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

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Contents

Chapter 1

General introduction

"An incentive is a bullet, a key: an often tiny object with astonishing power to change a situation"

Steven Levitt

Financial incentives are everywhere. People receive salary to perform their jobs and are fined if they drive too fast in their cars. Although, arguably, there are other good reasons to work and adhere to speed limits, imagine a world without these incentives. Financial incentives shape behavior in many domains of life. Increasingly, financial incentives are also being applied to health behavior. For instance, health insurance companies provide people with different financial incentives for healthy living (e.g., cinema tickets, discounts on travelling, payback on purchase of an activity tracker, see Hafner et al., 2020). These incentive programs support health behavior change by introducing immediate financial incentives for healthy behavior. As a result, people, impatient by nature, no longer have to wait for the delayed rewards (e.g., becoming more fit) of healthy behavior to emerge. Broadly speaking, financial incentives come in two different shapes: carrots and sticks (Adams et al., 2014). Carrots can be defined as financial incentives that create the opportunity for a financial gain. For example, by rewarding someone with a certain amount of money contingent on successful behavior change. Sticks can be defined as financial incentives that create the threat of a financial loss. For example, by having someone deposit their own money in a deposit contract, and allowing them to earn it back contingent on successful behavior change. A deposit contract adds skin in the game, because when someone is not successful, their monetary deposit could be lost. This dissertation explores if and how deposit contracts can be utilized for health behavior change.

Why health behavior change is necessary

The everyday choices we make impact our health. Unhealthy eating, smoking, alcohol consumption, and physical inactivity are among the most important lifestyle behaviors that contribute to disease and mortality (World Health Organization, 2009). In this dissertation we focus on improving health behavior with a specific focus on physical activity. Daily life has become so sedentary, especially in high-income Western countries, that people now suffer widely from a lack of physical activity, and as a result many negative health consequences (Woessner et al., 2021). Studies show that 27.5% of adults worldwide, and 42.3% or adults in high-income Western countries, are not getting enough physical activity (Guthold et al., 2018). Physical inactivity is one of the key risk factors for non-communicable diseases (e.g., cardiovascular disease, obesity) and causes millions of preventable deaths worldwide (World Health Organization, 2009). Recent analysis shows that up to 8% of non-communicable diseases and around 7% of deaths are attributable to physical inactivity (Katzmarzyk et al., 2022). Furthermore, estimates indicate that the economic burden of physical inactivity on health-care systems worldwide was at least 53.8 billion international dollars in 2013 (Ding et al., 2016). While physical inactivity is linked to chronic disease and early death (Anderson & Durstine, 2019), increasing physical activity is associated with important health benefits. Becoming

more physically active reduces the risk of chronic disease, improves mental health and contributes to longevity (Pedersen & Saltin, 2015). Importantly, these benefits are found not only for intense aerobic training, but also for the mere number of steps taken in daily life (Lee et al., 2019; Saint-Maurice et al., 2020). Meta-analysis among over 200.000 people has shown that increasing daily steps by 1000 steps a day is associated with a 15% decreased risk of all-cause mortality, while walking 500 steps a day more is associated with a 7% decrease in cardiovascular related mortality (Banach et al., 2023).

What makes health behavior change difficult

Although people often have intentions to live healthily, following through on these intentions can be challenging. A rainy day can keep one from going for a run, a well-deserved holiday break can interrupt a successful gym streak, and friends smoking cigarettes at a party can cause a relapse in a smoking cessation attempt. An increasingly large body of research, confirmed by painful personal experience, establishes unequivocally: behavior change is tough. The finding that intentions do not always translate into behavior has been coined the intention-behavior gap and has been found to apply to a variety of (health) behaviors (Sheeran & Webb, 2016), including physical activity (Rhodes & Bruijn, 2013). Although people are often aware of the benefits of physical activity, and have positive intentions to be (more) physically active, many do not achieve sufficient physical activity in daily life (Rhodes & Bruijn, 2013).

Psychological models for behavior, such as the reflective-impulsive model (Strack & Deutsch, 2004), describe why a gap exists between intentions and behavior. In a typical dual process fashion, the reflective-impulsive model explains behavior as a function of both reflective processes and impulsive processes. Both of these processes follow distinct operating principles. Reflective processes are described as effortful decisional processes based on reasoning and knowledge about consequences that lead to intentions, and ultimately behavior. On the other hand, impulsive processes are effortless, and can automatically (without the persons intention or goal), trigger behavior. Imagine someone who - after reflecting on the negative health consequences of being sedentary - intends to go for a walk after work each day. After a long day at work, and when the comfortable couch is in sight, the impulsive system might (automatically) override the previously formed intention to go for a walk, and the person lies down on the couch to watch a sitcom instead. This example illustrates how, under challenging contextual circumstances such as being tired, goal conflicts between reflective and impulsive processes can be triggered by environmental cues (e.g., seeing the couch), and make us fall for immediate temptation (e.g., watch TV) instead of acting in line with our long-term health goals (e.g., be more physically active). Similar explanations for what makes behavior change difficult come from behavioral economics (Mullainathan & Thaler, 2000), a field of study that

has challenged the traditional notion that people act rationally, and in their own best interest. Rather, because they are biased, people often act in predictably irrational ways, even against their own best interest (Mullainathan & Thaler, 2000). A key finding from behavioral economics is that people are present biased; they are more strongly influenced by consequences in the here and now than they are by the long-term consequences of their behavior (Laibson, 1997). As a result, people tend to procrastinate on their long-term goals (Laibson, 1997). Being present biased makes people vulnerable when it comes to improving their long term health outcomes, because living healthily often involves a trade-off between short term temptations (e.g., lying on the couch) and long-term health goals (e.g., losing weight by being physically active)(Hunter et al., 2018). Although behavioral economists label this tendency to grab immediate rewards a 'bias', it was once probably an adaptive response (Haselton et al., 2009). Over the largest part of our evolutionary history, acting on directly available rewards (rather than abstract, uncertain ideas about possible future rewards) had important survival advantages. However, we now live in environments with an abundance of food, and no need for physical exertion to attain it. It appears that when it comes to our health, being present biased no longer helps, but hurts. Importantly, the insight that people are present biased also helps to understand why introducing immediate financial incentives might be suitable as an intervention strategy for health behavior change.

Financial incentives for health behavior change

Incentives can be defined as reinforcements and punishments that motivate people to take up an activity and guide the way they perform it (Hagger et al., 2020). Incentives can be tangible (e.g., money, vouchers, gifts) or intangible (e.g., feedback, praise, affection) (Hagger et al., 2020). Incentive interventions have their roots in operant conditioning, a field of study originated in the 1950s by B.F. Skinner. Skinners' classic experiments with the conditioning of pigeon and rat behavior showed that animal behavior (and ultimately human behavior) is continuously shaped and maintained by its consequences (Skinner, 1953). Broadly speaking, behavior can either be reinforced (strengthened and increased) or punished (weakened and decreased). The stimulus (or consequence) used to shape behavior can be pleasant or aversive, and can either be introduced or removed. This results in the quadrant displayed in *Figure 1.* In this dissertation, we consider financial rewards (or *carrots*) and deposit contracts (or *sticks*) for stimulating increases in healthy behaviors (such as physical activity) as forms of respectively positive and negative reinforcement.

	Reinforcement (increase behavior)	**Punishment** (decrease behavior)
Positive (add stimulus)	Add pleasant stimulus to **Increase** behavior	Add aversive stimulus to **Decrease** behavior
Negative (remove stimulus)	Remove aversive stimulus to **Increase** behavior	Remove pleasant stimulus to **Decrease** behavior

Figure 1. Principles of operant conditioning

A common objection to providing incentives for health behavior change is that extrinsic rewards might undermine (or "crowd out") intrinsic motivation. This objection is based on the tenets of self-determination theory, and its proponents argue that while incentives can increase extrinsic motivation (i.e. desire to do something to receive an external reward), they might also reduce intrinsic motivation (i.e., desire to do something because it is inherently enjoyable) (Deci et al., 1999). Although this objection makes intuitive sense, studies show that providing financial incentives for health behavior does not reduce self-reported intrinsic motivation (Leahey et al., 2017; Ledgerwood & Petry, 2006). More importantly, meta-analyses show that, for a wide range of health behaviors, behavior measured at follow-up often drops back to pre-incentive baselines, but not below baselines (Boonmanunt et al., 2022; Giles et al., 2014; Mantzari et al., 2015; Mitchell et al., 2019). Finally, there is no evidence available that shows lower levels of behavior in previously incentivized groups, compared to no-incentive control groups (Promberger & Marteau, 2013). All in all, there seems to be very little evidence that supports the idea that financial incentives undermine intrinsic motivation for health behaviors. The original studies that did find a crowding out of intrinsic motivation often studied performance in simple tasks not related to health behavior such as completing puzzles or drawing pictures, for which participants already had high intrinsic motivation (operationalized as high pre-incentive levels of performance) (Deci et al., 1999). Health behavior differs from these tasks, because people who are targeted by financial incentive interventions often do not have high levels of pre-incentive intrinsic motivation and high levels of performance of the target behavior (Promberger & Marteau, 2013). Moreover, health behavior typically involves issues of self-control, because people have to trade off long term health benefits to short term temptations. Because financial incentives help tip the decisional balance in favor of the long-term health benefits, people might actually experience them as helpful in bringing their behavior more in line with their preferences (Promberger & Marteau, 2013).

Rewarding someone with an amount of money creates the opportunity for a financial gain (i.e., it adds a pleasant stimulus) contingent on performance of a behavior. Therefore, it is considered as positive reinforcement (Burns & Rothman, 2018). Offering immediate financial rewards for healthy behavior takes advantage of present bias by introducing a monetary benefit in the here and now. In contrast, a deposit contract is defined as an arrangement in which people deposit their own money which they can (partially) earn back by achieving behavioral goals (Donlin Washington et al., 2016). In this case, the threat of losing the deposit acts as an aversive stimulus that is removed when behavioral goals are met. Therefore, a deposit contract is considered as negative reinforcement (Burns & Rothman, 2018). Both financial rewards and deposit contracts bring an incentive into the present. However, deposit contracts bring a risk of loss into the present. Thus, deposit contracts should theoretically be more effective than financial rewards, because they capitalize on loss aversion. Loss aversion is the tendency to assign larger weight to potential losses associated with behavior than to potential gains (Kahneman & Tversky, 1979). For example, a prediction from loss aversion is that losing 100 dollars hurts more, than the pleasure derived from gaining 100 dollars (see *Figure 2* below).

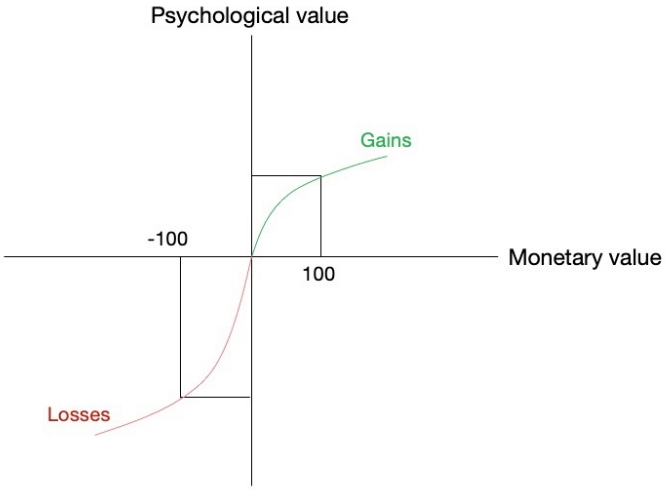

Figure 2. An illustration of loss aversion

Deposit contracts are considered a form of commitment device *(See the box on the next page): "an arrangement entered into by an individual with the aim of helping fulfill a plan for future behavior that would otherwise be difficult owing to intrapersonal conflict stemming from, for example, a lack of self-control"* (Bryan et al., 2010).

The ancient commitment strategy of Odysseus

The Odyssey, written by Homer in around 800 BC, is one of humanities oldest stories and tells the mythical tale of the Greek hero Odysseus' who returns home with his ship and crew after the Trojan war. Odysseus is aware that on his journey homeward he will encounter the Sirens: beautiful but dangerous creatures who lure sailors with their irresistible songs to crash their ships into the rocks. Foreseeing this future temptation, Odysseus orders his sailors to plug their ears with wax and to tie him firmly to the mast of the ship. In so doing, Odysseus is able to avoid the temptation of the Sirens' singing, steer his ship clear of danger, and make it back safe into their home harbor. The ancient strategy that Odysseus applied is what modern behavioral science calls a commitment device (Rogers et al., 2014).

A deposit contract constitutes a monetary commitment device in which the threat of losing the monetary deposit enforces the intended behavior (Giné et al., 2010). Similar to Odysseus' predicament, people often find themselves in situations in which they need to resist unhealthy temptations in the here and now, because they are in conflict with previously formed healthy intentions. In these situations, a deposit contract allows the (reflective) current self to impose restrictions on the behavior of the (impulsive) future self, under the threat of losing something that was once owned (i.e., in this case money). The reflective system in this way 'tames' the impulsive system through attaching financial consequences (i.e., losing or regaining the deposit) to impulse control failure and success.

The effects of financial rewards (carrots)

Financial rewards have proven to be effective in promoting behavior change in a wide range of health domains including: diet (Kurti et al., 2016), substance use (Kurti et al., 2016), 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 vaccination uptake (Giles et al., 2014). Importantly, financial rewards are rarely offered as a stand-alone intervention. Rather, they are usually added as a supplement to multi-component behavior change interventions that already include proven behavior change techniques such as goal setting, goal progress feedback, and counselling (Mantzari et al., 2015; Mitchell et al., 2019). Even when compared against such a strong comparison condition, adding financial rewards roughly doubles the odds of successful behavior change (Mantzari et al., 2015). For physical activity, meta-analysis (N = 6074) shows that adding financial rewards (of approximately US $1.50 per day per person) to existing step count interventions increases daily step counts by an additional 600 steps, or 10-15% (Mitchell et al., 2019).

However, while financial rewards are effective to promote short-term initiation of physical activity, it is uncertain whether effects are maintained in the long-term. Most interventions that target physical activity lasted 3 months or less, with no interventions lasting more than 6 months (Boonmanunt et al., 2022; Mitchell et al., 2019). More importantly, it is unclear what happens with achieved behavior change after incentives are removed. Meta-analyses across different health behaviors generally conclude that evidence for post-incentive behavior change maintenance is limited at best (Giles et al., 2014; Kurti et al., 2016; Mantzari et al., 2015). Research on physical activity indicates that effects are sometimes maintained up to 6 months after incentive removal (Mitchell et al., 2019), whereas other research shows that effects dissipate within three months (Mantzari et al., 2015). Without clear evidence for maintenance of achieved behavior change, offering financial rewards requires sustained funding by the intervention provider, which limits the opportunities for large scale implementation. Another important question is whether vulnerable people (such as those with lower socioeconomic positions) also benefit from financial rewards. This question is also important from an ethical perspective (see Lunze & Paasche-Orlow, 2013), since incentive interventions should contribute to closing (rather than widening) the socioeconomic health gap. Financial rewards might have greater effects on those with lower incomes, because a similar size incentive would provide greater relative value (Vlaev et al., 2019). Indeed, a meta-analysis has provided preliminary indications that people with lower socioeconomic positions show greater improvements when exposed to financial reward interventions (Mantzari et al., 2015).

Rationale for studying deposit contracts (sticks)

For long-term maintenance of behavior change, financial rewards (or *carrots*) would have to be offered indefinitely, or at least for extended periods of time. Importantly, this also means that offering financial rewards for health behavior change requires constant (or at least sustained) funding by the intervention provider. A key aspect of deposit contracts (or *sticks*) is that the incentive is not provided by an external source, but is instead provided by the person attempting the behavior change (Halpern et al., 2012). This results in three crucial benefits that deposit contracts have over financial rewards. Firstly, deposit contracts have the potential for large scale implementation, without requiring external funds to provide incentives. Secondly, because people voluntarily decide to incentivize themselves, the locus of control over the incentive is internal ("I deposit money") rather than external ("the intervention provider rewards me"). This helps to avoid some of the (ethical) concerns that are associated with rewarding people with external funds. For example, rewarding people for behavior that others perform without receiving rewards might be considered unfair, while having people voluntarily deposit their own money avoids this ethical concern (Sykes-Muskett et al., 2015). Thirdly, deposit contracts might

be more effective than financial rewards because people are generally more motivated to avoid losses than they are to receive gains (i.e., they are loss aversive)(Kahneman & Tversky, 1979). Downsides to deposit contracts are that their uptake is generally low (Giné et al., 2010; Kullgren et al., 2016; Royer et al., 2015), and that it is unclear whether they are also suitable for vulnerable subgroups such as people with lower socioeconomic positions, or with chronic conditions (e.g., cardiovascular disease).

The effects of deposit contracts (sticks)

Deposit contracts appear to have potential to improve health behavior change generally, and physical activity specifically. Deposit contracts have been applied successfully to weight loss (Kullgren et al., 2016; Volpp et al., 2008), smoking cessation (Halpern et al., 2015; Jarvis & Dallery, 2017) and daily step counts (Budworth et al., 2019; Burns & Rothman, 2018; Donlin Washington et al., 2016; Krebs & Nyein, 2021; Stedman-Falls & Dallery, 2020). However, the studies targeting daily step counts were either underpowered to determine effectiveness (Donlin Washington et al., 2016; Krebs & Nyein, 2021; Stedman-Falls & Dallery, 2020), or did not use an actual deposit of participants' own money (Budworth et al., 2019; Burns & Rothman, 2018). For example, Burns & Rothman (2018) used loss framing to mimic an actual deposit of their own money by telling participants at the start of intervention that they would receive $50, and that they would lose money for each day they did not meet their walking goal. As another example, Budworth et al. (2019) first provided participants with vouchers for participation, which could then be used as a deposit. These operationalizations do not require participants to deposit their own money, and thus do not allow for a valid assessment of deposit contract uptake or effects. There are also some indications that deposit contracts might be effective to promote maintenance of physical activity after incentive removal (see Boonmanunt et al., 2022), but more fully powered research with actual deposits of participants' own money is needed. Furthermore, also for deposit contracts specifically, long-term effects have not yet been examined, and it remains unclear whether deposit contracts are suited for more vulnerable subgroups.

Features that make deposit contracts more effective

Designing a financial incentive entails making design decisions on features such as frequency, channel, duration, framing, and schedule of incentive delivery (Adams et al., 2014). Existing meta-analyses across different health behaviors have not yet been able to identify which features of financial incentive interventions make them more effective (Giles et al., 2014; Mantzari et al., 2015). However, with regards to financial incentives for physical activity, previous research indicates that longer intervention duration,

more immediate incentive delivery, higher incentive amounts, and targeting less active populations increases intervention effects (Mitchell et al., 2019). Furthermore, several studies indicate that financial incentives might be more effective when they leverage our tendency to be loss aversive, such as is the case with a deposit contract (Boonmanunt et al., 2022; Haff et al., 2015; Vlaev et al., 2019). One option to increase deposit contract effects would be to use loss framing to further enhance feelings of losses (thus capitalizing on loss aversion) and potentially increase the effectiveness of a deposit contract. Loss framing has been shown to increase the effectiveness of financial rewards (Patel et al., 2016), but no research has been done yet on whether loss framing enhance the effects of deposit contracts. A second possibility to increase deposit contract effects is to make use of what has been called the Fresh Start Effect (Dai et al., 2014). Research has shown that interest to pursue lifestyle goals peaks around fresh start moments such as the first day of the week, month, or year (Dai et al., 2014). Possibly, because of the peak in motivation that surrounds the passage of the calendar year, the effects of a deposit contract would be enhanced when it is started as a New Year's Resolution. Finally, research might further investigate how deposit contracts should be designed for optimal effectiveness, without compromising uptake. As an example, larger deposit amounts are predicted to have stronger effects on behavior, but might deter people from participating, thus reducing overall uptake and ultimately efficacy of the intervention (Halpern et al., 2012).

Strategies that help increase the uptake of deposit contracts

It is important to explore methods for increasing deposit contract uptake, because research shows that uptake of deposit contracts is generally low, often below 15% (Giné et al., 2010; Kullgren et al., 2016; Royer et al., 2015). Low uptake is especially problematic when those most in need of intervention (e.g., lower socioeconomic subgroups) would not be reached. Strategies that hold potential to increase deposit contract uptake are customization and matching. Firstly, offering a customizable deposit contract allows participants to self-tailor the right deposit amount (Sykes-Muskett et al., 2015) instead of offering a take it or leave it fixed deposit amount. A fixed deposit amount might deter people who are reluctant to participate or who think the fixed deposit amount is too high, and customization might thus remove a barrier for participation by allowing small deposit amounts. Secondly, matching a deposit (doubling the deposit amount with an additional reward of equal size) adds elements of positive reinforcement to the existing negative reinforcement that is already present in a deposit contract, and might increase the overall attractiveness of the deposit contract (Finkelstein et al., 2019). However, to the best of our knowledge, whether customization and matching of deposit contracts indeed increase uptake has not been shown yet. The only study known to us provided matching of deposit contracts for weight loss, but did not find an effect on uptake (Kullgren et al., 2016).

The acceptability of deposit contracts for people with cardiovascular disease

Because deposit contracts have been shown to have low uptake, it is important to study their acceptability among different subgroups. One subgroup to whom lifestyle change is critically important are those with cardiovascular disease (CVD). After a health incident, people with CVD are often referred to cardiac rehabilitation (CR): a 12-week program during which patients receive psycho-education, support with lifestyle change and guided physical exercise training (Brouwers et al., 2021). Although lifestyle changes are often initiated successfully during cardiac rehabilitation, when people return to everyday life they often relapse into their old unhealthy habits (Kotseva et al., 2019). Therefore, there is an urgent need to find new approaches that help solidify lifestyle changes in people with CVD, and that can serve as a supplement to cardiac rehabilitation. Deposit contracts might form such a supplement. Offering deposit contracts might be beneficial to for example cardiovascular disease patients who are in a pre-operative lifestyle change program, recovering in a post-operative cardiac rehabilitation program, or who are entering the non-supported home environment after cardiac rehabilitation is completed. To the best of our knowledge, little research has been done yet on whether people with cardiovascular disease find deposit contracts for lifestyle change acceptable. One study among overweight and obese recipients of incentives did show low support for any type of financial incentive for weight loss, and especially for deposit contracts (McGill et al., 2018). More specifically, another study among a sample of cardiac rehabilitation patients found that nearly all participants preferred voucher-based incentives over cash incentives, which might indicate low acceptability of monetary deposit contracts among CVD patients (Mitchell et al., 2014). Furthermore, although evidence from other countries on the acceptability of financial incentives among healthcare professionals (HCPs) is promising (Hoskins et al., 2019), whether Dutch healthcare professionals find financial incentives for health promotion among CVD patients acceptable is unclear. More research is needed to assess the acceptability of deposit contracts from the perspective of both patients themselves and HCPs involved in cardiac care.

Despite their proven effectiveness in changing health behavior, using financial incentives to promote health has raised ethical objections. The main objections are that incentives may be coercive, undermine autonomy of individuals, undermine personal responsibility for health, and may be considered unfair to those who already have healthy lifestyles (Ashcroft, 2011; Lunze & Paasche-Orlow, 2013). Although these ethical objections exist, it appears that they can be mitigated through thoughtful incentive design. For example, among cardiovascular disease patients, ethical concerns to using financial incentives were prominent, but highly dependent on how incentives were designed (Mitchell et al., 2014).

The current dissertation

Deposit contracts are promising for improving population health, because they might be implemented on a large scale without requiring external funding of incentives. The main aim of this dissertation is to fill the knowledge gap surrounding the effectiveness of deposit contracts for health behavior change. Existing research has shown that deposit contracts hold potential to improve health behavior change in physical activity, but previous work was either underpowered or has used loss framing or vouchers that were first given to mimic an actual deposit of participants' own money. Therefore, to assess their potential to increase population health it is important to establish the effects of actual deposit contracts, and which features make them more effective. Generally, low uptake is a key obstacle for large scale implementation of deposit contracts, and it is unclear how uptake can be increased. Finally, because health behavior change is critically important for people with chronic conditions such as cardiovascular disease, it is important to investigate patients' and healthcare professionals' opinions on using financial incentives, and more specifically deposit contracts, for health behavior change. Our ultimate aim is to stimulate further theoretical investigation and practical application of deposit contracts for health behavior change.

To summarize, the main aim of this dissertation is to assess the potential of deposit contracts for health behavior change. More specifically we aim to:

1. Establish the effects of deposit contracts
2. Explore which features of deposit contracts make them more effective
3. Identify strategies that help increase the uptake of deposit contracts
4. Assess the acceptability of deposit contracts for people with cardiovascular disease

Overview of the chapters of this dissertation

This dissertation starts with the results of two field experiments in which we manipulated features of deposit contracts and measured effects on uptake and effectiveness (chapters 2 & 3). In addition, we report an observational study in which we evaluate the real-world effects of commercially available deposit contracts (chapter 4). Finally, we report two studies on the perspectives of cardiovascular disease patients and healthcare professionals to gauge acceptability (chapters 5 & 6).

Chapter 2 explores the effectiveness and uptake of deposit contracts for improving physical activity. Comparing the existing evidence on the effectiveness and uptake of deposit contracts for physical activity between studies is complicated, because existing studies were underpowered and operationalizations of deposit contracts differed substantially. Sometimes completely self-funded deposit contracts are used, and sometimes loss framing is used to create the psychological experience of losing one's

own money, without actually requiring individuals to put money at risk. Therefore, in a field experiment we aim to disentangle the effects of incurring actual losses (through self-funding a deposit contract) and loss framing. We use a smartphone app that provides financial rewards or requires actual deposit contracts of participants' own money (which are either loss or gain framed) and measure uptake and the effects on daily step counts of healthy students. We expect that, due to loss aversion, deposit contracts are more effective than financial rewards, and that loss gained incentives are more effective than gain framed incentives.

Chapter 3 follows up on the results of *Chapter 2* and investigates ways to increase the uptake of a deposit contract. Low uptake is an important obstacle to large scale implementation of deposit contracts, especially when groups that are most in need of intervention are not reached. Therefore, in *Chapter 3* we investigate how the uptake of deposit contracts for physical activity can be increased. Two elements that might increase deposit contract uptake are: (1) deposit matching (doubling the money participants deposit) and (2) deposit customization (allowing self-selection of what amount of money participants want to deposit). We revised the smartphone app that was designed for chapter 2 and implement deposit contracts that are either matched (or not), and customizable (or fixed). We investigate the effects of these manipulations on the uptake and effectiveness among healthy students. We expect that both matching and customization of deposit amounts increase the uptake of a deposit contract for physical activity.

