# Individual Versus Team-Based Financial Incentives to Increase Physical Activity: A Randomized, Controlled Trial

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***BACKGROUND:*** More than half of adults in the United States do not attain the minimum recommended level of physical activity to achieve health benefits. The optimal design of financial incentives to promote physical activity is unknown.

***OBJECTIVE:*** To compare the effectiveness of individual versus team-based financial incentives to increase physical activity.

***DESIGN:*** Randomized, controlled trial comparing three interventions to control.

***PARTICIPANTS:*** Three hundred and four adult employees from an organization in Philadelphia formed 76 four-member teams.

***INTERVENTIONS:*** All participants received daily feedback on performance towards achieving a daily 7000 step goal during the intervention (weeks 1–13) and follow-up (weeks 14– 26) periods. The control arm received no other intervention. In the three financial incentive arms, drawings were held in which one team was selected as the winner every other day during the 13-week intervention. A participant on a winning team was eligible as follows: $50 if he or she met the goal (individual incentive), $50 only if all four team members met the goal (team incentive), or $20 if he or she met the goal individually and $10 more for each of three teammates that also met the goal (combined incentive).

***MAIN MEASURES:*** Mean proportion of participant-days achieving the 7000 step goal during the intervention.

***KEY RESULTS:*** Compared to the control group during the intervention period, the mean proportion achieving the 7000 step goal was significantly greater for the combined incentive (0.35 vs. 0.18, difference: 0.17, 95 % confidence interval [CI]: 0.07–0.28, $p$ <0.001) but not for the individual incentive (0.25 vs 0.18, difference: 0.08, 95 % CI: -0.02–0.18, $p$=0.13) or the team incentive (0.17 vs 0.18, difference: -0.003, 95 % CI: -0.11–0.10, $p$=0.96). The combined incentive arm participants also achieved the goal at significantly greater rates than the team incentive (0.35 vs. 0.17, difference: 0.18, 95 % CI: 0.08–0.28, $p$<0.001), but not the individual incentive (0.35 vs. 0.25, difference: 0.10, 95 % CI: -0.001–0.19, $p$=0.05). Only the combined incentive had greater mean daily steps than control (difference: 1446, 95 % CI: 448–2444, $p \leq 0.005$). There were no significant differences between arms during the follow-up period (weeks 14– 26).

***CONCLUSIONS:*** Financial incentives rewarded for a combination of individual and team performance were most effective for increasing physical activity.

***TRIAL REGISTRATION:*** Clinicaltrials.gov identifier: NCT02001194.

*KEY WORDS:* behavioral economics; financial incentives; physical activity; step counts; connected health; smartphones; teams.
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## INTRODUCTION

Physical inactivity is a major risk factor for cardiovascular disease and all-cause mortality.[1–5] More than half of adults in the United States (US) do not attain the minimum recommended level of physical activity to achieve health benefits, which can be met by either 150 minutes per week of moderate activity or 75 minutes per week of more vigorous activity.[6,7] The Centers for Disease Control and Prevention and many State Public Health Departments have recommended that the workplace may be a good environment to implement interventions to increase physical activity levels.[8–11] However, evidence suggests that most workplace physical activity interventions are not effective, particularly for more sedentary individuals.[12–14]

The importance of employer use of incentives has grown with the inclusion of a provision in the Affordable Care Act that significantly increases the proportion of health insurance premiums that can be used for outcome-based wellness incentives.[15] More than 80 % of large employers now use financial incentives for health promotion.[16–18] The evaluation of financial incentives for promoting physical activity has been limited, and many of the prior studies utilize designs that are based on standard economic theory, which generally assumes individuals act rationally.[19,20] Insights from behavioral economics reveal that the design and the delivery of incentives have an important influence on their effectiveness.[21,22] Evidence also suggests that behavioral change programs may be more effective when individuals participate together,[23,24] and when they are more socially connected.[25,26] While a team-based model might enhance social incentives,[27,28] the optimal combination of individual and team-based financial incentives is unknown.

In this study, our objective was to test different forms of a team-based model for promoting physical activity with financial incentives that varied the proportion of the reward that was dependent on individual vs. team performance. We used smartphones to track step counts, because more than two-thirds of US adults have a smartphone,[29,30] most carry it with them everywhere, and our prior work has demonstrated that these devices accurately track step counts.[31]

## METHODS

### Study Design

We conducted a 26-week randomized, controlled trial between March and September 2014, consisting of a 13-week intervention period and 13-week follow-up period. Three hundred and four participants gave their informed consent, formed 4-member teams and were randomly assigned as teams to control or one of three financial incentive designs (Fig. 1). All participants were given a goal of achieving at least 7000 steps per day, a target endorsed by the American College of Sports Medicine to be approximately equivalent to meeting the federal guidelines for recommended levels of physical activity to achieve health benefits.[32,33] This level is 40 % higher than the average daily step count of 5000 among US adults.[34,35] This study was approved by the University of Pennsylvania Institutional Review Board.

