Supplement 1

Study Protocol

Table of Contents

1. Summary of changes to the protocol

2. Original and Final Study Protocol

Summary of Changes to the Protocol

No changes were made to the protocol or analysis plan.

Original and Final Study Protocol

Social Incentives and Gamification to Increase Physical Activity Among Overweight and Obese Adults: The STEP UP Randomized Clinical Trial

Study Protocol

August 11, 2017

Outline

1. Abstract
2. Overall objectives
3. Aims
    3.1 Primary outcome
    3.2 Secondary outcomes
    3.3 Exploratory outcomes
4. Background
5. Study design
    5.1 Design
    5.2 Study duration
    5.3 Target population
    5.4 Accrual
    5.5 Key inclusion criteria
    5.6 Key exclusion criteria
6. Subject recruitment
7. Subject compensation
8. Study procedures
    8.1 Consent
    8.2 Procedures
9. Analysis plan
10. Investigators
11. Human research protection
    11.1 Data confidentiality
    11.2 Subject confidentiality

11.3 Subject privacy

11.4 Data disclosure

11.5 Data safety and monitoring

11.6 Risk/benefit

11.6.1 Potential study risks

11.6.2 Potential study benefits

11.6.3 Risk/benefit assessment

1. Abstract

Regular physical activity is associated with reduced risk of cardiovascular disease, diabetes, hypertension, and obesity. Despite these benefits, more than half of adults in the United States do not achieve enough physical activity to obtain these benefits. Moreover, nearly 70% of Americans are overweight or obese and could benefit from greater physical activity. Many stakeholders are increasingly interested in using digital health approaches to increase physical activity including using wearable devices to monitor activity and using engagement strategies such as gamification to change behaviors. However, the evidence on these approaches is limited. Social incentives, the influences that impact individuals to adjust their behaviors based on social ties or connections, are ubiquitous and could be leveraged within gamification interventions to provide a scalable, low cost approach to increase engagement. Gamification, or the use of game design in non-game situations, is commonly used in the real world, but in most cases has not appropriately leveraged principles from theories of health behavior. By incorporating insights from behavioral economics, these approaches could be designed to anticipate predictable barriers to behavior change. In this study, we will test the effectiveness of three social incentive-based gamification interventions to increase physical activity using a 24-week intervention period with a 12-week follow-up.

2. Overall objectives

The objective of this study is to use a randomized, controlled trial to test the effectiveness of three interventions using social incentives and gamification to increase physical activity among overweight and obese adults.

3. Aims

3.1 Primary outcome

The primary outcome is change in daily steps from baseline to the intervention period (weeks 5 to 24 which excludes the 4-week ramp-up phase).

3.2 Secondary outcomes

Secondary outcomes include the proportion of participant-days that step goals are achieved during the intervention and follow-up periods, and change in daily steps from baseline to the follow-up period.

3.3 Exploratory outcomes

We will explore how participant characteristics and behaviors are associated with strong or poor physical activity performance.

4. Background

Regular physical activity is associated with reduced risk for cardiovascular disease, diabetes, hypertension, and obesity. Less than half of adults in the United States, however, achieve enough physical activity to obtain these benefits. Digital health approaches that use engagement strategies such as gamification are commonly found within workplace wellness programs and mobile applications, but the evidence on their effectiveness is limited. Our prior work has demonstrated that insights from behavioral economics can be used to design interventions to address predictable barriers to behavior change.

Social incentives or those influences that impact individuals to adjust their behaviors based on social ties and connections have been demonstrated in retrospective studies to influence behavior but have not been well examined prospectively. Insights from behavioral economics can be used to design gamification interventions to enhance social incentives such as the support, competition, or collaboration but the optimal design to increase physical activity is unknown.

5. Study design

5.1 Design

This is a four-arm randomized, controlled trial with a 24-week intervention period and 12-week follow-up period. The study will be conducted using Way to Health, a research information technology platform at the University of Pennsylvania used previously for physical activity behavioral interventions.