Chapter 4 moves beyond the realm of traditional academic research and investigates what the effects are of publicly accessible deposit contracts for physical activity. We report analysis of over 70.000 gamified deposit contract challenges to increase step counts that are offered through a commercial smartphone app. Understanding whether deposit contracts are not only efficacious in lab settings, but also effective in real life conditions, provides important additional evidence that may help inform public health policy making and future intervention design. We perform a naturalistic evaluation of the challenges and their association with increases in physical activity, explore for whom these challenges work best, and under which conditions they are most effective.

Chapter 5 explores what people with cardiovascular disease (CVD) think of using deposit contracts for their lifestyle change. Because people with CVD often have difficulties maintaining the lifestyle changes that are important to their health, there is an urgent need to find new approaches that improve long-term adherence to a healthy lifestyle. Although people with CVD might benefit from using deposit contracts, it is unknown whether they would find deposit contracts acceptable. The limited evidence that is available implies that, despite their effectiveness in helping people achieve lifestyle goals, deposit contracts might in fact not be acceptable to people with CVD. Therefore, in *Chapter 5* we investigate the acceptability of a deposit contract for physical activity

with a survey among members of the Harteraad patient panel of the Dutch CVD patient organization.

Chapter 6 investigates healthcare professionals' perspectives on using financial incentives to support healthy living among people with cardiovascular disease. When financial incentives are applied to patient populations, healthcare professionals are expected to deliver the intervention, promote uptake among patients, and guide implementation in current health care. Although financial incentives have proven to be effective, their implementation in healthcare remains controversial. It is unknown whether healthcare professionals involved in CVD care find it acceptable to provide financial incentives to patients with CVD as support for lifestyle change. Therefore, in *Chapter 6* we report the results of 16 qualitative interviews with Dutch Healthcare professionals' who are involved in supporting people with cardiovascular disease with their lifestyle changes.

Chapter 2

Less carrot more stick? Investigating rewards and deposit contract financial incentives for physical activity

Based on: Buisonjé D.R. de, Reijnders T.R., Cohen Rodrigues T.R., 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.

Abstract

Background: Financial incentive interventions for improving physical activity have proven to be effective but costly. Deposit contracts (in which participants pledge their own money) could be an affordable alternative. In addition, deposit contracts may have superior effects by exploiting the power of loss aversion. Previous research has often operationalized deposit contracts through loss framing a financial reward (without requiring a deposit) to mimic the feelings of loss involved in a deposit contract.

Objective: This study aimed to disentangle the effects of incurring actual losses (through self-funding a deposit contract) and loss framing. We investigated whether incentive conditions are more effective than a no-incentive control condition, whether deposit contracts have a lower uptake than financial rewards, whether deposit contracts are more effective than financial rewards, and whether loss frames are more effective than gain frames.

Methods: Healthy participants (N=126) with an average age of 22.7 (SD 2.84) years participated in a 20-day physical activity intervention. They downloaded a smartphone app that provided them with a personalized physical activity goal and either required a €10 (at the time of writing: €1=US $0.98) deposit up front (which could be lost) or provided €10 as a reward, contingent on performance. Daily feedback on incentive earnings was provided and framed as either a loss or gain. We used a 2 (incentive type: deposit or reward) × 2 (feedback frame: gain or loss) between-subjects factorial design with a no-incentive control condition. Our primary outcome was the number of days participants achieved their goals. The uptake of the intervention was a secondary outcome.

Results: Overall, financial incentive conditions (mean 13.10, SD 6.33 days goal achieved) had higher effectiveness than the control condition (mean 8.00, SD 5.65 days goal achieved; P=.002; ηp^2=0.147). Deposit contracts had lower uptake (29/47, 62%) than rewards (50/50, 100%; P<.001; Cramer V=0.492). Furthermore, 2-way analysis of covariance showed that deposit contracts (mean 14.88, SD 6.40 days goal achieved) were not significantly more effective than rewards (mean 12.13, SD 6.17 days goal achieved; P=.17). Unexpectedly, loss frames (mean 10.50, SD 6.22 days goal achieved) were significantly less effective than gain frames (mean 14.67, SD 5.95 days goal achieved; P=.007; ηp^2=0.155).

Conclusions: Financial incentives help increase physical activity, but deposit contracts were not more effective than rewards. Although self-funded deposit contracts can be offered at low cost, low uptake is an important obstacle to large-scale implementation. Unexpectedly, loss framing was less effective than gain framing. Therefore, we urge further research on their boundary conditions before using loss-framed incentives in practice. Because of limited statistical power regarding some research questions, the results of this study should be interpreted with caution, and future work should be done to confirm these findings.

Pre-registration: OSF registries; https://osf.io/34ygt.

Background

Since the beginning of time, humans have been developing tools and technologies that have made life easier. These technological advances have led to historically unprecedented levels of physical inactivity (Woessner et al., 2021). For example, currently, only 23% of adults in the United States meet the recommended guidelines for physical activity (FastStats, 2021). Although physical inactivity is linked to chronic disease and early death (Anderson & Durstine, 2019), increasing physical activity reduces the risk of chronic disease, has positive effects on mental health, and increases longevity (Pedersen & Saltin, 2015). Importantly, the positive effects of physical activity are observed not only for intense aerobic training but also for the mere number of steps taken in daily life (Lee et al., 2019; Saint-Maurice et al., 2020). Intervening on improving daily step counts has the advantage of being objectively measurable (compared with self-reports), low cost (compared with pharmaceutical treatment), and relatively easy to implement in daily life (compared with gym-based aerobic training), and as a result, it is also suitable for deprived, vulnerable, and older populations worldwide. Therefore, stimulating an increase in daily step counts appears to be a promising and feasible avenue to help humanity become healthier and happier and to live longer.

Although many people are aware of the benefits of physical activity and have positive intentions to be (more) physically active, achieving sufficient physical activity in daily life is not achieved by many (Rhodes & de Bruijn, 2013). The finding that positive intentions do not always translate into the desired behavior has been linked to the intention-behavior gap and has been found in a variety of (health) behaviors (Sheeran & Webb, 2016), including physical activity (Rhodes & de Bruijn, 2013). Insights from behavioral economics help explain the causes of the intention-behavior gap. A key finding is that people are present biased (Rhodes & de Bruijn, 2013). Present bias refers to the tendency of people to be more strongly driven by consequences in the here and now, rather than by the long-term consequences of their decisions. Consequently, people tend to procrastinate. Although differences among individuals exist, the general pattern found is one wherein "people grab immediate rewards and avoid immediate costs in a way our long-run selves do not appreciate" (O'Donoghue & Rabin, 1999). Present bias has been shown to apply to health behavior in general (Wang & Sloan, 2018) and to physical activity specifically (Hunter et al., 2018). For example, people with a stronger present bias have lower levels of physical activity, arguably because they overweight the short-term and often negative consequences of physical activity (eg, increased heart rate and sweating) and assign a lower value (ie, discount) to the long-term positive consequences of physical activity (eg, longevity) (Hunter et al., 2018). Present bias, therefore, helps explain why despite having good intentions to achieve long-term health goals, people are prone to fall for immediate temptation. Present bias also helps explain why introducing

financial incentives might be suitable as an intervention strategy for health behavior change. Offering immediate financial incentives for healthy behavior takes advantage of the present bias by introducing a monetary benefit in the here and now. As such, people no longer have to *wait* for the delayed rewards of healthy behavior to emerge but instead are immediately rewarded. Indeed, meta-analyses and systematic reviews show that financial incentives are an effective tool for promotion of (at least short term) health behavior change, 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). Financial incentives are often added as a supplement to already active behavior change interventions and even then roughly double the odds of successful behavior change (Mantzari et al., 2015). For physical activity, a recent meta-analysis (N = 6074) on the effectiveness of financial incentives on step counts showed an average daily increase of about 600 steps (or 10-15%) during active intervention (Mitchell et al., 2019).

Another relevant insight from behavioral economics is that people are loss averse (Kahneman & Tversky, 1979). This refers to individuals' tendency to assign larger weight to potential losses associated with their behavior, than to potential gains. Losses and gains are defined with respect to a reference-point, e.g. individuals' current status quo, their expectations or goals (Kahneman & Tversky, 1979). Loss aversion and reference-points have been shown to be of importance in health-related decision-making (Lipman et al., 2019), and might lead to suboptimal decision making for physical activity if it causes people to outweigh what they might lose by being physically active (e.g., time and energy) over what they might gain (e.g., satisfaction after a workout). Furthermore, loss aversion is often used to motivate financial incentive designs that involve potential losses rather than rewards only (Halpern et al., 2015; Patel et al., 2016), such as deposit contracts.

Deposit contracts are a specific form of financial incentive wherein people deposit their own money and can earn it back contingent on behavior change (Stedman-Falls & Dallery, 2020). There are several real-world commercial products (e.g., Waybetter (*Waybetter*, n.d.) & Stickk (*Stickk*, n.d.)) with deposit contracts that have proven to be commercially viable and claim to help people change their behavior. Whereas rewards involve the introduction of a pleasant stimulus to increase behavior (i.e., positive reinforcement), deposit contracts involve the alleviation of an aversive stimulus (avoiding loss of money) to increase behavior (i.e., negative reinforcement) (Burns & Rothman, 2018). Deposit contracts offer several advantages over reward-based incentives. First, although both rewards and deposit contracts bring an incentive into the present, a deposit contract brings a risk of loss into the present and thus should be more effective because it capitalizes on loss aversion (Halpern et al., 2015). Second, the use of reward-based financial incentives for physical activity imposes a significant cost (eg, approximately US

$1.50 per day per person, see the study by Mitchell et al (Mitchell et al., 2019)), whereas the use of deposit contracts introduces (partial) cost sharing by recipients. Such cost-sharing may be desirable, e.g. to employers promoting physical activity among employees (Cawley & Price, 2013). Moreover, while rewarding people for behavior that others perform without receiving rewards might be considered unfair, having people voluntarily deposit their own money avoids this ethical concern (Sykes-Muskett et al., 2015).

Existing evidence indicates that deposit contracts are effective to help people lose weight (Sykes-Muskett et al., 2015), stop smoking (Halpern et al., 2015; Jarvis & Dallery, 2017) and increase physical activity (Budworth et al., 2019; Burns & Rothman, 2018; Donlin Washington et al., 2016; Krebs & Nyein, 2021; Patel et al., 2016; Stedman-Falls & Dallery, 2020). However, the voluntary uptake of deposit contracts is generally low (Halpern et al., 2015; Royer et al., 2015). In fact, some authors suggest that those who would benefit the most from interventions using incentives with potential losses are not likely to enter into them (Adjerid et al., 2021; Lipman, n.d.). However, comparing the evidence on the uptake and effectiveness of deposit contracts for physical activity among studies is complicated, as operationalizations differ substantially. In particular, 3 different types of deposit contracts can be distinguished. First, in line with their potential to promote cost sharing, several authors have used completely self-funded deposit contracts (Gine et al., 2008; Royer et al., 2015). Without the potential for financial gain, such self-funded deposit contracts involve only losses compared with the status quo. Second, uptake of deposit contracts is often encouraged through "matching" individuals' contribution into the deposit scheme or combining deposits with a reward-based incentive (Finkelstein et al., 2017; Halpern et al., 2015; John et al., 2011). Such matched deposit contracts thus involve both potential gains and losses compared with the status quo. Third, some authors have used loss framing to mimic the feelings of loss involved in a deposit contract without actually requiring individuals to put their own money at risk (Burns & Rothman, 2018; Patel et al., 2016). For example, in a loss-framed condition, Patel et al (Patel et al., 2016) promised respondents US $42 up front of which they could then lose US $1.40 for every day they did not attain physical activity goals. This loss-framed condition proved more effective in promoting physical activity compared with a gain-framed condition in which respondents simply earned US $1.40 for every day they attained physical activity goals. However, participants in all conditions of this study faced no actual losses, but in fact were making gains compared with their preintervention status quo.

This Study

In this study, we investigate the impact of deposit contracts on increasing physical activity by disentangling the effects of incurring actual losses (through self-funding) and loss framing. We will use an actual deposit contract (ie, a stick) that requires participants to

make a deposit of their own money before the intervention starts and compare this with receiving a reward (ie, a carrot) of equivalent size. In line with the study by Adams et al (Adams et al., 2014), we refer to this as the *direction* of incentives. Furthermore, we will investigate whether loss framing (compared with gain framing) enhances the effectiveness of both reward and deposit contract incentives. First, we expect that, overall, incentive conditions are more effective than an active no-incentive control condition (H1). Second, we hypothesize that deposit contracts will have lower uptake than regular rewards (H2); however, deposit contracts are expected to be more effective than regular rewards for those that partake in the intervention (H3). In addition, we hypothesize that loss framing an incentive will increase effectiveness compared with gain framing (H4). Finally, we propose that incentives in which both direction of the incentive and framing of the incentive are loss congruent (ie, loss-framed deposit contracts) are most likely to invoke loss aversion and are therefore especially effective in promoting physical activity (H5).

Methods

Participants

We recruited healthy participants aged between 18 and 30 years through a university research participation system (SONA), flyers on campus, and posts on social media. Participants had to be willing to improve 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 199 for detecting a between-conditions difference in effectiveness with a medium effect size (f=0.20), 80% power, and an α of .05 (analysis of covariance [ANCOVA] with 5 groups). On the basis of a similar research (Kramer et al., 2019) that showed a relatively high dropout rate between recruitment and participation, we assumed a dropout rate of 20% and aimed to recruit 240 eligible participants. Participants were excluded if they reported any medical condition that could hinder their physical activity (based on their response to the Physical Activity Readiness Questionnaire) (Thomas et al., 1992). A detailed description of the flow of participants through the study, including reasons for exclusion and dropout, is provided in

Multimedia Appendix 1. All the participants who completed the study had a chance to win 1 of 3 grand prizes (3 Fitbit devices worth €100 [at the time of writing: €1=US $0.98]) and 1 of 50 small prizes (50 webshop vouchers worth €10) in a raffle. Participants who were first-year psychology students at Leiden University additionally received research credits (needed to complete their first year).

Ethics Approval

We obtained informed consent before the start of the study. This study was approved by the Psychology Research Ethics Committee of Leiden University (2020-02-24-T. Reijnders-V2-2089), and the study protocol was preregistered on the Open Science Framework (https://osf.io/34ygt).

Materials

The intervention for this study was delivered entirely on the web via the Benefit Move app, which the participants downloaded on their smartphones. The Benefit Move app was implemented using MobileCoach (Filler et al., 2015; Kowatsch et al., 2017), an open-source software platform for smartphone-based and chatbot-delivered behavioral interventions (eg, study by Kowatsch et al (Kowatsch et al., 2021) and ecological momentary assessments (eg, study by Tinschert et al (Tinschert et al., 2019). MobileCoach was developed by the Centre for Digital Health Interventions at Eidgenössische Technische Hochschule Zürich and the University of St. Gallen in Switzerland (www.mobile-coach.eu). The Benefit Move app had two main functions: (1) objectively measuring physical activity and (2) communicating with the participant.

To measure physical activity, the Benefit Move app asked the participants for permission to retrieve step counts from existing health apps already installed on their smartphones. Most smartphones have a gyroscope-based pedometer or location-tracking device integrated to record movements made while the phone is being carried. Algorithms recode the raw data from these sensors into an estimated step count, which is then stored in the database of apps, such as Apple Health and Google Fit. Depending on the operating system, Benefit Move would pull data from either Google Fit (www.google.com/fit/) for Android or Apple's Health Kit (developer.apple.com/documentation/healthkit) for iOS. Overall, out of 126 participants, 67 individuals (53.2%) used Apple iOS devices and 59 participants (46.8%) used Android devices. The percentage of Apple iOS users ranged from 41.1% to 69.6% across conditions and was considered to be spread evenly across conditions. Both of these apps showed good validity for measuring step counts (Höchsmann et al., 2018; Polese et al., 2019). The Benefit Move app retrieved these data to provide a tailored step goal at the start of the intervention and to record step counts during the intervention. During the intervention phase, at any given time, the participant could click a button to retrieve the up-to-date step count at that moment. In addition, to communicate with the participant, an automated digital coach (chatbot) sent daily prompts to provide the participant with feedback about goal progress, their accumulated financial earnings or losses, and a trigger to click the button for step count retrieval (Figure 1 provides an impression of the app).

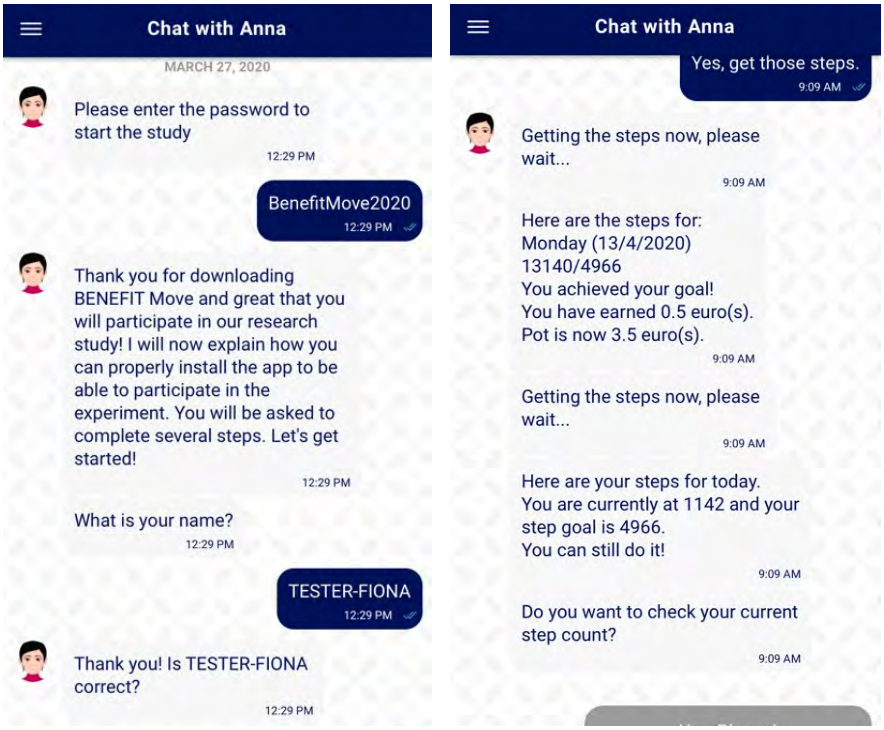

Figure 1. Impression of the Benefit Move app.

Measures

Baseline Survey

The baseline survey was administered during onboarding in the app to obtain basic demographic information such as sex, birth year, nationality, country of residency, education level, employment status, subjective estimation of income relative to peers, and subjective estimation of weight status (Multimedia Appendix 2 provides an overview of the survey items).

Final Survey

The final survey was administered after the intervention was completed. First, as a sensitivity check, we asked the participants whether they carried their smartphone with them more often because of the intervention (Multimedia Appendix 3 provides an overview of the final survey items). Furthermore, we asked the participants if they cheated the intervention but assured them that their answer would not impact the payout of incentives. We also performed a contamination check to explore whether participants were aware

of the condition that others were assigned. Because the intervention coincided with the worldwide COVID-19 pandemic, we included several items to assess its impact on our study. First, we assessed whether participants experienced influenza-like symptoms, whether these symptoms led them to be less physically active, and, in general, whether they engaged in less physical activity owing to the COVID-19 pandemic. Furthermore, we administered the Generalized Anxiety Disorder-7 (Spitzer et al., 2006), a brief 7-item measure that assesses generalized anxiety symptoms that could be related to the COVID-19 pandemic. Finally, as a manipulation check, we included 2 items (answered on a 10-point Likert scale from 1=totally disagree to 10=totally agree) that asked whether participants experienced a feeling of loss during the intervention ("I felt that I was losing money if I did not increase my step count") and whether they experienced goal commitment ("I felt strongly committed to the goal of increasing my step count").

Procedure

After recruitment, all the participants were put on a waitlist before they received the screening survey and informed consent. One week before the start of the intervention, participants completed the screening survey with the inclusion and exclusion criteria and provided digital informed consent. Thereafter, eligible participants received a URL to the iOS or Android app stores where they could download the Benefit Move intervention app and install it on their smartphone. Once the participants installed the app, they were asked to complete onboarding in the app within 2 days. Thereafter, participants were sent a link to the survey platform LimeSurvey that opened within the Benefit Move app. Here, they filled in the baseline survey (for more details, see the Baseline Survey section) and then returned to the app after completion. Participants were excluded from the study if they did not complete the onboarding process and baseline survey before the start of the intervention.

After participants completed the baseline survey, they received a tailored step goal based on their 7-day historic daily step average that was retrieved through Google Fit or Apple Health. Retrieving step counts for 7 consecutive days should accurately estimate habitual activity levels of individuals (Yao et al., 2021), and providing an individualised and realistic goal should increase intervention effectiveness (Mitchell et al., 2019). A limitation to using a 7-day historic step count is that meteorological factors could impact baseline levels of activity (Togo et al., 2005). If historic data were available, the participant was assigned a goal that was 120% of the historic daily step average. For example, someone who, in the 7 days before goal setting, took an average of 5000 steps per day would automatically receive a 6000 steps daily step goal. If no historic data were available, the participant was assigned a default step goal of 10,000 steps per day because it is an often-used guideline for sufficient physical activity (Schneider et al., 2006).

All the participants started simultaneously with the 20-day intervention on Monday, March 30, 2020, at 9 AM. Owing to the COVID-19 pandemic, a partial lockdown was issued by the Dutch government on March 15, 2020. Onboarding for this study (and retrieval of 7 days of historic step counts) was performed from March 23, 2020, until the active study phase started on March 30, 2020. Therefore, it is possible that the estimates of the baseline activity were lower than normal. Each day during the 20-day intervention, the participants received a push notification at 9 AM. This notification prompted them to click a button to retrieve their step count performance of the previous day and get an update on the progress for the current day. If the user skipped doing this for several days but then responded and requested an update, the feedback for multiple days was given in separate consecutive messages, with a separate update message per day. The feedback per day consisted of the achieved step count compared with the daily step goal, a conclusion about whether the goal was achieved or not, the money that was earned or lost on that day, and the running total of earnings or losses during the entire intervention (Figure 1 provides an example). On the basis of their study conditions, participants received different instructions at the start of the intervention and received different feedback messages during the intervention.

Study Conditions

We used a 2 incentive direction (reward or deposit) × 2 feedback frame (gain or loss) design with an additional control condition. The participants were automatically randomized to these 5 conditions by the app.

Condition 1: Control Condition

Participants received an active basic intervention with a tailored goal and daily feedback on their goal progress without a financial incentive or specific framing of feedback.

Condition 2: Reward and Gain Frame Condition

After having been assigned their step goal, participants were informed that they would receive a monetary reward of a maximum of €10 for achieving their step goals during the intervention (the incentive amount of €10 was determined in a pilot study during which we sent a short survey to 26 students to assess what incentive amount they would find stimulating and acceptable). More specifically, to create a gain frame, they were informed that there was an empty pot at the start of the intervention and that for every successful goal achievement, they would receive €0.50 that would be added to the pot. If they were not successful, nothing would be added to the pot. After their condition was explained to the participants, we explicitly asked them if they wanted to participate in this challenge (this is especially relevant for participants in the deposit conditions, as they will be asked

to make a monetary payment to the experiment). After they explicitly agreed to the specific challenge that was presented to them, the participants were instructed to wait until the intervention started the next Monday morning.

Condition 3: Reward and Loss Frame Condition

After having been assigned their step goal, participants were also informed that they would receive a monetary reward of a maximum of €10 for achieving their step goals during the intervention. However, to create a loss frame, and in contrast to the gain frame condition, they were informed that there was a full pot with €10 at the start of the intervention and that for every goal failure €0.50 would be deducted from the pot. If they were successful, nothing would be deducted from the pot.

Condition 4: Deposit and Gain Frame Condition

After having been assigned their step goal, participants in the deposit and gain frame condition were asked to deposit €10 of their own money via bank transfer to improve their commitment to the challenge. In all cases, the full amount was refunded after the intervention, but participants were unaware of this and were informed that the amount they would get back would depend on their performance during the intervention. More specifically, they were informed that there was an empty pot at the start of the intervention and that for every successful goal achievement, €0.50 would be added to the pot. If they were not successful, nothing would be added to the pot. The final amount of the pot would be the amount of their deposit that would be returned to them after the intervention.

After their condition was explained to them, we explicitly asked the participants if they wanted to participate in this challenge. When participants agreed to participate, they were sent a digital payment request via "Tikkie" (a direct digital payment URL) in the app. By clicking on this payment request, they directly transferred €10 of their own funds to the experiment bank account. Participants who could not use this automated system were able to transfer the required amount manually to the experiment bank account. The experiment bank account was monitored closely, and when a deposit payment was received, we confirmed this to the participant through the intervention app. If no payment was received, participants were automatically reminded via push messages, SMS text messages, telephone calls, and email reminders. Participants were excluded if deposit payments were not confirmed 12 hours before the start of the intervention. After confirming the received deposit payment, we instructed the participants to wait until the intervention started the next Monday morning.

Condition 5: Deposit and Loss Frame Condition

Participants in this condition followed the same overall procedure as the participants in the deposit and gain frame condition did. However, to create the loss-framed feedback, they were informed that there was a full pot of €10 at the start of the intervention and that for every goal failure, €0.50 would be deducted from the pot. If they were successful, nothing would be deducted from the pot. The final pot amount was the amount of their deposit that we promised to return after the intervention.

Debriefing

After the participants completed the 20-day intervention, they received a summary of their performance in the challenge. In the 4 experimental conditions, the participants were additionally informed about their incentive earnings and told that they would receive this money (back) into their bank account as soon as possible. Thereafter, the participants were sent a link to the survey platform LimeSurvey that opened within the Benefit Move app. Here, they filled in the final survey (for more details, see the Final Survey section) and returned to the intervention app after completion. Participants were then debriefed about their condition; the other conditions and the deceptive element around their deposit were revealed. All payments to the participants were made within 2 weeks after the experiment ended.

Statistical Analysis

The primary outcome (continuous) was the effectiveness. This was measured through the mobile registration of step count data and defined as the number of days (0-20) the goal was achieved. The secondary outcome (binary) was the uptake of the intervention and defined as explicitly agreeing to participate in the challenge and paying the deposit (if required). We report results on the effectiveness based on a restricted sample that only included participants who retrieved steps on at least one intervention day and who received a tailored step goal. We excluded participants who received a default goal, because in hindsight, these participants were confronted with a goal that was unachievable (

Multimedia Appendix 4 provides an overview of analyses where these participants were included). Furthermore, we report the main analyses for effectiveness based on models that include baseline step counts as a covariate. The pattern of the results was similar, but the models gained accuracy by including the covariate. Data analysis was performed using SPSS statistics for Mac (version 28; IBM Corp). We dealt with missing cases by using pairwise exclusion and used the standard $P<.05$ criterion for determining statistical significance. For ANOVA and ANCOVA, we considered an effect size small when $\eta p^2>0.01$, medium when >0.06, and large when >0.14 (Cohen, 1988). For chi-square,

we considered an effect size small when Cramer *V*>0.1, medium when >0.3, and large when >0.5.

