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Less carrot more stick: promoting health behavior change with deposit contracts

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Chapter 3

Less stick more carrot? Increasing the uptake of deposit contract financial incentives for physical activity

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Abstract

Background: Financial incentives are a promising tool to help people increase their physical activity, but they are expensive to provide. Deposit contracts are a type of financial incentive in which participants pledge their own money. However, low uptake is a crucial obstacle to the large-scale implementation of deposit contracts. Therefore, we investigated whether (1) matching the deposit 1:1 (doubling what is deposited) and (2) allowing for customizable deposit amounts increased the uptake and effectiveness of a deposit contract for physical activity.

Methods: In this randomized controlled trial, 137 healthy students (age M = 21.6 years) downloaded a smartphone app that provided them with a tailored step goal and then randomized them to one of four experimental conditions. The deposit contract required either a €10 fixed deposit or a customizable deposit with any amount between €1 and €20 upfront. Furthermore, the deposit was either not matched or 1:1 matched (doubled) with a reward provided by the experiment. During 20 intervention days, daily feedback on goal progress and incentive earnings was provided by the app. We investigated effects on the uptake (measured as agreeing to participate and paying the deposit) and effectiveness (measured as participant days goal achieved).

Findings: Overall, the uptake of deposit contracts was 83.2%, and participants (n = 113) achieved 14.9 out of 20 daily step goals. A binary logistic regression showed that uptake odds were 4.08 times higher when a deposit was matched (p = .010) compared to when it was not matched. Furthermore, uptake odds were 3.53 times higher when a deposit was customizable (p = .022) compared to when it was fixed. Finally, two-way ANCOVA showed that matching (p = .752) and customization (p = .143) did not impact intervention effectiveness.

Conclusions: We provide the first experimental evidence that both matching and customization increase the uptake of a deposit contract for physical activity. We recommend considering both matching and customization to overcome lack of uptake, with a preference for customization since matching a deposit imposes significant additional costs. Future research should investigate which user characteristics are predictive of deposit contract uptake and effectiveness.

Pre-registration: OSF Registries, https://osf.io/cgq48

Introduction

Although many people are aware of the benefits of physical activity and want to be (more) physically active, many people do not achieve sufficient physical activity (Rhodes & de Bruijn, 2013). This finding has been coined the intention-behavior gap and has been found for various health behaviors (Sheeran & Webb, 2016), including physical activity (Rhodes & de Bruijn, 2013). Insights from behavioral economics help explain what causes the intention-behavior gap, and how interventions can be designed to help bridge this gap. A key insight from behavioral economics is that people are present biased; they are more strongly driven by consequences in the here and now than they are by the long-term consequences of their decisions (Laibson, 1997). Present bias can frustrate goal pursuit for physical activity (Hunter et al., 2018), for example because someone overweighs the short-term (negative) consequences of physical activity (e.g., sweating) to the long-term (positive) consequences (e.g., lose weight). Financial incentives are thought to help people overcome initial reluctance towards desired behavior by introducing a monetary benefit in the here and now. Financial incentives are often added as a supplement to behavior change interventions and have proven to be effective for promotion of a wide range of health behaviors, such as improving diet (Kurti et al., 2016), combating substance use (Kurti et al., 2016), increasing physical activity (Mantzari et al., 2015; Mitchell et al., 2019), weight loss (Kurti et al., 2016), smoking cessation (Giles et al., 2014; Mantzari et al., 2015), and increasing vaccination uptake (Giles et al., 2014). A meta-analysis (N = 6074) shows that, with an average financial incentive of about US $1.50 per day per person (at the time of writing this translated to €1.51), financial incentive interventions increase daily step counts by about 600 steps (or 10-15% increase compared to baseline) during active intervention (Mitchell et al., 2019). Although the evidence base for the short-term effectiveness of financial incentives is convincing, evidence for maintenance of behavior change after incentive removal is mixed. Mantzari et al. (2015) showed that, also for physical activity, behavioral effects dissipate within three months after removal of incentives. On the contrary, more recent meta-analyses of interventions for physical activity by Mitchell et al. (2019) showed sustained effects 3-6 months post incentive removal. Another recent meta-analysis by Boonmanunt et al. (2022) showed some evidence of behavior change maintenance for physical activity, but only when incentives were self-funded by participants in the form of deposit contracts. It appears that financial incentives are effective to promote short-term initiation of physical activity, but it is uncertain whether incentives promote long-term maintenance of physical activity. If financial incentives promote initiation, but not long-term maintenance of physical activity, offering them to a large population requires significant and sustained funding from intervention providers. This limits opportunities for large-scale implementation (Jeffery, 2012).

Fortunately, certain financial incentives avoid issues with external funding and might have additional benefits. At least two types of financial incentives (carrots and sticks) can be distinguished based on their 'direction'. In line with the framework provided by Adams et al. (2014), we define a carrot as a reward incentive that provides the opportunity for a positive gain (compared to the pre-intervention status quo) contingent on performing healthy behavior. Thus, a carrot incentive involves the introduction of a pleasant stimulus (in our case gaining money) to increase behavior (i.e., positive reinforcement) (Burns & Rothman, 2018). An example of a carrot is when people receive a financial reward for achieving a daily step goal. We define a stick as a loss incentive that creates the risk of a negative loss (compared to the pre-intervention status quo) which can be avoided by performing healthy behavior. Thus, a stick incentive involves the alleviation of an aversive stimulus (in our case loss of money) to increase behavior (i.e., negative reinforcement) (Burns & Rothman, 2018). An example of a stick is a deposit contract in which people deposit their own money and can earn it back contingent on behavior change (Stedman-Falls & Dallery, 2020). Importantly, we only focus on negative and positive reinforcement, since we are interested in finding ways to increase physical activity. Punishment involves decreasing behavior and falls outside our current scope. Importantly, different types of financial incentives can lead to different reactions among the people who are targeted by them. For example, Tannenbaum et al. (2013) have shown that stick, but not carrot, incentives were evaluated especially negatively by overweight employees. Therefore, caution is warranted when implementing stick financial incentives.

A crucial benefit of deposit contracts is that the financial incentive, in this case, is (partially) provided by the person attempting the behavior change and thus does not require external funding. Besides this implementation advantage, while both rewards and deposit contracts bring an incentive into the present, a deposit contract brings a risk of loss into the present. A deposit contract should thus be more effective because it capitalizes on loss aversion (Burns & Rothman, 2018). Loss aversion is the tendency to assign larger weight to potential losses associated with behavior than to potential gains (Kahneman & Tversky, 1979). Previous research has shown that deposit contracts are effective in helping people lose weight (Kullgren, Troxel, et al., 2016; Sykes-Muskett et al., 2015), quit smoking (Halpern et al., 2015; Jarvis & Dallery, 2017) and increase their physical activity (Budworth et al., 2019; de Buisonjé et al., 2022; Burns & Rothman, 2018; Donlin Washington et al., 2016; Krebs & Nyein, 2021; Stedman-Falls & Dallery, 2020). In fact, recent meta-analysis shows that - in line with predictions from the theory of loss aversion - of different financial incentive structures, deposit contracts are the most effective financial incentive for improving healthy diet, weight control, and physical activity (Boonmanunt et al., 2022). Yet, in an experimental comparison of the effectiveness of rewards and deposit contracts for physical activity, de Buisonjé et al. (2022) did not find differences between rewards and deposit contracts. In this study, participants had to achieve daily

step goals for 20 intervention days. Therefore, de Buisonjé et al. (2022) measured short term effectiveness of adopting physical activity, but not long-term maintenance (see Dunton et al., 2022 for a discussion on the importance of discerning between these two conceptual operationalizations). Participants were randomized to either receive a reward, or to make a deposit of their own money before the intervention started. Furthermore, daily feedback on incentive earnings was provided and framed as either a loss or a gain. Whereas prior research showed that loss framed incentives are more effective than gain framed incentives (Patel et al., 2016), de Buisonjé et al. (2022) found loss frames to be less effective than gain frames. While deposit contracts were not superior to rewards in this study, the authors did find that deposit contracts had lower uptake than rewards (61.7% vs. 100%). This finding is consistent with research on the uptake of deposit contracts offered to employees in the workplace to increase gym attendance (12%) (Royer et al., 2015). It appears that deposit contracts are, at least, equally effective as reward incentives, but they have a (much) lower uptake.

