Text Messages for Encouraging Physical Activity

Are they effective after the novelty effect wears off?

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Abstract— **Many studies have found text messaging to be a promising medium for healthcare delivery. However, since the studies that successfully used text messages for encouraging physical activity were all short term (10 days to 3 weeks) and conducted with a small sample (n≤15), we do not know if people will not be motivated by these technologies after the novelty effect dies. In this paper, we present the results from a study conducted for a longer term (3 months) with a larger sample size (n=28) to discover if text messages are effective for encouraging physical activity once the novelty effect of the technology wears off. We chose a population of young adults (age 18-24) as they are one of the heaviest users of text messages. Measures of analysis included number of steps, message ratings, level of motivation and interviews. Our findings suggest that text messages are a good way for encouraging physical activity in young adults, even after the novelty effect wears off.**

Keywords-text messaging; texting; sms; physical activity; mobile phone; novelty effect; persuasive technology; young adults

I. INTRODUCTION

With the rise of obesity as a global epidemic [1] and billions of dollars spent in healthcare costs related to obesity and being overweight, many researchers are trying to find effective ways to use technology for encouraging physical activity. The main advantage of using information and communication technologies (ICTs) for promoting physical activity in comparison to traditional media (e.g., print and television) is interactivity. With technology, persuasion methods can be personalized to individual needs. Further, technology allows interventions anywhere and anytime, targeting individuals at critical decision-making points.

One such promising technology that is both pervasive and low-cost is text messaging. Research has investigated if text messages are effective as persuasive reminders for managing chronic diseases [3, 4, 5], addiction [6], weight [7] and physical activity [8, 9]. While many of these studies found text messaging to be promising, the short duration (10 days to 3 weeks) and small sample (n≤15) of the physical activity studies leaves an unanswered question: will people stay engaged with persuasive text messaging systems that encourage physical activity after the novelty effect wears off?

In this paper we report the findings from a study conducted for a longer term (3 months) with a larger sample size (n=28) to discover if daily mobile phone text messaging is indeed an effective delivery channel for encouraging physical activity, even once the novelty effect of the technology wears off. Participants received two daily text messages which encouraged walking towards a personalized step goal. Participants rated the text messages, completed a monthly survey that determined their motivational level and had an end-of-study, semi-structured interview. Our findings show that most participants had an increasing trend of step counts when receiving text messages, as well as increased motivation levels. These results suggest that participants continued to be physically active after the novelty effect of the text messages wore off.

II. RELATED WORK

In this section, we provide a brief overview of ICTs that focus on increasing physical activity.

Stephen Intille et al. introduced "just-in-time" technologies by placing messages in public spaces at points of decision with the intention of getting more people to take the stairs instead of the escalator [10]. Their positive results suggest that using ICTs to deliver persuasive messages "just-in-time" during a person's daily activities might be an effective way to encourage people to participate in opportunistic physical activities.

Other researchers integrated tracking step counts with social support to motivate increased physical activity [11, 12]. Lin et al. developed *Fish'n'Steps*, a public computer kiosk that hosted a game in which animated fish grew and changed expressions based on the number of steps a particular individual or group took [11]. The idea was to encourage physical activity through a healthy competition. Similarly, *Shakra* was a mobile application meant to increase awareness of current physical activity levels in social networks through avatars on mobile phones [12]. Evaluations of both systems were positive, suggesting that addition of a social component to tracking physical activity levels increases motivation.

Houston [13] and *Chick Clique* [9] combined a pedometer and a mobile phone application with text messaging from peers to encourage an increase in daily steps. *Houston* findings showed that while both personal awareness of activity level and social support were effective in increasing the number of steps, their combination was most effective. Specifically, motivating text messages from friends provided additional encouragement in the form of praise and recognition for goal achievement.