Recruitment will occur by email invitation to employees in the United States at Deloitte, a large consulting company. Interested participants will be instructed to visit the study website to create an account, review and provide informed consent, and complete a baseline eligibility survey. Eligible participants will also be asked to complete a custom sociodemographic survey; the DOSPERT survey to evaluate risk preferences; the Big Five Inventory survey to evaluate personality characteristics; and the Grit Scale to assess perseverance at the time of enrollment. At 0 and 6 months, participants will be asked to complete an EQ-5D-5L survey for economic evaluation of health status, the Self Efficacy for Exercise Behaviors survey, the Eating Habits Questionnaire, the Pittsburgh Sleep Quality Index, the PHQ-9 questionnaire to assess mental health state, the MOS Social Support survey, and a qualitative survey to provide feedback on their experience in the study. Once surveys are completed in enrollment, a wearable activity tracking device will be mailed to the participant and they will be told to wear the device during day and night to get accustomed to it during a 2-week run-in period. Data collected from this time will be used to estimate a baseline step count by using data from the second week (days 8 to 14), ignoring values less than 1000 steps (since evidence suggests these value are unlikely to represent actual activity). Participants without at least 4 days of data will be called to inquire if

there are any issues with using the device and the period will be extended until at least 4 days of data are available to estimate a baseline step count.

Participants that have been confirmed by the study team to have an appropriate baseline step count will be asked to select a step goal increase as follows:

--Goal Setting--

Each participant will be asked to choose a step goal increase that is either 33%, 40%, or 50% higher than baseline (each step goal will be rounded up to the nearest hundred). A participant may also select to choose another goal as long as it is at least 1500 steps greater than his or her baseline.

--Randomization—

Participants are considered ready to be randomized once they have completed all surveys, established a baseline step count, and selected a step goal increase.

Participants will be stratified on baseline step count (less than 5000 steps, 5001 to 7500 steps, or more than 7500 steps). Participants will then be randomly assigned within their strata in blocks of four groups, with each group having 3 participants. The first participant in the group will be randomly assigned to the arm and the next 2 participants will be assigned to fill that group. Then the next participant will be randomly assigned to an arm within that block and the following two participants will be assigned to fill that group, and so on until the block within the strata is filled of 4 groups, each with three participants per group.

Participants in all arms will be asked to complete a series of follow-up surveys the end of the 24-week intervention period and again at the end of the 12-week follow up period. The interventions within each arm are as follows:

--Arm 1: Control—

Participants in this arm will receive no other interventions during the 24-week intervention period or the 12-week follow-up period.

--Arm 2-4: social incentive-based gamification interventions--

Participants randomized to the one of the three intervention arms will have a 4-week ramp up towards their step goal (the “ramp-up period). The net difference between baseline and their goal will be divided by 4 and the participant will be asked to achieve the 25% increase each week for the 4-week ramp-up and then maintain the step goal for the remaining study period. For example, a participant with a baseline of 6000 steps and goal of 8000 steps will be asked to achieve goals of 6500, 7000, 7500, and 8000 for each of the first four weeks of the study. The participant will be asked to maintain their goal (e.g. 8000 steps per day) during the 20-week “maintenance period” and the 12-week “follow-up period”

Participants in arms 2-4 will be entered into an intervention approach that has points and levels designed to incorporate insights from behavioral economics. First, participants will be asked to sign a pre-commitment pledge to strive to achieve their step goal during the 36-week study. Pre-commitment has been demonstrated to motivate behavior change. Second, at the beginning of each week the participant receives 70 points (10 for each day that week). If the participant does not achieve their step goal, they lose 10 points from their balance. This leverages loss aversion, which has been demonstrated to motivate behavior change more effectively with losses than gains. Third, at the end of each week if the participant has at least 40 points, he or she will move up a level (levels from lowest to highest: blue, bronze, silver, gold, platinum). If not, participants will drop a level. All participants begin at the silver level. Each week, participants get a fresh set of 70 points on Monday.

At 8 and 16 weeks, participants struggling to meet their goals (defined as in the blue or bronze levels of the game) will be called to inquire about their progress in the study. They will be reset to the silver level and given the opportunity to readjust their goals among the initial options.

Weekly feedback will differ among the three arms to induce the different social incentives (support, competition, and collaboration) as follows:

--Arm 2: Supportive social incentive intervention—

Participants in this arm will be asked to identify a family member or friend to be their support sponsor. This sponsor will be encouraged to support the participant in their progress during the study. A weekly report will be sent by email to the sponsor with the participant's performance (e.g., step goal, average step count for that week, points and level).

--Arm 3: Competitive social incentive intervention—

Participants in this arm will be in a group of three total participants. At the end of each week the participants will receive an email with a leaderboard that ranks them on their cumulative points in the study thus far and also displays their level. In the event there is a tie in total cumulative points, the participants will be secondarily ranked on level. This feedback may help to induce participants to compete for the top spot among the group.