Hypothesis Testing

Hypothesis 1: Effectiveness of Incentive Conditions Compared With the Control Condition

First, we performed an ANCOVA with baseline steps as a covariate in which we compiled incentive conditions to compare all incentive conditions combined (mean of conditions 2-5) to the control condition (ie, condition 1). Second, we performed an ANCOVA with baseline steps as a covariate and effectiveness as the dependent variable to separately compare incentive conditions (ie, conditions 2-5) to the no-incentive control condition (ie, condition 1). The ANCOVA was performed with factor "condition" with 5 levels (conditions 1-5). We compared each incentive group separately to the control condition with four planned contrasts: 1=control versus deposit and gain, 2=control versus deposit and loss, 3=control versus reward and gain, and 4=control versus reward and loss.

Hypothesis 2: Uptake of the Intervention

We performed a chi-square test of independence to investigate whether the uptake was lower for deposit contracts (ie, conditions 4 and 5) compared with regular rewards (ie, conditions 2 and 3).

Hypothesis 3 to 5: The Effect of Incentive Direction and Feedback Framing on Effectiveness

We performed a 2-way ANCOVA with baseline steps as a covariate. Effectiveness was the dependent variable, and the model contained 2 factors: incentive direction (deposit or reward) and feedback frame (loss or gain). In the model, we specified both the main effects of the factors (H2 and H3) and their interactions (H4).

Results

Descriptives

In total, we analyzed the data on the uptake of participants (N=126) with a mean age of 22.7 (SD 2.84) years of which 68.2% (86/126) identified as female. Most participants had the Dutch nationality (69/126, 54.8%), approximately half (60/126, 47.6%) were students, most reported to have an income similar to their peers (71/126, 56.3%), and most considered themselves to have an appropriate body weight (89/126, 70.6%). After their condition was explained to them, 11 participants explicitly refused the challenge, 7

participants did not pay their deposit in time, and 12 participants did not retrieve steps on any day of the intervention. Therefore, the data from 96 participants were available for the analysis of effectiveness, and the data from 65 participants remained after exclusion of nontailored goals (see the Methods section for rationale). Table 1 provides more details on the characteristics of the full sample that was analyzed for uptake and the subsample that was analyzed for effectiveness.

Table 1. Sample characteristics of the full sample and the subsample that was analyzed for effectiveness.

Variable	Full sample (N=126)	Subsample effectiveness (N=65)
Age (years), mean (SD)	22.7 (2.84)	22.2 (2.53)
Sex, n (%)		
Male	40 (31.7)	13 (20)
Female	86 (68.3)	52 (80)
Nationality, n (%)		
Dutch	69 (54.8)	40 (61.5)
German	20 (15.9)	10 (15.4)
Other	37 (29.4)	15 (23.1)
Work, n (%)		
Student without a job	54 (42.8)	33 (50.8)
Student with a job	6 (4.8)	1 (1.5)
Working part time	14 (11.1)	6 (9.2)
Working full time	45 (35.7)	21 (32.3)
Do not want to answer	7 (5.6)	4 (6.2)
Income, n (%)		
Less than my peers	15 (11.9)	9 (13.8)
Same as my peers	71 (56.3)	39 (60)
More than my peers	20 (15.9)	9 (13.8)
Do not want to answer	20 (15.9)	8 (12.3)
Weight (kg), n (%)		
Underweight	3 (2.4)	1 (1.5)
A bit underweight	7 (5.6)	4 (6.2)
Appropriate weight	89 (70.6)	48 (73.8)
A bit overweight	19 (15.1)	9 (13.8)
Overweight	7 (5.6)	2 (3.1)
Do not want to answer	1 (0.8)	1 (1.5)

Hypothesis Testing

Hypothesis 1: Effectiveness of Incentive Conditions Compared With Control Condition

First, a 1-way ANCOVA with baseline steps as a covariate showed that, overall, incentive conditions (mean 13.10, SD 6.33 days goal achieved) had higher effectiveness than the control condition (mean 8.00, SD 5.65 days goal achieved; $F_{1,62}$=10.72; P=.002; ηp^2=0.147). Furthermore, to test specific contrasts, a second 1-way ANCOVA with baseline steps as a covariate showed that the factor condition was related to the effectiveness of the intervention ($F_{4,59}$=5.48; P<.001; ηp^2=0.271). Participants in the control condition achieved their step goal on a mean of 8.00 (SD 5.65) days. Planned contrasts indicated that this was significantly less than that in the participants in reward and gain condition (mean 13.30, SD 5.49 days goal achieved; P=.003; SE 1.86). Furthermore, this was also significantly less than that of participants in the deposit and gain condition (mean 17.40, SD 6.17; P<.001; SE 2.25). We did not find a significant difference between the control condition and the reward and loss condition (mean 10.00, SD 7.01 days goal achieved; P=.23; SE 2.19). No significant difference was found between the control condition and the deposit and loss condition (mean 11.29, SD 5.16 days goal achieved; P=.19; SE 2.53). Owing to indications that normality of the dependent variable was violated, we performed a Kruskal-Wallis test to check the robustness of these findings. We only found a significant contrast between the control condition and the deposit and gain condition (P=.001, adjusted with Bonferroni correction). There was no evidence of a significant difference for the other contrasts.

Hypothesis 2: Uptake of the Intervention

Uptake of the intervention was defined as explicitly agreeing to participate in the challenge and paying the deposit (if required). A chi-square test of independence showed that requiring a deposit decreased the uptake of the intervention (N=97; χ^2_1=23.5; P<.001; Cramer V=0.492). In the reward conditions, 100% (50/50) of the participants accepted the intervention compared with 62% (29/47) in the deposit conditions (Table 2 provides a descriptive overview of the results). We explored whether those with uptake differed from those with no uptake but were underpowered for these analyses and accordingly found no differences in demographic data (sex, income, weight status, and age) or other baseline characteristics (goal type, self-efficacy, risk proneness, self-control, autonomous motivation, extrinsic motivation, and historic step count).

Table 2. Descriptive overview of the results.

Variable	Condition					Total (N=126)
	Control (n=29)	Reward and gain frame (n=32)	Reward and loss frame (n=18)	Deposit and gain frame (n=23)	Deposit and loss frame (n=24)	
Uptake, n (%)	29 (100)	32 (100)	18 (100)	15 (65)	14 (58)	108 (86)
Explicit refusal, n (%)	0 (0)	0 (0)	0 (0)	4 (17)	7 (29)	11 (9)
Deposit not paid, n (%)	N/A[a]	N/A	N/A	4 (17)	3 (12)	7 (6)
Steps never retrieved, n (%)	2 (7)	4 (12)	3 (17)	0 (0)	3 (12)	12 (10)
Goal type, n (%)						
Tailored goals	18 (62)	21 (66)	11 (61)	17 (74)	14 (58)	81 (68)
Default goals 10,000	11 (38)	11 (34)	7 (39)	6 (26)	10 (42)	45 (36)
Assigned step goal, mean (SD)	6189 (3604)	6384 (3700)	6992 (3111)	5960 (3544)	7714 (3724)	6602 (3574)

[a]N/A: not applicable.

Hypothesis 3 to 5: Effect of Incentive Direction and Feedback Framing on Effectiveness

A 2-way ANCOVA with baseline steps as a covariate showed no main effect of incentive direction ($F_{1,43}$=1.98; P=.17; ηp^2=0.044), indicating that deposits (mean 14.88, SD 6.40 days goal achieved) were not more effective than rewards (mean 12.13, SD 6.17 days goal achieved). We did find a main effect of feedback framing ($F_{1,43}$=7.91; P=.007; ηp^2=0.155), indicating that loss frames (mean 10.50, SD 6.22 days goal achieved) were significantly less effective than gain frames (mean 14.67, SD 5.95 days goal achieved). Finally, the interaction effect of incentive direction×feedback framing was not significant ($F_{1,43}$=1.16; P=.29; ηp^2=0.026), indicating that feedback framing did not have a different effect on deposit conditions compared with reward conditions. Table 3 provides a descriptive overview of the results for each arm of the experiment.

Furthermore, to test the robustness of these findings, we additionally performed a Kruskal-Wallis test. For the main effects, we performed 2 separate tests, one for each factor from the 2-way ANOVA. However, the interaction effect could not be tested with this alternative method. Consistent with the results of the 2-way ANCOVA, we found that incentive direction was not significantly related to effectiveness (P=.06), but feedback framing was significantly related to effectiveness (P=.03). Additional checks to test the sensitivity of the main findings are reported in Multimedia Appendix 5.

Table 3. Descriptive overview of results for participants with tailored goals.

Variable	Condition, mean (SD)					Total (N=65), mean (SD)
	Control (n=17)	Reward and gain frame (n=20)	Reward and loss frame (n=11)	Deposit and gain frame (n=10)	Deposit and loss frame (n=7)	
Baseline step count	3406 (1982)	3868 (2673)	4232 (2056)	4036 (3187)	3472 (1537)	3792 (2347)
Assigned step goal	4087 (2378)	4642 (3207)	5078 (2467)	4843 (3825)	4166 (1844)	4550 (2816)
Intervention step count	3130 (2466)	5071 (2783)	4763 (2105)	6395 (4526)	3993 (2464)	4599 (3025)
Days goal achieved	8.00 (5.65)	13.30 (5.49)	10.00 (7.01)	17.40 (6.17)	11.29 (5.16)	11.77 (6.52)

Effect of the Manipulations on Experienced Feelings of Loss and Goal Commitment

To check the effect of our manipulations, we analyzed the effects of incentive direction and feedback framing on feelings of loss and goal commitment. We performed 2 separate 2-way ANOVAs (one for feeling of loss and one for goal commitment) with factor incentive direction (deposit or reward) and factor feedback frame (loss or gain). The model included both main effects and their interactions. The first ANOVA, with feeling of loss as the dependent variable, showed a significant effect of incentive direction ($F_{1,41}$=19.66; P<.001; ηp^2=0.324). Deposit contracts (mean 7.19, SD 2.23) resulted in stronger feelings of loss compared with rewards (mean 4.21, SD 2.19). However, feedback framing did not influence the feeling of loss, and we did not find a significant interaction. The second ANOVA, with goal commitment as the dependent variable, showed a significant effect of feedback framing ($F_{1,41}$=4.95; P=.03; ηp^2=0.108). Loss-framed incentives (mean 5.24, SD 3.11) resulted in weaker goal commitment compared with gain-framed incentives (mean 7.14, SD 2.37). However, incentive direction did not influence goal commitment, and we did not find any interaction.

Discussion

Principal Findings

This study found that financial incentives increase intervention effects compared with an active no-incentive control condition. Furthermore, as expected, the results showed that self-funded deposit contracts for physical activity have a lower uptake than regular reward incentives. However, in contrast to our hypothesis, we did not find deposit contracts to be more effective than reward incentives, but they were also not less effective and have important benefits for large-scale implementation. An important unexpected finding was that loss framing decreased the effectiveness of the intervention compared with gain framing. This finding is in contrast to the existing literature and seems to provide the first preliminary evidence that for improving physical activity with financial incentives in a healthy population, loss framing is less effective than gain framing.

First, the finding that financial incentive conditions were more effective than an active no-incentive control condition is in line with the results from meta-analyses (Giles et al., 2014; Mantzari et al., 2015; Mitchell et al., 2019). Compared with participants in the control condition, participants who received a financial incentive were shown to reach about 5 more daily step goals (and took about 2000 steps more per day) during the 20-day intervention. This is a large and clinically relevant effect with a mortality-reducing potential (Lee et al., 2019; Saint-Maurice et al., 2020). We explain this finding through the idea that financial incentives capitalize on the present bias and introduce an immediate monetary incentive for being physically active.

Second, we found that the uptake of deposit contracts was lower than that of regular rewards. This finding is in line with the work by Halpern et al (Halpern et al., 2015) on deposit contracts for smoking cessation. A common sense explanation for this finding is that people are more open to an intervention where they stand to gain something (ie, a reward) than where they stand to lose something (ie, their own money). The same aversion to losses that is thought to increase effectiveness might deter people from entering into a deposit contract. In fact, this tension between effectiveness and uptake has been recognized before (Halpern et al., 2012). Furthermore, although we simplified all steps in the payment process, it could be that the logistical barrier of having to provide a monetary deposit deterred some individuals, regardless of whether they dismissed the concept of deposit contracts per se. Finally, it is important to understand which people are most likely to accept and reject a deposit contract intervention. For example, it has previously been suggested that individuals who recognize their challenges while resisting temptation (ie, sophisticates) might be open to using deposit contracts (Halpern et al., 2012). Future research should use a self-funded deposit contract and investigate the moderators of uptake to shed light on which subgroups are best reached.

Third, in contrast to our hypothesis, deposit contracts were not more effective than regular reward incentives. We expected, in line with others, that deposit contracts would invoke loss aversion and therefore would be more effective than regular rewards. Our analyses indeed showed that deposit contracts resulted in stronger feelings of loss than rewards did, but this did not result in higher effectiveness. Our results are in contrast to those reported for smoking cessation by Halpern et al (Halpern et al., 2015). Possibly, for physical activity, deposit contracts are not more effective than rewards. Another explanation might be that participants perceived the stakes in our study as low and therefore were not averse to potentially losing their deposits. This would be in line with the work by Mukherjee et al (Mukherjee et al., n.d.) who found that for high stakes, participants rated losses more impactful than gains (ie, loss aversion), but for low stakes, this tendency reversed, and gains were rated as more impactful than losses. It is possible that subjective judgments by our participants rated the incentive as low stakes and therefore deposit contracts were not more effective than rewards. Future work should investigate deposit contracts and rewards of varying sizes to determine the potential tipping points at which deposit contracts are superior to rewards and when this is reversed. In addition, it is possible that deposit contracts are superior to rewards (the descriptive means were in the expected direction), but we did not have enough statistical power to detect a significant difference. More fully powered studies that investigate self-funded deposit contracts for physical activity are needed to draw firmer conclusions on this point. Existing studies in the domain of physical activity either operationalized deposit contracts differently using loss framing (Burns & Rothman, 2018; Patel et al., 2016), or were also not powered (Budworth et al., 2019; Donlin Washington et al., 2016; Krebs & Nyein, 2021; Stedman-Falls & Dallery, 2020) to provide a clear answer to this question.

Finally, unexpectedly, we found that loss framing decreased the effectiveness of the intervention compared with gain framing. In line with the study by Patel et al (Patel et al., 2016), we expected that framing an incentive as a loss would activate loss aversion and therefore increase effectiveness compared with gain framing an incentive. However, our analyses showed that loss framing did not increase feelings of loss compared with gain framing. Thus, it appears that our attempt at shifting participants' reference point was unsuccessful. We did find that loss framing decreased feelings of goal commitment, which might explain why the effectiveness of loss frames was lower than that of gain frames. Our results contradict the findings of Patel et al (Patel et al., 2016) who showed that loss-framed incentives were more effective than gain-framed incentives. However, Patel et al (Patel et al., 2016) studied university employees who are obese, with a BMI >27, whereas our sample consisted of healthy university students. Possibly, a difference in regulatory fit related to differences in the study sample might explain this discrepancy. Regulatory fit is when the persuasiveness of a health message is increased when its frame is congruent with the regulatory orientation of the individual (Ludolph & Schulz, 2015). Regulatory

focus theory discerns 2 modes of regulatory orientation: promotion focus and prevention focus. Although people with a promotion focus aim for desired end states, people with a prevention focus aim for avoiding undesired end states (Ludolph & Schulz, 2015). Perhaps, adults who are obese are more focused on avoiding obesity-related health problems, and therefore have a stronger prevention focus when increasing physical activity. This could lead them to respond better to a loss-framed incentive (in which losing money is prevented) because of a greater experienced regulatory fit. By contrast, perhaps healthy students have a stronger promotion focus (on becoming more fit rather than avoiding health problems) and therefore respond better to a gain-framed incentive. Whether the regulatory fit effect also applies to incentive framing (and not only to framing of persuasive health messages) is an interesting avenue for future research. Future research should measure regulatory orientation and investigate the possible interactions with different incentive frames.

Strengths and Limitations

An important strength of this study is that we used a self-funded deposit contract that required participants to make a monetary deposit before the intervention started. This allowed us to compare the effects of self-funded deposit contracts with those of loss frames. Another strength is that we used objective registrations of step counts and did not rely on self-reported estimations of physical activity. Finally, the app automatically provided participants with tailored goals based on their historical step counts, thus creating a personalized intervention experience. However, requiring a deposit beforehand also resulted in a lower uptake of the deposit contract conditions. As a result, the deposit requirement may have filtered out people who lacked motivation, thus leading to an overestimation of effectiveness in the deposit contract conditions. Consequently, caution is warranted when interpreting the effectiveness of the deposit contract conditions. Another limitation of our study is that high dropout before onboarding, unbalanced allocation, lack of uptake in the deposit contract conditions, and the exclusion of nontailored goals decreased the statistical power of our analyses. Limited statistical power might have especially affected the findings for specific analyses on effectiveness such as when we compare deposit contracts with regular rewards or loss frames with gain frames. Therefore, the results of this study should be interpreted with caution, and future work should be done to confirm these findings. Furthermore, before onboarding, participants read the informed consent form, which mentioned that the study possibly required them to deposit €10 of their own money. Mentioning this possibility was important for informed consent but may have deterred some participants from participating before they onboarded in the app. It is possible that this biased our analysis of uptake and that the actual uptake of deposit contracts is lower than our analyses suggest. In addition, although we propose that objective measures of physical

activity are superior to subjective self-reports, an important criticism of pedometer-based intervention research is that it is impossible to differentiate an increase in step count from an increase in pedometer wear time (Finkelstein et al., 2019). In our case, participants in the gain-framed conditions reported having carried their smartphone more often than they normally do (Multimedia Appendix 5), and this might partly explain why gain-framed conditions were more effective than loss-framed conditions. Furthermore, a relatively high proportion of the participants (45/126, 35.7%) did not have historical step data available on their smartphones. These people were assigned a default goal (10,000 steps per day) that was unachievable in hindsight. Although 10,000 steps per day is often used as a goal in commercial physical activity trackers and apps, this already exceeds the guidelines for sufficient physical activity, which translates to approximately 7000 to 8000 steps per day (Tudor-Locke et al., 2011). Future research with a similar goal-setting module should assign more achievable default goals when the goals cannot be tailored. In our sample, the mean baseline step count of participants with historical data was approximately 3800 steps per day. On the basis of a meta-analysis of financial incentive intervention effects, we suggest that step goals should not exceed baseline levels by >20% to 30% (Mitchell et al., 2019). In addition, the intervention was launched in March 2020, and during this period, the first COVID-19 lockdown measures in the Netherlands were implemented. Although this probably impacted all conditions equally, a large part (51/65, 78%) of the sample reported having been less physically active than they normally were because of the situation around COVID-19. As a result, it is possible that the estimates of baseline activity were lower than normal; therefore, the intervention led to stronger improvements than would be found under normal circumstances. Furthermore, our sample consisted of predominantly healthy, young, female students at universities. Although we purposefully recruited a homogenous sample to increase internal validity, the external validity of our findings is therefore restricted. Older or more chronically ill populations might respond differently to this type of intervention. Finally, we only investigated short-term effects during a 20-day intervention period. Therefore, we are unable to answer questions about the long-term effectiveness of the different incentive directions and incentive frames that we tested. Future work with longer intervention durations should be done to study how rates of goal achievement (and step counts) vary over time during and after the intervention.

Implications

An important theoretical contribution of this study is that we did not replicate the finding that loss-framed financial incentives are more effective than gain-framed financial incentives for increasing physical activity (Patel et al., 2016). By contrast, our results show that gain-framed incentives are more effective. Although we are unable to ascertain what

has produced this effect, by itself it provides evidence that (perceptions of) losses are not always more impactful than (perceptions of) gains. Rather, it supports the argument made by Gal and Rucker (Gal & Rucker, 2018) that loss aversion is a context-dependent tendency with boundary conditions, instead of a ubiquitous phenomenon. This finding also has implications for those who want to implement loss-framed financial incentives in practice. Because our results show that loss frames might hurt incentive effectiveness, we warn against implementing them in practice without further research on their boundary conditions. Finally, we were unable to show that deposit contracts were more effective than rewards, but they were also not less effective. Considering that deposit contracts are (partially) self-funded makes them attractive for large-scale implementation. However, before deposit contracts can be implemented on a large scale, it is important to further understand which subgroups are not reached by them. Although to the best of our knowledge the relationship between income and uptake of deposit contracts has not yet been studied, one can imagine that people with lower incomes might reject a deposit contract because they are less able to deposit a sum of their own money. This could cause vulnerable key subgroups (eg, people with lower socioeconomic status or cardiovascular disease) not to be reached by a deposit contract intervention. Possibly, this issue could be overcome by offering income-dependent deposit sizes or allowing participants to freely choose an amount that is motivating but that does not cause financial harm when lost (Sykes-Muskett et al., 2015).

Conclusions

Although this study was underpowered and the results have to be interpreted with caution, we have shown that deposit contracts have lower uptake than rewards but appear to have (at least) comparable effects on physical activity. Loss framing an incentive might undermine effectiveness, and we therefore urge for more research before implementing them in practice. Deposit contracts might be a promising tool for behavior change; however, more research is needed on who is willing to use them and for whom they are most effective.

Authors' Contributions

DRDB, TR, and AWME helped in the study design; DRDB, SP, and TK performed the intervention and app design and development; DRDB, TRCR, and performed the data acquisition; DRDB, TR, AWME, and LDB performed the data analysis and interpretation; DRDB, TR, SP, TK, and AWME drafted the manuscript; and DRDB, TR, TRCR, SP, TK, SAL, LDB, VRJ, RAK, AWME, and THAB revised the manuscript. All the authors gave their final approval and agreed to be accountable for all aspects of the work, ensuring integrity and accuracy.

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Chapter 3

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

Based on: De Buisonjé, D. R., Reijnders, T., Cohen Rodrigues, T. R., Santhanam, P., Kowatsch, T., Breeman, L. D., Janssen, V. R., Kraaijenhagen, R. A., Kemps, H. M., & Evers, A. W. (2024). Less stick more carrot? Increasing the uptake of deposit contract financial incentives for physical activity: A randomized controlled trial. *Psychology of Sport and Exercise, 70*, 102532.

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).

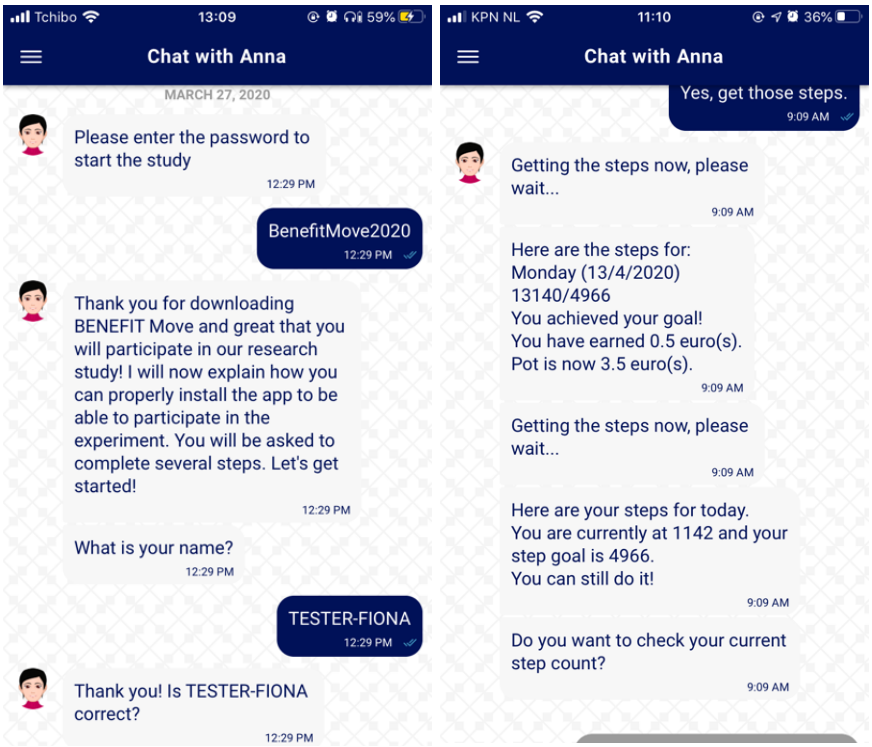

Figure 1. Impression of the Benefit Move application

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.

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Chapter 4

Put your money where your feet are: the real-world effects of gamified deposit contracts for physical activity

Based on: de Buisonjé, D.R., Brosig, F., Breeman, L.D., Bloom, E.L., Reijnders, T., Janssen, V.R., Kraaijenhagen, R.A., Kemps, M.C., and Evers, A.W.M. (2023). Put your money where your feet are: The real-world effects of StepBet gamified deposit contracts for physical activity. *Internet Interventions, 31*, 100610.

Abstract

Background: Gamification and deposit contracts (a financial incentive in which participants pledge their own money) can enhance effectiveness of mobile behavior change interventions. However, to assess their potential for improving population health, research should investigate implementation of gamified deposit contracts outside the research setting. Therefore, we analyzed data from StepBet, a smartphone application originally developed by WayBetter, Inc.

Objective: To perform a naturalistic evaluation of StepBet gamified deposit contracts, for whom they work best, and under which conditions they are most effective to help increase physical activity.

Methods: WayBetter provided data of StepBet participants that participated in a stepcount challenge between 2015 and 2020 (N = 72,974). StepBet challenges were offered on the StepBet smartphone application. The modal challenge consisted of a $40 deposit made prior to a 6-week challenge period during which participants needed to reach daily and weekly step goals in order to regain their deposit. Participants who met their goals also received additional earnings which were paid out from the money lost by those who failed their challenge. Challenge step goals were tailored on a 90-day historic step count retrieval that was also used as the baseline comparison for this study. Primary outcomes were increase in step count (continuous) and challenge success (dichotomous).

Results: Overall, average daily step counts increased by 31.2% (2,423 steps, *SD* = 3,462) from 7,774 steps *(SD* = 3,112) at baseline to 10,197 steps *(SD* = 4,162*)* during the challenge. The average challenge success rate was 73%. Those who succeeded in their challenge (n = 53,281) increased their step count by 44.0% (3,465 steps, *SD* = 3,013), while those who failed their challenge (n = 19,693) decreased their step count by -5.3% (-398 steps, *SD* = 2,993). Challenges started as a New Year's resolution were slightly more successful (77.7%) than those started during the rest of the year (72.6%).

Discussion: In a real-world setting, and among a large and diverse sample, participating in a gamified deposit contract challenge was associated with a large increase in step counts. A majority of challenges were successful and succeeding in a challenge was associated with a large and clinically relevant increase in step counts. Based on these findings, we recommend implementing gamified deposit contracts for physical activity where possible. An interesting avenue for future research is to explore possible setback effects among people who fail a challenge, and how setbacks can be mitigated.