### Setting and Participants

Eligible participants were employees aged 18 or greater from Independence Blue Cross, a health insurance organization in Philadelphia, Pennsylvania. Many in this population had roles in which they were sitting most of the day and therefore may have been more sedentary than employees with more physically active roles.[36,37] Participants were excluded if they were already participating in another physical activity study, not able or willing to carry an iPhone or Android smartphone, currently pregnant or lactating, intending to become pregnant within the next 6 months, or stated any other reason that they did not expect to be able to complete the study.

Potential participants were instructed to form a team of four members and select a captain to complete online informed consent and an eligibility screening questionnaire. The captain listed the contact information for potential teammates. All participants were asked to complete a basic sociodemographic questionnaire, self-report measures of height and weight, report physical activity in the last 7 days using the long form of the International Physical Activity Questionnaire (IPAQ),[38] and to download the Moves smartphone application (ProtoGeo Oy Inc., Helsinki, Finland). Each participant was given a unique personal identification number to enter into the smartphone application and verify permission that the study team could access step count data. Once the application was installed on their phones, participants were not required to ever re-open the application, although they could as often as they wished. Instead, participants had to allow the application to run passively on their phone, and they had to have their phone powered on and had to carry it with them (e.g., in pocket, belt clip, or arm band) while they were active. Step counts were tracked during the entire day, including when outside of the work site.

### Randomization and Interventions

The study was conducted using *Way to Health*, an automated information technology platform that has been used in prior behavioral intervention studies.[23,39–41] After 76 teams completed the enrollment process, they were electronically randomized to control or one of three intervention arms: an individual incentive arm, a team incentive arm, and an arm that combined individual and team incentives. Participants in all arms received daily individual performance feedback for 26 weeks on whether the goal of at least 7000 steps was achieved on the prior day. Participants were able to choose whether to receive this feedback by email, text message, or automated voice call. The control arm received no other interventions. In the three financial incentive arms, a drawing was held every other day during the 13-week intervention period, in which one team in each arm was chosen at random as the winning team. This design provided variable reinforcement, which has been demonstrated to be more effective for changing behavior than constant reinforcement.[42] In the individual incentive arm, each participant on a winning team was eligible to collect $50, but only if he or she had at least 7000 steps on the prior day. In the team incentive arm, each participant on the winning team was eligible to collect $50 only if all four members of their team had each achieved at least 7000 steps on the prior day. In the combined incentive arm, each participant on the winning team was eligible to collect $20 if he or she had at least 7000 steps on the prior day and then an additional $10 for each team member who also had at least 7000 steps on the prior day. For example, a winning team that