Low uptake of deposit contracts is an important obstacle for large-scale implementation because those who might be most in need of intervention (e.g., lower socioeconomic subgroups) might not be reached by them. For example, deposit contracts might be less suitable for reaching participants with lower incomes because they are less able to deposit their own money into an intervention. Indeed, Raiff et al. (2013) found a relationship between participants' income and the amount they would be willing to deposit. Therefore, a "one-size-fits-all" deposit contract may not appeal to all participants equally (Raiff et al., 2013). A possible solution might be to offer a customizable deposit contract that allows participants to self-tailor the right deposit amount (Sykes-Muskett et al., 2015). Offering a customizable deposit amount (compared to a fixed amount) might lead to a higher uptake by allowing participants to select the most appropriate incentive amount, increase autonomy over the intervention, and, for example, allow participants to choose a small amount when they are less inclined to participate, thus removing a barrier for participation. We are not aware of studies that have directly tested this hypothesis. With regard to effectiveness, in weight loss, a meta-analysis shows that customizable deposit amounts are related to larger effectiveness (Sykes-Muskett et al., 2015). However, the authors noted that customizable deposit amounts also had higher payout frequencies, which made it impossible to disentangle the effects of customization and payout frequencies of the deposit. Finally, in two experiments on smoking cessation, Jarvis & Dallery (2017) employed customizable deposit contracts. Although the design of these experiments was not geared towards investigating uptake, and the experiments included few participants, promising preliminary results were found for acceptability and effectiveness (Jarvis & Dallery, 2017).

A second strategy to increase deposit contract uptake is matching a deposit 1:1 (doubling the deposit amount with an additional reward of equal size). A systematic

review shows that when deposit contracts are used in research, they are often combined with matching to increase uptake or deposit amount (Finkelstein et al., 2019). However, whether matching a deposit contract in fact increases uptake is unclear. In a study on deposit contracts for weight loss, Kullgren et al. (2016) did not find an effect of matching (1:1 or even 1:2) on the uptake or deposit amount. On the other hand, in a feasibility study on deposit contracts for increasing physical activity, Budworth et al. (2019) provide evidence that matching a deposit increased deposit amount (which the authors considered a proxy for uptake) and increased effects on step counts. Furthermore, while matching is often used to increase uptake, it might also impact intervention effectiveness. Although evidence on the effect of matching on effectiveness is lacking, the study by Budworth et al. (2019) indicates that a combination of a deposit contract with a matched reward might be especially effective in increasing physical activity. Completely self-funded deposit contracts contain only negative reinforcement and matching a deposit contract introduces elements of positive reinforcement. Finally, matching a deposit increases the size of the incentive (in fact, doubling it) and should thus logically lead to greater incentive effects. Indeed, the meta-analysis by Finkelstein et al. (2019) shows that greater incentive sizes are related to larger intervention effects.

The current study

This study aims to identify strategies that help increase the uptake of deposit contracts. Although both customization and matching of deposit contracts seem to hold potential, there is limited evidence for their effect on uptake and effectiveness of behavioral adoption. Therefore, we investigate whether matching and customization influence the uptake and effectiveness of behavioral adoption of a deposit contract for physical activity. We expect that both matching (vs not matching) and customization of deposit amount (vs fixed amount) increase uptake (H1, H2) and effectiveness of behavioral adoption (H3, H4) of a deposit contract for physical activity. Furthermore, we explore whether matching (vs not matching) a customizable deposit increases the amount participants choose to deposit (H5). Finally, we explore whether (in not matched conditions) customization of deposit amount (vs fixed amount) leads to a smaller deposit amount (H6).

Methods

Participants

We recruited healthy participants between 18 and 30 years old through posting flyers on campus, social media and through a university research participation system (SONA). Participants had to be interested in improving their physical activity, own a smartphone

and be proficient in English. A priori sample size calculations with G*Power (Faul et al., 2007) suggested a minimum sample size of 128 (i.e., 32 participants per group) for detecting a between conditions difference in effectiveness with a medium effect size (f = .25), 80% power and an alpha of .05 (ANOVA with 4 groups and numerator df of 1). Based on a study with similar design (de Buisonjé et al., 2022) we expected a 25% dropout during onboarding. We, therefore, aimed to recruit at least 160 participants. Additionally, we expected only 50% uptake in the most critical condition (fixed/not matched). For analysis of effectiveness, therefore, we aimed to recruit at least 320 participants in total. During the screening, participants filled in the Physical Activity Readiness Questionnaire (PAR-Q) (Thomas et al., 1992) and were excluded if they reported any medical condition that could hinder their physical activity. A detailed description of how participants flowed through the study, including reasons for exclusion and dropout, is provided in *Appendix A*. All participants who completed the study had a chance to win one of three grand prizes (3 x Fitbit Inspire device worth €100) in a raffle. Participants who were first-year psychology students additionally received research credits (needed to complete their first year). Before the start of the study, we obtained informed consent from a Psychology Research Ethics Committee.

Materials

The Benefit Move smartphone application

The intervention for this study was delivered entirely online via the Benefit Move application, which participants downloaded on their smartphones. The Benefit Move application had two main functions: (1) objectively measuring physical activity and (2) communicating with the participant. We have described the Benefit Move application in more detail elsewhere (de Buisonjé et al., 2022).