Pre-registration: Open Science Framework (https://doi.org/10.17605/OSF.IO/D237C)

Introduction

Physical inactivity is one of the key risk factors for non-communicable diseases and causes millions of preventable deaths (World Health Organization, 2009). While physical inactivity is linked to chronic disease and early death (Anderson and Durstine, 2019), increasing physical activity improves mental health, reduces chronic disease, and increases longevity (Pedersen and Saltin, 2015). Importantly, these effects are found not only for intense aerobic training, but also for the mere number of steps taken in daily life (Lee et al., 2019; Saint-Maurice et al., 2020). Due to technological advances, steps taken in daily life can now easily be measured with the sensors that are available in smartphones. Besides allowing for real-time measurement of physical activity behavior (change), smartphones offer unique intervention opportunities. Many people habitually check their smartphone every 5 minutes, from the moment they wake up until the moment they go to bed (Heitmayer and Lahlou, 2021). Therefore, mobile behavior change interventions delivered on a smartphone have important benefits over traditional interventions (Murray et al., 2016). Instead of requiring resource intensive face-to-face contact, mobile behavior change interventions can be delivered cost-effectively to a broad audience and provide on-demand support, tailored to the dynamic nature of real-life behavior change (Mair et al., 2022). Despite these benefits, mobile behavior change interventions often suffer from a lack of adherence and high levels of attrition (Short et al., 2018). A strategy that is increasingly used to enhance engagement with mobile interventions is gamification (Alahäivälä and Oinas-Kukkonen, 2016). Gamification is defined as the use of game design elements in non-game contexts (Cugelman, 2013). The idea is that certain elements of games are highly engaging and can be incorporated in behavior change interventions to make them more engaging too. Cugelman (2013) has identified 7 persuasive strategies that are commonly applied in the gamification of behavior change. These are goal setting, challenges, feedback on performance, reinforcement, comparing progress, social connectivity, and fun and playfulness. A systematic review has shown that gamification can positively impact the effectiveness of health behavior change interventions, with the strongest evidence found for improving physical activity (Johnson et al., 2016). Furthermore, a meta-analysis has shown that gamified interventions for physical activity are not only effective in changing behavior, but also more effective compared with other behavioral interventions (Mazeas et al., 2022). It appears that adding gamification elements increases engagement with and effectiveness of mobile behavior change interventions.

StepBet ("StepBet," n.d.), a smartphone application originally developed by WayBetter, Inc., offers commercially accessible gamified mobile walking (stepcount) challenges. WayBetter also offers gamified behavior change interventions for weight loss in their DietBet (Leahey and Rosen, 2014) and WayBetter apps and is developing

QuitBet for cigarette smoking cessation (Bloom et al., 2021). WayBetter proposes that the three main components of their challenges are the use of gamified microgoals, financial incentives and social support ("Waybetter," n.d.). In Waybetter challenges, participants deposit some of their own money into a pool and join a group challenge with a concrete goal to improve their lifestyle. During the challenge they are provided with personally tailored goals, feedback on their goal progress, and they can interact with other participants to discuss and compare their progress. At the end of a challenge, those who failed lose their initial deposit while winners split the entire pool of money and receive a full refund of their deposit plus a profit. Although the Waybetter challenges contain all 7 persuasive gamification strategies identified by Cugelman (2013), a key element is the monetary 'bet' participants make at the start of a challenge. Theoretically, this type of financial incentive (in which participants pledge their own money as an incentive) is referred to as a deposit contract (Stedman-Falls and Dallery, 2020). The use of deposit contracts is often argued for using present bias and loss aversion (e.g., Halpern et al., 2012). Present bias is the finding that people tend to procrastinate on their long-term goals because they are more strongly influenced by the here and now (Laibson, 1997). Loss aversion refers to the finding that people are more strongly influenced by potential losses than they are by potential gains (Kahneman and Tversky, 1979). We argue that gamified deposit contracts hold promise as a tool to increase engagement with and effectiveness of mobile behavior change interventions, because people put something of themselves 'on the line' in the here and now, and have fun doing so. Deposit contracts have been successfully applied to weight loss , smoking cessation (Halpern et al., 2015; Jarvis and Dallery, 2017) and to increase physical activity (Budworth et al., 2019; Burns and Rothman, 2018; de Buisonjé et al., 2022; Donlin Washington et al., 2016; Krebs and Nyein, 2021; Patel et al., 2016; Stedman-Falls and Dallery, 2020). Interestingly, a recent meta-analysis of different types of financial incentives has shown that deposit contracts are the most effective financial incentive for improving healthy diet, weight control and physical activity (Boonmanunt et al., 2022).

The evidence for the effectiveness of adding gamification elements and deposit contracts to mobile behavior change interventions is promising. However, to improve population health, research has to investigate implementation of gamified deposit contracts outside the research setting and among larger and more diverse samples. Mobile behavior change interventions are often developed for research purposes, tested among WEIRD (White, Educated, Industrialized, Rich, Democratic) samples (see Rad et al., 2018), and only made available for the limited duration of a research study. In contrast, the StepBet challenges provide the opportunity to perform an ecologically valid investigation into the effect of gamified deposit contract challenges. Understanding whether gamified deposit contracts are not only efficacious in research settings, but also effective in real life conditions may inform public health policy making and may inspire future intervention

design. Previous scientific evaluations of the gamified deposit contracts offered by Waybetter have shown that they are effective for weight loss (Hirt-Schierbaum and Ivets, 2020; Leahey and Rosen, 2014) and acceptable for smoking cessation (Bloom et al., 2021). Interestingly, larger bet amounts, more frequent self-monitoring, more social interactions in the app, and more sharing on social media were associated with larger weight loss (Hirt-Schierbaum and Ivets, 2020; Leahey and Rosen, 2014). With regards to when challenges are started, research has shown that a 'fresh start' effect exists. People are more interested and committed to pursue lifestyle goals following temporal landmarks such as the passage of the year (Dai et al., 2014). Although interest in dieting and weight loss spikes right after the new year (Dai et al., 2014), it is not known whether people are also more successful in achieving goals that are started as a New Year's resolution. On the contrary, DietBet challenges for weight loss started as a New Year's resolution were less successful than challenges started during any other period of the year (Hirt-Schierbaum and Ivets, 2020). Perhaps these New Year's resolution challenges attract more naive participants, who underestimate their future self-regulation difficulties to a greater extent (Hirt-Schierbaum and Ivets, 2020). The effects of StepBet challenges on physical actvity have not yet been scientifically evaluated.

The current study

The primary aim of this study is to perform a naturalistic evaluation of the effect of participating in a StepBet challenge with gamified deposit contracts. Furthermore, we explore for whom these challenges work best, and under which conditions they are most effective to help increase physical activity. Based on evidence with regards to gamification (Mazeas et al., 2022) and deposit contracts (Budworth et al., 2019; Burns and Rothman, 2018; de Buisonjé et al., 2022; Donlin Washington et al., 2016; Krebs and Nyein, 2021; Patel et al., 2016; Stedman-Falls and Dallery, 2020), we hypothesize that participating in a StepBet challenge is associated with an increase in step counts. Furthermore, based on previous research on weight loss (Hirt-Schierbaum and Ivets, 2020), we hypothesize that StepBet challenges started as a New Year's resolution (between the 1st and 14th of January) have lower odds of success compared to challenges started during all other periods. Finally, we explore which features of deposit contracts or demographic variables are predictive of challenge success and increases in step counts.

Method

Participants

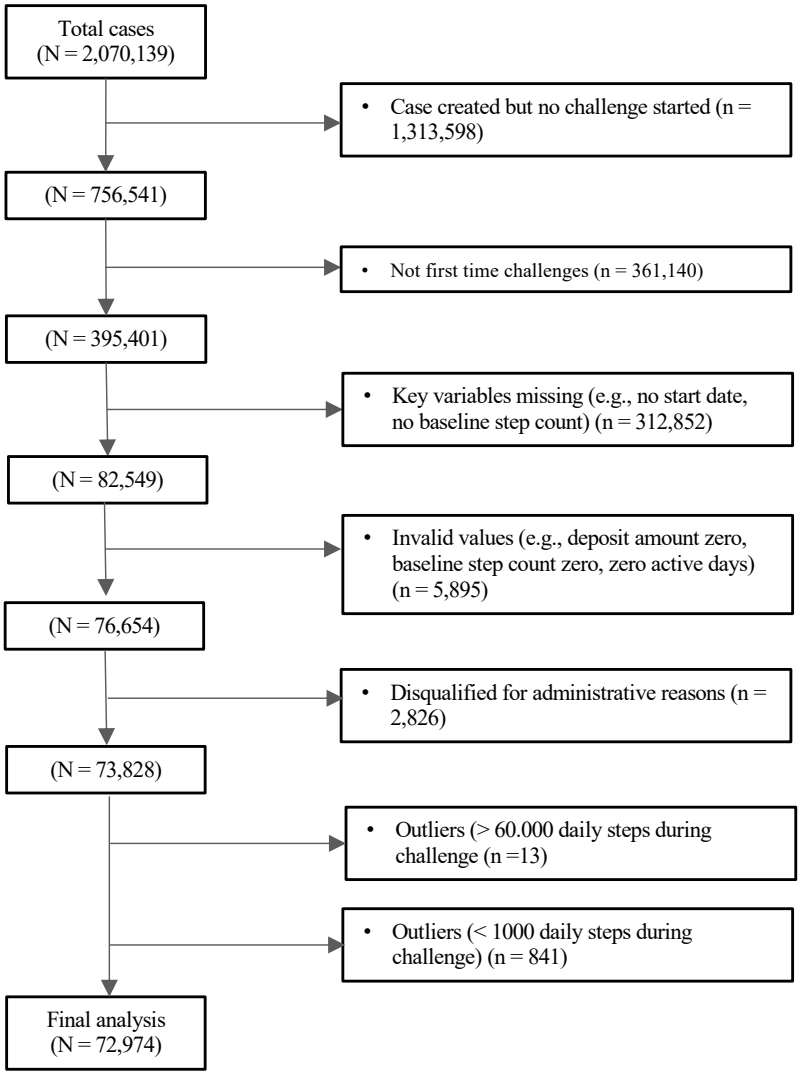

Figure 1 – Flowchart of data cleaning process

We analysed data of in total 72,974 unique participants. These individuals participated in at least one StepBet challenge in the 5-year time span between 11 December 2015 and 16 March 2020. The original data file we received from WayBetter contained over 2,000,000 cases and contained all challenges that were registered on the platform during

the timespan mentioned above. Prior to analysis we cleaned the dataset and excluded outlier cases with a daily average step count during the challenge of >60,000 steps per day (n = 13) or <1,000 steps per day (n = 841) (see *Appendix B* for rationale). See *Figure 1* for a flowchart of the data cleaning process. Final analysis was performed on data of 72,974 unique participants who participated in their first-time StepBet challenge. We did not obtain informed consent before the start of the study since we used anonymous research data collected by StepBet. WayBetter informs its users about the possibility of academic research on anonymized data in their privacy policy statement. The study protocol was preregistered on Open Science Framework: https://doi.org/10.17605/OSF.IO/D237C.

Procedure

WayBetter collected the data of StepBet participants and provided this to researchers from Leiden University. Since participants were customers of StepBet who by themselves decided to participate in these challenges, we characterize the data collection procedure as convenience sampling. To participate in a StepBet challenge, participants had to download the StepBet smartphone application (see section *The StepBet app* for more detail), allow it to record their step counts, and enter a challenge that requires a monetary deposit. During onboarding, participants were first asked to connect to their existing health tracking device (e.g., Fitbit, Garmin, Apple Health, Google Fit) for synchronization of their step count data. In doing so, the participant also allowed StepBet to retrieve their daily step count for the previous 90 days. This historic step count was used to determine a baseline and calculate a personalised step goal for during the challenge. Importantly, StepBet tried retrieving step counts for the previous 90 days, but considered 30 days as a minimum requirement and removed outlier days to calculate a baseline and tailor intervention goals (see *Appendix B* for more detail on the goal setting algorithm). Thereafter, participants were required to sign up to StepBet (via existing Social Media apps or their email account) and pick a challenge that they wanted to participate in. Upon entering a challenge, participants needed to pay the deposit amount required for the challenge (via PayPal or credit card) and then wait until it started. Most challenges started with a warm-up week during which steps were already being recorded, but participants would not fail their challenge if they did not reach their step goals. After the warm-up week the actual challenge began, and participants had to reach their daily step goal for a certain number of days per week (see section *The StepBet app* for more detail on goal setting) and received push notifications to inform them about their progress. If participants failed their challenge, they were disqualified and they lost their bet. If participants would fall ill during a challenge, they could request a refund of their deposit. When participants completed their challenge successfully (i.e., winners), they received their initial bet back plus a profit. The amount of this profit was determined by how many

participants in that challenge failed and lost their deposit, such that the total amount of the deposits from failed participants was split equally among the winners. The business model of StepBet consists of both membership fees and a cut taken from challenge pots. In the unlikely event that everyone in the game is a winner (or the win rate is so high that winners would not regain their entire bet if the company took their standard cut), the company forfeits their cut.

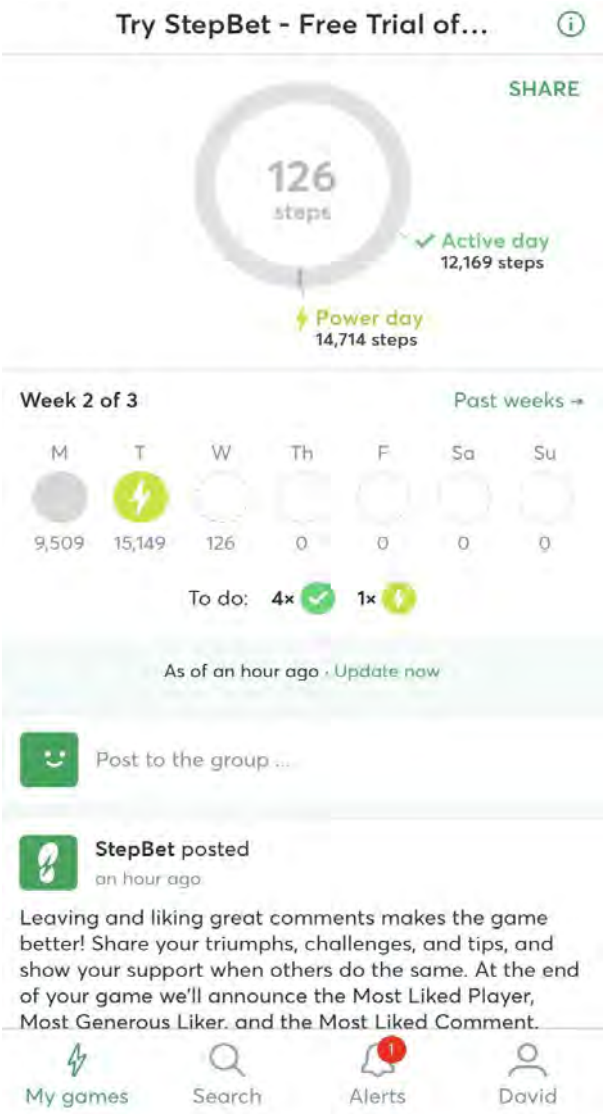

Figure 2. Screenshot of the StepBet application

Materials

The StepBet app

In the StepBet app (*see Figure 2),* participants entered into a deposit contract and paid an amount of money that they could earn back by reaching daily and weekly step goals. The amount of this deposit varied per challenge and ranged between a minimum of 10$ and a maximum of 60$ (N = 72,974, M = 37.78 $US, SD = 6.79). Challenges varied in duration (N = 72,974, M = 40.86 days, SD = 2.97) but most challenges lasted 6 weeks and included a warmup week. Furthermore, challenges varied in the number of participants who participated (N = 72,974, M = 864.29 participants, SD = 797.54). Also, participants had to achieve weekly goals which were made up of a certain ratio of daily goals. The ratio of these different goal types (rest-, active-, and power days) differed per challenge, but in a modal challenge, participants had to achieve step goals on 4 active days (110 % of baseline steps), 2 power days (130% of baseline steps) and got 1 rest day on which they didn't have to reach any certain number of steps. If the participant did not achieve the step goal on at least 4 active days and 2 power days for one week, the challenge was failed and the deposit was lost. The participant could choose on which day they reached which goal, but they needed to reach each of those goals on a weekly basis. Once a challenge was failed, participants could continue to track their steps and achieve daily and weekly goals but would no longer be able to get their deposit back. Participants could interact socially through the application by posting about their achievement, see those of others, and liking and commenting on posts of others. Participants received push notifications from the app and emails throughout the challenge. These notifications were provided to increase the frequency with which participants opened the StepBet app, to inform them about their daily goal achievement or failure, and to inform participants on whether the challenge was failed or successfully completed.

Measures

The StepBet app automatically registered general information about challenges and challenge outcome (failure/success). Furthermore, the app automatically retrieved baseline step counts, calculated personalised goals and automatically recorded step counts during a challenge. Participants could connect an existing health tracking device (e.g., Fitbit, Garmin, Apple Watch) or use the internal gyroscope-based sensors in their smartphone to report their step counts. Algorithms recode the raw data from these sensors into an estimated step count. Most studies that investigated the validity of tracking step counts with commercially available devices (in free living conditions), showed acceptable levels of measurement error (equal to or less than 10% measurement error) (Fuller et al., 2020). Overall, commercial trackers tend to slightly overestimate

actual step counts, but differences exist between brands and devices (Fuller et al., 2020). The interdevice reliability of measuring step counts is overall very strong, while the intradevice reliability was found to be moderate with an average correlation coefficient between measurements of 0.58 (Fuller et al., 2020). To prevent cheating, StepBet actively monitors players' steps and flag any suspicious behavior. Players may be asked to provide additional data from their phone or tracking device if they are flagged ("StepBet FAQ," n.d.). On a voluntary basis, participants also entered demographic information such as their birthdate, gender, and region of residence. Age was determined based on birthdate at the moment of registration in the app. Because all demographic information was provided on a voluntary basis, we do not have complete information for all participants (see *Table 1* for an overview of the sample characteristics).

Statistical Analysis

Primary outcomes were step count increase (continuous) and challenge success (binary). We calculated step count increase by subtracting the baseline average daily step count from the average daily step count during the active challenge period. Importantly, after a challenge was failed, steps were still recorded until the final challenge day (unless the participant disconnected their step tracker, stopped wearing their step tracker, or requested to delete their account). We computed the average daily step count during the active challenge period by dividing the total steps taken during a challenge through the number of days the challenge lasted. Challenge success was determined by whether the participant achieved all weekly goals of the challenge. When one weekly goal (consisting of specific daily goals) was missed, a challenge was automatically registered as failed. Due to the large sample size (N = 72,974) of this study, even small effects will become significant (Cumming, 2014). Therefore, we emphasize effect sizes expressed in their original measurement units (instead of only significant tests) and confidence intervals (instead of only point parameters), as suggested by Cumming (2014). To ensure scientific independence from the company that provided us with the research data, we pre-registered the study on Open Science Forum (https://osf.io/d237c). With this pre-registration, the company agreed to publish any findings (including null findings) that would result from our analyses. During the analysis process, we consulted with the company, and made decisions with regards to sample selections that impacted the findings. Whenever a decision was made with regards to sample selections, we decided to add a separate sensitivity check as an appendix, to be as transparent as possible about the impact that this had on the findings. Although not included in formal pre-registration, before data-analysis we decided that daily step count changes of 1000 steps or more would be considered clinically relevant (see *Appendix A* for a rationale). We excluded outliers (see *Appendix B* for rationale) who had a daily average of >60,000 steps (n = 13)

or <1,000 steps (n = 841) during the challenge. In *Appendix C* we report a sensitivity check where these outliers are included. Data analysis was done with IBM SPSS statistics for Mac, version 28 (IBM Corp). We dealt with missing cases by using pairwise exclusion and used standard p <.05 criterium for determining statistical significance.

Hypothesis testing

Hypothesis 1: Step counts during the challenge will increase compared to baseline

We performed a two-tailed paired samples t-test comparing the baseline historic daily average steps with the daily average steps during a StepBet challenge. We interpret effect size Cohens d ≥.2, ≥.5, and ≥.8 as small, moderate, and large, respectively (Cohen, 1988).

Hypothesis 2: Challenges started as New Year's Resolutions are less successful.

A Chi square test of independence was performed to investigate if the odds of success differ for New Years resolution challenges (NYRC: started between the 1st and the 14th of January of each year) compared to challenges started during any other period of the year. We interpret effect size Phi (φ) (df = 2) ≥.07, ≥.21, ≥.35 as small, moderate, and large, respectively (Cohen, 1988).

Exploratory analysis

In additional analyses, we explored whether age, gender, historic daily average step count, number of participants per challenge, and bet amount predicted step increases (forced entry multiple linear regression model) and challenge outcome (forced entry binary logistic regression model). Unstandardised b values and odds ratios are used for interpretation.

Results

Demographics

Of those who provided demographic information, 86.7% identified as female, with a mean age of 36.47 years old (*SD = 9.40*), and 42.2% was between 30 to 40 years of age. 92.9% of participants were from North, South, and Middle America, with the remaining mostly coming from Europe (4.6%). See *Table 1* for more details on the characteristics of the sample.

Table 1. Sample characteristics (N = 72,974)

Variable	*n (%)*
Sex	
Total valid	61,502
Female	53,241 (86.6%)
Male	8,261 (13.4%)
Region of residence	
Total valid	70,747
America	65,758 (92.9%)
Europe	3,216 (4.5%)
Other	1,773 (2.6%)
Age	
Total valid	29,285
0-10 years	2 (0.0%)
10-20 years	220 (0.8%)
20-30 years	7,717 (26.4%)
30-40 years	12,353 (42.2%)
40-50 years	6,204 (21.2%)
50-60 years	2,247 (7.7%)
60-70 years	492 (1.7%)
70-80 years	43 (0.1%)
80-90 years	7 (0.0%)

Note: Data are frequencies (%)

Hypothesis testing

Hypothesis 1: Step counts during the challenge will increase compared to baseline

In line with our hypothesis, daily step count was significantly increased during a StepBet challenge, t (72,973) = 189.03, p = .000, d = .700, 95% CI [.692; .708]. Specifically, daily average step counts during a challenge (M = 10,197 steps, SD = 4,162) increased by 2,423 steps (SD = 3,462) (95% CI [2,397, 2,448]) (31.2% increase) compared to baseline (M = 7,774 steps, SD = 3,112). This is a medium effect size and exceeds the pre-determined threshold for clinical relevance (>1,000 steps). See *Table 2* for an overview of the descriptive results.

Table 2. Descriptive results per challenge outcome (N = 72,974)

	Winner (n = 53,281)	**Loser (n = 19,693)**	**Total (N = 72,974)**
Baseline daily step count	7,869 (3,059)	7,561 (3,235)	7,774 (3,112)
Challenge daily step count	11,334 (3,661)	7,118 (3,868)	10,197 (4,162)
Change in daily step count	3,465 (3,013)	-398 (3,013)	2,423 (3,462)
Relative change in step count	+44.0%	-5.3%	+31.2%
Challenge success odds	1	0	.73

Note: Data are means (SD) and percentages

Additionally, we explored changes in daily average step counts separately for winners and losers of a StepBet challenge. Firstly, there was a difference in daily step count change between winners and losers, t (72,972) = -154.0, p = .000, d = -1.28, 95% *CI* [-1.30, -1.27]. Secondly, we explored whether these changes were significant for winners and losers separately. For winners, daily step count was significantly increased during a StepBet challenge, t (53,280) = 265.5, p = .000, d = 1.15, 95% CI [1.14; 1.16]. Daily average step counts during a challenge increased by 3,465 steps (*SD* = 3,013) (95% *CI* [3,439, 3,490]) (44.0% increase) compared to baseline. This is a large effect size that exceeds the pre-determined threshold for clinical relevance (>1,000 steps). For participants who lost their challenge, daily step count was significantly decreased during a StepBet challenge, t (19,692) = -18.64, p < .001, d = -.133, 95% CI [-.147, -.119]. Daily average step counts during a challenge decreased by 398 steps (*SD* = 2,993) (95% *CI* [-439, -356]) (5.3% decrease), compared to baseline. However, this is a small effect size and it does not reach the pre-determined threshold for clinical relevance (>1,000 steps).

Hypothesis 2: Challenges started as New Year's Resolutions are less successful

Cross-tabulation (see *Table 3*) of challenge success shows that 73.0% of challenges were successful (winners) and 27.0% were not successful (losers). In contrast to our hypothesis, a Chi square test of independence showed that challenges started as a New Year's Resolution (start date between the 1st and the 14th of January of each year) have a significantly higher odds of success than challenges started during any other period of the year, $\chi 2$(1, N = 72,974) = 66.41, p = <.001, φ = .030. Specifically, challenges started as a New Year's Resolution were successful in 77.7% of the cases, while challenges started during any other period of the year were successful in 72.6% of the cases. The effect size of this difference is small. Based on these results we conclude that StepBet challenges started as a New Year's Resolution are slightly more likely to be successful.

Table 3. Descriptive results of success rates per challenge type (N = 72,974)

	Winner 5,3281 (73.0%)	**Loser 19,693 (27.0%)**	**Total 72,974 (100%)**
Regular challenge	48,987 (72.6%)	18,460 (27.4%)	67,447 (100%)
New Year's Resolution challenge (start date between 1-14 January)	4,294 (77.7%)	1,233 (22.3%)	5,527 (100%)

Note: Data are frequencies and percentages

Exploratory Analysis

We performed exploratory analyses on a subsample of 29,002 participants who did not have missing values for the following variables: gender, age, baseline step count, participants per challenge, and bet amount.

Multiple linear regression model on increase in step count

We combined the independent variables in a model with step count as the dependent variable (see *Table 4*). No major violations against the assumptions of linearity, multicollinearity, residual variance, and independence were detected. The model explained 4.4% of the variation in step increase, (R^2 *adjusted* = .044). All predictors in the model were found to be significant predictors (p < .008), but the effects were small. Older age, being a man, and larger games (more participants) were associated with higher step count increases whereas higher baseline step counts and higher bet amounts were associated with lower step count increases. Importantly, the b-values of predictors in this model are too small to predict clinically relevant increases in step counts (>1,000 steps).

Table 4. Multiple Linear Regression Model on increase in step count (N = 29,002)

	b	***95% CI for b***	***Beta (ß)***	***t***	***Sig.***
(Constant)	3,768.33	3,468.83; 4,067.83		24.66	<.001
Gender [a]	-424.50	-541.67; -307.33	-.041	-7.10	<.001
Age	33.01	29.16; 36.86	.097	16.81	<.001
Baseline step count	-.188	-.200; -.176	-.181	-31.37	<.001
Participants per Challenge	.067	.018; .117	.015	2.66	.008
Bet amount	-16.73	-22.43; -11.02	-.033	-5.75	<.001

Note: b = unstandardized regression coefficient, B = standardized regression coefficient, 95 % CI for b = Confidence interval for unstandardized regression coefficient. [a] gender: 0 = males, 1 = females

Multiple binary logistic regression model on challenge outcome

We combined the independent variables in a model with challenge outcome (success/failure) as dependent variable (see *Table 5*). No major violations against the assumption of linearity between the continuous independent variables and the logit transformation of the dependent variable (Box-Tidwell procedure) were detected. The overall model explained 3.0 % of the variation in challenge outcome, (R^2 Nagelkerke = .030). The model was statistically significant compared to the null model, ($\chi 2(5) = 602.0$, $p < .001$), and correctly predicted 73.9% of challenge outcomes. All variables were found to be significant predictors ($p < .001$), but the effects were small. Older age , being a man, and larger bet amounts were associated with higher odds of success whereas being female was associated with lower odds of success.