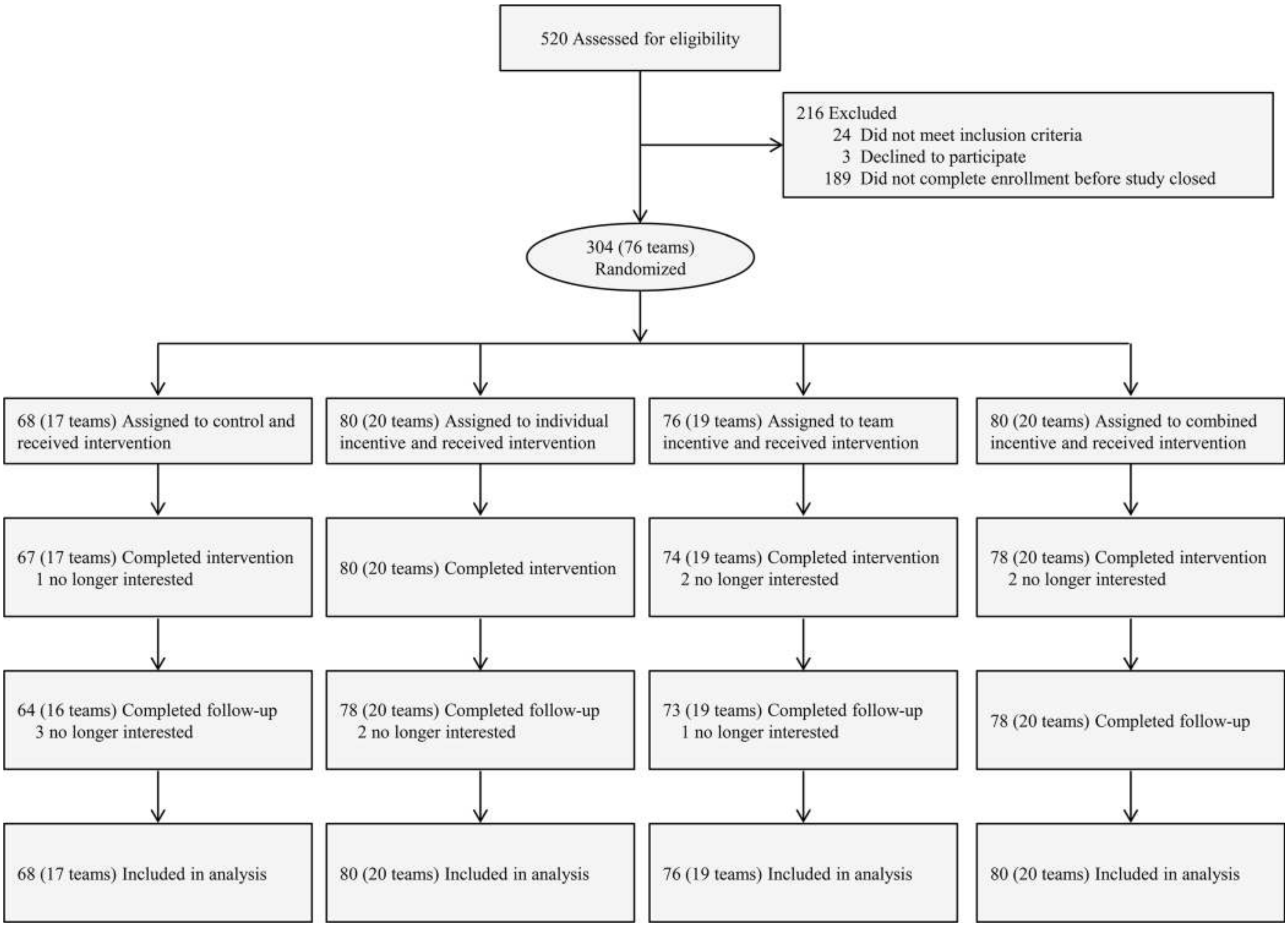


**Figure 1. Study flow diagram.**

had three of four members with at least 7000 steps on the prior day would result in three members receiving $40 ($20 for individual achievement and $20 for the achievements of two team members) and one member receiving $0. Participants were mailed a bank check at the end of each month with all accumulated earnings. After the intervention period, steps were monitored for an additional 13 weeks, during which daily performance feedback was continued but incentives were not.

The expected daily economic value per participant in the individual financial incentive arm was designed to be about $1.25, a value similar to that used in a prior successful intervention.[41] Participants in the team and combined incentive arms had the same maximum incentive value ($50), but these participants could only win this amount if their teammates also achieved the step goals. A programming error in the automated drawing system resulted in random days in which no team was selected as the winner. This reduced the expected value for the individual, team, and combined incentive arms by 17 %, 42 %, and 38 %, respectively, biasing the outcomes in all intervention arms toward the null relative to the planned design. After the follow-up period was completed, each participant was compensated for the average amount of winnings they should have but had not received over the course of the intervention period ($3.93, $7.54, $12.28, respectively per participant).

## Outcomes and Follow-up

The primary outcome was the mean proportion of participant-days that the 7000 step goal was achieved during the intervention period (weeks 1–13). Secondary outcomes included mean daily steps during the intervention and as well as mean proportion of participant-days achieving goal and mean daily steps during the follow-up period (weeks 14–26).

All participants received $25 for enrolling in the study and $75 for participating through the primary endpoint at 13 weeks. There was no participation incentive during the follow-up period. Neither the participants nor the study coordinator could be blinded to the arm assignment due to the nature of the interventions. All investigators, statisticians and data analysts were blinded to arm assignments until the entire study was completed.

## Statistical Analyses

All participants randomly assigned to a study arm were included in the intention-to-treat analysis. We estimated the mean proportion of participant-days achieving goal in each study arm for the intervention period, the follow-up period, and for each week during the study. To adjust the standard errors for clustering by team, the mean and 95 % confidence intervals were estimated using the unit of analysis as the proportion achieving goal at the level of the team. The mean daily steps were estimated for the intervention and follow-up period, with standard errors adjusted to account for clustering by team.