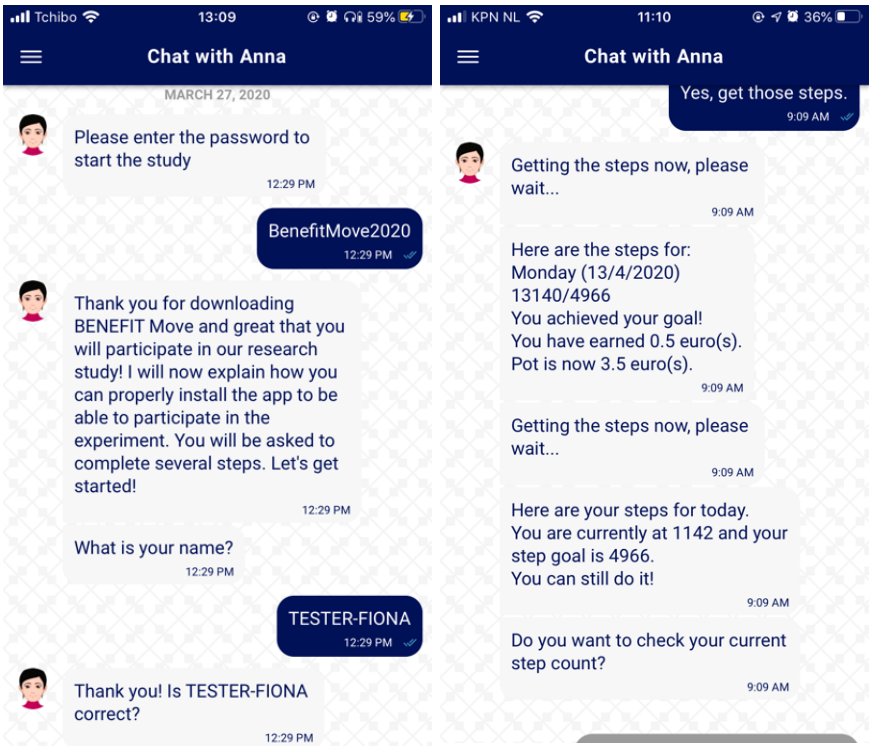

Figure 1. Impression of the Benefit Move application

Procedure

After completing screening and informed consent, participants downloaded the Benefit Move app from the app store on their smartphone and filled in the baseline survey (for more detail, see *Appendix B: baseline survey*). After completing the baseline survey, participants received a tailored step goal based on their 7-day historic daily step average which was retrieved from Google Fit or Apple Health. We used tailoring of step goals because individualized and realistic goals should increase intervention effectiveness (Mitchell et al., 2019). For practical reasons we tailored goals on a 7-day step history. Although this method should accurately estimate habitual activity levels of individuals (Yao et al., 2021), temporal or meteorological factors could impact baselines (Togo et al., 2005). If historic data could be retrieved, participants were assigned a challenging, but achievable goal that was 120% of the historic daily step average (tailored goals ended up being set at M = 4814 steps/day, SD = 2982), as authors of a meta-analysis recommend intervention goals at 10-15% over baseline levels (Mitchell et al., 2019). For example, someone who took on average 5000 steps per day in the 7 days prior to goal setting would automatically receive a 6000 steps daily step goal. If no historic data

was available, the participant was assigned a default step goal of 4667 steps per day. This default goal was based on the mean historic step data from a previous experiment with a similar design and sample, performed by the same researchers (see, de Buisonjé et al., 2022). In that earlier study we found that, for participants who had historic data available, the average tailored goal participants received (based on the same 120% of baseline step count rule) was 4667 steps per day.

After tailored goals were provided to participants, we explained the rationale behind using a commitment contract: *"We all have goals, and we all know what a struggle it can sometimes be to achieve them. We lead busy lives that are filled with distractions and temptations, which can be obstacles between us and our goals. Therefore, to help you stick to your resolution and achieve your goal, we will offer you a commitment contract. A commitment contract is a binding agreement that you sign with yourself to help you achieve your goal. By putting some of your own money on the line, the contract will help you stay committed during those difficult moments of distraction and temptation and turn your goal into reality. These ideas are backed by behavioural science."*. After reading this explanation, all participants were required to provide a monetary deposit via a digital bank transfer before the experiment started. We told participants that the amount they would get would depend on their performance during the intervention. Still, to avoid financial harm, in reality, the full amount was refunded to all participants, and we explained this to participants during the debriefing. Specifics of the deposit differed per condition and are further explained below.

All participants started simultaneously with the 20-day intervention on Monday, November 23th 2020, at 9 AM. The intervention primarily aimed to improve uptake of the deposit contract. In addition, the intervention aimed to improve the adoption, but not maintenance, of physical activity behavior change (see Dunton et al., 2022 for a discussion on the importance of these conceptual operationalizations). Therefore, an intervention duration of 20 days was considered sufficient. Due to the COVID-19 pandemic, a partial lockdown was issued by the Dutch government on the 14th of October 2020. This lockdown was intensified with a stay-at-home advice from the 2nd of November 2020 until a full lockdown was finally issued on the 14th of December 2020. Onboarding for this study (and retrieval of 7 days of historic step counts) was done from the 19th of November onwards until the active study phase started on November 23rd. The active intervention phase lasted until 13 December 2020. During the intervention, participants received daily feedback about their goal progress and incentive earnings. It is possible that estimates of baseline activity and observed activity levels during the intervention were lower than they would be under normal circumstances. After participants completed the 20-day intervention, they filled in the final survey (for more detail, see *Appendix C: final survey*). We then debriefed participants about the deceptive element around their deposit and informed them that they would receive their payment within 2 weeks after the experiment ended.

Study conditions

We employed a 2: deposit customization (fixed/customizable) x 2: deposit matching (not matched/matched) between-participants design. The application automatically (and thus blindly) generated a number from 1 to 4, which allocated the participant to one of the four conditions in the following ratios:

- Condition 1 (Fixed/not matched): 60 participants (30.7%) randomized (expected uptake: 50%)
- Condition 2 (Fixed/matched): 45 participants (23.1%) randomized (expected uptake: 75 %)
- Condition 3 (Customizable/not matched): 45 participants (23.1%) randomized (expected uptake: 75 %)
- Condition 4 (Customizable/matched): 45 participants (23.1%) randomized (expected uptake: 75 %)

Condition 1: Fixed/not matched condition.

After reading the rationale behind the commitment contract, participants were required to make a €10 deposit of their own money via bank transfer to improve their commitment to the challenge. Based on a pilot study and findings from a previous experiment (see, de Buisonjé et al., 2022) we decided that an incentive of 10 euro's (in the base condition of this study) would be sufficient to incentivize physical activity among students. Participants were informed that they would start with an empty pot and that for every successful goal achievement, a certain amount would be added to the pot. Nothing got added to the pot if they were not successful. They were told that the final amount in the pot would be returned to them after the intervention. The app prompt read: "*To improve your commitment to the challenge and help you achieve your goal you are now asked to deposit 10 euros"*. Each day a participant in this condition reached their goal, they earned back €0.50. The maximum cashback at the end of the study was €10.

After explaining their condition, we asked participants if they wanted to participate in this challenge. If they agreed, participants were sent a digital payment request via 'Tikkie' (a direct digital payment system commonly used in the Netherlands) in the app. Through this digital payment, participants directly transferred €10 of their funds to the experiment bank account. If participants could not use this automated payment system, they were required to manually transfer the amount. Participants were reminded to perform the payment via push message, text message, and e-mail reminders. Participants had 5 days to perform the deposit payment and were excluded from the intervention if no payment was received 12 hours before the start of the intervention.

Condition 2: Fixed/matched condition.

Participants in this condition followed the same overall procedure as did participants in the fixed/not matched condition. However, in this condition the deposit made by the participant was matched (doubled) by the experiment. Therefore, participants in this condition could not only earn their own deposit back but could also earn extra money. The app prompt read: "*To improve your commitment to the challenge and help you achieve your goal you are now asked to deposit 10 euros. To further support your motivation, we will double the amount that you deposit and provide you with an extra 10-euro reward. You can earn back your 10-euro deposit and earn 10 euros extra by reaching your daily step goals".* In this condition, for each day a participant reached their step goal, they earned back €1. The maximum cashback at the end of the study therefore was €20.

Condition 3: Customizable/not matched condition.

Instead of requiring a fixed amount of €10 to be deposited, participants were given the opportunity to choose their own deposit amount between €1-20. The app prompt read: "*To improve your commitment to the challenge and help you achieve your goal you are now asked to deposit any amount between 1 and 20 euros. You can choose which amount would be best to support your motivation, but we recommend you pick an amount that is large enough to be motivating for you".* In this condition, for each day a participant reached their step goal, they earned back between €0.05 and €1, depending on their self-chosen deposit amount. The minimum and maximum cashback at the end of the study were €1 and €20, respectively.