Table 5. Multiple Binary Logistic Regression Model on Challenge Outcome (N = 29,002)

	b	***Wald***	***Exp(B)***	***95% CI for Exp(B)***	***Sig.***
(Constant)	-.760	46.46	.468		<.001
Gender [a]	-.205	19.94	.815	0.744; 0.891	<.001
Age	.026	283.00	1.026	1.023; 1.029	<.001
Baseline step count	.000	106.45	1.000	1.00; 1.00	<.001
Participants per Challenge	.000	100.85	1.000	1.00; 1.00	<.001
Bet amount	.014	46.98	1.014	1.010; 1.018	<.001

Note: b = unstandardized regression coefficient, B = standardized regression coefficient, 95 % CI for b = Confidence interval for unstandardized regression coefficient. [a] gender: 0 = males, 1 = females

Discussion

The aim of this study was to perform a naturalistic evaluation of the effect of participating in a step count challenge with gamified deposit contracts. We found that participating in a StepBet challenge was associated with a 31.2% increase in step counts compared to baseline. The average challenge success rate was 73%. Succeeding in a challenge was associated with a large and clinically relevant increase in step counts (44%), while failing a challenge was related to a slight reduction in step counts (-5.3%). It is possible that a setback effect after failure caused participants to stop tracking their steps or reduce their efforts in improving their step count. Furthermore, unexpectedly, we found that New Year's resolution challenges were more successful than challenges started during the rest of the year. Several characteristics of challenges and of participants were significant predictors of step counts and challenge success, but were not considered clinically relevant due to low effect size.

In line with our hypothesis, average daily step counts during a challenge increased by 2,423 steps (or 31.2%) compared to baseline. We explain this result through the idea that participating in a gamified deposit contract increases engagement with and effectiveness of a mobile behavior change intervention. This finding is in line with earlier findings on the effects of gamification (Mazeas et al., 2022) and deposit contracts on physical activity (Budworth et al., 2019; Burns and Rothman, 2018; de Buisonjé et al., 2022; Donlin Washington et al., 2016; Krebs and Nyein, 2021; Patel et al., 2016; Stedman-Falls and Dallery, 2020). The size of this effect has mortality reducing potential. For example, research has shown that a 1,700 daily steps increase is related to a 41% reduction in overall mortality among elderly women (Lee et al., 2019). Furthermore, the effect size we found greatly exceeds what is commonly found in randomized controlled trials. Meta-analysis of randomized controlled trials with financial incentives reported an average daily step count increase of 607 steps (10-15% increase compared to baseline) (Mitchell et al., 2019). However, this meta-analysis included financial incentives that did not require a personal monetary deposit in the form of a deposit contract. It is possible that the deposit contract used in the StepBet challenge further increased effectiveness (compared to regular financial incentives) through exploiting loss aversion. This would be in line with recent meta-analysis by Boonmanunt et al. (2022) who showed that deposit contracts were the most effective type of financial incentive. Yet, caution is warranted when trying to explain these findings. Since the intervention consisted of a combination of gamification elements and deposit contracts, it is impossible to determine which intervention elements specifically were related to this increase in step counts. For example, besides the deposit contract, the intervention also helped participants set concrete (personally tailored) daily step goals, and organized social support by allowing challenge participants to communicate with each other. We know from previous research that goal setting increases physical activity (Mcewan et al., 2015), and that social support is positively related to physical activity (Mendonça et al., 2014). Therefore, although we consider the deposit contract to be the key feature of this intervention, we assume that additional elements such as the gamified microgoals and social support partly explain the effects we found. To determine the isolated effects of the deposit contract element of the Stepbet challenges, future research should compare a StepBet challenge with all active gamification elements but no deposit requirement to a full-fledged StepBet challenge that does have a deposit requirement.

Interestingly, those who succeeded in their challenge increased their daily step count by 3,465 steps (or 44%) while those who failed their challenge decreased their step count by 398 steps (- 5.3%). Succeeding in a challenge was related to a large and clinically relevant increase in step counts. Failing a challenge was related to slightly lower step counts, although this reduction was not large enough to be considered clinically relevant. Since this study was observational, causal explanations are not possible. Therefore, we

have to speculate on what explains this finding. The StepBet challenges are engineered so that after failing one weekly goal, the overall challenge for that person is failed and the monetary deposit is forfeited. Although participants can still track their step counts, and enjoy the gamified elements of the app, this failure (and loss of deposit) might lead to disappointment and demotivation. Perhaps, after a challenge is failed, participants become less motivated to track their step counts (by carrying their smartphone or wearing their external activity tracker) or to actually increase their step counts. In contrast, participants who succeed in their challenge might sustain their efforts until the final challenge day. Although this explanation seems plausible, we cannot rule out the possibility that participants reduce their step count for external reasons and therefore fail their challenge. The dataset we received only contained aggregated data, and not day-by-day step counts. Therefore, we were unable to specifically investigate what happens to daily step counts when a challenge was failed. Future analysis of StepBet data could investigate what happens to step counts when a challenge is failed, and whether this is caused by changes in measurement behavior or in physical activity. Although we can not ascertain what produced the decrease in step counts we found among losers, it is possible that these participants experienced what has been dubbed a setback effect. In everyday situations of goal striving, Wenzel et al. (2020) have shown that, after an initial instance of failure, a 'setback effect' occurs and people are more likely to fail again on subsequent attempts. Others have shown that this effect is related to self-efficacy (ten Broeke and Adriaanse, 2023), and that people can be protected against it by helping them make external attributions ("the weather was just too bad to go outside"), rather than internal attributions ("I am a lazy person") for their self-regulation failure (Adriaanse and ten Broeke, 2022) Possibly, people who failed a Stepbet challenge made (partly) internal attributions, experienced reduced self-efficacy after failure, and decreased their efforts in goal striving. Future research could develop a simple intervention that helps people in failed Stepbet challenges to make an external attribution and measure their subsequent goal striving to investigate if this protects against the setback effect. Another option to maintain engagement in physical activity when a challenge is failed could be to allow participants to re-enter the challenge with a 'double or nothing' option. Research has shown that breaking a streak of successful goal achievement can reduce subsequent goal striving, but this reduction is attenuated when participants are offered the option to repair their streak (Silverman and Barasch, 2022). Future research could investigate the effects of offering a double or nothing option to participants who fail their challenge.

Unexpectedly, challenges started as a New Year's resolution were slightly more successful (77.7%) than those started during the rest of the year (72.6%). We hypothesized that New Year's resolution challenges would be less successful than challenges started during other periods of the year, because previous research showed that DietBet challenges for weight loss in January had a lower success rate than during other months

(Hirt-Schierbaum and Ivets, 2020). Our results are not in line with this finding, and show that New Year's resolutions for increasing step counts are in fact slightly more successful. Possibly, improving step counts differs from weight loss because it is under direct control of the participant and not a proxy of other behaviors such as eating and physical activity - as is the case for weight loss. Another explanation could be that a resolution to improve step counts is more successful because it is an approach-oriented goal, whereas losing weight is an avoidance-oriented goal. Previous research on New Year's resolution challenges has shown that challenges with approach-oriented goals were more successful (58,9%) than avoidance-oriented goals (47.1%) (Oscarsson et al., 2020). Since interest to pursue goals is heightened at the end of the year, and our results show that these goals might be pursued with a higher success rate, future research should study what makes New Year's resolutions for increasing step counts more successful than challenges started during other periods of the year.

Finally, the exploratory regression models for predicting challenge success odds and step count increases only explained a small part of the variance. Although all predictors in both models were significant, none of the predictors had a clinically relevant effect size on challenge success odds or step count increases. Being a man, and being older predicted both slightly higher increases in step counts, and also slightly higher odds of success. It is possible that men and older people respond better to a gamified deposit contract, but it is also possible that, through a selection bias, the men and older people in our sample were more motivated to improve their physical activity. Additionally, being part of a challenge with more participants (and therefore a larger potential prize) predicted a small increase in step counts, but had no effect on odds of success. Furthermore, higher baseline step counts predicted lower step count increases, but had no relationship to the odds of success. Finally, a higher bet amount predicted lower step count increases, but higher odds of success. Although speculative, perhaps a higher bet amount increases the focus on goal achievement, but not on physical activity in itself. For future research, we recommend measuring additional demographic information of participants (e.g., income, educational level), and psychological variables (e.g., motivation, self-efficacy) to further investigate which subgroups benefit most from participating in a StepBet challenge

Strengths and limitations

An important strength of this study is that we analyzed more than 70,000 StepBet challenges that were performed over the course of 5 years, whereas most research on deposit contracts reports findings based on small samples (often because low uptake is an obstacle) and limited time frames. Therefore, this study provides a naturalistic evaluation of the true effectiveness (and not mere efficacy) of gamified deposit contracts implemented in real life. This large dataset also allowed us to report effect sizes with

tight confidence intervals, which means that we are relatively certain that the effects we found in this sample also exist in the population at large. Finally, participants who started StepBet challenges did this on their own initiative, and this resulted in a demographically heterogenous sample that was not recruited by the researchers. However, this also invited a self-selection bias. We assume that our sample consisted of participants that were motivated to improve their physical activity, were (made) aware of the existence of the StepBet challenges, and were able and willing to make a financial deposit of their own money. Furthermore, an important limitation of this study was the lack of a control condition that was not exposed to the gamification elements or deposit contract. Therefore, we cannot draw causal conclusions on the effect of participating in a StepBet challenge. Instead, we used the available baseline data and determined the within-participant changes in step counts. However, the baseline data was not entirely comparable to the challenge data because the baseline data was trimmed (low and high outliers were excluded before the baseline was determined, see *appendix B* for more detail). Therefore, caution is warranted when drawing conclusions on step count improvements compared to this trimmed baseline. To overcome this limitation, we performed a sensitivity check that only included non-trimmed baselines and report the results in *appendix D*. The pattern of results was not affected in a major way, but step increases among winners were attenuated. Finally, because a StepBet challenge contained all 7 persuasive gamification strategies (including the deposit contract) identified by Cugelman (2013), we cannot ascertain which elements of the challenge produced the effects.

Implications

Randomized controlled trials already identified gamified deposit contracts as an effective tool to support health behavior change. The current findings add to the existing evidence base by showing that, in real world conditions, among a large and diverse sample, gamified deposit contracts are associated with clinically relevant increases in physical activity. Although our study design does not allow for causal explanations, it appears plausible that participating in a gamified deposit contract challenge helped participants increase their physical activity. The effects we found provide further support for implementing (elements of) gamified deposit contracts to improve physical activity in future behavior change interventions. Furthermore, our findings show that New Year's resolution challenges are more effective than other challenges. Therefore, we suggest that StepBet (and other intervention providers) stimulate their participants to make use of New Year's resolution challenges and increase their odds of successful behavior change. Finally, because it is unknown how acceptable gamified deposit contracts are among people with cardiovascular disease or other chronic conditions, future research

should explore whether these more vulnerable subgroups might also benefit from this type of intervention. Ultimately, we hope that the current work will help inform public health policy making and may inspire future intervention design of behavior change interventions that improve population health.

Conclusion

In a real-world setting, and among a large and diverse sample, participating in a physical activity challenge using gamified deposit contracts was associated with a large increase in step counts. We recommend intervention providers to implement gamified deposit contracts for physical activity. However, we urge for more research into potential setback effects (and how to mitigate them) among those who fail their challenge. Finally, New Year's resolution challenges were more effective than regular challenges so we advise to make use of this temporal landmark to increase the odds of successful behavior change.

Authors' Contributions

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

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Chapter 5

CVD patients' views on financial incentives for health behavior change: are deposit contracts acceptable?

Based on: De Buisonjé, D. R., Reijnders, T., Cohen Rodrigues, T. R., Van den Broek, I., Kraaijenhagen, R. A., Janssen, V. R., Kemps, H. M., & Evers, A. W. (2023). Cardiovascular disease patients' views on using financial incentives for health behavior change: Are deposit contracts acceptable? *Clinical eHealth, 6,* 60-75.

Abstract

Background: There is an urgent need to find new approaches that improve long-term adherence to a healthy lifestyle for people with cardiovascular disease (CVD). Deposit contracts (a financial incentive in which the participant deposits own money) are inexpensive and effective, but acceptability among CVD patients is unclear. This study investigated the acceptability of a deposit contract intervention for physical activity among CVD patients.

Methods: We approached CVD patients through the Harteraad patient panel of the Dutch CVD patient organization and asked them to fill in an online survey. In total (N = 659) CVD patients with a mean age of 66.2 years completed the survey. The survey assessed acceptability of deposit contracts, responses to a concrete example of a deposit contract for physical activity behavior change, and suitable moments for implementation.

Results: Overall, half of the participants (45.6%) confirmed needing extra commitment to maintain lifestyle change. Yet, a small part of the sample was convinced by the idea that losing money could be motivating (18.8%) and indicated that they would be willing to deposit money themselves (13.2%). Responding to a concrete example of a deposit contract for physical activity, a quarter of the sample (26.2%) reported there was a chance they would participate. Furthermore, 27.1% of the participants found the deposit contract effective and 27.4% found it acceptable. Exploratory analyses showed that a subgroup of younger and lower educated participants responded more favorably. Opinions on when to start with a deposit contract were mixed.

Conclusions: Because acceptability was generally found to be low, future research should also investigate strategies to leverage commitment principles for CVD patients without a cash deposit requirement. When deposit contracts are offered to CVD patients in practice, we recommend offering them as an optional, additional element to existing interventions that patients can opt-in to.

Introduction

People with cardiovascular diseases (CVD) are often referred to cardiac rehabilitation (CR), a comprehensive 12-week program during which they receive psycho-education, support with lifestyle change and guided physical exercise training (Brouwers et al., 2021). At the same time, people with CVD are commonly advised to adhere to their medication, quit smoking, lose weight, eat more healthily and exercise more. While people often initiate lifestyle changes during CR (Long et al., 2019), many relapse when they return to their everyday life, and changes in lifestyle are often not sustained (Kotseva et al., 2019; Zullo et al., 2010). Therefore, there is an urgent need to find new approaches that could serve as a supplement to CR and improve long-term adherence to a healthy lifestyle for CVD patients (Peters, 2013).

The field of behavioral economics (a fusion of traditional economic theory and psychology) helps explain why adhering to lifestyle changes is difficult, even for people with CVD (Hare et al., 2021). Rather than making optimal decisions, people often fall for immediate temptations when decisions require short term sacrifice (e.g., exercising instead of relaxing on the couch with a spouse) to foster long-term goal achievement (e.g., preventing CVD related re-admission to the hospital)(Halpern et al., 2009). The finding that people tend to be most strongly driven by consequences in the here and now has been coined the present bias (Laibson, 1997). Present bias also helps explain why introducing immediate financial incentives is effective for promotion of (at least short term) health behavior change. Rather than having to wait for the long-term benefits of a healthy lifestyle to emerge, immediate financial incentives provide short term benefits in the here and now. Financial incentives require objective verification of behavior to avoid cheating and are therefore ideally combined with eHealth solutions. There is overwhelming evidence that adding financial incentives to existing interventions for health behavior change improves their efficacy (Giles et al., 2014; Kurti et al., 2016; Mantzari et al., 2015; Mitchell et al., 2019; Strohacker et al., 2014). However, financial incentive interventions are costly (US$ 1.5 /day/person)(Mitchell et al., 2019), and achieved intervention effects tend to disappear when incentives are withdrawn (Giles et al., 2014; Kurti et al., 2016; Mantzari et al., 2015; Strohacker et al., 2014). Deposit contracts, a form of incentive wherein people deposit their own money and risk losing it when not successful (Rogers et al., 2014), could be a solution to allow for large scale implementation without the need for external funding. Besides their implementation advantage, deposit contracts could have additional advantages over regular financial incentives, such as exploiting the mechanism of loss aversion (Tversky & Kahneman, 1992). Deposit contracts have proven to effectively support behavior change in various domains crucial to lifestyle change after a cardiovascular event: smoking cessation (Halpern et al., 2015), weight loss (Sykes-Muskett et al., 2015), and physical activity (Budworth et al., 2019; Donlin Washington et al.,

2016; Stedman-Falls & Dallery, 2020). Deposit contracts have also been applied specifically to a CVD population to increase medication adherence (Putt et al., 2019).

Besides evidence of effectiveness, for implementation in practice it is important to determine acceptability of deposit contracts. Others have outlined objections to using financial incentives and stated that they can be perceived as unfair, coercive, inequitable, inconsistent with shared social values and threaten privacy (Halpern et al., 2009). The available evidence on the acceptability of financial incentives and deposit contracts is mixed. Studies have shown that, for smoking cessation (Raiff et al., 2013; Stedman-Falls et al., 2018) and weight loss (Raiff et al., 2013) regular financial incentives and deposit contracts had similarly high levels of acceptability. On the other hand, a study on acceptability of financial incentives for weight loss showed that deposit contracts were about two times less acceptable compared to regular financial incentives (McGill et al., 2018). Furthermore, low support for any type of financial incentive was found, but especially for deposit contracts (McGill et al., 2018). More specifically, another study explored acceptability of financial incentives among a sample of cardiac rehabilitation patients (Mitchell et al., 2014). Results show that acceptability of cash-based incentives was highly divided and nearly all participants preferred voucher-based incentives over cash incentives (Mitchell et al., 2014). Although speculative, since deposit contracts are often operationalized as cash-based incentives, this might indicate low acceptability of deposit contracts among CVD patients.

The current study

To the best of our knowledge, it is currently unknown whether CVD patients find deposit contracts for lifestyle change acceptable. The available evidence implies that, despite their effectiveness in helping people achieve lifestyle goals, deposit contracts might not be acceptable to people with CVD. The primary aim of this study was to investigate the acceptability of a deposit contract for lifestyle change in CVD patients. Secondly, we evaluated responses to a concrete example of a deposit contract for physical activity and at what point in time during their patient journey CVD patients would like to start with a deposit contract.

Methods

Participants

Participants were recruited through an email sent to 2625 panel members of the Dutch Harteraad Patient Panel, the official national Dutch CVD patients' association. The panel consists of people who were diagnosed with cardiovascular disease or who were a close relative or caregiver to someone with cardiovascular disease. We included participants

who were 18 years and older and were diagnosed with heart disease (diseases related to the heart, e.g. coronary heart disease), vascular disease (diseases related to the blood vessels, e.g. peripheral artery disease), or both. We excluded participants who were a relative or caregiver to someone else with CVD. In total, 659 CVD patients completed the survey (for more detail on demographic information of the sample see *Table 1* below).

The survey

This cross-sectional survey study was approved by the Psychology Research Ethics Committee of Leiden University (2020-03-18-T. Reijnders-V1-2312). The survey was administered in Dutch and took about 15 minutes to fill in. The panel manager of the Harteraad Patient Panel shared a description of the study and a link to the survey with all members via email. After agreeing to the online consent form, participants were first asked to provide demographic information (gender, age, education, income, partner status, level of social support), and their disease status. Thereafter, the survey was separated into two parts. The first part belonged to a related research project and assessed preferences with regard to digital coaching. The latter half of the survey was analyzed for the current study and will be further explained below under section 2.3 Measures (see *appendix A* for the original items used in the current study). Responses to questions on education and income were categorised into low, middle and high (Nagelhout et al., 2012; *Opleidingsniveau*, n.d.; Reinwand et al., 2018). After completing the survey, participants were debriefed, thanked for their participation, and received a short summary of the results a few weeks later (see *appendix C*).

Measures

Here, we describe which items were used to measure responses to deposit contracts. For more detail on the survey items, see *appendix A*.

Acceptability of deposit contracts

People were explained what a deposit contract is and told they could use it to help them reach a concrete lifestyle change goal: *"Many people need extra commitment to sustain a long-term lifestyle change. With a lifestyle challenge, you set a concrete goal for lifestyle change and put your own money on the line. You can lose this money if you don't sustain the lifestyle change. Because you do not want to lose the money, you have an extra incentive to maintain a lifestyle change at difficult times."*. They were then asked to reply to the following three statements on a 5-point Likert scale (1 = totally disagree, till 5 = totally agree): *I need extra commitment to maintain my lifestyle change; I think the risk of losing money can motivate me to maintain my lifestyle change; I would be willing to deposit an*

amount of money for a lifestyle challenge. Furthermore, we asked "*What amount of money would you like to deposit in a lifestyle challenge?"*.

Responses to a concrete example for physical activity

Next, we provided a concrete example of a deposit contract for physical activity: *"Imagine you want to exercise more and therefore set the goal to take 1000 steps more per day than you normally do. For extra motivation, we now ask you to put in 10 euros of your own money as a challenge. Every day you will receive a message from us in which we tell you whether you succeeded in achieving your goal that day. Every day that you reach the goal, you earn back part of your own investment. The more goals you achieve, the more money you will get back."*. We then asked participants to reply to the following three questions on a 5-point Likert scale (1 = very small; totally not effective; totally not acceptable, 5 = very large; totally effective; totally acceptable): *How big is the chance that you would participate in this lifestyle challenge yourself; How effective do you think this lifestyle challenge is; How acceptable do you think this lifestyle challenge is?*

Suitable moments for implementation

Finally, to identify suitable moments for implementation, we used multiple choice questions, and asked participants at what time they would find starting with a deposit contract most appropriate. Firstly, on a general level, we asked *"What would be the right time for you to start a lifestyle challenge?"*. More specifically, we then asked *"Imagine that you are/have been admitted to the hospital for a problem with your heart. What would be the right time for you to start a lifestyle challenge?"*.

Design and analysis

We used 5-point Likert scales for items on deposit contract acceptability and responses to a concrete example for physical activity. We interpreted the percentage of participants that replied above the neutral midpoint of scale, thus indicating some or strong agreement (4 = agree or 5 = totally agree) with the presented statements. We used multiple choice questions to assess suitable moments for implementation. Data was analyzed using pairwise exclusion and no outliers were removed for the reported analyses. To analyze data and create graphs and tables, we used SPSS version 25 and Microsoft Word. In all tests, we used alpha = .05 for determining statistical significance.

Subgroup analysis

To explore whether subgroups within our patient population may differ in their responses to our outcome variables, we analyzed the relationship between the predictors age, social support, gender, education, income, disease and partner status and the outcome items. For continuous variable such as *age,* we used linear regressions to investigate the relationship with continuous outcome items, binary logistic regressions for binary outcome items, and multinomial logistic regressions for categorical outcome items. For categorical variables such as *education* (low/high) we ran MANOVAS to investigate the relationship with continuous items, and Chi Square tests for binary and categorical outcome items. For a full overview of all exploratory analyses. please see *appendix D*. Please note that although we performed multiple comparisons, due to the exploratory nature of these analyses, we did not apply any corrections. Therefore, we are very careful to interpretate the findings

Results

Descriptives

In total 659 (N = 659) CVD patients with a mean age of 66.2 (*SD* = 11.0) years old completed the survey (See *Table 1* on the next page). The sample consisted of a majority of males, with mostly medium or high incomes, educational level was spread evenly and most were living together with a partner. Furthermore, the majority of participants reported suffering from heart disease and scores for social support were relatively high.

Table 1. Demographic information (N = 659)

Age (N = 653)	
Years	66.18 (11.00) (minimum 22 years, maximum 94 years)
Gender (N = 659)	
Male	429 (65.1%)
Female	230 (34.9%)
Income (Monthly) (N = 659)	
Low (<€1500)	148 (22.5%)
Medium (€1500 – €2500)	278 (42.2%)
High (>€2500)	233 (35.4%)
Education (N = 643)	
Low	134 (20.3%)
Middle	196 (29.7%)
High	320 (49.8%)
Partner status (N = 659)	
No partner	143 (21.7%)
Partner not living together	19 (2.9%)
Partner living together	497 (75.4%)
Disease status (N = 659)	
Heart disease	343 (52.1%)
Vascular disease	149 (22.6%)
Heart and Vascular disease	167 (25.3%)
Social support score (N = 659)	
5-point Likert scale	4.09 (1.13)

*data are means (SD) or frequencies (%).

Main findings

Acceptability of deposit contracts

Almost half of the sample reported needing extra commitment to maintain their lifestyle change (45.6%). However, a smaller part of the sample was convinced by the idea that losing money could be motivating (18.8%) or reported to be willing to deposit money themselves (13.2%). When asked what amount they would deposit, more than half responded with 'nothing' (57.8%) and the rest (42.2%) responded they would be willing to deposit some of their own money. See *Figure 1* below for more detail. Descriptives are reported in more detail in *appendix B.*

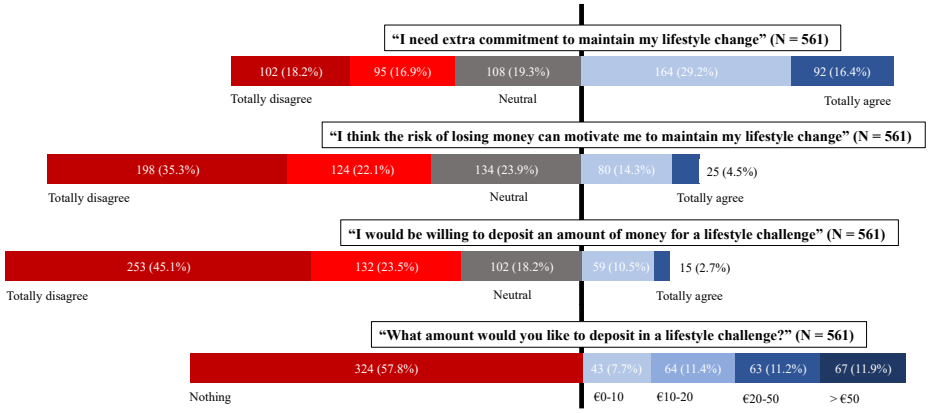

Figure 1. Results on acceptability of deposit contracts
*data are frequencies (%).

Responses to a concrete example for physical activity

Responding to a concrete example of a deposit contract for physical activity, around a quarter of the sample (26.2%) reported there was a chance they would participate. Furthermore, around a quarter of the sample found the deposit contract effective (27.1%) and acceptable (27.4%). See *Figure 2* below for more detail.