In the adjusted model, generalized linear mixed-models (via PROC GLIMMIX in SAS) were used to adjust for the repeated-measures of daily participant step counts and to adjust the standard errors for clustering by team.[43–45] Data could be missing if a participant turned off the smartphone or Moves application, disabled the study team's permission before data was accessed, or did not carry the smartphone at all. The percentage of missing data during the intervention period was 23 % for control, 18 % for the individual incentive arm, 15 % for the team incentive arm, and 15 % for the combined incentive arm. For the main analysis, we used only collected data (a step count value was received, which assumes missing data occurs at random and does not bias outcomes for arms with differing levels of missing data. The main model included fixed effects for arm and week of the study period. Several sensitivity analyses were conducted to assess the robustness of our findings. For the primary outcome of mean proportion of participant-days achieving goal, the model was further adjusted using fixed effects for smartphone type (iPhone or Android). Second, the model was also evaluated using all data and coding missing data (when a step value was not received) as not achieving goal (in contrast to using only collected data), a method used in prior work.[40] For the secondary outcome of mean daily steps, the model was further adjusted using fixed effects for smartphone type (iPhone or Android). Second, evidence suggests that step count values less than 1000 are unlikely to represent accurate data capture of actual activity.[34,46,47] Therefore, to avoid these observations from biasing mean daily step outcomes, a sensitivity analysis was conducted using the model with values less than 1000 excluded from the sample. All analyses were conducted using SAS, version 9.4 (SAS Institute, Cary, North Carolina).

A priori, we estimated that a sample of at least 280 participants (70 per arm) would ensure 80 % power to detect a 0.20 difference between each of the intervention arms and the control arm, using a conservative Bonferroni adjustment of the Type I error rate using a two-sided $\alpha$ of 0.017. A secondary comparison between each of the intervention arms would require a more conservative Bonferroni adjustment of the Type I error rate using a two-sided $\alpha$ of 0.0083. This calculation assumed that the mean proportion of participant-days achieving goal in the control arm would be 0.40 and accounted for clustering by team with an intracluster correlation coefficient of 0.025. We increased the participant enrollment target to 304 to account for potential drop-out rate of 8 % of teams.

## RESULTS

Figure 1 reports trial enrollment. Participants in the control arm had a mean age slightly higher than the intervention arms; otherwise, there were no significant differences in participant baseline characteristics across the four study arms (Table 1).

The mean proportion of participant-days achieving the 7000 steps goal peaked at about 0.45 in the combined incentive arm and 0.33 in the individual incentive arm, but was never greater than 0.23 in the team incentive arm or control. These levels declined over the intervention period for all arms (Fig. 2). Compared to control during the intervention period, the mean proportion of participant-days achieving the 7000 step goal was significantly greater for the combined incentive (0.35 vs. 0.18, difference: 0.17, 95 % confidence interval [CI]: 0.07–0.28, $p < 0.0,01$) but not for the individual incentive (0.25 vs 0.18, difference: 0.08, 95 % CI: -0.02–0.18, $p = 0.13$) or the team incentive (0.17 vs 0.18, difference: -0.003, 95 % CI: -0.11–0.10, $p = .96$). The combined incentive was also significantly greater than the team incentive (0.35 vs. 0.17, difference: 0.18, 95 % CI: 0.08–0.28, $p < 0.001$), but not the individual incentive (0.35 vs. 0.25, difference: 0.10, 95 % CI: -0.001–0.19, $p = 0.05$). In the main adjusted model during the intervention period, the combined incentive arm had higher odds of achieving goal compared to the control arm (Odds Ratio [OR]: 3.54, 95 % CI: 1.56–8.06, $p = 0.003$) and the team-based incentive arm (OR: 3.02, 95 % CI: 1.37–6.68, $p = 0.006$) (Table 2).

Compared to the control group during the intervention period, the mean daily steps were significantly greater for the combined incentive (5280 vs. 3929, adjusted difference: 1446, 95 % CI: 448–2444, $p = 0.005$), but not for the individual incentive (4516 vs. 3929, adjusted difference: 602, 95 % CI: -393–1596, $p = 0.24$) or the team incentive (3930 vs. 3929, adjusted difference: 193, 95 % CI: -819–1205, $p = 0.71$) (Table 3).

The patterns observed during the intervention period were qualitatively similar during the follow-up period, but there were no longer significant differences compared to control. Results were qualitatively similar in sensitivity analyses to that of the main model for all outcomes.

## DISCUSSION

This study used a team-based model and demonstrated that an incentive structure that provides rewards based on a combination of individual and team performance was most effective for increasing physical activity in the sample population.