--Arm 4: Collaborative social incentive intervention—

Participants in this arm will be in a group of three total participants as a team. Each day one of the members of the group will be randomly selected to represent their team for that day. If the participant selected met his or her step goal on the previous day, the team keeps their points. If he or she didn't meet their goal, then the team loses 10 points. In this design, each person is accountable to the others on the team and this may induce a collaborative effort to meet their daily goals. The entire team moves up a level only if the team has at least 40 points by the end of the week.

5.2 Study duration

This study is anticipated to take up to 2 years to complete and includes a 24-week intervention period and 12-week follow-up period

5.3 Target population

Adults age 18 years or older with a self-reported body mass index of 25 or greater, that are employees of Deloitte.

5.4 Accrual

This study has been powered for two phases of hypothesis testing. In the first phase, we will compare each of the three intervention arms to control. We estimate that a sample of 600 participants allocated in a 1:1:1:1 distribution, will ensure at least 80% power to detect an 800 step difference between each intervention arm and control, with a standard deviation of 2000 steps. This calculation assumes a 10% dropout rate and a conservative Bonferroni adjustment of the type I error rate with a 2-sided alpha of 0.017. In the second phase, we will compare successful intervention arms to each other. We expect that the magnitude of difference between intervention arms will be less than that of successful intervention arms compared to control. For this second phase of analyses will use a conservative Bonferroni adjustment of the type I error rate with a 2-sided alpha of 0.017 to adjust for up to 3 comparisons. Because only intervention arms which demonstrated a significant difference with the control are compared with each other in the second phase, the overall familywise error rate of this two-phase procedure is controlled at 0.05.

5.5 Key inclusion criteria

1) Age 18 years or older; 2) ability to read and provide informed consent to participate in the study; 3) Self-reported body mass index (BMI) of 25 or greater. 4) Smartphone or tablet compatible with application for the wearable activity tracking device.

5.6 Key exclusion criteria

1) Conditions that would make participation infeasible such as inability to provide informed consent, illiteracy or inability to speak, read, and write English; 2) conditions that would make participation unsafe such as pregnancy or being told by a physician not to exercise; 3) already enrolled in another study targeting physical activity; 4) any other medical conditions or reasons he or she is unable to participate in a physical activity study for 36 weeks.

6. Subject recruitment

Recruitment will occur by email invitation to employees in the United States at Deloitte, a large consulting company.

7. Subject compensation

All participants will receive $25 to enroll in the study (defined as being randomized and starting the intervention), $50 for completing the 24-week intervention and surveys, and $50 for completing the entire 36-week study.

8. Study procedures

8.1 Consent

Upon recruitment, individuals who are interested in learning more about the study will be directed to the Way to Health web portal. Upon reaching the portal, potential participants will be asked to create an account and will then be informed of the details of the study, including its objectives, duration, requirements, and financial payments. If participants are still interested in participating, the Way to Health portal will take them through an automated online informed consent. The consent document will be divided into sections and potential participants will have to click a button to advance through each section. This is to help ensure that participants read the consent form thoroughly by breaking down the form into manageable blocks of text. Successive screens will explain the voluntary nature of the study, the risks and benefits of participation, alternatives to participation, and that participants can withdraw from the study at any time. On the final consent screen, potential participants who click a clearly delineated button stating that they agree to participate in the study will be considered to have consented to enroll. Participants will be provided with details regarding how to contact the research team via email or phone at any time if they subsequently wish to withdraw from the study. This contact information will remain easily accessible via the participants' individual Way to Health web portal dashboards throughout the study.

8.2 Procedures

After providing informed consent, participants will complete an online questionnaire to determine their eligibility and complete the study surveys. Eligible participants will be mailed a wearable activity tracking device to wear a two week run-in period to collect a baseline step count.

Participants will select step goals and then be randomly assigned as described in the Study Design section.

We will obtain additional information about characteristics and behaviors of participants from the KBM Group, a data analytics firm. Participants will provide consent for the study team to send KBM Group their name and address using secure data transfer methods.

9. Analysis plan

All analyses will be performed using intention-to-treat. Data can be missing for any day if the participant did not use the activity tracking device or did not upload data. For the main analysis, we will use multiple imputation for step values that are either missing or for values less than 1000 steps because evidence suggests these are not accurate measures of actual activity. We will perform five sets of imputations and results will be combined using Rubin's standard rules. We will perform sensitivity analyses to assess the robustness of the findings using only collected data with and without step values less than 1000 steps.