Condition 4: Customizable / Matched condition.

Again, participants in this condition were asked to choose a custom deposit amount between €1-20, but now their chosen amount was matched (doubled) by the experiment. The app prompt read: *"To improve your commitment to the challenge and help you achieve your goal you are now asked to deposit any amount between 1 and 20 euros. You can choose which amount would be best to support your motivation, but we recommend you pick an amount that is large enough to be motivating for you. To further support your motivation, we will double the amount that you deposit and provide you with a maximum of 20 euros extra reward. You can earn back your deposit and earn a maximum of 20 euros extra by reaching your daily step goals".* In this condition, for each day a participant reached their step goal, they earned back between €0.10 and €2, depending on their self-chosen deposit amount. The minimum and maximum cashback at the end of the study were €2 and €40, respectively.

Statistical analysis

The primary outcome was uptake of the intervention and defined as explicitly agreeing to participate in the challenge and paying the deposit (yes/no). Uptake was analyzed with a binary logistic regression. In the model, we specified both main effects of the predictors matching (H1) and customization (H2). The secondary outcome was effectiveness of behavioral adoption measured through mobile registration of step count data and defined as the number of days (0-20) the step goal was achieved. Effectiveness of behavioral adoption was analyzed with a two-way ANCOVA with baseline steps as a covariate. In the model, we specified the main effects of matching (H3) and customization (H4) and their interaction. A significant interaction effect between the two factors was followed by a simple slopes analysis. We report the main analyses for effectiveness of behavioral adoption based on models that include baseline step counts as a covariate. The pattern of the results was similar to models without the covariate, but the models gained accuracy by including it. Finally, we performed two separate one-way between participants ANOVAs with deposit amount as the dependent variable to investigate the effect of matching (among customizable deposits) (H5) and customization (among not matched deposits) (H6) on deposit amounts. Data analysis was done with IBM SPSS Statistics for Mac, version 28. We dealt with missing cases by using pairwise exclusion and used the standard p <.05 criterium for determining statistical significance. For ANOVA and ANCOVA, we considered an effect size small when $\eta p2 > 0.01$, medium when > 0.06 and large when > 0.14 (Cohen, 1988).

Results

Descriptives

We analyzed data on the uptake of (N = 137) participants with a mean age of 21.58 years (*SD* = 2.55) of which 81% identified as female. Most participants had Dutch nationality (51.8%), were students (94.9%), reported having an income similar to their peers (62.8%), and considered themselves at appropriate body weight (66.4%). See *Table 1* for more detail on the characteristics of the sample (we report demographic information per study arm in Appendix D). After they received instructions on their condition, 7 participants explicitly refused the challenge, and 16 participants did not pay their deposit in time. Therefore, uptake across all conditions was 83.2%. See *Table 2* for more detail on the uptake. Furthermore, 1 participant did not retrieve steps on any day of the intervention. Therefore, data of (N = 113) participants was analyzed for effectiveness of behavioral adoption, which approached the a priori power analysis requirement of 128 participants (see *methods* for rationale). 39 participants received additional research credits that first year psychology students need for completing their study (see Appendix E for

a sensitivity check that shows these participants were slightly more successful in the intervention). Across all conditions, a two-tailed paired sample t-test showed that daily step counts increased from 3337 (*SD* = 2720) steps at baseline to 5531 (*SD* = 3004) steps during intervention, $p < .001$, *Cohen's d* = .896. See *Table 3* for more detail on effectiveness of behavioral adoption.

Table 1. Sample characteristics (N = 137)

Variable	
Age in years	Mean, SD[a]
	21.58 (2.55)
Sex	n (%)
Male	26 (19.0%)
Female	111 (81.0%)
Nationality	n (%)
Dutch	71 (51.8%)
German	16 (11.7%)
Slovenian	24 (17.5%)
Other	26 (19.0%)
Work	n (%)
Student no job	62 (45.3%)
Student with job	68 (49.6%)
Working part time	3 (2.2%)
Working full time	3 (2.2%)
Don't want to answer	1 (0.7%)
Self-perceived income	n (%)
Less than my peers	20 (14.6%)
Same as my peers	86 (62.8%)
More than my peers	21 (15.3%)
Don't want to answer	10 (7.3%)
Self-perceived weight	n (%)
Underweight	-
A bit underweight	6 (4.4%)
Appropriate weight	91 (66.4%)
A bit overweight	33 (24.1%)
Overweight	7 (5.1%)
Don't want to answer	-

SD[a] = standard deviation

Hypothesis testing

Hypothesis 1-2: Matching and customization increase uptake

A binary logistic regression with uptake (yes/no) as the dependent variable showed that deposit matching (p = .010) and deposit customization (p = .022) were both significant predictors of uptake. The odds of uptake were 4.08 times (95% CI [1.39, 11.96]) higher when a deposit was matched (compared to when it was not matched), and the odds of uptake were 3.53 times (95% CI [1.20, 10.37]) higher when a deposit was customizable (compared to when it was fixed). In the not-matched conditions, 74.3% of participants accepted the intervention, compared to 92.5% in the matched conditions. In the fixed conditions, 75.7% of participants accepted the intervention, compared to 92.1% in the customizable conditions. See *Table 2* for a descriptive overview of the results on the uptake of the deposit contract.

Table 2. Descriptive overview of results on the uptake of the deposit contract (N = 137)

Variable	**Condition**				
	Fixed / not-matched	**Custom / not-matched**	**Fixed / matched**	**Custom / matched**	**Total**
N	41	29	33	34	137
Uptake	27 (65.9%)	25 (86.2%)	29 (87.9%)	33 (97.1%)	114 (83.2%)
Explicit refusal	5	-	2	-	7
Deposit not payed	9	4	2	1	16
Never retrieved steps	1	-	-	-	1
Goal type					
Tailored goals	25 (96.2%)	16 (64%)	25 (86.2%)	28 (84.8%)	94 (83.2%)
Default goals	1 (3.8%)	9 (36%)	4 (13.8%)	5 (15.2%)	19 (16.8%)

Note: data are frequencies (%).

Hypothesis 3-4: Matching and customization increase effectiveness of behavioral adoption

To test the effects of matching on effectiveness of behavioral adoption, a two-way ANCOVA with baseline step count as a covariate did not show a main effect of deposit matching $F(1, 108) = .100$, $p = .752$, $\eta p2 = .001$, indicating that matched deposits (M = 14.76 days goal achieved, SD = 5.29) were not more effective than not matched deposits (M = 15.08 days goal achieved, SD = 5.44). Secondly, we did not find a main effect of deposit customization $F(1, 108) = 2.18$, $p = .143$, $\eta p2 = .020$, indicating that customizable deposits (M = 14.29 days goal achieved, SD = 5.51) were not more effective than fixed deposits (M = 15.55 days goal achieved, SD = 5.12). Because there were some indications

that the normality of the residuals was violated, a non-parametric analysis with Kruskall-Wallis was done and confirmed these findings (additional checks to test the sensitivity of the main findings are reported in *Appendix E*). Thirdly, the interaction effect of deposit matching X deposit customization was marginally significant, $F(1, 108) = 3.52$, $p = .063$, $\eta p2 = .032$. We performed simple slope analyses by splitting the file on matching. A separate ANOVA among not matched deposits ($F(1, 49) = 4.79$, $p = .033$, $\eta p2 = .089$) showed lower effectiveness of customizable deposits ($M = 13.44$ days goal achieved, $SD = 5.95$) compared to fixed deposits ($M = 16.65$ days goal achieved, $SD = 4.46$). A separate ANOVA among matched deposits ($F(1, 60) = 0.08$, $p = .776$, $\eta p2 = .001$) did not show a difference between customizable deposits ($M = 14.94$ days goal achieved, $SD = 5.15$) and fixed deposits ($M = 14.55$ days goal achieved, $SD = 5.53$). These results indicate that customizable deposits (compared to fixed deposits) led to reduced effectiveness of behavioral adoption, but only when the deposits were not matched. Sensitivity checks revealed that when *goal type* (default/tailored) and whether participants received *research credits* for participation (yes/no) were added to the model, the previously marginally significant interaction effect between deposit matching X deposit customization became non-significant (see Appendix G for more detail). See *Table 3* for a descriptive overview of the results on effectiveness of behavioral adoption.