These findings expand understanding of using team-based models and financial incentives for changing health behaviors. A study by Wing and colleagues evaluated a statewide intervention using a team-based model in a 16-week competition.[48] Over 4700 participants formed teams ranging in size from five to 11 persons and selected whether they wanted to compete for the most weight loss, step counts, or hours of exercise.

**Table 1. Characteristics of Study Participants**

| Characteristic | Control (n = 17 teams, 68 participants) | Individual Incentive (n = 20 teams, 80 participants) | Team Incentive (n = 19 teams, 76 participants) | Combined Incentive (n = 20 teams, 80 participants) | *p* Value |
|---|---|---|---|---|---|
| Female Gender, n (%) | 51 (75.0) | 62 (77.5) | 65 (85.5) | 57 (71.3) | 0.19 |
| Age, mean (SD) | 43.2 (10.0) | 39.3 (10.2) | 38.7 (10.2) | 41.2 (10.8) | 0.04 |
| Self-reported baseline measures | | | | | |
| Body mass index, mean (SD) | 29.0 (6.7) | 29.9 (6.3) | 28.1 (6.4) | 29.7 (6.2) | 0.31 |
| Physical activity in the last 7 days (MET-min), Median (IQR) | 4220.8 (2001.3, 6708.0) | 3510.0 (1704.0, 5875.5) | 3486.0 (2214.0, 5328.0) | 2967.0 (1465.0, 4904.3) | 0.70 |
| Race/Ethnicity, n (%) | | | | | 0.09 |
| White non-Hispanic | 38 (55.9) | 30 (37.5) | 43 (56.6) | 50 (62.5) | |
| African American non-Hispanic | 22 (32.4) | 37 (46.3) | 23 (30.3) | 19 (23.8) | |
| Other non-Hispanic | 3 (4.4) | 9 (11.3) | 6 (7.9) | 8 (10.0) | |
| Hispanic | 5 (7.4) | 4 (5.0) | 3 (3.9) | 3 (3.8) | |
| Education, n (%) | | | | | 0.73 |
| Less than college | 2 (2.9) | 7 (8.8) | 6 (7.9) | 7 (8.8) | |
| Some college | 20 (29.4) | 23 (23.8) | 26 (34.2) | 21 (26.3) | |
| College graduate | 45 (66.2) | 50 (62.5) | 44 (57.9) | 52 (65.0) | |
| Marital status, n (%) | | | | | 0.12 |
| Single | 28 (41.2) | 43 (58.8) | 33 (43.4) | 26 (32.5) | |
| Married | 35 (51.5) | 29 (36.3) | 32 (42.1) | 41 (51.3) | |
| Other | 5 (7.4) | 8 (10.0) | 11 (14.5) | 13 (16.3) | |
| Annual household income, n (%) | | | | | 0.08 |
| Less than $50,000 | 21 (26.3) | 21 (26.3) | 13 (17.1) | 11 (13.8) | |
| $50,000 to $100,000 | 34 (42.5) | 34 (42.5) | 38 (50.0) | 34 (42.5) | |
| Greater than $100,000 | 18 (22.5) | 18 (22.5) | 21 (27.6) | 30 (37.5) | |
| iPhone Smartphone, n (%) | 40 (50.8) | 47 (58.8) | 43 (56.6) | 55 (68.8) | 0.40 |

*MET = metabolic equivalent of task, a measure of energy expenditure; IQR = interquartile range*

Participants or their employers paid $15 per person to enter and competitions were held every 2 weeks. Winners received verbal praise and commendation but no other prizes. Among the 70 % that completed the study, mean weight loss was 3.2 kg and 30 % of them lost more than 5 % of their initial weight. Greater weight loss was associated with higher steps per day and hours of exercise. However, this study was limited in that data was mostly self-reported, there was no control group for comparison, and the main analysis did not include the nearly one-third of participants that failed to complete the program. Prior work using a randomized, controlled trial with 105 obese participants found that financial incentives for weight loss were more effective for groups of participants when compared to individuals alone or control.[23] After 24 weeks, group participants lost 4.4 kg more than control and 3.2 kg more than the individual arm participant. After an additional 12 weeks of follow-up without incentives, group participants had still lost 2.9 kg more than control. However, in that study, participants were blinded to the identities of other members and could on average earn higher rewards if other group members did not meet the goal. In comparison, the team-based model tested here was designed to increase an individual's accountability to the teammates with whom they signed up for the program and the maximal value that could be