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Chick Clique revealed that while social support from friends can be effective, a lack of reciprocity can be negative. In particular, when one of the participants in a group did not actively participate, the other participants in the group lost interest. In addition, they found that text messages may not be very useful unless they are substantial. Their participants often struggled with what to say to each other about physical activity beyond the typical "Good job!" The mixed results of the effectiveness of text messages in *Chick Clique* and *Houston* suggest that more research is needed to understand how to build effective text messaging systems for motivating physical activity.

Several non-physical activity studies have examined the usefulness of text messaging for managing chronic diseases, addiction, and weight. While some of these studies met with success, others did not. Text messaging systems were successful in helping smokers to quit smoking [6], Type I diabetic adolescents to adhere to regular insulin therapy [3], liver transplant patients to adhere to medication [5] and overweight adults to lose weight [7], but it was not effective in a bulimia nervosa aftercare program [4]. In [4], participants thought the text messages were "impersonal" and the program "too computerized". These studies were long duration and large sample, but their target behavior was not a preventative health behavior, such as increasing physical activity, and so the results cannot be generalized. Further, the results were mixed, so more research is needed to understand what makes text messages effective for managing health.

The only physical activity study with a larger sample size (n=78) and time frame (3 month) that exclusively examined the usefulness of text messages on physical activity behavior was conducted by Newton et al. for diabetic adolescents [8]. While they found text messages to be ineffective, the study had a very low frequency of messages (weekly), which likely impacted the results. The main objective of using text messages is to engage the user on a daily basis (pervasive persuasion) and the ability to intervene at the opportune time for greater persuasion (just-in-time persuasion) - weekly interaction is probably not enough. In fact, a follow up study [14] of the bulimia nervosa study replaced weekly text messages with daily text messages and was successful in helping patients control their bulimia. However, since their target behavior was not a preventative health behavior, the results cannot be generalized.

Since existing studies examining the effectiveness of technologies such as mobile phones and text messaging to encourage physical activity are either short-term with a small sample (e.g., *Houston* (3 weeks, n=13) and *Chick Clique* (3 weeks, n=15)), or investigated with weekly but not daily text messages, it is difficult to conclude if people will lose interest or will be motivated by daily text message-based technologies after the novelty effect dies. As a result, we conducted this study to provide a more conclusive answer to the effectiveness of text messages on physical activity behavior over the long term.

III. STUDY

The goal of our text messaging system was to encourage opportunistic physical activity, which is, incorporating activities into everyday life to increase the number of steps taken (e.g. walking to work instead of driving, taking the stairs instead of the elevator, walking to take a break from studies). The results reported in this paper were obtained from a study that was designed to answer several research questions. In addition to examining the novelty effect, we also examined the effect of the sender of the text messages and the tailoring of text messages based on the level of motivation of the recipient. The detailed analysis of these two factors will be reported elsewhere. In this paper, we focus on the overall impact of text messaging.

The system of study was a pedometer combined with text messaging that could work on any cell phone (i.e., a smart phone was not required). Researchers provided participants with the pedometer, while participants used their own cell phones.

Our target population was university students. We chose students because they already use text messaging extensively, making the pedometer the only "novel" technology, and thus allowing the participants to quickly get over the novelty effect.

A. Background: Stages of Change

To determine the motivational level of participants, we adapted the *stages of change* survey from a study by Marcus et al. [15]. The survey incorporated the Transtheoretical Model of Health Behavior Change (TTM), formulated by Prochaska et al. [16], which captures the level of motivation of the person in six *stages of change:*

1) **Pre-contemplation** - not intending to change in the next 6 months

2) **Contemplation** - intending to change in the next 6 months

3) **Preparation** - intending to change in the next 1 month, some action taken towards changing

4) **Action** - changes have been made in lifestyle within the past 6 months

5) **Maintenance** - changes made are maintained for at least 6 months to about 5 years trying to avoid relapse

6) **Termination** - changes are permanent, there is no chance of relapse

The TTM says that individuals who are engaging in a new behavior move through the first five *stages of change* before adopting the behavior permanently. Movement through these stages does not occur linearly but in a cyclical manner as many individuals relapse back to an earlier stage before ultimately progressing through all stages on their way to changing the particular behavior. In addition to physical activity, the TTM model has been successfully used in various other health behavior modifications [17].