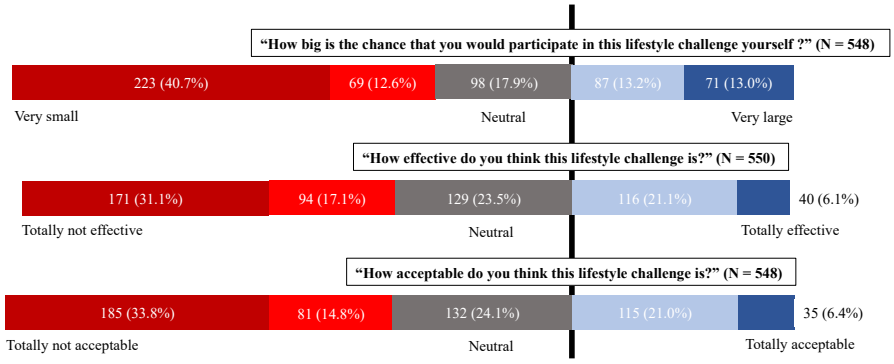

Figure 2. Results on a concrete example for physical activity
*data are frequencies (%).

Suitable moments for implementation

About half of the participants would start a deposit contract directly when they started with lifestyle change (50.1%), and the other half would like to start a deposit contract only when they would experience difficulties maintaining their lifestyle change (49.9%).

When asked when to start a deposit contract after a cardiac incident occurred, answers were spread across the answer options with no clear preference emerging. See *Figure 3* below for more detail.

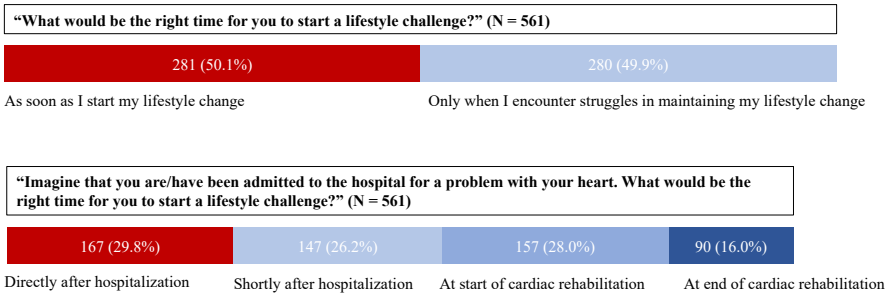

Figure 3. Results on suitable moments for implementation
*data are frequencies (%).

Subgroup analyses

Generally, most of the predictor variables we explored were barely related to our outcome variables, with the exception of *age* and *education*. With regards to age, older participants reported a lower need for extra commitment (β = -.181), lower willingness to deposit money (β = -.103) and less preference to deposit something rather than nothing into a deposit contract (β = -.023). Furthermore, older participants reported that they found the deposit contract example less acceptable (β = - .089). These effects however were small. With regards to education, participants with lower education reported a higher need for extra commitment than participants with higher education (M = 3.28, SD = 1.35 versus M = 2.92, SD = 1.33). Also, participants with lower education reported that losing money could motivate them more than participants with higher education (M = 2.46, SD = 1.28 versus M = 2.18, SD = 1.14). Furthermore, participants with lower education reported that they found the deposit contract example more effective than participants with higher education (M = 2.71, SD = 1.29 versus M = 2.44, SD = 1.31), and there was a trend towards significance where participants with lower education had a higher odd of participating than participants with higher education (M = 2.59, SD = 1.45 versus M = 2.35, SD = 1.48). Interestingly, regarding suitable moments for implementation preferences reversed according to educational level. For participants with lower education, the majority (n = 157) would start a deposit contract only when they would experience troubles with maintaining lifestyle change, while among participants with higher education, the majority (n = 150) would start a deposit contract directly. For the full overview of all exploratory analyses see *Appendix D.*

Discussion

We studied acceptability of deposit contracts for lifestyle change among CVD patients and found that, although participants often reported to need extra commitment, opinions on acceptability were divided. A large part of the sample was not convinced that depositing some of their own money - and possibly losing that - would be a suitable tool to support maintenance of lifestyle change. At the same time there was a small part of the sample that reported higher acceptability. This pattern of results was also found when participants responded to a concrete example of a deposit contract for improving physical activity. Most participants rejected the deposit contract in the example, while a minority responded positively. Exploratory subgroup analyses showed that a subgroup of younger and lower educated participants responded more favorably. Finally, opinions on suitable moments for implementation of a deposit contract were split across the answer options.

Deposit contracts did not appear acceptable to a large part of the sample. This finding is consistent with the two studies that indicated low or divided acceptability of cash deposit contracts (McGill et al., 2018; Mitchell et al., 2014). Possibly, CVD patients have ethical objections to deposit contracts and do not want to risk losing their own money. At the same time, our finding is in contrast with the two studies that indicated high acceptability (Raiff et al., 2013; Stedman-Falls et al., 2018). Importantly, these studies (Raiff et al., 2013; Stedman-Falls et al., 2018) that show high acceptability studied samples with a mean age of around 41 years, whereas the two studies that showed lower acceptability studied samples with a mean age of 64 years (McGill et al., 2018) or that ranged between 54 and 84 years (Mitchell et al., 2014). The mean age of our sample was 66 years and we suspect this might explain why our results are more in line with work that showed lower acceptability. Further support for the idea that age is related to acceptability comes from our subgroup analyses which showed that, within our sample, younger participants reported higher acceptability of deposit contracts. Possibly, because younger participants are more risk prone (Albert & Duffy, 2012), they show higher acceptability of an intervention that involves risking some of their own money. Whether risk proneness indeed explains why younger CVD patients report higher acceptability of deposit contracts should be further studied.

In response to a concrete example of a deposit contract for physical activity, again we found that for the majority of the sample acceptability was low. When asked about the chance that they would participate, the effectiveness and the acceptability of this deposit contract, consistently around 75% of participants rejected the deposit contract while 25% responded positively. Again, this result is in line with other studies (McGill et al., 2018; Mitchell et al., 2014) and shows that a cash deposit contract for physical activity will not appeal to the majority of CVD patients. Importantly, there appears to be a subgroup

of patients to whom deposit contracts do have an appeal and it is this subgroup that should be targeted when implementation of deposit contracts is considered. Future research should investigate what characterizes the subgroup of CVD patients who are open to using deposit contracts to maintain their lifestyle change.

Finally, with regards to when participants would like to start with a deposit contract, we found that answers were split across the answer options. To intervention providers, offering a deposit contract at the end of cardiac rehabilitation might make intuitive sense to help patients bridge the gap between cardiac rehabilitation and the 'unsupported' home environment. However, starting a deposit contract at the end of cardiac rehabilitation was the least preferred option among our sample. Most CVD patients indicated preference for starting a deposit contract either directly after hospitalization, shortly after hospitalization or at the start of cardiac rehabilitation. Perhaps patients believe that it is best to start a deposit contract early, because motivation to commit to lifestyle change (with a deposit contract) might then be at its peak. Based on these findings we recommend offering a deposit contract to CVD patients earlier rather than later in their rehabilitation process.

Interestingly, lower educated participants more often reported needing extra commitment, and were more accepting of deposit contracts. This finding is promising since CVD patients with lower socio-economic position (SEP), of which educational level is an indicator, are much less likely to make lifestyle changes after myocardial infarction (Gaalema et al., 2017). Therefore, others have argued that increasing lower SEP groups' participation in CR and other secondary prevention programs should be a priority (Gaalema et al., 2017). It is possible that lower educated participants are aware that they will experience more issues in maintaining their lifestyle changes and therefore are more open to receive support in the form of a deposit contract. Future work should further investigate whether and why lower educated people are indeed an appropriate target group for deposit contracts.

A limitation of the current study is that we asked participants to respond to hypothetical deposit contracts. While this setup allowed us to gain first insight in acceptability, actually offering them in practice would provide more realistic insights. Also, this study did not assess acceptability of other types of financial incentives or commitment strategies. Therefore, no direct comparison can be made between the acceptability of deposit contracts and other strategies that might support maintenance of physical activity behavior change among CVD patients. Another limitation is that the external validity of our findings is limited because the sample consisted of patient panel members. CVD patients who decide to participate in a patient panel might not be representative of the entire population of CVD patients. For example, our sample appeared to have a relatively high income and high level of education. This sample might have more active coping with their cardiovascular condition and could also be

more motivated to change their lifestyle. Future research should actually offer a deposit contract to CVD patients and investigate the real-world uptake, effects and acceptability. Since only a subgroup of CVD patients responded positively to deposit contracts, we recommend that intervention providers offer them as an additional element to existing interventions that CVD patients can opt-in to. Implementing deposit contracts in this way avoids issues with acceptability among those who refuse them, but allows uptake by those who are interested. Furthermore, future research should investigate strategies to leverage commitment principles for CVD patients that do not have a cash deposit requirement. For example, perhaps one could similarly capitalize on the principle of loss aversion by having CVD patients commit to a bet with some level of social discomfort (e.g., bad hair day picture will be spread on social media if challenge is failed).

Conclusion

This study in a large sample of CVD patients showed that opinions on acceptability of deposit contracts for lifestyle change were divided. The majority of CVD patients did not find deposit contracts acceptable. Only a subgroup of CVD patients found deposit contracts for lifestyle change acceptable. When deposit contracts are offered to CVD patients in practice, we recommend offering them as an optional, additional element to existing interventions that patients can opt-in to.

Authors' Contributions

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

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Chapter 6

Health Care Professionals' views on using financial incentives for healthy living in patients with cardiac disease

Based on: de Buisonjé, D., Van der Geer, J., Keesman, M., Van der Vaart, R., Reijnders, T., Wentzel, J., Kemps, H., Kraaijenhagen, R., Janssen, V. and Evers, A. (2021). Financial Incentives for Healthy Living for Patients With Cardiac Disease From the Perspective of Health Care Professionals: Interview Study. *JMIR cardio, 5(2)*, e27867.

Abstract

Background: A promising new approach to support lifestyle changes in patients with cardiovascular disease (CVD) is the use of financial incentives. Although financial incentives have proven to be effective, their implementation remains controversial, and ethical objections have been raised. It is unknown whether health care professionals (HCPs) involved in CVD care find it acceptable to provide financial incentives to patients with CVD as support for lifestyle change.

Objective: This study aims to investigate HCPs' perspectives on using financial incentives to support healthy living for patients with CVD. More specifically, we aim to provide insight into attitudes toward using financial incentives as well as obstacles and facilitators of implementing financial incentives in current CVD care.

Methods: A total of 16 semistructured, in-depth, face-to-face interviews were conducted with Dutch HCPs involved in supporting patients with CVD with lifestyle changes. The topics discussed were attitudes toward an incentive system, obstacles to using an incentive system, and possible solutions to facilitate the use of an incentive system.

Results: HCPs perceived an incentive system for healthy living for patients with CVD as possibly effective and showed generally high acceptance. However, there were concerns related to focusing too much on the extrinsic aspects of lifestyle change, disengagement when rewards are insignificant, paternalization and threatening autonomy, and low digital literacy in the target group. According to HCPs, solutions to mitigate these concerns included emphasizing intrinsic aspects of healthy living while giving extrinsic rewards, integrating social aspects to increase engagement, supporting autonomy by allowing freedom of choice in rewards, and aiming for a target group that can work with the necessary technology.

Conclusions: This study mapped perspectives of Dutch HCPs and showed that attitudes are predominantly positive, provided that contextual factors, design, and target groups are accurately considered. Concerns about digital literacy in the target group are novel findings that warrant further investigation. Follow-up research is needed to validate these insights among patients with CVD.

Background

Despite the proven effectiveness of cardiac rehabilitation in initiating lifestyle change, many people with cardiovascular disease (CVD) fail to maintain a healthy lifestyle in the long term and relapse into unhealthy habits when they return to everyday life (Kotseva et al., 2019). Therefore, there is an urgent need to find new approaches that increase the uptake of and long-term adherence to lifestyle interventions for patients with CVD (Peters, 2013). A promising new approach is the use of financial incentives as a supplement to existing lifestyle interventions in CVD care. Financial incentives have not been applied often in the context of CVD care but have proven to be effective for a wide range of lifestyle behaviors that are relevant to CVD, including medication adherence, weight loss, smoking cessation, and physical activity (Giles et al., 2014; Kurti et al., 2016; Mantzari et al., 2015; Volpp et al., 2008). However, implementing financial incentives for a healthy lifestyle remains controversial, and ethical objections have been raised (Ashcroft, 2011). For example, financial incentives can be perceived as paternalistic, coercive, involve bribery, or undermine the agency of the person (Ashcroft, 2011). Indeed, a recent systematic review on the acceptance of financial incentives for a healthy lifestyle has shown that acceptability is polarized and context dependent (Hoskins et al., 2019).

The acceptability of financial incentives has been studied often, among different populations, and with mixed results (Giles et al., 2015; Hoskins et al., 2019). The most recently available systematic review on financial incentive acceptability concluded that "acceptability remains polarized, and [...] is shaped in complex and unpredictable ways" (Hoskins et al., 2019). As an illustration of this polarization, incentives that specifically target deprived or vulnerable subgroups are found fair by some studies because they are a tool to redistribute resources to improve health among the disadvantaged (Hoddinott et al., 2014). In contrast, other research found a preference for generic incentives because targeted incentives were perceived as unfair to individuals who had already maintained a healthy lifestyle (Giles et al., 2016). Although polarized, the available research has identified factors that consistently moderate the acceptability of financial incentives. Financial incentives appear to be more acceptable when they are privately funded, perceived as fair, (cost) effective, and when offered in the form of vouchers instead of cash (Bigsby et al., 2017; Giles et al., 2015; Hoskins et al., 2019; Mitchell et al., 2014).

Despite the variability found in acceptability, when we look specifically at the acceptability of financial incentives among health care professionals (HCPs), Hoskins et al (Hoskins et al., 2019) reported consistently high levels of acceptability. However, the authors point out that the reviewed studies were performed only in the United States, the United Kingdom, Australia, Canada, and France, which limits the generalizability of these findings. To the best of our knowledge, one study has specifically investigated the acceptability among HCPs working in CVD care in the United States (Liu et al., 2017).

This study showed that primary care physicians show a *broad and deep* acceptance of financial incentives. More importantly, this study showed that physicians' perceptions of financial incentives were related to their patients' clinical outcomes, thus emphasizing the importance of studying acceptability among HCPs involved in delivering the incentives. To summarize, the acceptability of financial incentives is polarized, but reviews show indications of high acceptance among HCPs. At the same time, acceptability also appears highly dependent on the specific form and context in which financial incentives are offered and implemented.

Objectives

To our knowledge, this study is the first to investigate the perspectives of Dutch HCPs on financial incentives as a supplement to CVD care in the Netherlands. We study the perspectives of HCPs because they are expected to deliver the intervention, promote its uptake among patients, and guide implementation in current health care in the Netherlands. This study addresses two research questions. First, what are HCPs' attitudes toward using a financial incentive system for healthy living in patients with CVD? Second, what are the barriers and facilitators for implementing a financial incentive system as a supplement to existing CVD care?

Methods

Sample

A total of 16 semistructured in-depth face-to-face interviews were conducted between December 2017 and March 2018 with Dutch HCPs who support patients with CVD with living more healthily. In the Netherlands, the responsibility for supporting lifestyle changes in patients with CVD lies primarily with specialized nurse practitioners in hospitals, multidisciplinary professionals working in cardiac rehabilitation centers, and general practitioners and their assistants working in primary care. Therefore, we aimed to obtain diverse perspectives by including professionals with varying backgrounds from different institutions that are widely spread across the Netherlands (Table 1). After 16 interviews, no new information emerged, and data saturation was reached.

Table 1. Organization and professional background of respondents (N=16).

Organization and professional background	Values, n (%)
Academic hospital A	
Nurse practitioner working in cardiac rehabilitation	2 (12)
Academic hospital B	
Neurovascular nurse practitioner	1 (6)
Physician assistant specialized in cardiovascular risk factor management	1 (6)
Hospital A	
Physiotherapist working in cardiac rehabilitation	1 (6)
Nurse practitioner working in cardiac rehabilitation	1 (6)
Hospital B	
Physician-researcher working in cardiac rehabilitation	1 (6)
Nurse practitioner working in cardiac rehabilitation	1 (6)
Hospital C	
Neurologist specialized in cardiac rehabilitation	1 (6)
Nurse practitioner working in cardiac rehabilitation	1 (6)
Cardiac rehabilitation center A	
Cardiologist in residence	1 (6)
Lifestyle coach working in cardiac rehabilitation	1 (6)
Cardiac rehabilitation center B	
Physiotherapist working in cardiac rehabilitation	1 (6)
Cardiac rehabilitation center C	
Psychologist specialized in cardiac rehabilitation	1 (6)
General practice center A	
General practitioner specialized in cardiovascular disease care	1 (6)
Nurse practitioner working in cardiac rehabilitation	1 (6)

Procedure

We used convenience sampling and contacted individuals and organizations that were associated with the BENEFIT consortium. The BENEFIT consortium integrates care and noncare settings and connects public and private partners with the aim of scientifically evaluating the implementation of a reward system for healthy living in CVD. Interviewees were contacted based on three criteria: (1) the interviewee had to be involved in lifestyle changes in patients with CVD, (2) we aimed to recruit HCPs from diverse professional backgrounds, and (3) we aimed to recruit HCPs from different organizations geographically spread across the Netherlands. We did not receive any explicit rejection to participate. Interview appointments were made by phone, after which the interviews were planned based on the location of the interviewee. Before the

start of the interview, the interviewee was given a short introduction about the project of which this interview was a part of, the goal of the interview, the procedure that would be followed and how the data would be processed. If the interviewee agreed and had no further questions, he or she signed an informed consent form, and the interview started. The interviews were conducted by 2 researchers (JG, DB). One of the researchers led the interview, whereas the other was responsible for managing the audio recording and taking notes (these roles were alternated each time). The conversations were held in Dutch, audio recorded, fully transcribed, and finally pseudonymized to secure the privacy of the interviewees and possible relevant other people or organizations that were mentioned during the interviews. At the end of the interviews, the researcher summarized the key points covered and offered participants the chance to add to, revise, or clarify their views. Ethical approval for this study was obtained through a larger ethical approval process, which was required for the project at large. The main ethical concerns revolved around protecting the identity of individuals and the name of the organizations that were mentioned during the interviews, and we dealt with this by pseudonymizing the transcripts as described earlier.

A semistructured topic guide shaped the structure of the interviews, while allowing the interviewers to elaborate on the answers of the HCPs when relevant. This study reports on a subset of data related to the perceptions of HCPs on using a financial incentive system for lifestyle change in patients with CVD. This was one of the six themes discussed during the interviews. The other themes that were discussed, but not addressed in this study, were adherence of patients with CVD to a healthy lifestyle, supporting a healthy lifestyle, which stakeholders are involved in supporting a healthy lifestyle, using eHealth to support a healthy lifestyle, and using wearables and sensors to support a healthy lifestyle. Table S3 in Multimedia Appendix 1 contains the entire topic guide of the interviews. The interviews took an average of 60 minutes, of which approximately 15 minutes were spent on talking about an incentive system.

The interviewer first explained what the financial incentive system might look like. This explanation was based on the conceptual ideas developed within the BENEFIT consortium (Keesman et al., 2019):

With the BENEFIT program, patients can earn reward points for behaving healthily. For example, by going to their scheduled GP visits, but also by being physically active or self-monitoring their blood pressure. These reward points can then be exchanged for discounts on grocery items in the supermarket or to get a free healthy activity.

Then, the interviewer asked three questions: (1) What is your *opinion* on using an incentive system? (2) What could be *obstacles* for using an incentive system? and (3) What could be *solutions* to facilitate the use of an incentive system?

Analysis

Transcripts were analyzed using a bottom-up inductive approach. This means that we made meaning out of the data itself instead of using a top-down theoretical approach with a framework or theory to which data were fitted. To structure the data analysis process, we followed the six steps of thematic analysis (Braun & Clarke, 2006), which included (1) data familiarization, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. In each of the pseudonymized transcripts, 2 researchers (JG, DB) independently marked quotations containing pieces of data that were relevant for analysis. These quotations were compared, and a consensus document that contained all relevant pieces of data for each transcript was created. Each quotation was then classified as containing information about negative opinions, positive opinions, facilitating factors, barriers, or solutions. After this first rough classification into categories, the quotations were further interpreted by a single researcher who identified specific codes (eg, "people are naturally inclined to respond to rewards"). These specific codes were then again reviewed by an independent second coder who agreed or disagreed with the identified codes. Through discussion, all disagreements were eventually solved, resulting in a list of 33 codes. These specific codes were first categorized into broader categories and finally assigned to one of four overarching themes that emerged (eg, "positive attitude toward rewards"). This process involved sorting and categorizing similar codes and retracting each step multiple times until each of the 33 codes was assigned to one of the four overarching themes. Although data were analyzed and themes were identified using thematic analysis, we additionally used a technique taken from content analysis and counted how often a piece of code was encountered. This helped us quantify how often a specific code was mentioned. For publication purposes, quotation examples were translated into English by 2 researchers (JG, DB).

Results

The following themes emerged: (1) positive attitude toward rewards, (2) too much focus on extrinsic aspects, (3) structure and form of the reward, and (4) characteristics of the target group.

Positive Attitude Toward Rewards

The first important finding is that HCPs generally show high acceptance of and hold positive attitudes toward a financial incentive system. Although one respondent explicitly rejected the idea of rewarding people and 2 others were doubtful whether it would be a good idea, the majority of respondents (n=13/16, 81%) expressed positive attitudes.

Often mentioned was that a healthy lifestyle is challenging for patients with CVD and HCPs believe that a reward might help to provide a necessary nudge (n=7/16, 44%). HCPs believe that external commitment from a reward system would be effective in supporting sustained healthy living (n=7/16, 44%). One respondent explained this by emphasizing the affirmation that the delivery of a reward might provide:

> *"I certainly think that receiving a reward provides patients with a sort of feedback. That feedback gives them the recognition that they are doing something right. I certainly believe that it has potential.* [HCP1]"

Furthermore, respondents believed rewards to be effective because people are naturally inclined to respond to rewards (n=4/16, 25%):

> *"A reward system always works because that is how people are wired* [HCP2]."

Too Much Focus on Extrinsic Aspects

The second important finding is that half of the HCPs (n=8/16, 50%) believe that a financial reward system might put too much emphasis on extrinsic motivational aspects of lifestyle change. This could draw attention away from the intrinsically rewarding aspects of healthy living, such as feeling more fit (n=3/16, 19%). A proposed solution would be to always emphasize the intrinsic aspects and health benefits in addition to providing extrinsic rewards (n=2/16, 13%). Furthermore, providers of a reward system risk paternalizing patients by communicating to them what they *should be doing* and thus threatening patients' autonomy (n=2/16, 13%):

> *"I would have objections when a reward system moves in the direction of conditioning people to act like circus animals* [HCP3] "

According to the respondents, this focus on rewards could then also lead patients to overstrain themselves or even manipulate to get rewards (n=3/16, 19%). A possible solution would be to support autonomy by allowing freedom of choice in rewards (n=3/16, 19%). In addition, a sentiment strongly felt by some was that patients should find motivation from within, instead of needing a reward system (n=3/16, 19%):

> *"Patients should know better, especially patients that get acute hospitalizations [...] they should investigate their own behavior and change that* [HCP4] "

Finally, almost half of the HCPs expected the motivating effect of rewards to fade out over time (n=7/16, 44%).

Structure and Form of the Reward

The structure and form of the reward itself were deemed relevant for the success of implementing a reward system by 6 respondents. Related to the form of the reward, HCPs were worried that when rewards were not large enough, they would not have the intended motivating effect (n=2/16, 13%). Although one respondent argued for allowing as much freedom of choice as possible (eg, by letting participants choose how to be rewarded; n=1/16, 6%), another emphasized that to avoid supporting unhealthy behavior, only rewards should be provided that are in line with the behavior needed to attain them (eg, running for a discount on running shoes; n=1/16, 6%). Another concern was that the rules for how rewards could be earned would be made too complex or nontransparent (n=2/16, 13%). Finally, two respondents suggested to stimulate engagement with a reward system by using social interaction (n=2/16, 13%):

> *"I do think that a reward system would work best when you make it social [...] You are not going to celebrate when nobody is watching. While if there are many people watching—suppose I won a trophy at the Australian Open and 20.000 people are watching—I am going to scream from the top of my lungs to celebrate!* [HCP1]"

Characteristics of the Target Group

The respondents mentioned several concerns regarding the characteristics of subgroups of the population with CVD that could interfere with the successful implementation of a reward system. As patients with CVD are generally older, respondents are worried that some will have trouble using the technology necessary to measure their lifestyle behavior and receive the rewards (n=4/16, 25%): "A problem will be a lack of digital know-how, so logging into the system will be an issue, especially for the elderly" [HCP5]. This issue might be diminished by targeting a younger, more digitally literate population (n=2/16, 13%). Another issue is that respondents see 2 subgroups of patients who might not benefit from receiving rewards: (1) the already highly motivated individuals who will not receive additional motivation from being offered a reward system (n=1/16, 6%) and (2) the not-at-all motivated who will not respond to anything that is offered (n=1/16, 6%). Finally, respondents argued that a reward system risks rewarding the already successful (who do not need extra motivation) while punishing (and thus demotivating) nonachievers (n=4/16, 25%):

"[...] how do you deal with situations where people do not achieve their goal? This could of course have multiple different reasons and in that situation, people are in fact being punished. [HCP6]"

Key Concerns and Related Solutions

Whenever concerns were mentioned, we also asked for possible solutions. Therefore, in Textbox 1, we summarize the main concerns and related solutions suggested by the HCPs during the interviews.

Textbox 1. Key concerns and suggested solutions for implementing a financial incentive system.

Concern

- Focusing too much on extrinsic rewards
- Disengagement when rewards are insignificant, nontailored, or longitudinally provided
- Paternalization and threatening autonomy
- Lack of digital literacy in target group

Suggested solution

- Emphasize intrinsic aspects of healthy living while giving extrinsic rewards
- Integrate social aspects to increase engagement with rewards
- Support autonomy by allowing freedom of choice in rewards
- Focus on a target group that can work with the necessary technology

Discussion

Principal Findings

This is the first study to investigate the acceptability of a financial incentive system among Dutch CVD HCPs. Furthermore, we explored the barriers and facilitators of its implementation. The HCPs in our sample generally showed high acceptance of a reward system for healthy living in patients with CVD. This finding is consistent with the existing literature that also showed, among HCPs in the United States, high acceptance of a reward system for healthy living in CVD (Hoddinott et al., 2014). The level of acceptability we found is also in line with the idea that attitudes are not necessarily negative but depend on contextual factors such as how the incentive is designed and whom it targets (Giles et al., 2015; Mitchell et al., 2014; Promberger et al., 2012). With regard to these

contextual factors, Giles et al (Giles et al., 2015) and Promberger et al (Promberger et al., 2012) found that acceptability was higher when incentives were perceived as more effective ("pay them if it works"). In line with these findings, this study indeed found that many respondents perceived financial incentives as an effective intervention, which might have been related to the relatively high acceptance that was found. Furthermore, Giles et al (Giles et al., 2016) showed that policy makers perceive financial incentives as more acceptable when they target vulnerable subgroups. People with CVD might be considered a vulnerable group, which might explain why it is more acceptable to reward them for healthy living (Giles et al., 2016). Similarly, the high acceptability we found could be explained by previous research, suggesting that voucher-based incentives—as presented to HCPs in this research—are more acceptable than cash incentives (McGill et al., 2018; Mitchell et al., 2014). Finally, previous research has shown that privately funded incentives are considered more acceptable than publicly funded incentives (Hoddinott et al., 2014; Mitchell et al., 2014). The way the reward system for this study was explained to participants might have implied private funding, and thus high acceptance, because we mentioned the use of reward points that could be exchanged for discounts at commercial product and service suppliers.