Table 3. Descriptive overview of results on effectiveness of behavioral adoption and intervention cost (N =113)

Variable	**Condition**				
	Fixed / not-matched	**Custom / not-matched**	**Fixed / matched**	**Custom / matched**	**Total**
N	26	25	29	33	113
Baseline step count	3925 (3631)	2850 (2739)	3226 (2249)	3340 (2251)	3337 (2720)
Assigned step goal	4889 (4250)	5101 (2014)	4515 (2192)	4715 (2082)	4789 (2718)
Intervention step count	6012 (3407)	5225 (3081)	5274 (2771)	5611 (2889)	5531 (3004)
Days goal achieved	16.65 (4.46)	13.44 (5.95)	14.55 (5.53)	14.94 (5.15)	14.90 (5.34)
Deposit amount (euro)	10.00 (0.00)	9.08 (5.58)	10.00 (0.00)	16.12 (5.84)	11.58 (5.01)
Total incentive amount (euro)	10.00 (0.00)	9.08 (5.58)	20.00 (0.00)	32.24 (11.68)	18.86 (11.76)
Intervention cost (-) or earning (+) for intervention provider, per participant	+€1.68	+€2.98	-€4.55	-€7.96	-€2.47

Note: data are frequencies and means (SD)

Hypothesis 5-6: The effect of matching and customization on deposit amounts

To explore the effects of matching and customization on deposit amounts, we performed two separate ANOVAs. Firstly, a one-way between participants ANOVA among customizable deposit conditions showed an effect of deposit matching $F(1, 56) = 21.47$, $p < .001$, $\eta p2 = .277$, indicating that customizable deposit amounts increased when matched ($M = 16.12$ euro, $SD = 5.84$) compared to when they were not-matched ($M = 9.08$ euro, $SD = 5.58$). Secondly, a one-way between participants ANOVA among not-matched deposit conditions did not show an effect of deposit customization $F(1, 49) = .707$, $p = .405$, $\eta p2 = .014$, indicating that not-matched deposit amounts did not decrease when customizable ($M = 9.08$ euro, $SD = 5.58$) compared to when they were fixed ($M = 10.00$ euro, $SD = 0.0$).

Exploratory analyses

Exploring the effects of goal type on uptake, deposit amounts, and effectiveness of behavioral adoption

Uptake was 74.1% among those who received default goals and 85.5% among those who received tailored goals. A chi-square test of independence showed that uptake did not differ between participants who received default versus tailored goals ($N = 137$; $\chi 2 = 2.01$; $p = .156$; Cramer's $V = .121$). In customizable deposit conditions, goal type had a marginally significant effect on deposit amount, $F(1, 56) = 3.56$, $p = .064$, $\eta p2 = .060$. Participants who received a tailored goal ($M = 14.00$ euro, $SD = 6.31$) had marginally significantly higher deposit amounts than participants who received a default goal ($M = 10.21$ euro, $SD = 7.23$). Goal type had a significant effect on effectiveness of behavioral adoption, $F(1, 111) = 6.08$, $p = .015$, $\eta p2 = .052$, indicating that participants who received a tailored goal ($M = 15.45$ days goal achieved, $SD = 4.89$) were more successful than participants who received a default goal ($M = 12.21$ days goal achieved, $SD = 6.68$).

Exploring the effects of the intervention on motivation measured with the TSRQ

For exploratory purposes we administered the Treatment Self-Regulation Questionnaire (TSRQ) for physical activity. The TSRQ has been validated for physical activity (Levesque et al., 2007), and measures people's motivation for being more physically active. The overall picture that emerges from the exploratory analyses with the TSRQ is that motivation is not affected by the intervention, and does not differ for those with and without uptake (for more detail see Appendix F).

Discussion

This is the first study to show that both matching and customization of deposits increased uptake of a deposit contract intervention aimed at improving physical activity among a healthy student population. Uptake increased from 66% (when deposit contracts were not matched and not customizable) to over 86% in conditions that were matched and/or customizable. Overall, the intervention was highly effective in increasing short term increases in step counts. Participants across conditions achieved about 75% of their daily step goals, and daily step counts increased from 3337 steps at baseline to 5531 steps during the intervention. Yet, contrary to what we expected, matching and customization did not lead to higher effectiveness of the deposit contract. Furthermore, there were indications that customizable deposits (compared to fixed deposits) reduced effectiveness, but only when the deposits were not matched. This finding could not be explained by lower deposit amounts because customizable amounts did not decrease compared to the fixed amount used in this study. Finally, matching a customizable deposit did lead to higher deposit amounts. To the best of our knowledge, these findings provide the first experimental evidence that matching and customization of a deposit contract for physical activity increase uptake.

Firstly, we found that matching increased the uptake of the deposit contract. We propose that matching increases the attractiveness of the deposit contract by adding elements of positive reinforcement to the existing negative reinforcement that is already present in a deposit contract (Burns & Rothman, 2018). Our finding contrasts with the study by Kullgren et al. (2016), who did not find increased uptake of a deposit contract for weight loss when it was matched. This was the case even when the deposit was matched 1:2, thus tripling (instead of doubling) the total incentive size. In this study, people participated in a 24-week weight loss challenge and could optionally decide to also make monthly deposits for extra commitment. Kullgren et al. (2016) interviewed participants to investigate the reasons for making or not making deposits and found that, respectively, a desire for extra motivation and a lack of confidence in meeting the weight loss goals were the primary arguments they encountered. Behavioral control over weight loss (indirect through eating and physical activity) may differ from that over physical activity (direct) in the sense that people are more confident that they can increase their physical activity for 20 days than they are confident that they can achieve their weight loss goal in 24 weeks. A difference in confidence in meeting the intervention goals across studies might explain why in our study, matching did affect uptake.

To the best of our knowledge, the current study is the first to show that the uptake of a deposit contract is increased by matching the deposit. Importantly, in our study, the two matched conditions cost the intervention provider, on average, €4.6 and €8 per participant for the entire intervention. These costs associated with providing matching

of deposit contracts are an important downside that hinders large-scale implementation because they require significant external funding. It is important to understand the subgroup of participants who are persuaded to use a deposit contract only when matching is provided. It is possible that matching convinces precisely those who are in need of intervention (e.g., who have lower confidence that they can achieve intervention goals) and this could justify the extra funding needed to provide matching of a deposit contract. Although we measured several individual characteristics (e.g., gender, income, weight and motivation), we were underpowered to perform moderation analyses of uptake, partly because our sample was relatively homogeneous. Future work with a larger, more diverse sample should measure demographic and psychological characteristics (e.g., gender, income, motivation, self-efficacy) and investigate why, how, and for whom matching is effective in increasing uptake of deposit contracts.