B. Methods: Recruiting & Study Overview

We obtained approval for this study from the Institutional Review Board (IRB) at Indiana University (IU). To recruit students, we sent emails to different listserves and student e-newsletters, placed posters around campus, and advertised in the classifieds section of an online system for students.

Interested students contacted us by email or phone. Participants were screened to ensure they were a student (part-time or full-time) and owned a mobile device with text messaging capability. If they did not currently have a text messaging plan (n=5), we purchased it for them as part of the study.

We then had potential participants complete an online *stages of change* survey, and invited people who were in the contemplation and preparation stages to participate in the study. We selected people from these stages because Prochaska et al. [16] suggests that they would be most receptive for an intervention since they have the highest potential to change. People in these stages are also the most likely to want and benefit from such a system. We scheduled initial meetings with subjects who met all three screening criteria. Our advertisement also requested pairs of people to participate in the study together. When a pair contacted us and met all of the required criteria, we randomly assigned people to be the participant and the support member.

The study was designed with 2 phases: baseline (1 month) and intervention (2 months). We utilized a 2x3 research design varying the source of the text messages (automated, fitness specialist and friend/family) and message tailoring (tailored and non-tailored), for a total of 6 groups. During the baseline phase, participants familiarized themselves with the pedometers and recorded their steps in a web journal. Prior work demonstrated that the novelty effect of a pedometer wore off before one month [13]. In fact, our baseline data shows daily step averages leveling off after the 3rd week. In the intervention phase, participants received two daily text messages which encouraged walking towards a personalized step goal, which was determined by their previous month's average number of steps. Since the primary interest was to test the effectiveness of the text message system after the novelty effect of the technology wore off, 2 months was a reasonable time compared to the studies involving text messages that were conducted for 10 days to 3 weeks [9, 13]. A semi-structured interview with participants followed after the completion of the study.

C. Text Message and System Design

Preparation of the text messages were guided by the *stages of change*, the processes of change and decisional balance models [16]. 179 Messages were categorized into 9 categories: reduce barriers, pros and cons, personal testimonies, reward, motivation, information, goal setting, time management/tips and public testimonies. Table I provides descriptions and examples of each of the nine categories. During the intervention period, participants received two messages per day in addition to morning and evening reminders to wear the pedometer and complete the daily web journal. For participants in the tailored conditions, the number of messages to send from each category per week was based on the participants' *stage of change*. Text messages for participants in the non-tailored conditions were chosen at random. No two messages on any given day were the same and no messages were repeated in the same week. All messages began with "Hi Participant Name" and were signed off with a name if the participant was not in an automated condition. The support members forwarded messages sent to them by our system to the respective participants who were told the messages were personally sent by their support member.

TABLE I. MESSAGE CATEGORIES

Message Type	Target/Content	Sample Message
Reduce Barriers	Reduce common barriers to physical activity e.g. weather, lack of time.	-Start small. Small steps make a big difference. -Invite a friend for a chat-walk!
Pros and Cons	Highlight the benefits of physical activity and walking	-Walking can improve ur mood! -Walking won't contribute to traffic!
Public Testimonies	Encourage the participant to share their steps and goals with someone.	-Tell ur family about ur steps.
Rewards and Encouraging Messages	Prompt participants to reward themselves for the steps they were taking and add congratulatory messages based on how many steps they took and if they reached their daily goal the previous day.	-Steps: 5000 Goal: 4000 You did it! Do something special for yourself! -Steps: 2000 Goal: 5000 Keep walking! You can do it!
Motivation	Quotes from various public personalities and rhetorical messages about benefits of walking and maintaining an active life	-Nothing will work unless you do. - Maya Angelou -Dump the Pump. WALK!
Personal Testimonies	A quote and/or link to the full article about someone who has benefited from walking	-Walking is very soothing & mental stimulating <link>
Information	Facts and links to different websites for information about physical activity and leading a healthy active life.	-Cost of using a sedan for 1 yr= ~$7,834, bike ~$120. walking FREE -Tips, motivation, healthy recipes. <link>
Time Management /Tips	Tips on getting activity from day to day activities to reduce time barrier and good walking practices.	-Walk around when u r on the phone. - Don't over stride. It'll make u tired quickly.

