Technology-Based Contingency Management for Walking to Prevent Prolonged Periods of Sitting in the Workplace

By

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Abstract

Sedentary behavior is an emerging public health issue. The workplace is one variable contributing to the rising amount of sedentary time, where a growing number of individuals are employed in positions with primarily sedentary job responsibilities (e.g., computer-oriented work, desk-oriented work). Frequent, brief bouts of walking is one behavior recommended by health experts to reduce the health risks correlated with physical inactivity and prolonged periods of sedentary time. The purpose of the current study was to extend the literature by evaluating a technology-based contingency management intervention that reinforced frequent, brief bouts of walking to decrease prolonged periods of sitting. Specifically, this study had three goals. First, this study sought to extend the limited and mixed findings on interventions targeting sedentary behavior in the workplace by evaluating a packaged contingency management intervention. Second, this study attempted to demonstrate the utility of a goal-setting procedure using shaping and percentile schedules of reinforcement to increase the frequency of brief bouts of walking throughout the workday, which has not yet been evaluated. Finally, this study sought to extend the sedentary behavior literature by evaluating the efficacy and feasibility of a technology-based intervention in which all procedures were completed entirely remotely. The packaged intervention was effective in increasing the number of physically active hourly intervals (i.e., hours in which the $\geq$ 250 step goal was met) to the mastery criterion for four participants, thereby disrupting prolonged periods of sedentary time. For two participants, the intervention did not meaningfully increase bouts of walking. Implications of these findings and future directions are discussed.

Keywords: sedentary behavior, physical activity, walking, incentives, differential reinforcement, organizational behavior management, adults

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Technology-Based Contingency Management for Walking to Prevent Prolonged Periods of Sitting in the Workplace

Sedentary behavior is an emerging public health issue (U.S. Department of Health and Human Services, 2018). As an independent risk factor for various noncommunicable diseases, sedentary behavior is associated with an increased risk of cardiovascular disease, type 2 diabetes, colon cancer, and lung cancer, among others (Homer et al., 2019; Piercy, 2019; U.S. Department of Health and Human Services, 2018). Sedentary behavior is "any waking behavior characterized by an energy expenditure less than or equal to 1.5 metabolic equivalents, while in a sitting, reclining, or lying posture" (Tremblay et al., 2017). Several illustrative examples of sedentary behavior include reading a book, sitting at a desk, or watching television. Sedentary behavior is distinct from physical inactivity, which refers to a behavioral deficit in meeting recommended physical activity guidelines (i.e., engaging in at least 150 min of physical activity at a moderate intensity per week; U.S. Department of Health and Human Services, 2018). Thus, it is possible for an individual both to meet the recommended physical activity guidelines and spend too much time sedentary.

According to the U.S. Bureau of Labor Statistics (2019), the workplace is where adults with full-time employment spend approximately 8.5 hours a day during the work week. One aspect contributing to the rise in sedentary time, particularly in western countries and amongst adults (Tudor-Locke et al., 2011), is the rising number of individuals employed in positions with primarily sedentary job responsibilities (e.g., computer-oriented, desk-oriented). Each of the last six decades has seen a proportional increase in the number of office employees whose tasks are primarily sedentary (Brierley et al., 2019; Church et al., 2011), with employees sedentary for an average of 11 hours per day during waking hours (Tudor-Locke et al., 2011). Moreover, less than

20% of private industry jobs today require physical activity at a moderate intensity, compared to approximately 50% just five decades ago (Church et al., 2011). With respect to office employees, it is estimated that individuals spend upwards of 65% to 70% of their work time sedentary (Clemes et al., 2014; Green & Dallery, 2019; Parry & Straker, 2013; Thorp et al., 2014), with more than a quarter of this time occurring in sedentary bouts lasting 60 min or more (Hadgraft et al., 2016; Ryan et al., 2011).