Notwithstanding the generally positive evaluations we found, several important concerns emerged within the themes that were discussed. HCPs were concerned that rewards could lead to focusing too much on the extrinsic aspects of lifestyle change and could threaten autonomy. This might have negative effects, such as increasing pressure on patients with CVD and possibly leading to manipulation for rewards. These concerns can be interpreted as a reflection of ethical objections among HCPs in our sample. This finding is in line with the ethical reflection by Ashcroft, which states that financial incentives can be perceived as paternalistic, coercive, involve bribery, or undermine the agency of the person (Ashcroft, 2011). At a more practical level, concerns emerged around disengagement with rewards in the long term. For those looking to implement a financial incentive system that aims to be in place long term, it is important to take these practical concerns into account. For example, as mentioned by the respondents, through integrating social aspects in the incentive system.

An important new finding that emerged from this work is that digital literacy in the target population might be an obstacle to implementing a reward system for healthy living in CVD. The use of digital technology is necessary to objectively measure goal progress and provide associated rewards. As the onset of CVD generally occurs at an older age, patients with CVD are expected to have lower digital literacy. For those looking to implement a financial incentive system that targets a less digitally literate group (eg, patients with CVD) and aims to be in place long term, it appears important to take these practical concerns into account. This obstacle could be overcome by either focusing on a subsection of younger, more technologically savvy participants or by simplifying the

technological solutions to accommodate a larger group of patients with CVD. Future research should investigate whether patients with CVD recognize this obstacle and what they see as viable solutions. Developing a reward system in cocreation with patients with CVD can help simplify the technological solution and match its complexity to the digital literacy of the intended users. On the basis of the answers of the HCPs in this study, and in line with what other authors found (Mitchell et al., 2014), we propose that both ethical and practical concerns should be mitigated through thoughtful incentive design in cocreation with patients with CVD.

A limitation of this study is the possibility that HCPs opinions on using a financial incentive system were influenced by preceding discussions (as described in the *Method*s section) about other themes related to lifestyle change. More specifically, having thought about obstacles in providing support for lifestyle changes in patients with CVD might have primed HCPs to the necessity of accepting alternative intervention supplements such as financial incentives. This could have led to an overestimation of acceptability to levels that would not be found when the financial incentive system would have been discussed in isolation. In addition, because we used convenience sampling and contacted individuals and organizations that were associated with the BENEFIT consortium, opinions on a reward system could be more positive than would otherwise be the case. Although the high acceptability that we found is consistent with existing research, some caution in drawing firm conclusions with regard to acceptability is warranted. Another consideration is that before asking HCPs about their opinions, we provided a concrete example of what a financial incentive system might look like. Therefore, the findings of this study should be interpreted in relation to a voucher-based financial incentive system (points to be exchanged for goods and services), and generalizing these insights to other forms of financial incentive systems should be done with caution. Finally, the sample used in this study was heterogeneous and relatively small. Integrating the perspectives of HCPs from various disciplines and institutes across the Netherlands ensures a broad view of opinions but makes in-depth discussions about discipline-specific or institute-specific insights impossible. Future research that aims to support local implementation could use a more homogenous sample and a fine-grained approach to overcome this.

Conclusions

This study mapped the opinions of Dutch HCPs working in CVD care. In line with existing studies on different populations outside the Netherlands, Dutch HCPs in general showed high acceptance of a financial incentive system for healthy living in patients with CVD. However, there are important concerns that should be considered when designing a financial incentive system. In particular, the concern about digital literacy in the target group is a novel finding and warrants further investigation. According to

the HCPs interviewed in this study, suggested solutions to overcome concerns around a financial incentive system for patients with CVD are (1) emphasizing intrinsic aspects of healthy living while giving extrinsic rewards, (2) integrating social aspects to increase engagement with rewards, (3) supporting autonomy by allowing freedom of choice in rewards, and (4) aiming for a target group that can work with the necessary technology.

The high level of acceptability we found among Dutch HCPs provides support for further investigation and development of a reward system for CVD, as will be pursued in the BENEFIT consortium. Finally, although investigating HCPs' opinions is an important first step, it is also important to know the opinions of the patients that would be targeted by financial incentives. Therefore, in the next step, we will validate the current insights among Dutch patients with CVD. The aim of these cocreation efforts is to contribute to the design of financial incentive interventions to better fit the needs of both clinicians and patients in CVD care.

Authors' Contributions

DB, MK, JG, VJ, AE contributed to conception and design of the work, JW contributed to design of the work, HK and RK, contributed to conception of the work. DB, MK, JG, RV, HK, VJ, AE contributed to acquisition, analysis, or interpretation. DB and TR drafted the manuscript and all critically revised the manuscript, gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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Chapter 7

Summary and General Discussion

Financial rewards can be effective to promote initiation of health behavior change, but there is little evidence for maintenance of behavior change after incentive removal. Deposit contracts, a specific type of financial incentive, require people to deposit their own money, and allow them to earn it back contingent on successful behavior change. Because deposit contracts are provided by the person attempting the behavior change, they do not require external funding, and could thus more easily be implemented on a large scale. Additionally, deposit contracts might be more effective than other types of financial incentives, because they capitalize on our tendency to be loss aversive. Therefore, deposit contracts are a promising tool for improving population health. In this dissertation, we investigated the application of deposit contracts to improve health behavior change. We focused on physical activity specifically, because it potentially has important health benefits, is relatively easy to implement in daily life, and is therefore also suitable for deprived, vulnerable and older populations. Also, deposit contracts can be designed in many different ways, and it is currently unknown which features of deposit contracts make them more effective. While deposit contracts do not require external funding, they require participants to put their own money at risk. This requirement deters part of the population from participating in a deposit contract, and it is important to explore methods for increasing deposit contract uptake. Finally, health behavior change is most urgent in populations such as those with chronic conditions like cardiovascular disease.

The main aim of this dissertation was to assess the potential of deposit contracts for health behavior change. More specifically, we aimed to (1) establish the effects of deposit contracts, (2) explore which features of deposit contracts make them more effective, (3) identify strategies that help increase the uptake of deposit contracts, and (4) assess the acceptability of deposit contracts for people with cardiovascular disease. In this final chapter, a summary of the main findings per empirical study will be given in relation to these aims. Thereafter, we discuss the main findings of this dissertation, and then outline the strengths and limitations of our methods. Finally, we provide an agenda for future research into deposit contracts for health behavior change.

Summary of the main findings

Chapter 2 contributed towards our aims of (1) *establishing the effects of deposit contracts on physical activity,* and (2) *exploring which features of deposit contracts make them more effective.* Previous research has used loss framing of a financial reward (without requiring a deposit) to mimic the feelings of loss involved in a deposit contract, and leverage loss aversion. Previous studies operationalized loss framing by first giving participants a reward and then subtracting money from that reward when participants were not successful. Gain framing consists of participants simply earning rewards for every goal

success. We investigated whether loss framing a financial incentive increases effectiveness (measured as participant days goal achieved), compared to gain framing. Furthermore, we compared the effectiveness of deposit contracts with that of financial rewards. Healthy participants (N = 126) with an average age of 22.7 years participated in a 20-day physical activity intervention that aimed to improve daily step counts. We used a 2 (incentive type: deposit or reward) × 2 (feedback frame: gain or loss) between-participants factorial design with a no-incentive control condition. Interestingly, and contrary to what we expected, we found that, in a healthy population aiming to improve daily step counts, loss framing of financial incentives led to reduced effectiveness. Our results showed that deposit contracts were not more (but also not less) effective than financial rewards, while they did have lower uptake (measured as agreeing to participate and paying the deposit). Furthermore, we found that gain framed incentives resulted in higher effectiveness, which is why we applied gain frames in our follow up study in chapter 3.

Chapter 3 aimed to (3) *identify strategies that help increase the uptake of deposit contracts for physical activity.* Secondarily, this chapter also contributed towards (1) *establishing the effects of deposit contracts on physical activity,* and (2) *exploring which features of deposit contracts make them more effective.* 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 (measured as agreeing to participate and paying the deposit) and short-term effectiveness (measured as participant days goal achieved) of a deposit contract for physical activity. Healthy participants (N = 137) with an average age of 21.6 years participated in a 20-day physical activity intervention that aimed to improve daily step counts. We employed a 2 (deposit customization: fixed or customizable) x 2 (deposit matching: not matched or matched) between-participants factorial design. The deposit contract intervention used in this study was effective in helping people increase their step counts, and customization and matching did not have additional effects. However, both matching and customization did increase the uptake of a deposit contract for physical activity. Therefore, both matching and customization might be considered to overcome lack of uptake, with a preference for customization since matching a deposit imposes significant additional costs.

In **Chapter 4** the purpose was (1) *establishing the effects of deposit contracts on physical activity,* and (2) *exploring which features of deposit contracts make them more effective.* To assess their potential for improving population health, research has to investigate implementation of deposit contracts outside the research setting and among larger and more diverse samples. Therefore, we performed a naturalistic evaluation of StepBet gamified deposit contracts, for whom they worked best, and under which conditions they were most effective to help increase physical activity. We analyzed (N = 72,974) unique first time StepBet challenges that were offered on the StepBet smartphone

application. The modal challenge consisted of a $40 deposit made prior to a 6-week challenge period during which participants needed to reach daily and weekly step goals in order to regain their deposit plus possible additional earnings, paid out from the money lost by those who failed their challenge. We measured the challenge success ratio and compared the average step count during a challenge to a baseline that was determined on a 90-day historic step count retrieved before a challenge started. Findings show that, in a real-world setting, and among a large and diverse sample, participating in a physical activity challenge using gamified deposit contracts was associated with a large increase in step counts (+ 31.2%). The average challenge success rate was 73% and while winners increased their step count by 44%, losers in fact decreased their step count by 5.3%. Exploratory analyses indicated that males and older people had larger increases in step counts and higher odds of succeeding in their challenge. Finally, New Year's resolution challenges were more effective than regular challenges. Overall, this chapter showed that in real world conditions, gamified deposit contracts are associated with clinically relevant increases in physical activity.

Chapter 5 focused on (4) *assessing whether deposit contracts are suitable for people with cardiovascular disease*. There is an urgent need to find new approaches that improve long-term adherence to a healthy lifestyle among people with cardiovascular disease (CVD), but it is unknown whether they would find deposit contracts acceptable. Therefore, we investigated the acceptability of a deposit contract for physical activity with a survey among (N = 659) members of the Harteraad patient panel of the Dutch CVD patient organization. Findings confirm the idea that cardiovascular disease patients feel they need extra commitment to maintain their lifestyle changes. Yet, only a small part of this sample responded positively to using deposit contracts to maintain physical activity behavior change. When exploring subgroup responses, younger patients, and male patients, showed higher acceptability. All in all, this chapter revealed that deposit contracts have a limited acceptability among the CVD patient group.

Chapter 6 contributed towards our aim of (4) *assessing whether deposit contracts are acceptable for people with cardiovascular disease*. It is unknown whether healthcare professionals (HCPs) involved in cardiovascular disease (CVD) care find it acceptable to provide financial incentives to patients with CVD as support for lifestyle change. Therefore, we investigated HCPs' perspectives on using financial incentives to support healthy living for patients with CVD. We performed (N = 16) semi structured, in-depth, face-to-face interviews with Dutch HCPs involved in supporting patients with CVD with lifestyle changes. Findings show that HCPs perceived an incentive system for healthy living for patients with CVD as possibly effective and showed generally high acceptance. However, there were concerns related to focusing too much on the extrinsic aspects of lifestyle change, disengagement when rewards are insignificant, paternalization and threatening autonomy, and low digital literacy in the target group. Together, these

findings reveal that, according to HCPs, financial incentives might be suitable for patients with CVD if contextual factors, design of incentives, and target groups are accurately considered.

Discussion of the main findings

In this section we bring together the main findings from the separate empirical studies in light of our aims.

Aim 1: Establish the effects of deposit contracts

An important finding of this dissertation is that deposit contracts potentially have large, clinically relevant effects on physical activity, among those who decide to participate in them. The existing research to date showed promising results, but was either underpowered (Donlin Washington et al., 2016; Krebs & Nyein, 2021; Stedman-Falls & Dallery, 2020), or did not require participants to make a deposit of their own money (Budworth et al., 2019; Burns & Rothman, 2018). The results from our two field experiments (chapters 2 and 3) were consistent with the findings from our real-world observation (chapter 4), and provide additional evidence that deposit contracts can successfully be applied to increase step counts. Our current findings are in line with existing research on promoting physical activity with financial incentives generally (Mitchell et al., 2019), and deposit contracts specifically (Boonmanunt et al., 2022). Although it is important to show that deposit contracts are effective in promoting initiation of physical activity, we did not study behavior change maintenance in the current dissertation. Meta-analysis across studies has provided indications that financial rewards, lottery incentives, and deposit contracts all had short term effects on physical activity, but deposit contracts were the only type of incentive which led to maintenance of improvements in physical activity up to 4 months after incentive removal (Boonmanunt et al., 2022). Furthermore, this dissertation (chapter 4) has identified that those who fail in a deposit contract challenge might be at risk of decreased physical activity. After a deposit contract challenge is failed, participants might become less motivated to track their step counts (by carrying their smartphone or wearing their external activity tracker) or to actually increase their step counts. This finding is important because it points to a possible setback effect (see Wenzel et al., 2020) among those who fail their deposit contract, and may stimulate further research into understanding setback effects, and ways to mitigate them. Overall, based on the existing evidence, supplemented by our current findings, deposit contracts appear to have potential to help improve physical activity, and potentially also other health behaviors.

Aim 2: Explore which features of deposit contracts make them more effective

Previous research had indicated that several features of financial incentive interventions (longer duration, more immediate incentive delivery, higher incentive amounts, less active target population) are associated with larger effects on physical activity (Mitchell et al., 2019). This dissertation investigated whether matching (chapter 3), customization (chapter 3), and loss framing of a financial incentive (chapter 2) increased effects on physical activity. Unexpectedly, we found that matching (although it doubled the incentive amount), and customization did not result in larger effects of a deposit contract. These results are in contrast to previous findings which showed that higher incentive amounts (Mitchell et al., 2019) and customizable deposit contracts were related to larger effects (Sykes-Muskett et al., 2015). We explain these findings through a ceiling effect, because the overall intervention was highly effective in all experimental conditions (chapter 3). Furthermore, we found that loss framing a financial incentive for improving physical activity decreased the effectiveness of the intervention compared with gain framing (chapter 2). This unexpected finding stands in contrast with previous findings on loss framed financial rewards (Patel et al., 2016), and provides evidence that (perceptions of) losses are not always more impactful than (perceptions of) gains. Instead, this finding supports arguments made by others that loss aversion is a context-dependent tendency with boundary conditions, instead of a ubiquitous phenomenon (Gal & Rucker, 2018). Possibly, differences in regulatory fit between the samples of our study and the study by Patel et al. (2016) help explain the discrepancy in these findings. Our findings might form the starting point for new research into how incentive framing might interact with regulatory focus or other features of health goals, behaviors or characteristics of participants. With regards to when deposit contracts are best initiated, we found that deposit contracts started as a New Year's resolution were more effective than when they were started during any other period of the year. Our finding extends on previous findings on the Fresh Start Effect by showing that people are not only more inclined to pursue behavioral goals around the passage of the year (Dai et al., 2014), but these goals might also be pursued with greater success. Therefore, our findings suggest to make use of this temporal landmark to increase the odds of successful behavior change.

Aim 3: Identify strategies that help increase the uptake of deposit contracts

Previous research on deposit contracts clearly identified that they suffer from a lack of uptake (Giné et al., 2010; Kullgren et al., 2016; Royer et al., 2015). The findings from our field experiment in chapter 2 confirmed that deposit contracts for physical activity have lower uptake than financial rewards. Additionally, previously no experimental evidence was available on how to increase uptake of deposit contracts for physical activity

behavior change. Our field experiment in chapter 3 identified that both matching and customization of a deposit contracts have the potential to increase uptake. This finding might be relevant for the large-scale implementation of deposit contracts in practice. Through matching and customization of deposit amounts, a broader population can benefit from using deposit contracts to increase their physical activity, and perhaps other health behaviors as well. Matching might convince people who are hesitant to put their money at risk, because an extra reward can be earned. Customization creates 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 might make deposit contracts more attractive for targeting vulnerable subgroups.

Aim 4: Assess the acceptability of deposit contracts for people with cardiovascular disease

Although opinions of healthcare professionals (HCPs) were generally positive towards using financial incentives to support health behavior change among people with cardiovascular disease (chapter 6), most people with cardiovascular disease showed reluctance towards using deposit contracts (chapter 5). These findings are in line with existing research that showed high acceptability of financial incentives among HCPs (Hoskins et al., 2019), but indications of low acceptability among patients themselves (McGill et al., 2018; Mitchell et al., 2014). It is important to note that we did not study the acceptability of deposit contracts specifically among HCPs, but rather gauged acceptability of a financial incentive system generally. Nevertheless, assuming that healthcare professionals would also show acceptability towards deposit contracts, the suitability of deposit contracts would be limited if people with cardiovascular disease themselves do not accept them. These findings are important for practitioners who consider applying monetary deposit contracts to CVD patient populations. The high level of acceptability we found among HCPs provides support for further investigation and development of a financial incentive system for lifestyle change in CVD. However, because only a subgroup of CVD patients found deposit contracts for lifestyle change acceptable, it is important to offer them as an optional, additional element to existing interventions that patients can opt-in to. Because we did not offer deposit contracts in practice, (but merely gauged their hypothetical acceptability) actual uptake and acceptability in practice might be higher, especially when methods of customization or matching are applied (chapter 3). Finally, to reach a broader target group among CVD patients, it might be relevant to further identify strategies that leverage similar commitment principles as used in deposit contracts, but that do not have a cash deposit requirement (e.g., picture of the person sitting in a lazy pose on the couch will be spread on social media if challenge is failed).

Strengths and limitations

The empirical studies that make up this dissertation had several strengths and limitations. We applied a mixed methods approach to study the potential of deposit contracts for improving health behavior change. We performed both qualitative and quantitative research, and used both observational and experimental methods to further understand the potential of deposit contracts for health behavior change. While experimental and observational studies allowed us to get insight into the (real world) effects of deposit contracts, qualitative methods helped us to gain insight in acceptability and opinions on financial incentives and deposit contracts among relevant populations. An additional strength of the studies in this dissertation is the diversity of samples and settings that were studied. Firstly, we performed theoretically informed field experiments among healthy students (pre-dominantly living in the Netherlands) that shed light on features of deposit contracts that increase uptake and effectiveness. In addition, we collaborated with a business partner that allowed us to perform a naturalistic evaluation of deposit contracts in the real world, among a general (pre-dominantly living in the United States) population that purchases deposit contracts as a service to achieve behavior change. These observations provide additional evidence for the real-world feasibility of deposit contracts, something that is crucial when one aims to assess the potential of this intervention to increase population health. Thirdly, we studied financial incentives and deposit contracts for lifestyle change among cardiovascular disease patients in the context of the Dutch healthcare system. All in all, the multitude of these perspectives paints a broad picture of the short-term effectiveness, real world efficacy, subgroup differences, and acceptance in healthcare. We believe this adds to the real-world applicability of our findings. Another strength of the experimental studies is that we did not rely on self-reported outcomes, but used behavioral outcomes, such as automatic registration of step counts and deposit contract challenge outcomes. This increases the internal validity of our findings and avoids some of the common concerns associated with biases in self-reported health behavior change. By using smartphone registration of step counts, we were also able to personally tailor intervention goals based on historic step counts saved on participants' smartphones. Finally, a strength of the experimental and observational studies is that we investigated a strict operationalization of a deposit contract. Namely, a contract in which the participant prior to participating has to transfer an amount of his or her own money through credit card (chapter 4) or a direct digital bank transfer (chapter 2 and 3). Other studies relied on loss framing of a financial reward (Burns & Rothman, 2018) or provided participants with vouchers first (Budworth et al., 2019) which participants could then use a deposit. Because we used deposit contracts with actual deposits of participant's own money, we were able to accurately assess uptake, ways to increase uptake, and effectiveness of deposit contracts.

An important limitation of this dissertation is the short time horizon on which effects of deposit contracts were studied. Our two field experiments investigated initiation of behavior change during 20 intervention days, while our real-world observation investigated initiation of behavior change during 41 intervention days. To increase population health, maintaining behavior change is the ultimate aim (see Dunton et al., 2022). The current work does not yet provide evidence for maintenance of behavior change. A second limitation is that we determined the effectiveness of deposit contracts (chapter 2, 3, 4) by analyzing those who decided to participate in them (per protocol analysis). Instead, analyzing the effectiveness of deposit contracts among the entire sample, instead of only those who decided to participate (intention to treat analysis) would provide stronger, and perhaps more realistic, evidence for their efficacy when deposit contracts are offered in the real world. Because deposit contracts generally have low uptake (in our two experiments around 50%), those who decide to participate might be differently (more strongly) motivated than those who decide not to participate, and thus show greater improvements as a result. This introduces a selection bias that confounds the comparison that is subsequently made with financial rewards conditions. This selection bias operates on several levels. People might be deterred at the stage of recruitment when the intervention is described (for example on a flyer), at the stage of informed consent (when ethical guidelines require researchers to mention the deposit contract), and at randomization (when participants are explained the details of their deposit contract). Furthermore, some of our studies (chapter 2 and 3) were performed during a period in which COVID-19 related lockdowns and a stay-at-home advice were issued by the Dutch government. Although all of the conditions in these studies were probably impacted equally, it is possible that the overall intervention effects we found were different than they would be under non-lockdown circumstances. Finally, the deposit contracts we investigated consisted of several additional behavior change components (goal setting, daily progress feedback, peer support) on top of the deposit contract (see Michie et al., 2013). Therefore, we are not able to disentangle which part of the effects found can be attributed to the monetary deposit. It would be relevant to compare challenges with a monetary deposit to similar challenges without this deposit to isolate the effect of the monetary component.

Future research

In this section we provide suggestions for future research based on the findings of the studies performed in this dissertation.

How can deposit contracts facilitate long term maintenance of behavior change?

Although it is crucial to first show that deposit contracts are effective for initiation of behavior change (chapter 2, 3, 4), an important challenge is to investigate whether deposit contracts can also promote maintenance of behavior change in the long term. We envision three avenues that future research can follow.

Firstly, deposit contracts could be offered as a tool that people can repeatedly use to strengthen their commitment to lifestyle goals (Erev et al., 2022). Motivation for health behavior change is dynamic over time (Dai et al., 2014), and whenever there's a peak in motivation (such as when people pursue New Year's resolutions or when they want to become beach fit for summer), people could repeatedly use deposit contracts to support their lifestyle goals. In this way, each behavior change attempt can gradually help people experience the benefits of new behavior and incrementally improve their lifestyle in the long term. Future research could investigate whether this application of deposit contracts is feasible and effective to promote long term maintenance of behavior change. Future studies could do this by giving a group of people long-term access to a tool that allows them to enter into repeated deposit contracts for different health behaviors. By systematically evaluating who uses this tool, for which health behavior, and to which effect, researchers could then investigate to what extent people are willing to use deposit contracts over the course of several behavior change attempts. It is especially relevant to analyze whether people are willing to participate repeatedly in deposit contracts (for the same or different health behaviors), and which chronological (e.g., New Year's resolutions) or life events (e.g., upcoming beach holiday) trigger the initiation of new deposit contracts.

Secondly, deposit contracts with a (really) long time horizon could be offered. In the current dissertation we tested deposit contracts with a 20-day (chapter 2, 3) or at maximum 41-day duration (chapter 4). However, it is interesting to investigate the uptake and effects of deposit contracts with a duration of a full year (perhaps started as a New Year's resolution), or even longer. No research to date has studied deposit contracts for physical activity with a duration extending past 3 months (Boonmanunt et al., 2022), but there is no reason to expect that longer durations will be less effective. On the contrary, longer intervention durations have shown to increase maintenance of behavior change effects produced by financial incentives (Mitchell et al., 2019). For example, deposit contracts have been shown to increase weight loss outcomes with a post-incentive follow up period of up to 12 months (Finkelstein et al., 2017). Future research could study long duration deposit contracts by offering participants a deposit contract with a 1- or 2-year time horizon, and measure uptake and effects on behavior change maintenance.

Finally, the ultimate goal is to develop healthy habits that are self-supportive and do not require any external incentive. Previous research has shown that when financial

rewards were provided on intermittent reinforcement schemes (either at increasing time intervals or with unpredictable timing) they were more effective than fixed (per visit) payments in facilitating long term maintenance of behavior change in gym visits (Arad et al., 2023). Future research could design dynamic deposit contracts that gradually fade out while habits develop, or that provide intermittent reinforcement, and measure their impact on long term maintenance of behavior change during active deposit contract, and with long term follow up measurements.

Who benefits most from deposit contracts?

Understanding the factors that influence the effectiveness of deposit contracts is crucial to tailor the intervention to specific subgroups. In this dissertation (chapter 2, 3, 4) we explored the impact of several demographic and psychological variables on uptake and effectiveness. Our findings suggested that males, and older people might have greater improvements in physical activity as a result of participating in a deposit contract challenge (chapter 4). Future research should be done to confirm these findings and explore why this might be the case. Research could also investigate the role of other psychological variables. For example, individual variation in present bias has been shown previously (see Hunter et al., 2018), and those who show a greater level of present bias might respond especially strong to immediate financial incentives. A second interesting psychological variable to investigate is loss aversion. Although many studies on deposit contracts posit they should have superior effects compared to regular financial rewards because of loss aversion (see for example Budworth et al., 2019; Burns & Rothman, 2018), we are not aware of studies that have actually measured loss aversion. Future research might measure present bias and loss aversion (see Abdellaoui et al., 2007), to investigate their moderating role in producing effects of deposit contracts.

How can incentive frames be tailored to increase deposit contract effects?