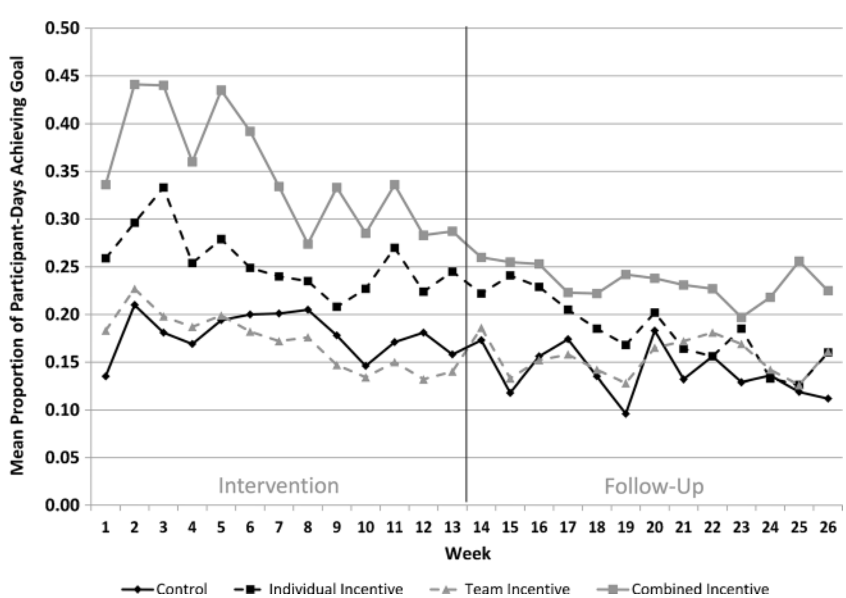


**Figure 2. Unadjusted mean proportion of participant-days achieving the 7000 step goal, displayed by study arm for each week of the study.**

**Table 2. Adjusted Odds of Achieving the 7000 Step Goal During the Intervention and Follow-up Periods**

| Model* | Arm Comparison | Intervention (Weeks 1– 13) | | Follow-up (Weeks 14– 26) | |
|---|---|---|---|---|---|
| | | Odds Ratio (95 % CI) | p Value | Odds Ratio (95 % CI) | p Value |
| Main Model | Individual incentive vs. control | 1.72 (0.76, 3.93) | 0.19 | 1.27 (0.55, 2.96) | 0.58 |
| | Team incentive vs. control | 1.17 (0.51, 2.71) | 0.71 | 1.01 (0.43, 2.38) | 0.98 |
| | Combined incentive vs. control | 3.54 (1.56, 8.06) | 0.003 | 1.72 (0.74, 4.00) | 0.21 |
| | Team incentive vs. individual incentive | 0.68 (0.31, 1.49) | 0.34 | 0.79 (0.35, 1.82) | 0.58 |
| | Combined incentive vs. individual incentive | 2.04 (0.94, 4.55) | 0.07 | 1.35 (0.60, 3.03) | 0.47 |
| | Combined incentive vs. team incentive | 3.02 (1.37, 6.68) | 0.006 | 1.70 (0.75, 3.86) | 0.20 |
| Main Model—Adjusted by device | Individual incentive vs. control | 1.77 (0.80, 3.94) | 0.16 | 1.23 (0.53, 2.85) | 0.62 |
| | Team incentive vs. control | 1.23 (0.55, 2.78) | 0.61 | 1.03 (0.44, 2.40) | 0.95 |
| | Combined incentive vs. control | 3.44 (1.55, 7.64) | 0.002 | 1.63 (0.71, 3.76) | 0.25 |
| | Team incentive vs. individual incentive | 0.69 (0.32, 1.49) | 0.36 | 0.83 (0.37, 1.89) | 0.66 |
| | Combined incentive vs. individual incentive | 1.96 (0.92, 4.17) | 0.08 | 1.32 (0.60, 2.94) | 0.49 |
| | Combined incentive vs. team incentive | 2.79 (0.55, 2.78) | 0.009 | 1.59 (0.71, 3.57) | 0.26 |
| Main Model—Adjusted by device and with missing data as not achieving goal | Individual incentive vs. control | 2.03 (0.94, 4.42) | 0.07 | 1.17 (0.51, 2.71) | 0.71 |
| | Team incentive vs. control | 1.43 (0.65, 3.15) | 0.37 | 1.09 (0.47, 2.53) | 0.84 |
| | Combined incentive vs. control | 3.57 (1.65, 3.00) | 0.001 | 1.55 (0.67, 3.56) | 0.30 |
| | Team incentive vs. individual incentive | 0.70 (0.33, 1.49) | 0.36 | 0.93 (0.41, 2.08) | 0.86 |
| | Combined incentive vs. individual incentive | 1.75 (0.84, 3.70) | 0.13 | 1.32 (0.59, 2.94) | 0.50 |
| | Combined incentive vs. team incentive | 2.49 (1.18, 5.25) | 0.02 | 1.42 (0.63, 3.19) | 0.39 |