The technical system had 3 parts- PHP scripts, Perl Scripts and a MySQL database. PHP scripts selected and formatted messages based on required criteria from the database and sent them as emails which were delivered as text messages to the recipient. Recipients could directly reply to the text message and the response was sent to a server which parsed it using Perl scripts to collect the message ratings and update the database.

D. Population

The target population was college students of any gender aged between 18 and 24. The total number of participants who completed consent for the study was 49, of which 35 were female and 14 were male (Table II). All participants were in the United States for the duration of the study.

Three participants never started the study because their phones did not work with our system, one participant did not complete the web journals, and data from three other participants was discarded because their *stages of change*

TABLE II. SUMMARY OF ALL PARTICIPANT'S AGE/GENDER BEFORE AND AFTER DROP OUTS (FINAL)

Age Group	Males	Females	Males (final)	Females (final)
18-19	4	16	2	10
20-21	4	11	2	6
22-24	6	8	3	5
	14	35	7	21

survey reported they were in the maintenance stage after the first month of the study, which implies that they were in the maintenance stage at the beginning of the study which violates our screening criteria. Note that inclusion of these three participants' data would have improved our findings, so their removal was to remove potential bias due to incorrectly identifying them as in being in the contemplation or preparation stages during screening.

Of the remaining 42 participants, 14 of them dropped out at different times during the study leaving us with 28 (20 female and 8 males) participants in total (Table III). Far more females than males volunteered for the study. We expected participants to drop out due to lack of interest or dislike of the text messages during the intervention period. However, 8 people dropped out during the baseline period due to lack of interest in entering step data and/or wearing the pedometer, personal problems or phone problems. Only 6 participants dropped out during the intervention period.

E. Experimental Tasks and Study Procedure

After screening, a researcher met with participants to obtain consent, explain the study procedures, and administer a brief questionnaire. At this meeting, participants were given a pedometer and their phones were tested with our text message system. If the participants came in a pair, a researcher met with them each separately and concluded with a joint meeting in which the researcher let them know who would be the support person and who would participate in the intervention. Both the intervention and support participants completed informed consent. Each participant and support member received an email with all information and documents regarding the study after the meeting.

Table IV summarizes the data collected from each participant. During the intervention period, participants received 2 text messages a day (one in the morning and afternoon). Participants were asked to respond via text message to each of the messages with a rating on a scale of 1 to 5 where 5 is "high motivator" and 1 is "low motivator". There was a note at the end of each text message on how to respond. A message was sent early in the morning to remind participants to wear the pedometer, and another was sent at night as a reminder to complete the web journal. The daily web journal included individual step history and open-ended questions about their day including a day rating between 1(bad)-5(good), their step progress, the messages that they had received and how they felt. They also had the option of adding message ratings that were not received by our system. If the

TABLE III. REASONS FOR PARTICIPANT DROP OUT (GREY: DROPPED AFTER INTERVENTION)

	Time of drop out	Reason
1	3/4 days	forgot to wear pedometer
2	10 days	forgot to log steps in web journal
3	1 week	too stressful (pedometer, web journal)
4	2 weeks	the two reminder text messages got annoying
5	2 weeks	personal problems (family related)
6	2 weeks	stopped entering data without any notification
7	3 weeks	stopped entering data without any notification
8	3 weeks	personal problems (not known)
9	1 month	personal problems(fallout with support member)
10	1 month	couldn't set up phone with our system
11	1 month	personal problems (busy schedule)
12	1 month	stopped entering data without any notification
13	1 month	stopped entering data without any notification
14	1.5 months	Journal entries and the four text messages got annoying. Lost pedometer.

participants missed a journal entry for any reason, they had the option of completing a paper version of the web journal. The 3-month average response rate for web journal entry was 80% (Mode: 87%, Median: 87%).