The primary analysis will fit mixed effects regression models to evaluate changes in physical activity outcomes measures adjusting for each participant's baseline step, time at the observation level using calendar month fixed effects, participant random effects, and adjusting for repeated observations of participant step counts. We will compare changes from baseline to the intervention period (excluding weeks 1 to 4 during the ramp-up phase) and from baseline to the follow-up period. Secondary analyses will fit mixed effects regression models adjusted for other variables of interest such as participant characteristics. Exploratory analyses will fit mixed effects regression models to evaluate associations of participant characteristics or behaviors with strong or poor performance in the outcome measures. We will also conduct an exploratory qualitative evaluation of the survey free text responses.

This study has been powered for two phases of hypothesis testing. In the first phase, we will compare each of the three intervention arms to control. We estimate that a sample of 600 participants allocated in a 1:1:1:1 distribution, will ensure at least 80% power to detect an 800 step difference between each intervention arm and control, with a standard deviation of 2000 steps. This calculation assumes a 10% dropout rate and a conservative Bonferroni adjustment of the type I error rate with a 2-sided alpha of 0.017. In the second phase, we will compare successful intervention arms to each other. We expect that the magnitude of difference between intervention arms will be less than that of successful intervention arms compared to control. For this second phase of analyses will use a conservative Bonferroni adjustment of the type I error rate with a 2-sided alpha of 0.017 to adjust for up to 3 comparisons. Because only intervention arms which demonstrated a significant difference with the control are compared with each other in the second phase, the overall familywise error rate of this two-phase procedure is controlled at 0.05.

10. Investigators

Mitesh Patel, MD, MBA, MS is the Principal Investigator (PI) and is an Assistant Professor of Medicine and Health Care Management at the Perelman School of Medicine and The Wharton School at the University of Pennsylvania. He is the Director of the Penn Medicine Nudge Unit and has led more than 15 randomized clinical trials including many physical activity behavioral interventions that use the Way to Health research information technology platform. He has experience and training in behavioral economics, clinical trial design and analysis, health

services research, and statistical analysis. He currently spends 80% of his effort on research and 20% on clinical and teaching activities.

11. Human research protection

11.1 Data confidentiality

Paper-based records will be kept in a secure location and only be accessible to personnel involved in the study. Computer-based files will only be made available to personnel involved in the study through the use of access privileges and passwords. Wherever feasible, identifiers will be removed from study-related information. Precautions are in place to ensure the data are secure by using passwords and encryption, because the research involves web-based surveys.

11.2 Subject confidentiality

Research material will be obtained from participant surveys and wearable devices. All participants will provide informed consent for access to these materials. The data to be collected include data on participant characteristics and behaviors, step counts, and sleep patterns. Research material that is obtained will be used for research purposes only. The same procedure used for the analysis of automated data sources to ensure protection of patient information will be used for the survey data, in that patient identifiers will be used only for linkage purposes or to contact patients. The study identification number, and not other identifying information, will be used on all data collection instruments. All study staff will be reminded to appreciate the confidential nature of the data collected and contained in these databases. The Penn Medicine Academic Computing Services (PMACS) will be the hub for the hardware and database infrastructure that will support the project and is where the Way to Health web portal is based. The PMACS is a joint effort of the University of Pennsylvania's Abramson Cancer Center, the Cardiovascular Institute, the Department of Pathology, and the Leonard Davis Institute. The PMACS provides a secure computing environment for a large volume of highly sensitive data, including clinical, genetic, socioeconomic, and financial information. Among the IT projects currently managed by PMACS are: (1) the capture and organization of complex, longitudinal clinical data via web and clinical applications portals from cancer patients enrolled in clinical trials; (2) the integration of genetic array databases and clinical data obtained from patients with cardiovascular disease; (3) computational biology and cytometry database management and analyses; (4) economic and health policy research using Medicare claims from over 40 million Medicare beneficiaries. PMACS requires all users of data or applications on PMACS servers to complete a PMACS-hosted cybersecurity awareness course annually, which stresses federal data security policies under data use agreements with the university. The curriculum includes Health Insurance Portability and Accountability Act (HIPAA) training and covers secure data transfer, passwords, computer security habits and knowledge of what constitutes misuse or inappropriate use of the server. We will implement multiple, redundant protective measures to guarantee the privacy and security of the participant data. All investigators and research staff with direct access

to the identifiable data will be required to undergo annual responsible conduct of research, cybersecurity, and HIPAA certification in accordance with University of Pennsylvania regulations.