To address sedentary behavior, one recommendation is to frequently interrupt sitting—that is, break up periods of prolonged sedentary time—which has been shown to improve various cardiometabolic health markers (Chastin et al., 2015; Healy et al., 2008; Homer et al., 2017). Although a consensus has yet to be determined, research to date suggests positive changes in several cardiometabolic health markers when taking breaks from sitting every 30 min to 60 min (Colberg et al., 2016; Diaz et al., 2017); however, breaks every 60 min to 90 min may be more feasible, and thus, likely to be adopted in practice (Diaz et al., 2017). In examining the relation between objectively measured sedentary time and several metabolic risk factors, Healy et al. (2008) found that increasing the frequency of breaks (i.e., interruptions with step counts ≥ 100 steps per minute) was associated with beneficial changes in several biological markers including body adiposity measures (e.g., percent body fat), triglyceride levels (high levels are associated with an increased risk of heart disease), and 2-hr plasma glucose levels (high levels are a potential sign of diabetes). These findings are convergent with those of more recent studies and meta-analyses (Loh et al., 2020; Saunders et al., 2018; Saunders et al., 2020), where an association has also been observed between frequent interruptions to prolonged sitting and positive changes in postprandial glucose and insulin levels.

Given its negative health implications, the extant literature has also sought to identify interventions to decrease sedentary behavior. Broadly, interventions have ranged from providing adults with wearable activity trackers (Qui et al., 2015) to providing sit-to-stand workstations (Pronk et al., 2012) to replacing traditional desks with treadmill desks (Koepp et al., 2013). As part of a broader review of sedentary behavior, Gardner et al. (2016) examined interventions conducted specifically within the workplace. In doing so, the researchers found that goal setting, social support, and self-monitoring were the most commonly used behavior-change techniques, with all three reported to be ‘very promising’ interventions. Shrestha et al. (2018) also conducted a meta-analysis evaluating the efficacy of interventions to reduce sedentary behavior in the workplace. Interventions were categorized into four types: environmental (i.e., physical workplace) changes, workplace policy changes, information (i.e., feedback) and counseling, and multicomponent. The researchers concluded that the evidence to date for each type of intervention was limited and inconsistent, with more research needed to identify effective interventions for reducing sedentary behavior.

Within the behavior-analytic literature, two studies have been conducted that targeted sedentary behavior (Green et al., 2016; Green & Dallery, 2019). Green et al. (2016) evaluated an intervention that included tactile prompts, feedback, and goal setting on the physical activity of three office employees in a university setting. The primary dependent measure was sedentary bouts (i.e., periods of prolonged sitting), defined as sitting for more than 30 min without disruption. Overall, the researchers found the packaged intervention decreased the number of sedentary bouts per workday across all three participants.

Green and Dallery (2019) extended this research by using a commercially available accelerometer (i.e., Fitbit Zip) and by incorporating recommendations from experts regarding workplace physical activity. The dependent variable was active bouts, defined as 30-min periods with 100 or more steps. During baseline, participants took part in an education and self-monitoring condition, where they were informed of the health implications from excessive sitting and told to move every 30 min. Next, participants experienced the intervention, which initially consisted of feedback, then feedback plus task clarification if the feedback alone was not successful at improving performance. During the feedback conditions, participants were provided with written feedback via email regarding their performance from the previous day. With respect to the results, the researchers concluded that, based on their visual inspection, the intervention decreased prolonged periods of sitting for four of eight participants; thus, an intervention effect was observed for 50% of participants.

In the extant literature, financial incentives are another type of intervention component that have been used to address physical health. Most of the research to date has focused on incentives for increasing physical activity, with less known about its efficacy for decreasing sedentary behavior (Ball et al., 2017). In general, interventions including monetary incentives have been found to be more effective if they target specific physical activity goals as opposed to more general behaviors (e.g., gym attendance; Barte & Wendel-Vos, 2017). They have also been shown to improve physical activity when compared to a control condition in which no incentive was provided (Finkelstein et al., 2016). In addition, research has manipulated various dimensions of monetary reinforcement (i.e., immediacy vs. delayed, fixed vs. variable; Adams et al., 2017; Burns & Rothman, 2018; Patel et al., 2016) to evaluate their efficacy under different environmental conditions. For example, Burns and Rothman (2018) used a between-groups factorial design to compare the effects of two reinforcement types and two reinforcement schedules on physical activity, where the target goal was taking 10,000 or more steps per day for four days of the week. The two reinforcement types were a monetary reward condition in which participants could earn up to $50 and a hypothetical deposit contract condition in which participants were asked to imagine they had deposited $50 and could meet their target goals to earn the money back. Burns and Rothman also manipulated two reinforcement schedules including a fixed schedule in which $10 could be earned each week and a variable schedule in which the incentive amount could range from $0 to $20 each week. The researchers found no statistically significant differences between the four conditions on meeting target goals.