Secondly, we found that customization increased uptake of the deposit contract. It is possible that offering participants the opportunity to self-tailor the deposit amount to their preferences might have increased autonomy over the intervention and therefore made the deposit contract more attractive. Although we did not test this with the current study design, the idea that autonomy (over the intervention or over the intended behavior change itself) is important, and could moderate incentive effects, has been stressed by others (Kullgren, Williams, et al., 2016; Moller et al., 2019). Exploratory analyses (see Appendix F) did show that customization (and matching) did not affect motivation to be more physically active. Important to consider here is that, although this impacted all conditions equally, we used autonomy supportive (rather than controlling) language to explain the rationale behind the deposit contract. To be specific, we told participants: *"To improve your commitment to the challenge and help you achieve your goal you are now asked to deposit 10 euros"*. Others have shown that seemingly small choices in how incentives are framed can influence incentive effects (Thirumurthy et al., 2019), and the rationale we provided to participants for using a deposit contract might have increased the uptake and effects we found. Future research should investigate how deposit contracts can be designed for optimal autonomy by allowing for customization of deposit amounts and use of autonomy supportive language. Furthermore, when participants were reluctant to participate, perhaps because they were not confident in their ability to achieve the intervention goals (Kullgren, Troxel, et al., 2016), a customizable deposit contract allowed for making small deposits instead of rejecting the intervention as a whole. Although on average we did not find lower deposit amounts for customizable deposit contracts, it is possible that reluctant participants ended up participating because they were able to choose smaller deposit amounts. We are not aware of other research that directly compared fixed deposit contracts with customizable ones. The finding that offering customizable deposit contracts increases uptake is important because customization does not increase intervention costs, which is an important benefit for large scale implementation.

Thirdly, the intervention was effective in helping participants increase their step count. We explain this finding through the idea that deposit contracts capitalize on present bias and loss aversion by introducing an immediate monetary incentive for being physically active. Overall, the total incentive was €0.94 per day and the intervention helped participants increase their step count from 3337 steps per day at baseline to 5531 steps per day during the intervention. That is a 66% increase in step count and resulted in participants achieving their step goal on around 15 out of 20 possible days (75% successful). A meta-analysis has shown that financial incentive interventions with an average incentive of US $1.50 per day help increase step counts by about 15-20% (Mitchell et al., 2019). Commitment contracts without financial incentives have previously been shown to increase goal achievement (Lesser et al., 2018), with larger effects found when financial deposit were included in the contract. Although we cannot ascertain which active ingredients of our intervention (goal setting, daily feedback, deposit contract) produced the effects, it appears that the intervention was highly effective in promoting behavioral adoption of physical activity. Importantly though, and contrary to what we expected, matching and customization did not lead to higher effectiveness of the deposit contract. It is surprising that participants in matched conditions (where the average incentive was €26.51) did not outperform participants in not matched conditions (where the average incentive was €9.55), since incentive size has previously been found to be related to intervention effectiveness (Finkelstein et al., 2019). A possible explanation is that a ceiling effect occurred and the fact that participants were required to make an actual monetary deposit before the intervention started already had such a strong effect on goal striving, that potential extra earnings through matching had no additional effect (besides increasing uptake of the intervention). Furthermore, we expected customization to increase effectiveness because a previous meta-analysis showed that self-tailored incentives for weight loss were more effective than researcher-tailored incentives (Sykes-Muskett et al., 2015). However, we did not find customizable deposit contracts to be more effective than fixed deposit contracts. On the contrary, there were indications that customizable deposit contracts, when no matching was provided, were less effective than fixed deposit contracts. Lower deposit amounts cannot fully explain this reduced effectiveness because deposit amounts did not differ significantly between customizable (€9.08) and fixed deposit contracts (€10). It is possible that the effects of both matching and customization were attenuated because a selection bias might have occurred. Both matching and customization increased uptake to over 86%, while uptake was about 66% in the fixed/not-matched condition. Future work with a larger sample should investigate which demographic and psychological characteristics (e.g., gender, income, motivation, self-efficacy) moderate deposit contract uptake, effectiveness, and the impact of deposit matching and customization.

With regards to deposit amounts, when a customizable deposit contract was matched, the deposit amount did significantly increase from €9.08 to €16.12. Although in the current study, this did not result in higher effectiveness, these results show that deposit amounts will increase when customizable deposit contracts are matched by the intervention provider. This finding is consistent with Kullgren et al. (2016) and Budworth et al. (2019) who also showed that matching increased deposit amounts. Logically, higher incentive amounts might lead to stronger intervention effects (Finkelstein et al., 2019).

Finally, we analyzed the effects of goal type (default/tailored) on uptake, effectiveness of behavioral adoption and deposit amounts. We found that goal tailoring (although it did not significantly impact uptake) may have had important benefits. People who received tailored goals did not receive easier (lower) goals than did those with default goals, but may have been tempted to deposit more money and did achieve more of the daily intervention goals. This finding supports the idea that tailoring of physical activity goals is important for intervention effectiveness (Neville et al., 2009).

Strengths and limitations

An important strength of this study is that we required all participants to make an actual financial deposit before the intervention started instead of mere loss framing a regular reward (Patel et al., 2016). Importantly, requiring a deposit also allowed us to investigate the uptake of deposit contracts for physical activity. Although we show that uptake was increased by both customization and matching, because we were underpowered to perform moderation analyses, the process through which these effects were achieved remains unknown, and should be studied in future research. Another limitation of this study is that our analysis of uptake might be biased by the fact that the informed consent form already mentioned the possibility that participants would be required to deposit €10 of their own money into the intervention. Possibly, the actual uptake of a deposit contract for physical activity is lower than our analyses suggest because some participants rejected the intervention before we had obtained informed consent (and could thus measure uptake). Future research should aim to capture uptake already at the level of informed consent. Furthermore, please note that the number of participants included in the comparisons was relatively small. Therefore, the results of this study should be interpreted with caution, and future work should be done to confirm our findings on uptake. With regards to the effects we found on step counts, because we included participants who were motivated to increase their physical activity, it is possible that the effects we found are inflated and might be smaller when assessed among the general public. Because our intervention consisted of a combination of goal setting, commitment contract, daily goal progress feedback and financial incentives, it is impossible to attribute the effects found to any one of these incentive components specifically. Additionally,

a partial lockdown and a stay-at-home advice due to the situation around COVID-19 were issued by the Dutch government around the time participants were onboarded and participated in the intervention. Although all conditions were probably impacted equally, a large part of the participants (60.2%) reported that the situation around COVID-19 indeed caused them to be less physically active than they are normally. Therefore, it is possible that estimates of baseline activity were lower than they would be normally, and consequently, intervention effects were larger than they would be under normal circumstances. Furthermore, the external validity of our findings is primarily restricted to healthy, young, female student populations. It is possible that older or more vulnerable populations respond differently to deposit contracts (and matching and customization). Additionally, since the intervention was delivered on a smartphone device, people who do not own smartphones could not be reached. An important limitation of using smartphone measurement of step counts, is that it is impossible to differentiate an increase in step count from an increase in smartphone wear time. Exploratory analyses show that it is likely that participants in this study indeed carried their smartphone more often due to the experiment (see Appendix E for more detail). Furthermore, part of our sample received research credits for participation in this study, and those participants were slightly more successful than participants who did not receive credits (see Appendix E for more detail). A final limitation of this work is that we only measured short-term effectiveness of behavioral adoption during a 20-day intervention period. Future studies with a longer intervention duration should measure how rates of goal achievement (and step counts) vary over time during and after the intervention period.