At the end of each month, participants completed an online *stages of change* survey to determine if the intervention was helping them progress from one stage to the next. A link to the survey appeared in their web journal at the appropriate time and remained for 5 days unless completed. If the survey was not completed, the investigator sent an email reminder. At the end of the intervention period, participants were interviewed about their experience.

Participants were compensated for their time based on completion of tasks (percent of message ratings, percent of journal entries submitted and participation in the post-study interview). Compensation was *not* linked to the value of step counts or message ratings. All participants could receive up to $100. Out of 28 participants, 17 received full amount.

IV. RESULTS

From the analysis of the various data collected, we can say that text messages are a good method for encouraging physical activity in young adults even after the novelty effect of the technology wears off. Here, we present the analysis of the number of steps walked, text message ratings and the changes in the *stages of change* over time. We also utilize the qualitative information from the interviews and comments about the text messages in the web journal to understand the impact of the text messages on participant daily activity. Due to space constraints, this paper focuses on the overall results of participants in all groups. Another paper investigates the nuances of the different groups.

TABLE IV. DATA COLLECTION

	Pre-study	Post-baseline	Mid-intervention	Post-intervention	Daily
1. *Paper Questionnaire:* basic demographic information, phone model, phone and text messaging usage, and exercise habits.	X				
2. *Web journal.* free form responses about their day, physical activity during the day and the text messages received.					X
3. *Step Data:* daily number of steps (recorded in the web journal).					X
4. *Message ratings*: ratings of motivational level of each message.					X
5. *Stages of change survey*: stage of participant with respect to increasing physical activity.	X	X	X	X	
6. *Interview:* semi-structured interview to better understand response to system during study.				X	

A. Step Analysis

1) Average Step Analysis: Figure 1a shows the trend of the daily average number of steps for each of the three months (month 1: baseline, month 2 & 3: intervention). The trend line is represented as a linear line where the slope represents the change in the average step value per day and the intercept represents the starting average step value. This graph shows that during the baseline period, there was a downward trend (solid black line) in the daily average number of step over time but during the intervention period (the dashed black lines) there was an upward trend in the daily average number of steps over time. These results indicate that without the text messages, the participants step average decreased over time (leveling off after the 24th day as the novelty effect of the pedometer wore off), but with text messages the participants' step average increased over the entire intervention period instead of leveling off after 3 weeks. These results suggest that text messages were indeed helping the participants to take more steps on average over time and the effect was not just the novelty factor of the text messages. It should also be noted that the step averages increased more in the 2nd month of intervention than the 1st, which indicates that the change in behavior was not immediate but gradual- the more time passed, the effect of the text messages became more visible. In fact, in the post-study interviews, two participants mentioned that they were not serious about the study initially but after two months, the messages motivated them to take more steps.

To verify if our assessment of the daily step averages are statistically significant, we conducted a one factor repeated measures ANOVA on the daily average number of steps grouped by the three different months. The analysis of variance revealed a significant difference among the average number of steps for the three different time periods, F (2, 90) = 13.95, $p < 0.0001$. Tukey post-hoc comparisons of the three groups indicate that the average number of steps in the month 3 group (M = 9602, 95% CI [9235, 9969]) was significantly higher than the average number of steps in the month 2 group (M = 8381, 95% CI [7732, 9031]), $p = 0.0014$ and the baseline group (M = 7969, 95% CI [7668, 8270], $p < 0.0001$. The difference between month 2 group and baseline group was not significant at $p < 0.05$. These results suggest that our initial assessments that the daily average number of steps increased from baseline to post-intervention and the increase in average steps was higher from month 2 to month 3 than from baseline to month 2 are all statistically significant.