**Main model adjusts for repeated measures of daily participant step counts and for temporal trends by week using all collected data. Outcome measure is a binary term (0 or 1) based on not achieving or achieving goal*
*vs. = versus; CI = confidence interval; device refers to type of smartphone*
*Grey highlighting indicates meeting significance threshold of $p < 0.0167$ for primary comparison to control and $p < 0.0083$ for secondary comparison between arms*
*Odds ratios represent the ratio of odds of achieving the 7000 step goal for a participant on a random day during either the intervention period (third column) or follow-up period (fourth column) if that participant's team were to be assigned to the one specified study arm vs. the other specified study arm*

won was the same across study arms. The collaborative rather than competitive design may also enhance the team's unity toward achieving a common goal.

Prior work found that a combination of individual and team-based rewards was effective in increasing engagement in a one-time health promotion activity—completion of a health risk assessment (HRA).[24] In that intervention, if a given team had their lottery number chosen, individuals within that team would receive $100 if they personally completed an HRA, with this amount increased to $125 if more than 80 % of their team members did. This study builds upon that prior work, and enhances our understanding of designing individual vs. team-

**Table 3. Adjusted Daily Step Differences Between Study Arms During the Intervention and Follow-up Periods**

| Model* | Arm Comparison | Intervention (Weeks 1–13) | | Follow-up (Weeks 14– 26) | |
|---|---|---|---|---|---|
| | | Difference in Daily Steps (95 % CI) | p Value | Difference in Daily Steps (95 % CI) | p Value |
| Main Model | Individual incentive vs. control | 602 (-393, 1596) | 0.24 | 405 (-668, 1479) | 0.46 |
| | Team incentive vs. control | 193 (-819, 1205) | 0.71 | 10 (-1063, 1084) | 0.98 |
| | Combined incentive vs. control | 1446 (448, 2444) | 0.005 | 1077 (7, 2146) | 0.049 |
| | Team incentive vs. individual incentive | -409 (-1370, 553) | 0.40 | -395 (-1433, 643) | 0.46 |
| | Combined incentive vs. individual incentive | 844 (-102, 1791) | 0.08 | 671 (-363, 1705) | 0.20 |
| | Combined incentive vs. team incentive | 1253 (288, 2218) | 0.01 | 1066 (32, 2100) | 0.04 |
| Main Model—Adjusted by device | Individual incentive vs. control | 628 (-322, 1577) | 0.20 | 372 (-675, 1420) | 0.49 |
| | Team incentive vs. control | 264 (-702, 1231) | 0.59 | 41 (-1006, 1088) | 0.94 |
| | Combined incentive vs. control | 1378 (424, 2331) | 0.005 | 985 (-60, 2029) | 0.06 |
| | Team incentive vs. individual incentive | -364 (-1282, 554) | 0.44 | -332 (-1345, 682) | 0.52 |
| | Combined incentive vs. individual incentive | 750 (-155, 1654) | 0.10 | 612 (-397, 1622) | 0.23 |
| | Combined incentive vs. team incentive | 1113 (190, 2037) | 0.02 | 944 (-67, 1955) | 0.07 |
| Main Model—Adjusted by device and excluding step counts less than 1000 | Individual incentive vs. control | 632 (-254, 1518) | 0.16 | 381 (-587, 1349) | 0.44 |
| | Team incentive vs. control | 302 (-601, 1205) | 0.51 | 98 (-870, 1065) | 0.84 |
| | Combined incentive vs. control | 1227 (339, 2115) | 0.01 | 815 (-148, 1779) | 0.10 |
| | Team incentive vs. individual incentive | -330 (-1184, 524) | 0.45 | -284 (-1221, 653) | 0.55 |
| | Combined incentive vs. individual incentive | 595 (-244, 1435) | 0.16 | 434 (-498, 1366) | 0.36 |
| | Combined incentive vs. team incentive | 925 (67, 1783) | 0.03 | 718 (-215, 1651) | 0.13 |

**Main model adjusts for repeated measures of daily participant step counts and for temporal trends by week using all collected data*
*vs. = versus; CI = confidence interval; device refers to type of smartphone*
*Values are presented as the difference between the intervention arm and control; CI = confidence interval*
*Grey highlighting indicates meeting significance threshold of $p < 0.0167$ for primary comparison to control and $p < 0.0083$ for secondary comparison between arms*

based financial incentives to achieve higher peak levels of performance in the short-term for achieving a minimum level of daily physical activity, an example of a behavior that requires ongoing effort and sustained engagement. These new insights develop evidence that can be built upon in future studies to further refine incentive design to focus on longer-term outcomes.