Implications

We provide the first experimental evidence that both matching and customization increase deposit contract uptake. Future work may study the process through which these effects occur and for whom precisely. Our findings also have implications for those who want to implement deposit contracts in practice. When uptake needs to be increased, our findings support the use of both deposit matching and deposit customization. However, while matching increased uptake, it was an expensive option to provide. To overcome this burden, intervention providers could use the money that is forfeited because some participants are not perfectly successful and thus (partially) lose their initial deposit (Jarvis & Dallery, 2017). Furthermore, customization increased uptake without requiring additional funding, which is an important benefit for large-scale implementation. However, caution is warranted when customizable deposit contracts are employed without additional matching because our findings indicate that the effectiveness of customizable deposit contracts might be reduced. Therefore, before they are implemented on a large scale, we urge for more research on the effectiveness of

customizable deposit contracts. Importantly, customization does create the opportunity for people with lower incomes to self-tailor a deposit contract amount that does not cause financial harm when lost. Thereby, customization of deposit amounts makes deposit contracts more attractive for targeting vulnerable subgroups. Finally, it is currently unknown how acceptable or effective deposit contracts are among people in vulnerable conditions, such as those with chronic illness or financial problems. It is important to further understand who is and is not reached successfully by a deposit contract intervention. Therefore, future research should investigate which psychosocial variables (e.g., motivation, self-efficacy), demographic variables (e.g., income, educational level), and health conditions (e.g., cardiovascular disease, obesity) predict uptake and effects of deposit contracts.

Conclusion

The deposit contract intervention used in this study was highly effective in helping people increase their step counts. Both customization and matching of deposit amounts increased the uptake of a deposit contract for physical activity without affecting effectiveness. Whereas matching a deposit contract is expensive to the intervention provider, customization can be offered without additional costs. We recommend consideration of both matching and customization to overcome issues with uptake. Future research should investigate which characteristics of individuals or contracts are predictive of deposit contract uptake and effects. Deposit contracts are a promising tool for behavior change, but more research is needed on uptake, effectiveness, and cost-effectiveness before they can be implemented on a population scale.

Authors' Contributions

Study design (DB, TR, AE); intervention and app design and development (DB, PS, TK, TC); data acquisition (DB, TC); data analysis and interpretation (DB, TR, AE, LB); drafting the manuscript (DB, TR, PS, TK, AE); manuscript revision (DB, TR, TC, PS, TK, LB, VJ, RK, AE). All authors gave final approval and agreed to be accountable for all aspects of the work ensuring integrity and accuracy.

References

1. Adams, J., Giles, E. L., McColl, E., & Sniehotta, F. F. (2014). Carrots, sticks and health behaviours: A framework for documenting the complexity of financial incentive interventions to change health behaviours. *Health Psychology Review*, *8*(3), 286–295. https://doi.org/10.1080/17437199.2013.848410

2. Boonmanunt, S., Pattanaprateep, O., Ongphiphadhanakul, B., McKay, G., Attia, J., Vlaev, I., & Thakkinstian, A. (2022). Evaluation of the Effectiveness of Behavioral Economic Incentive Programs for Goal Achievement on Healthy Diet, Weight Control and Physical Activity: A Systematic Review and Network Meta-analysis. *Annals of Behavioral Medicine*, kaac066. https://doi.org/10.1093/abm/kaac066

3. Budworth, L., Prestwich, A., Sykes-Muskett, B., Khatun, K., Ireland, J., Clancy, F., & Conner, M. (2019). A feasibility study to assess the individual and combined effects of financial incentives and monetary contingency contracts on physical activity. *Psychology of Sport and Exercise*, *44*, 42–50. https://doi.org/10.1016/j.psychsport.2019.04.021

4. Burns, R. J., & Rothman, A. J. (2018). Comparing Types of Financial Incentives to Promote Walking: An Experimental Test. *Applied Psychology: Health and Well-Being*, *10*(2), 193–214. https://doi.org/10.1111/aphw.12126

5. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Erlbaum.

6. de Buisonjé, D. R. de, Reijnders, T., Rodrigues, T. R. C., Prabhakaran, S., Kowatsch, T., Lipman, S. A., Bijmolt, T. H. A., Breeman, L. D., Janssen, V. R., Kraaijenhagen, R. A., Kemps, H. M. C., & Evers, A. W. M. (2022). Investigating Rewards and Deposit Contract Financial Incentives for Physical Activity Behavior Change Using a Smartphone App: Randomized Controlled Trial. *Journal of Medical Internet Research*, *24*(10), e38339. https://doi.org/10.2196/38339

7. Donlin Washington, W., McMullen, D., & Devoto, A. (2016). A matched deposit contract intervention to increase physical activity in underactive and sedentary adults. *Translational Issues in Psychological Science*, *2*(2), 101–115. https://doi.org/10.1037/tps0000069

8. Dunton, G. F., Leventhal, A. M., Rebar, A. L., Gardner, B., Intille, S. S., & Rothman, A. J. (2022). Towards consensus in conceptualizing and operationalizing physical activity maintenance. *Psychology of Sport and Exercise*, *61*, 102214. https://doi.org/10.1016/j.psychsport.2022.102214

9. Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/bf03193146

10. Finkelstein, E. A., Bilger, M., & Baid, D. (2019). Effectiveness and cost-effectiveness of incentives as a tool for prevention of non-communicable diseases: A systematic review. *Social Science & Medicine*. https://doi.org/10.1016/j.socscimed.2019.05.018

11. Giles, E. L., Robalino, S., McColl, E., Sniehotta, F. F., & Adams, J. (2014). The Effectiveness of Financial Incentives for Health Behaviour Change: Systematic Review and Meta-Analysis. *PLoS ONE*, *9*(3), e90347. https://doi.org/10.1371/journal.pone.0090347

12. Halpern, S. D., French, B., Small, D. S., Saulsgiver, K., Harhay, M. O., Audrain-McGovern, J., Loewenstein, G., Brennan, T. A., Asch, D. A., & Volpp, K. G. (2015). Randomized Trial of Four Financial-Incentive Programs for Smoking Cessation. *New England Journal of Medicine*, *372*(22), 2108–2117. https://doi.org/10.1056/NEJMoa1414293

13. Hunter, R. F., Tang, J., Hutchinson, G., Chilton, S., Holmes, D., & Kee, F. (2018). Association between time preference, present-bias and physical activity: Implications for designing behavior change interventions. *BMC Public Health*, *18*(1), 1388. https://doi.org/10.1186/s12889-018-6305-9

14. *IBM SPSS Statistics for Mac* (Version 28). (n.d.). IBM Corp.