2) Statistical Modeling of Step Data: The overall average step graph gives us a sense of the effect of the intervention on the participants. However, we cannot for sure say that it was indeed the messages that caused this change There can be other reasons for which the steps might have changed over time - the main one being individual differences. Each person is unique in terms of his/her lifestyle, personality, habits, interests etc. which may have an effect on the steps. It is important to take the within-person differences into account when analyzing the data. For this purpose, we used a multilevel statistical model of change to analyze the steps. The model includes a level 1 sub-model that describes how each person changes over time and a level 2 sub-model that describes how these changes differ across participants in different groups (tailored/non-tailored/varying sources) [18]. The model represents the behavior of the target population based on the sample data.

a) Level-1 sub model: For this analysis, the level 1 sub-model of the multilevel model represents the individual change in the number of steps that each participant is expected to experience during the three month period of the study. After initial inspection of the step data, we decided to use a linear individual-change model with random slopes and intercepts.

In the population from which the sample data was collected, S_{ij}, the value of steps for participant i at time j, is a linear function of day of the study where i goes from 1-28 for the 28 participants and j goes from 1-90 for the number of days of the study. This model assumes that a straight line represents each person's true change over time and any deviations from linearity observed in the sample data results from random variation of individuals (ε_{ij}). In the equation below π_{0i} represents the intercept of each participant and π_{1i} represents the slope of each participant.

$$S_{ij} = \pi_{0i} + \pi_{1i}\,(DAY_{ij} - 1) + \varepsilon_{ij}$$

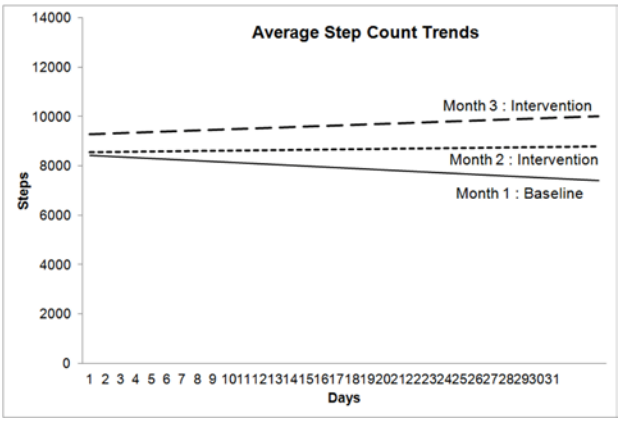

Figure 1a. Trend lines for the average daily step progress of all particpants for each of the three months.

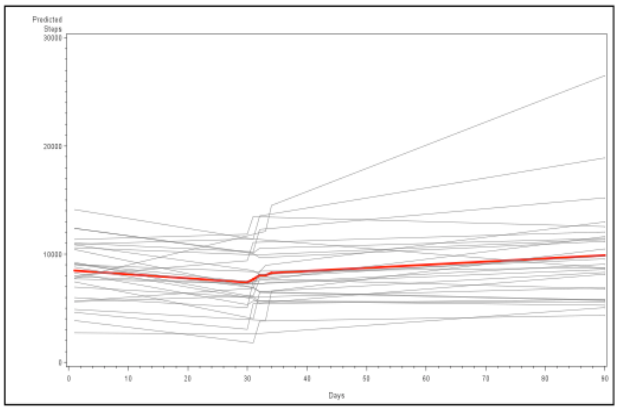

Figure 1b. Multilevel statistical model of step data showing pre and post intervention predicted step values for each participant.

b) Level-2 sub-model: The sub-model creates the relationship between inter-individual differences in the change trends (between-person differences) and individual characteristics of the participant (within-person differences). The slope and the intercept in the level 1 model can vary based on individual differences and the time. In this model, the slopes and the intercepts of level 1 model are formulated as a function of a combination of the 5 fixed effects (the two types of text messages- tailored and non-tailored, and the three sources of the text messages- automated, fitness specialist and friend/family). In equations below, MSGTYPE (0 or 1) represents tailored or non-tailored text messages, SOURCE1 (0 or 1) represents automated messages or messages sent by fitness specialist and SOURCE2 (0 or 1) represents messages sent by a friend or family member or not. Any remaining "unexplained" reasons for change seen in the individual steps over time are represented by the error term (δ_{0i} and δ_{1i}).