One key element when it comes to deposit contract tailoring is how to frame the incentive. This dissertation showed that in a healthy population aiming to improve their daily step counts, gain framed financial incentives were more effective than loss framed incentives (chapter 2). This finding might be explained by an interaction between incentive framing (loss or gain framed) and participants' regulatory focus (prevention or promotion focused). People with a promotion focus aim for desired end states, while people with a prevention focus aim for avoiding undesired end states (Ludolph & Schulz, 2015). It has previously been shown that the persuasiveness of a health message is increased when its frame is congruent with the regulatory orientation of the individual. This has been

labelled regulatory fit (Ludolph & Schulz, 2015). Following this line of reasoning, it is possible that the healthy students we studied (in chapter 2 and 3) were pre-dominantly promotion focused (on becoming more fit rather than avoiding health problems), and therefore responded better to a gain-framed financial incentive. Future research on whether the regulatory fit effect also applies to incentive framing (and not only to framing of persuasive health messages) could further our understanding of incentive framing effects. Ultimately, this might help tailor the framing of financial incentive interventions to specific target populations and their regulatory orientations.

How to overcome low uptake of deposit contracts?

A key obstacle to large scale implementation of deposit contracts is low uptake (Giné et al., 2010; Kullgren et al., 2016; Royer et al., 2015). In our two experiments (chapter 2, 3), uptake of deposit contracts was around 50%, while our financial reward conditions had over 95% uptake. In order to overcome issues with uptake of deposit contracts, more research is needed to further understand what causes it. For example, future research should shed more light on which demographic or psychological variables predict (a lack of) uptake.

A demographic variable that is potentially relevant to deposit contract uptake is participants' income. People with lower incomes (and educational attainments) have been shown less likely to participate in health interventions generally. For example, cardiac rehabilitation is less likely to be attended by people from low income areas after they have been hospitalized with a heart condition (Lemstra et al., 2013). Therefore, it can be expected that these people are also deterred from participating in a health behavior change intervention that involves a monetary deposit of their own money. In order to improve uptake among subgroups with lower incomes, customization of deposit amounts could be offered. This would allow individuals to select a deposit amount that motivates them, but does not cause financial harm when it is forfeited upon failure (Sykes-Muskett et al., 2015).

A psychological variable that might be relevant when trying to understand uptake of deposit contracts is sophistication with regards to future self-control abilities (Bryan et al., 2010). In order to take a measure such as risking one's own money to improve lifestyle, one has to have the self-critical insight that future self-control might be limited. Here, a distinction can be made between sophisticates, those who foresee that they will have self-control problems in the future (e.g., Odysseus who ties his hands), and naives, those who don't foresee such self-control problems (O'Donoghue & Rabin, 1999). Naives are supposed to need extra commitment, but do not recognize this fact, and might therefore be less likely to use a commitment device such as a deposit contract (Bryan et al., 2010). Future research could measure and intervene on sophistication with regards to self-control and investigate whether this predicts and increases uptake of deposit contracts.

Finally, low uptake of deposit contracts creates a selection bias that makes comparisons with other types of financial incentives difficult. Low uptake of deposit contracts might filter out those with different levels of motivation, resulting in a selection bias when comparisons are made to financial incentives that have a much higher (near perfect) uptake. Therefore, it is possible that the existing evidence over-estimates the effectiveness of deposit contracts compared to other types of financial incentives (see Boonmanunt et al., 2022). Analysis of deposit contract uptake in future research should take into account that there are several phases during which uptake should be measured (recruitment, informed consent, after randomization). Future research should take a broader approach, and also include (lack of) uptake during recruitment and informed consent when studying the relative effectiveness of deposit contracts and financial rewards.

How can setback effects among those who fail a deposit contract be mitigated?

Some people will inevitably fail their deposit contract challenge (chapter 2, 3, 4). Not much research has been done yet on what effect failure has on motivation, self-efficacy and the subsequent propensity for sustained or repeated effort in pursuing behavior change. Our findings (chapter 4) showed that upon failure in a deposit contract, possibly a setback effect occurs in which people become demotivated to continue their behavior change attempt. Others have shown that setback effects are related to a decrease in self-efficacy (ten Broeke & Adriaanse, 2023), and that people can be protected against it by helping them make external attributions ("the weather was just too bad to go outside"), rather than internal attributions ("I am a lazy person") for their self-regulation failure (Adriaanse & ten Broeke, 2022). Experimental field research in various populations might give insight into the motivational and behavioral dynamics around failing a deposit contract, and how possible setback effects can be mitigated. For example, a future study could offer a deposit contract for physical activity and randomly assign participants to one of two experimental conditions. An intervention condition that helps facilitate external attributions for failure ("You did not make it this time, but cheer up! – the weather was really bad this month and that made it difficult for you to achieve your goal this time"), and a filler control condition. A reduction in self-efficacy among those who fail would provide support for a self-efficacy mediated setback effect. A less strong reduction in self-efficacy among those who received the intervention would provide evidence for how external attributions for failure can help protect against the setback effect. Measuring the amount of newly started challenges among the people who initially failed, might shed additional light on how external attributions for failure might influence the actual propensity for repeated effort in pursuing behavior change.

How can large scale implementation of deposit contracts be facilitated?

The short-term effectiveness (chapter 2, 3) and real-world efficacy (chapter 4) of deposit contracts provide evidence to support their large-scale implementation to increase health behavior change. Future research should implement deposit contracts and measure their uptake and effects among specific target groups such as those with lower levels of education, income and existing chronic conditions, such as cardiovascular disease. When certain groups are not reached, interventions such as matching and customization of deposits should be introduced to improve uptake among specific subgroups. Secondly, deposit contracts could be used by people themselves, without an intervention provider. In practice, people could set their own lifestyle goals, agree (with others publicly or with themselves privately) on the terms for regaining or losing the deposit, and start a deposit contract by themselves. In this way, deposit contracts operate as a tool that people can use to self-incentivize themselves with (see Lesser et al., 2018). Future research should study how feasible, acceptable and effective these self-initiated deposit contracts are, and what instructions would be needed to help people construct optimal deposit contracts for themselves. In addition, an interesting future direction is to explore how the working mechanisms of deposit contracts could be leveraged without money. For example, one could capitalize on the principle of loss aversion by having people commit to a bet with some level of social discomfort at stake (e.g., picture of the person sitting in a lazy pose on the couch will be spread on social media if challenge is failed). Others refer to these different types of commitment as 'hard' and 'soft' commitments (Bryan et al., 2010). Hard commitments involve monetary consequences (such as losing money), and soft commitments involve psychological consequences (such as shame). Deposit contracts with soft commitments are under researched up to date (Manthri Savani, 2019). Exploring soft commitment strategies without a cash deposit requirement can help reach subgroups that would benefit from extra commitment to their lifestyle goals.

Finally, future research should identify business models that help increase the scale at which deposit contracts can be offered. In current practice, customers of health insurance companies can purchase a wearable device and by achieving their daily step goals earn a cashback on the purchase of this device (Hafner et al., 2020). This deal in essence constitutes a deposit contract, because a certain amount of money is transferred and can be earned back by achieving behavioral goals. These forms of deposit contracts appear attractive to consumers and are already being applied with some form of success in practice (Hafner et al., 2020). There are many other possible health promoting products or services that could be purchased by consumers, under the agreement that upon verified behavior change (using the service or product), discounts can be earned. For example, fitness gyms can offer contracts wherein customers receive a discount on their annual subscription fee when they achieve a certain number of objectively verified gym

visits. Whether these deals facilitate sustained improvements in health behavior change remains an interesting topic for future research.

Conclusion

This dissertation showed that deposit contracts have potential to facilitate health behavior change, and can be offered to large populations without requiring external funding of incentives. Our research showed that deposit contracts can be effective in supporting short term improvements in physical activity (chapter 2, 3, 4). Because of their strong and clinically relevant effects among those who elect to use them, we recommend intervention providers to consider offering deposit contracts to support health behavior change. Deposit contracts were more effective when daily feedback was gain framed (emphasized wins instead of losses) (chapter 2). Deposit contracts were also more effective for males, older people, and when they were started as a New Year's resolution (chapter 4). Although effective, deposit contracts will not reach everyone because their uptake is limited (chapter 2, 3). When one aims to improve deposit contract uptake, our findings show that both matching and customization are effective strategies (chapter 3). Although healthcare professionals are generally positive towards using financial incentives to support lifestyle change of cardiovascular disease patients (chapter 6), patients themselves are generally skeptical towards using deposit contracts (chapter 5). Because only certain subgroups are interested in using them, and deposit contracts involve a risk of financial harm, deposit contracts might be offered on an opt-in basis. Additionally, we recommend exploring how non-monetary forms of commitments can help people achieve health behavior change. Finally, researchers and intervention providers who aim to enhance health behavior change interventions with financial incentives have both carrots (financial rewards) and sticks (deposit contracts) at their disposal. The evidence base for the effectiveness of carrots was already convincing, and this dissertation showed that sticks can be at least equally effective. We hope that this dissertation, by providing evidence for the potential of deposit contracts, stimulates a broader use of the tools available in the financial incentive toolbox. Hence, it's title: less carrot more stick.

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Appendices

Nederlandse samenvatting (summary in Dutch)

Minder wortel meer stok. Het stimuleren van gezonde gedragsverandering met depositocontracten

Financiële prikkels zijn overal. Mensen ontvangen salaris om hun werk uit te voeren en krijgen een boete als ze te hard rijden in hun auto. Ook al zijn er andere goede redenen om naar je werk te gaan en je aan de snelheidslimieten te houden, kun je je een wereld voorstellen zonder deze prikkels? Financiële prikkels bepalen op veel aspecten van het leven ons gedrag. Ook op gezondheidsgedrag worden steeds vaker financiële prikkels toegepast. Zorgverzekeraars bieden mensen bijvoorbeeld verschillende financiële prikkels voor een gezonder leven (denk aan bioscoopkaartjes, kortingen op reizen, terugbetaling bij aankoop van een activity tracker, zie Hafner et al., 2020). Deze programma's ondersteunen verandering van gezondheidsgedrag door onmiddellijke financiële prikkels voor gezond gedrag te introduceren. Hierdoor hoeven mensen niet langer te wachten op de uitgestelde beloningen (bijvoorbeeld fitter worden) die het gevolg zijn van hun gezondere gedrag. Grofweg kunnen twee vormen van financiële prikkels worden omschreven: wortels en stokken (Adams et al., 2014). Wortels kunnen worden gedefinieerd als financiële prikkels die de mogelijkheid creëren voor een financiële winst. Bijvoorbeeld door iemand te belonen met een bepaald geldbedrag voor succesvolle gedragsverandering. Stokken kunnen worden gedefinieerd als financiële prikkels die de dreiging creëren van een financieel verlies. Bijvoorbeeld door iemand eigen geld te laten storten in een depositocontract, en dit terug te laten verdienen middels succesvolle gedragsverandering. Een depositocontract zorgt voor een stok achter de deur, want als iemand niet succesvol is kan het gestorte eigen geld verloren gaan. Dit proefschrift onderzoekt of én hoe depositocontracten kunnen worden gebruikt voor verandering van gezondheidsgedrag.

Financiële beloningen (wortels) kunnen effectief zijn om het starten van gezondheidsgedragsverandering te bevorderen, maar er is weinig bewijs dat mensen de bereikte gedragsverandering ook volhouden na het wegnemen van de beloning. Depositocontracten (stokken) vereisen dat mensen hun eigen geld storten en stelt hen vervolgens in staat om dit terug te verdienen middels succesvolle gedragsverandering. Omdat depositocontracten worden betaald door de persoon zelf, is er geen externe financiering nodig en kunnen ze dus gemakkelijker op grote schaal worden geïmplementeerd. Bovendien kunnen depositocontracten effectiever zijn dan andere soorten financiële prikkels, omdat ze inspelen op onze neiging om verlies aversief te zijn. We hebben ons hierbij voornamelijk gericht op het verbeteren van beweeggedrag, omdat dit potentieel belangrijke gezondheidsvoordelen heeft, relatief eenvoudig te implementeren is in het dagelijks leven en daarom ook geschikt is voor achtergestelde, kwetsbare en oudere doelgroepen. Verder kunnen depositocontracten op veel verschillende manieren

worden ontworpen en is het momenteel niet bekend welke kenmerken van een contract de effectiviteit verhogen. Hoewel depositocontracten geen externe financiering vereisen, vereisen ze wel dat deelnemers hun eigen geld storten en dit dus ook kunnen verliezen. Deze voorwaarde vormt voor sommigen een barrière om deel te nemen aan depositocontracten, en het is belangrijk om te onderzoeken hoe we het gebruik van depositocontracten kunnen vergroten. Ten slotte is het van belang om te onderzoeken of dit soort contracten ook veelbelovend zijn voor de verandering van gezondheidsgedrag in doelgroepen met chronische aandoeningen zoals mensen met hart- en vaatziekten.

Overzicht van de hoofdstukken van dit proefschrift

Het doel van dit proefschrift was onderzoeken welk potentieel depositocontracten hebben voor het veranderen van gezondheidsgedrag. Meer specifiek wilden wij (1) de effecten van depositocontracten vaststellen, (2) onderzoeken welke kenmerken van depositocontracten ze effectiever maken, (3) strategieën identificeren die het gebruik van depositocontracten helpen verhogen, en (4) de acceptatie van depositocontracten voor mensen met hart- en vaatziekten in kaart brengen. Dit proefschrift bespreekt de resultaten van twee veldexperimenten waarin we kenmerken van depositocontracten manipuleerden en de effecten hebben gemeten op het gebruik en de effectiviteit (hoofdstukken 2 en 3). Daarnaast rapporteren we een observationeel onderzoek waarin we de effecten van commercieel verkrijgbare depositocontracten hebben geëvalueerd (hoofdstuk 4). Ten slotte rapporteren we twee onderzoeken waarin wij de perspectieven van patiënten met hart- en vaatziekten en zorgprofessionals in kaart hebben gebracht om de acceptatie van depositocontracten te peilen (hoofdstukken 5 en 6).

Hoofdstuk 2 was gericht op de doelstellingen: (1) *het vaststellen van de effecten van depositocontracten op fysieke activiteit,* en (2) *onderzoeken welke kenmerken van depositocontracten deze effectiever maken*. Hiervoor werden in een veldexperiment de effecten van daadwerkelijke verliezen (door zelffinanciering van een depositocontract) en verlies framing van feedback (een variant zonder werkelijk verlies van de deelnemer) onderzocht. In tegenstelling tot wat we hadden verwacht, leidde een verliesframe van financiële prikkels tot verminderde effectiviteit. Deze onverwachte bevinding staat in contrast met eerdere bevindingen over financiële beloningen met verliesframes (Patel et al., 2016), en levert bewijs dat (gepercipieerde) verliezen niet altijd meer impact hebben dan (gepercipieerde) winsten. In plaats daarvan levert deze bevinding ondersteuning voor de redenering dat verliesaversie een contextafhankelijk fenomeen is dat optreedt onder bepaalde randvoorwaarden, in plaats van een alomtegenwoordig fenomeen (Gal & Rucker, 2018). Verder lieten onze resultaten zien dat depositocontracten niet effectiever (maar ook niet minder effectief) waren dan financiële beloningen, terwijl er wel minder gebruik van werd gemaakt.

Hoofdstuk 3 is een vervolg op de resultaten van Hoofdstuk 2 en had tot doel (*3) strategieën te identificeren die het gebruik van depositocontracten voor fysieke activiteit helpen vergroten.* Uit de resultaten van hoofdstuk 2 en eerder onderzoek naar depositocontracten is duidelijk gebleken dat niet iedereen bereid is deze te gebruiken (Giné et al., 2010; Kullgren et al., 2016; Royer et al., 2015). Het feit dat niet iedereen deze wil gebruiken is een belangrijk obstakel voor grootschalige implementatie van depositocontracten, vooral wanneer groepen die interventie het meest nodig hebben, niet worden bereikt. Twee elementen die het gebruik van depositocontracten zouden kunnen vergroten zijn: (1) het matchen van deposito's (verdubbeling van het bedrag dat deelnemers storten) en (2) maatwerk van het deposito bedrag (waardoor zelf kan worden geselecteerd hoeveel geld deelnemers willen storten). De depositocontract interventie die wij gebruikten in dit onderzoek hielp mensen om hun stappenaantal te verhogen. Echter hadden maatwerk en matching geen aanvullende effecten. Zowel matching als maatwerk leidden wel tot een toename van het gebruik van een depositocontract voor fysieke activiteit. Daarom kunnen zowel matching als maatwerk worden overwogen om het gebruik van depositocontracten te stimuleren. Door matchen en maatwerk van depositobedragen kan een bredere populatie profiteren van depositocontracten om hun fysieke activiteit te verbeteren. Daarbij gaat de voorkeur uit naar maatwerk, aangezien het matchen van een deposito aanzienlijke extra kosten met zich meebrengt.

Hoofdstuk 4 had als doel *(1) het vaststellen van de effecten van depositocontracten op fysieke activiteit, en (2) onderzoeken welke kenmerken van depositocontracten deze effectiever maken.* Inzicht in de vraag of depositocontracten niet alleen effectief zijn in een onderzoeksetting, maar ook effectief in het dagelijks leven van consumenten, levert belangrijk aanvullend bewijs dat kan helpen bij het maken van beleid voor gezondheid en het ontwerpen van toekomstige interventies. We hebben (N = 72.974) unieke challenges geanalyseerd die werden aangeboden op de StepBet smartphone applicatie. De modale challenge bestond uit een storting van $40 die gedaan werd voorafgaand aan een challenge van zes weken waarin deelnemers dagelijkse en wekelijkse stapdoelen moesten bereiken. Deelnemers konden hun storting terugkrijgen, plus mogelijke extra inkomsten die werden uitbetaald van het geld dat verloren was gegaan doordat sommigen niet slaagden in hun challenge. Uit de resultaten blijkt dat deelname aan een stappen challenge met behulp van gegamificeerde depositocontracten gepaard ging met een grote toename van het aantal stappen (+31,2%). Het gemiddelde succespercentage van de challenges was 73%. Terwijl de winnaars hun stappenaantal met 44% verhoogden, verlaagden de verliezers hun stappenaantal met 5,3%. Deze bevinding is belangrijk omdat het wijst op een mogelijk tegenslageffect (zie Wenzel et al., 2020) onder degenen die hun depositocontract niet haalden. Deze bevinding kan verder onderzoek stimuleren naar het begrijpen van tegenslageffecten en manieren om deze te verzachten. Exploratieve analyses lieten zien dat mannen en oudere deelnemers

een grotere toename van stappenaantal hadden en een grotere kans op succes in hun challenge. Ten slotte waren de challenges die gestart werden als goed voornemen voor het nieuwe jaar effectiever dan reguliere uitdagingen. Daarom suggereren onze bevindingen dat we gebruik moeten maken van oud & nieuw om de kans op succesvolle gedragsverandering te vergroten. Over het geheel genomen laat dit hoofdstuk zien dat gegamificeerde depositocontracten die door consumenten gebruikt worden in hun dagelijks leven gerelateerd zijn aan klinisch relevante toenames in fysieke activiteit.

Hoofdstuk 5 richtte zich op (*4) het beoordelen of depositocontracten acceptabel zijn voor mensen met hart- en vaatziekten.* Er is dringend behoefte aan nieuwe interventies die mensen met hart- en vaatziekten (HVZ) helpen om een gezonde leefstijl op lange termijn vol te houden, maar het is onbekend of zij depositocontracten acceptabel vinden. Het beperkte bewijsmateriaal dat beschikbaar is impliceert dat, ondanks hun effectiviteit, depositocontracten mogelijk niet acceptabel zijn voor mensen met hart- en vaatziekten (zie McGill et al., 2018; Mitchell et al., 2014). Daarom hebben wij de acceptatie van een depositocontract voor fysieke activiteit onderzocht met een enquête onder (N = 659) leden van het Harteraad patiënten panel van de Nederlandse patiëntenorganisatie voor mensen met hart- en vaatziekten. De resultaten bevestigden het idee dat mensen met hart- en vaatziekten een extra stok achter de deur nodig hebben om hun leefstijl veranderingen vol te houden. Toch reageerde slechts een klein deel van deze steekproef positief op het gebruik van depositocontracten om gedragsverandering op het gebied van fysieke activiteit langer vol te houden. Exploratieve analyses lieten zien dat jongere deelnemers en mannelijke deelnemers een hogere acceptatie hadden van depositocontracten. Al met al blijkt uit dit hoofdstuk dat depositocontracten een beperkte acceptatie hebben onder mensen met hart- en vaatziekten. Omdat slechts een subgroep van de mensen met hart- en vaatziekten depositocontracten voor leefstijlverandering acceptabel vond, is het aan te bevelen om depositocontracten enkel als optioneel, aanvullend element op bestaande interventies aan te bieden. Tot slot, wanneer men een bredere doelgroep wil bereiken, kan het relevant zijn om strategieën te identificeren die gebruik maken van vergelijkbare commitment principes zoals gebruikt in depositocontracten, maar die geen contante storting van eigen geld vereisen.

Hoofdstuk 6 heeft bijgedragen aan het doel om (4) *te beoordelen of depositocontracten acceptabel zijn voor mensen met hart- en vaatziekten.* Wanneer financiële prikkels worden toegepast op patiënten populaties, wordt van zorgprofessionals verwacht dat zij de interventie uitvoeren, het gebruik onder patiënten bevorderen en de implementatie in de huidige zorgprocessen begeleiden. Daarom onderzochten we de perspectieven van zorgverleners op het gebruik van financiële prikkels om gezond leven voor patiënten met hart- en vaatziekten te stimuleren. We voerden (N = 16) semigestructureerde, diepgaande, face-to-face interviews uit met Nederlandse zorgverleners die betrokken zijn bij het ondersteunen van leefstijlverandering van

patiënten met hart- en vaatziekten. Uit de bevindingen bleek dat zorgverleners een beloningssysteem voor leefstijlverandering van hart- en vaatziekte patiënten als mogelijk effectief beschouwden en vertoonden over het algemeen hoge acceptatie. Deze bevindingen komen overeen met bestaand onderzoek dat een hoge acceptatie van financiële prikkels onder zorgverleners rapporteerde (Hoskins et al., 2019). Wel uitten de zorgverleners in onze interviews zorgen over een te grote nadruk op de extrinsieke aspecten van leefstijlverandering, lage betrokkenheid van deelnemers als de beloningen onbeduidend zijn, paternalisme en ondermijnen van autonomie, en lage digitale geletterdheid bij de doelgroep. Al met al laten deze bevindingen zien dat, volgens professionals in de gezondheidszorg, financiële prikkels geschikt zouden kunnen zijn voor een deel van de patiënten met hart- en vaatziekten als contextuele factoren, het ontwerp van de prikkels en de wensen van de doelgroep nauwkeurig in overweging worden genomen.

Conclusie

Dit proefschrift laat zien dat depositocontracten potentieel hebben om veranderingen in gezondheidsgedrag te faciliteren, en aan grote populaties kunnen worden aangeboden zonder dat hiervoor externe financiering van financiële prikkels nodig is. Uit het onderzoek is gebleken dat depositocontracten effectief kunnen zijn bij het verbeteren van fysieke activiteit op de korte termijn (hoofdstuk 2, 3, 4). Vanwege hun sterke en klinisch relevante effecten bij degenen die ervoor kiezen om ze te gebruiken, raden we interventieaanbieders aan te overwegen om depositocontracten aan te bieden voor het stimuleren van veranderingen in gezondheidsgedrag. Depositocontracten waren effectiever als de dagelijkse feedback geframed was als een winst (in plaats van als een verlies) (hoofdstuk 2). Depositocontracten waren ook effectiever voor mannen en oudere deelnemers, en als ze werden gestart als goed voornemen voor het nieuwe jaar (hoofdstuk 4). Hoewel ze effectief zijn, zullen depositocontracten niet iedereen bereiken omdat het gebruik ervan beperkt is (hoofdstuk 2, 3). Wanneer men het gebruik van depositocontracten wil verhogen, laten onze bevindingen zien dat zowel matching als maatwerk van het deposito bedrag effectieve strategieën zijn (hoofdstuk 3). Hoewel professionals in de gezondheidszorg over het algemeen positief staan tegenover het gebruik van financiële prikkels om leefstijlverandering van patiënten met hart- en vaatziekten te ondersteunen (hoofdstuk 6), staan patiënten zelf over het algemeen sceptisch tegenover het gebruik van depositocontracten (hoofdstuk 5). Omdat slechts bepaalde subgroepen geïnteresseerd zijn in het gebruik ervan, en depositocontracten een risico op financiële schade met zich meebrengen, kunnen depositocontracten het beste op een opt-in-basis worden aangeboden. Daarnaast raden we aan om te onderzoeken hoe niet-monetaire vormen van depositocontracten mensen kunnen helpen een verandering

in hun gezondheidsgedrag te bewerkstelligen. Ten slotte hebben onderzoekers en interventieaanbieders die zich richten op gezondheidsgedragsverandering met financiële prikkels zowel wortels (financiële beloningen) als stokken (depositocontracten) tot hun beschikking. De wetenschappelijke basis voor de effectiviteit van wortels was al overtuigend, en dit proefschrift heeft laten zien dat stokken minstens even effectief kunnen zijn bij bepaalde doelgroepen. We hopen dat dit proefschrift, door bewijs te leveren voor het potentieel van depositocontracten, een breder gebruik van de instrumenten die beschikbaar zijn in de toolbox met financiële prikkels stimuleert. Vandaar de titel: minder wortel, meer stok.

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Curriculum Vitae

David de Buisonjé was born on 18 June 1988 in Amsterdam, the Netherlands. He started his studies at Etty Hillesum Lyceum Deventer where he received his HAVO diploma in 2005. In 2009 he obtained a Bachelor in architecture from Saxion University of applied sciences in Enschede. After realizing that it was people (rather than bricks) which sparked his curiosity, he decided to pursue a degree in Psychology at Radboud University Nijmegen. There he received a Bachelor (cum laude) with a specialization in social psychology, and a Master (bene meritum) with a specialization in health behavior change in 2014.

In 2015, David started working as a behavior analyst for the digital health startup Selfcare. In this role, David collaborated with the company founders, software programmers and designers to develop and implement a digital health behavior change platform. In 2017, David started his PhD project at Leiden University. During his PhD project, David initiated a collaboration with the Centre for Digital Health Interventions at ETH Zürich in Switzerland to develop a smartphone application that was used for two field experiments included in this dissertation. Furthermore, David initiated a collaboration with the company Waybetter Inc. in the United States to perform research on their data. During his PhD, David was elected to represent the PhD candidates for a one-year term as spokesperson in the daily board of the department of Health, Medical and Neuropsychology at Leiden University.

In 2021, while wrapping up his PhD dissertation, David started as project lead of the innovation project 'Healthy Society Map'. His role is to coordinate a multidisciplinary team of researchers, policy makers, public health advisors and designers from the province Zuid-Holland, the Municipal Health Services (GGD) and Leiden-Delft-Erasmus universities, with the aim to improve public health research and policy. He currently combines this role with a postdoctoral position at the department of Human Centered Design at TUDelft where he continues his research on (financial) incentives for health behavior change.

David remains committed to study and develop digital tools that support health behavior change, preferably on the intersection between product development, scientific research and policy making.

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