15. Jarvis, B. P., & Dallery, J. (2017). Internet-based self-tailored deposit contracts to promote smoking reduction and abstinence. *Journal of Applied Behavior Analysis*, *50*(2), 189–205. https://doi.org/10.1002/jaba.377

16. Jeffery, R. W. (2012). Financial incentives and weight control. *Preventive Medicine*, *55*(Supplement), S61–S67. https://doi.org/10.1016/j.ypmed.2011.12.024

17. Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, *47*(2), 263–291. https://doi.org/10.2307/1914185

18. Krebs, C. A., & Nyein, K. D. (2021). Increasing physical activity in adults using self-tailored deposit contacts. *Behavior Analysis: Research and Practice*, *21*(3), 174–183. https://doi.org/10.1037/bar0000222

19. Kullgren, J. T., Troxel, A. B., Loewenstein, G., Norton, L. A., Gatto, D., Tao, Y., Zhu, J., Schofield, H., Shea, J. A., Asch, D. A., Pellathy, T., Driggers, J., & Volpp, K. G. (2016). A Randomized Controlled Trial of Employer Matching of Employees' Monetary Contributions to Deposit Contracts to Promote Weight Loss. *American Journal of Health Promotion*, *30*(6), 441–452. https://doi.org/10.1177/0890117116658210

20. Kullgren, J. T., Williams, G. C., Resnicow, K., An, L. C., Rothberg, A., Volpp, K. G., & Heisler, M. (2016). The Promise of Tailoring Incentives for Healthy Behaviors. *International Journal of Workplace Health Management*, *9*(1), 2–16. https://doi.org/10.1108/IJWHM-12-2014-0060

21. Kurti, A. N., Davis, D. R., Redner, R., Jarvis, B. P., Zvorsky, I., Keith, D. R., Bolivar, H. A., White, T. J., Rippberger, P., Markesich, C., Atwood, G., & Higgins, S. T. (2016). A Review of the Literature on Remote Monitoring Technology in Incentive-Based Interventions for Health-Related Behavior Change. *Translational Issues in Psychological Science*, *2*(2), 128–152. https://doi.org/10.1037/tps0000067

22. Laibson, D. (1997). Golden Eggs and Hyperbolic Discounting. *The Quarterly Journal of Economics*, *112*(2), 443–478. https://doi.org/10.1162/003355397555253

23. Lesser, L. I., Thompson, C. A., & Luft, H. S. (2018). Association Between Monetary Deposits and Weight Loss in Online Commitment Contracts. *American Journal of Health Promotion*, *32*(1), 198–204. https://doi.org/10.1177/0890117116661157

24. Levesque, C. S., Williams, G. C., Elliot, D., Pickering, M. A., Bodenhamer, B., & Finley, P. J. (2007). Validating the theoretical structure of the Treatment Self-Regulation Questionnaire (TSRQ) across three different health behaviors. *Health Education Research*, *22*(5), 691–702. https://doi.org/10.1093/her/cyl148

25. Mantzari, E., Vogt, F., Shemilt, I., Wei, Y., Higgins, J. P. T., & Marteau, T. M. (2015). Personal financial incentives for changing habitual health-related behaviors: A systematic review and meta-analysis. *Preventive Medicine*, *75*, 75–85. https://doi.org/10.1016/j.ypmed.2015.03.001

26. Mitchell, M. S., Orstad, S. L., Biswas, A., Oh, P. I., Jay, M., Pakosh, M. T., & Faulkner, G. (2019). Financial incentives for physical activity in adults: Systematic review and meta-analysis. *British Journal of Sports Medicine*, bjsports-2019-100633. https://doi.org/10.1136/bjsports-2019-100633

27. Moller, A. C., Ntoumanis, N., & Williams, G. C. (2019). Financial Incentives May Influence Health Behaviors, But Do We End Up With Less Than We Paid For? A Self-determination Theory Perspective. *Annals of Behavioral Medicine*, *53*(11), 939–941. https://doi.org/10.1093/abm/kaz038

28. Neville, L. M., O'Hara, B., & Milat, A. (2009). Computer-tailored physical activity behavior change interventions targeting adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *6*(1), 30. https://doi.org/10.1186/1479-5868-6-30

29. Patel, M. S., Asch, D. A., Rosin, R., Small, D. S., Bellamy, S. L., Heuer, J., Sproat, S., Hyson, C., Haff, N., Lee, S. M., Wesby, L., Hoffer, K., Shuttleworth, D., Taylor, D. H., Hilbert, V., Zhu, J., Yang, L., Wang, X., & Volpp, K. G. (2016). Framing Financial Incentives to Increase Physical Activity Among Overweight and Obese Adults: A Randomized, Controlled Trial. *Annals of Internal Medicine*, *164*(6), 385. https://doi.org/10.7326/M15-1635

30. Raiff, B. R., Jarvis, B. P., Turturici, M., & Dallery, J. (2013). Acceptability of an Internet-based contingency management intervention for smoking cessation: Views of smokers, nonsmokers, and healthcare professionals. *Experimental and Clinical Psychopharmacology*, *21*(3), 204–213. https://doi.org/10.1037/a0032451

31. Rhodes, R. E., & de Bruijn, G.-J. (2013). How big is the physical activity intention–behaviour gap? A meta-analysis using the action control framework. *British Journal of Health Psychology*, *18*(2), 296–309. https://doi.org/10.1111/bjhp.12032

32. Royer, H., Stehr, M., & Sydnor, J. (2015). Incentives, Commitments, and Habit Formation in Exercise: Evidence from a Field Experiment with Workers at a Fortune-500 Company. *American Economic Journal: Applied Economics*, *7*(3), 51–84. https://doi.org/10.1257/app.20130327

33. Sheeran, P., & Webb, T. L. (2016). The Intention-Behavior Gap: The Intention-Behavior Gap. *Social and Personality Psychology Compass*, *10*(9), 503–518. https://doi.org/10.1111/spc3.12265

34. Stedman-Falls, L. M., & Dallery, J. (2020). Technology-based versus in-person deposit contract treatments for promoting physical activity. *Journal of Applied Behavior Analysis*, *53*(4), 1904–1921. https://doi.org/10.1002/jaba.776

35. Sykes-Muskett, B. J., Prestwich, A., Lawton, R. J., & Armitage, C. J. (2015). The utility of monetary contingency contracts for weight loss: A systematic review and meta-analysis. *Health Psychology Review*, *9*(4), 434–451. https://doi.org/10.1080/17437199.2015.1030685

36. Tannenbaum, D., Valasek, C. J., Knowles, E. D., & Ditto, P. H. (2013). Incentivizing wellness in the workplace: Sticks (not carrots) send stigmatizing signals. *Psychological Science*, *24*, 1512–1522. https://doi.org/10.1177/0956797612474471

37. Thirumurthy, H., Asch, D. A., & Volpp, K. G. (2019). The Uncertain Effect of Financial Incentives to Improve Health Behaviors. *JAMA*, *321*(15), 1451–1452. https://doi.org/10.1001/jama.2019.2560

38. Thomas, S., Reading, J., & Shephard, R. J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Canadian Journal of Sport Sciences = Journal Canadien Des Sciences Du Sport*, *17*(4), 338–345.

39. Togo, F., Watanabe, E., Park, H., Shephard, R. J., & Aoyagi, Y. (2005). Meteorology and the physical activity of the elderly: The Nakanojo Study. *International Journal of Biometeorology*, *50*(2), 83–89. https://doi.org/10.1007/s00484-005-0277-z

40. Yao, J., Tan, C. S., Lim, N., Tan, J., Chen, C., & Müller-Riemenschneider, F. (2021). Number of daily measurements needed to estimate habitual step count levels using wrist-worn trackers and smartphones in 212,048 adults. *Scientific Reports*, *11*(1), 9633. https://doi.org/10.1038/s41598-021-89141-3