$$\pi_{0i} = \gamma_{00} + \gamma_{01} MSGTYPE_i + \gamma_{02} SOURCE1_i + \gamma_{03} SOURCE2_i + \delta_{0i}$$

$$\pi_{1i} = \gamma_{10} + \gamma_{00} MSGTYPE_i + \gamma_{12} SOURCE1_i + \gamma_{13} SOURCE2_i + \delta_{1i}$$

The combination of the two sub-models (M1) describes the expected population behavior based on the fixed effects in the different groups and the individual characteristic differences.

The graph in Figure 1b was created from a set of models (M2: derived from M1) where "phase" (pre-intervention and post-intervention) was also included as a factor along with the interactions to give separate slopes and intercepts for each time periods. This way the changes between pre- and post-intervention can be observed easily. The graph shows the predicted step values from model M2 for each individual in the study verifying that the trend seen in the overall average number of steps graph in the previous section is a general trend among the participants. As we can see, most participants slope is negative during the baseline period and then picks up after intervention (upward slope, higher intercept). The red line is an average of all the participants.

It is important to note that there is one participant whose step progress was very different from all other participants- a steep positive slope in the baseline period and a steeper positive slope during the post-intervention period. To verify that this participant's "unusual" steps were not affecting the overall results, we examined the model after removing this data and found similar results. Furthermore, participants are not only different in terms of the fixed conditions but they are also different in terms of the groups of text messages they received due to the different *stages of change* and different participation times. These differences may explain the variations seen in each of the individuals.

3)External factors affecting steps: During the interviews, participants mentioned some common factors other than text messages that affected their activity level. When participants were shown their step progress graph from the study and asked to explain the changes in their steps- weather (n=10) and lifestyle (n=6) were the two most common factors mentioned. Commute to work or class, illness, exams, nature of job and family life were also mentioned as reasons for change in the step activity. The study effect [19] was also mentioned by some participants.

Since there was a group of participants who started in November/December (study progressing from warmer to colder months) and another group of people who started in January/February (study progressing from colder to warmer months), we added weather as a factor in the model. The addition of the weather factor did not change the results.

B. *Message Rating Analysis*

The total number of messages sent to participants was 3398, of which 10% of the messages were not rated (including one participant who never rated any of the messages) and 3% of the messages were not delivered to the recipient. Of the remaining 2965 messages that were rated by participants, the percentage ratings of 1 and 2 (low/not motivating) were 14.7% and 17.5% respectively. The percentage ratings of 4 and 5 (high motivating) were higher with 20.7% and 22% respectively. The rating of 3 had the highest percentage with 25%. Hence, we can say that 43% of the messages were rated positively (4, 5) and were motivating enough to generate

interest in physical activity, 25% of the messages were neutral and 32% of the messages were rated negatively (1, 2) and were not motivating for physical activity. These results indicate that participants were motivated by most of the messages they received. However, there was no statistically significant correlation between the daily message ratings (average of the two daily ratings) and the number of steps that day of each participant. The correlation values were also very small ranging from 0.004 to 0.2 (positive or negative).

C. Stages of Change Analysis

Table V shows that before the start of the study, 22 out of 28 participants were in the contemplation stage and at the end of the study, 19 out of 26 participants were in the action stage. This movement from contemplation and preparation to the action stage shows overall increased motivation. To test for statistical significance of change in the stages during the study, we ran a Chi-Squared test on the frequency of occurrence of each stage grouped by the four different time limits of the study. The test reveals that the frequency of each of the stages differs significantly among the four time limits, c^2 (6, N=108) = 38.1, $p < 0.0001$. This result suggests that participants made positive progress in their *stages of change* and that the text messages had a positive influence on participants' activity level.