There are several important implications for the design of physical activity interventions and wellness programs more broadly. First, physical activity interventions have often been challenged by the need to accurately measure and record data from daily behaviors.[49–52] Prior studies have relied mostly on either self-reported activity.[52] In this study, physical activity was measured using smartphones, which are already in possession by two-thirds of US adults,[29,30] but have not previously been well evaluated.[53] Our study demonstrates that using smartphones for activity tracking may be a scalable method to deploy physical activity interventions in real-word settings.

Second, while technology may help to facilitate monitoring of outcomes, it is the behavioral intervention strategies that will be critical to driving ongoing engagement and behavior change.[27] Financial incentives in this study were designed using insights from behavioral economics to leverage individuals' tendencies to avoid regret, overestimate small probabilities, and to be more engaged by variable reinforcement.[21,22,54] Our finding that the combined incentive was most effective suggests that team-based incentives may be better designed if they balance rewarding individual accomplishments and reinforcing accountability and peer support to the team. While individual rewards have been shown in a variety of contexts to be effective, they may have been less effective here because in the context of a team-based structure they did not provide adequate social reinforcement.[24,27,48]

Third, while sedentary individuals may benefit the most from increased physical activity and the workplace may be an important setting to identify and target these individuals,[8–14] there is a lack of evidence of effective programs to change sedentary behaviors.[55–57] In this study, participants in the control arm had mean daily step counts below the national average, supporting our hypothesis that this study population may be more sedentary.[36,37] Among participants in this study, 70 % had a BMI > 25 (overweight) and 39 % had a BMI > 30 (obese); further indication that these participants may be relatively sedentary.[58] Nevertheless, participants had a high engagement rate: 96.4 % of them completed the 26-week study despite no financial incentive of any kind during the follow-up period. This success may be due to the smartphone-based approach to data collection, which required little additional individual effort.

Future studies might compare different methods of using combined incentives to test the optimal magnitude and frequency of incentives. Social incentives such as accountability and peer support may be further tested by comparing team-based designs (such as those used in this study) to participating alone. While step counts are an important metric of activity, future studies might test physical activity programs that increase activity duration and allow for other types of activity besides steps such as swimming or biking.

Our study is subject to several limitations. First, participants were from a single organization in the same city, which may limit generalizability. Second, participants in this study were required to have a smartphone, potentially making participation less accessible to those without these devices. Third, participants' physical activity was not tracked when they were not carrying their smartphones, and captured physical activity levels may be lower than actual activity. In addition, we assumed that the smartphones were only carried by the participants themselves. However, at the end of the intervention period, about 92 % of respondents stated that they carried their smartphone most or all of the time. Fourth, we did not obtain data on baseline step counts; however, randomization resulted in study arms that were well balanced, and therefore outcomes between arms may well reflect the differential effectiveness of interventions. In addition, self-reported physical activity did not differ between arms; however, these data appear to reflect over-estimates of baseline activity as study outcome data reflect that this is a more sedentary population than participants initially reported. Fifth, as previously noted, a programming error led to winning frequencies lower than intended. If participants adjusted their expectations based on the rate at which they won, incentive arm participants could be less motivated to walk relative to how much they might have walked if the incentive were delivered as designed. However, these differences were subtle and likely imperceptible to participants, given the small differences in payout amounts. This error is conservative in its main effect, strengthening the observation that the combined incentive is superior to control, but tempering our ability to draw definitive conclusions about the effectiveness of the individual and team incentives when used alone. Sixth, physical activity levels peaked early during the intervention period and then declined over the rest of the study for all arms. Further study is necessary to determine how to sustain higher rates of physical activity over a longer time period.

## CONCLUSIONS

Despite many associated health benefits, less than half of adults in the US attain the minimum recommended level of physical activity. In this study, a team-based physical activity intervention using a combination of individual and team incentives nearly doubled the mean proportion that achieved the goal during the intervention period. Our findings may give promise to using smartphones to track outcomes in behavioral interventions, and should be evaluated in broader populations to inform scalable applications to increase physical activity.

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***Compliance with Ethical Standards:***

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