmir.pub/assets/9a98b03b1d2e74d6595950068e15e54e.docx>

Demographic characteristics of the exit interview participants.

URL: <http://asset.jmir.pub/assets/44b2096bbd47d1ee25b71699e130e9a1.docx>