Data will be stored, managed, and analyzed on a secure, encrypted server behind the University of Pennsylvania Health System (UPHS) firewall. This server was created for projects conducted by the Penn Medicine Nudge Unit related to physician and patient behavior at UPHS. All study personnel that will use this data are listed on the IRB application and have completed training in HIPAA standards and the CITI human subjects research. Data access will be password protected. Whenever possible, data will be deidentified for analysis.

11.3 Subject privacy

Interested participants will be directed to the Way to Health portal where they will be asked to enter data related to eligibility and their demographic characteristics. Enrollment will include a description of the voluntary nature of participation, the study procedures, risks and potential benefits in detail. The enrollment procedure will provide the opportunity for potential participants to ask questions and review the consent form information with family and friends prior to making a decision to participate. Participants will be told that they do not have to answer any questions if they do not wish and can drop out of the study at any time, without affecting their medical care or the cost of their care. They will be told that they may or may not benefit directly from the study and that all information will be kept strictly confidential, except as required by law. Subjects will have access to a copy of the consent document. All efforts will be made by study staff to ensure subject privacy.

11.4 Data disclosure

The following entities, besides the members of the research team, may receive protected health information (PHI) for this research study: Wells Fargo, the company which processes study-related payments. Patient addresses and account balances will be stored on their secure computers. Nokia, the company that designs and manufactures the wearable devices used in the study to track participant physical activity. Twilio, Inc., the company which processes some study-related messages. Twilio will store patients' phone numbers on their secure computers. Qualtrics, Inc., the company which processes most study-related surveys. Qualtrics will house de-identified answers to these surveys on their secure servers. The Office of Human Research Protections at the University of Pennsylvania -Federal and state agencies (for example, the Department of Health and Human Services, the National Institutes of Health, and/or the Office for Human Research Protections), or other domestic or foreign government bodies if required by law and/or necessary for oversight purposes.

11.5 Data safety and monitoring

The Principal Investigator will be responsible for monitoring the study. All participants will be given anticipatory guidance on when to seek medical attention. In addition, participants will be asked to report to the study team any injuries or medical care that they feel resulted from participation in the study. They can either call the study team or send an email. The research coordinator will call the participant to collect information regarding the issue and then the PI will review and determine whether it is ok to proceed, further investigation is needed, or the participant should stop the study. For this study there will be no stopping rules or endpoints and thus no planned interim analyses.

11.6 Risk/benefit

11.6.1 Potential study risks

To minimize the chance for serious and unexpected adverse events, study participants will be screened through exclusion criteria for any health conditions that may be exacerbated by participating in a physical activity study. The program will use a gradual increase in physical activity during the first month that should pose little health risk to participants. Participants are given guidance on when to seek medical attention and a reporting protocol is in place to capture any changes in symptoms with physical activity. Another potential risk of this study is a breach of participant confidentiality. We will minimize this risk by using secure data methods as described previously. Due to the financial incentives in this study, we will be collecting social security numbers so that we can complete W-9 forms for participants. Social security numbers only will be used to generate W-9 forms and will be deleted once they are no longer needed. We will also collect home addresses to mail incentive payments. This will be done through a University of Pennsylvania approved partnership with Wells Fargo. Accidental disclosure of social security numbers could lead to identity theft. We will use commercial-grade encryption to protect social security information in transit. Names and addresses will be stored in encrypted databases. These data will be viewable only by the respective participants, the study coordinator(s) and the project manager(s). All other members of the research team will be able to view only participant ID numbers. Even the study arms will be identified by code letters until both the statistician and PI agree that analysis is complete.

11.6.2 Potential study benefits

Through participation in this study, each participant will have the potential to increase physical activity which could improve their health and reduce their risk for future disease. If this approach is effective, it could have tremendous benefits for society if adopted on a wide scale to help individuals. It is expected that other people will gain knowledge from this study and that participation could help understand how to effectively motivate individuals to change behavior. Participants may also receive no benefit from their participation in the study.

11.6.3 Risk/benefit assessment

Anticipated risks of this study should be minimal and the risk/benefit ratio is very favorable. To minimize the chance for serious and unexpected adverse events, study participants will be screened through exclusion criteria for any health conditions that may be exacerbated by participating in this study. We have previously outlined the procedures that will be used to prevent a breach of participant data.