D. Post-Study Interview

During the post interviews we asked the participants to rank the overall effect of the messages on their physical activity on a scale of 1-5 where 1 is "not effective" and 5 is "very effective". The rating was mostly average with 15 participants rating 3 out of 5. 8 participants rated the system with a 4-5 and 5 participants rated the system with a 1-2. . The ranking implies that most of the participants had a positive experience with the text messages.

We also asked the participants if they would subscribe to a similar system in reality. 11 participants said that they would, 7 participants said they would but with more personalized messages, 5 participants said "maybe" and 5 participants said they would not. 3 participants said they would be willing to pay $5 for such messages. This implies that text messages encouraging physical activity can be a useful system in reality and if the messages are further personalized, the system can be very successful.

22 of the 28 participants said the messages prompted them to get more active, with several specifically mentioning that the messages prompted them to take steps that they wouldn't have otherwise taken:

"Sometimes I'd be playing indoors e.g. video games, and I would ask my friends…let's go outside…and that happened because of the messages…a few times."

"Really cold day and do not want to go out…and then I get message saying 'Walking leads to better health' and then I would go to the gym or something."

TABLE V. NUMBER OF PARTICIPANTS IN EACH *STAGES OF CHANGE* AT DIFFERENT PERIODS OF THE STUDY

	Contemplation	**Preparation**	**Action**
Start	22	6	0
Post- Baseline (1 missing data)	18	3	6
Mid- Intervention (1 missing data)	10	6	11
Post-Intervention (2 missing data)	4	3	19

Some participants noted that they implemented some of the suggestions in the messages:

"Some of the ideas stayed and applied it some other time. Lot of the tips e.g. park farther away from the store…today I got off the bus and walked".

While the analysis of step data, text message ratings and progress in the *stages of change* supports that text messaging systems are powerful for motivating physical activity even after the novelty effect wears off, the lack of correlation between message ratings and step counts for any participant was unexpected. The interviews suggest two reasons for this.

First, not all messages must be motivating for the system as a whole to have an impact. Indeed, it is likely that a few personally relevant messages can impact people's behavior. As an example, one participant felt that messages relating to traffic and other environmental benefits of walking were highly motivating, while many other messages were not:

"At times, the messages did work. Quotes did not work for me. Listening to music, stair, traffic and environmental related messages worked… I walk more now because of the traffic messages [that said walking helps in easing traffic]."

It is possible that further tailoring of messages to those topics individuals find most motivating would improve the system's impact.

The second reason that message ratings may not have been correlated to step counts is that participants reported that the *combined* messages acted like reminders or nudges, regardless of individual message content:

"Not so much what the message said but they acted as a reminder that I should work out since I haven't today".

This participant only rated 30% of his messages as 4-5, but his average number of steps for the two months of intervention was higher than most: 15192.

Other participants mentioned text messages as being persuasive reminders:

"[I] initially ignored the messages but continuous messages could not be ignored. Guilt factor works"

"The messages reminded me to be a little more active. They acted like triggers…I actually did not start to get active after getting the messages but it stayed in my mind.

These findings also suggest that the reason the bulimia nervosa study [4] and the physical activity study with weekly text messages [8] were unsuccessful was the infrequent messaging. Daily text messages engage the user on a daily basis (pervasive persuasion) and intervene at opportune times for maximum impact, which weekly text messages cannot do.

V. Conclusion and Future Work

The goal of this study was to evaluate the power of text messages beyond the novelty period for promotion of healthy physical activity. Previous studies that involved mobile phones and text messaging for physical activity were promising, but they were all short term and with a small n. In this study, we conducted a 3 month long study with 28 participants and found that text messages is a good method for encouraging physical activity among young adults who are comfortable with text messages. Most participants' number of steps over the 2-month intervention period had an upward trend with an increase in daily physical activity, and most had very positive things to say about the text messages. There was also positive progress in the *stages of change* of most participants. While this paper focused on the overall results of participants in all groups, another paper will investigate the nuances in the results of the different groups. Further research is required for observing permanent behavior change for at least 6-months (according to the TTM theory 6 months is minimum for observing long term behavior change [16]).

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