Another procedure that often uses financial incentives is Contingency Management (CM; Higgins et al., 2007; Petry et al., 2000; Silverman et al., 1999), a behavior change technique based on the principles of operant conditioning and reinforcement (Skinner, 1953). Broadly, CM interventions are comprised of three components. First, a target behavior is selected that is both observable and measurable (e.g., step counts per day). Second, a reinforcing consequence (i.e., a putative positive reinforcer) is delivered contingent on the occurrence of the target behavior. Finally, the reinforcing consequence is withheld for the nonoccurrence of the target behavior (Higgins et al., 2007). Contingency Management has been shown to be effective for a myriad of target behaviors and populations. For instance, CM has been used to improve substance abstinence (Dallery & Glenn, 2005; Dallery et al., 2007; Davis et al., 2016; Higgins et al., 2007), work attendance (Wong et al., 2004), medication adherence (DeFulio & Silverman, 2012; Rosen et al., 2007; Sorensen et al., 2007), weight loss (Volpp et al., 2008), and physical activity (Donlin Washington et al., 2016; Wysocki et al., 1979), among others.

Within the behavior-analytic literature, CM has been used in three studies to increase physical activity (Donlin Washington et al., 2016; Kurti & Dallery, 2013; Stedman-Falls & Dallery, 2020; for a comprehensive review, see Appendix A). In all three studies, CM was included as one component of a packaged intervention that also included goal setting, self-monitoring, and feedback. For example, Kurti and Dallery (2013) conducted two studies where they specifically examined the role of monetary incentives on the physical activity of sedentary older adults. Only in study 1, though, were participants provided with the opportunity to earn monetary incentives for meeting their target goal. Overall, the researchers found a more robust increase in physical activity for participants provided with the opportunity to earn the monetary incentive (study 1) than for those without (study 2), with a median increase of 182% (range, 80%–256%) and 108% (range, 8%–186%), respectively, when compared to baseline averages. Moreover, those with the opportunity to earn a monetary incentive met 88% of their target goals, compared to 52% when no incentive was available.

Taken together, the results of Kurti and Dallery (2013), Donlin Washington et al. (2016), and Stedman-Falls and Dallery (2020) suggest that CM, when included as part of packaged intervention that also contains feedback, goal setting, and self-monitoring, improves physical activity with adult populations. This corresponds with the findings of my systematic review (see Appendix A), which also found feedback, goal setting, and self-monitoring to be (a) the most common intervention components and (b) effective when used in packaged interventions. In addition, the findings of the comprehensive review note the variations with which each of these intervention components have been employed along with potential recommendations based on the current evidence. For example, one commonly endorsed approach for feedback is to deliver textual information on a daily schedule via text message. A popular approach to goal setting is to set goals using percentile schedules of reinforcement at or around the 70th percentile (Galbicka, 1994), which has been shown to be a value that is both achievable and likely to improve performance.

Although several studies in the behavior-analytic literature have shown CM to be effective as a component of a packaged intervention to increase physical activity, no study has been conducted using CM to decrease prolonged periods of sitting (i.e., a type of sedentary behavior). Therefore, a contribution to the literature may be to examine the effects of a packaged intervention including CM, feedback, and goal setting that targets frequent bouts of walking to decrease prolonged periods of sitting. Whereas more is currently known about the negative biological and cardiometabolic health implications associated with sedentary behavior, much less is known about effective interventions to address prolonged periods of sitting in the natural environment, including within the workplace.

The purpose of the current study was to extend the sedentary behavior literature—both in general as well as in behavior analysis and in the workplace in particular—by evaluating the effects of a technology-based CM intervention for decreasing prolonged periods of sitting by reinforcing frequent, brief bouts of walking (i.e., walking breaks). Specifically, this study sought to address three primary goals. First, this study sought to extend the limited and mixed findings on interventions targeting sedentary behavior in the workplace. To do so, I evaluated the efficacy of a packaged CM procedure for increasing frequent, brief bouts of walking (i.e., hourly intervals with ≥ 250 steps) throughout the workday as an approach to decrease prolonged periods of sitting. Second, this study sought to evaluate the utility of a goal-setting procedure using shaping and percentile schedules of reinforcement (Galbicka, 1994) for increasing the number of physically active hourly intervals (i.e., hours in which the ≥ 250 step goal was met) per workday, which had not been evaluated to date. Finally, this study sought to extend the sedentary behavior literature by evaluating the efficacy and feasibility of a technology-based intervention in which all procedures are completed entirely remotely (i.e., without any in-person contact).

Method

Participants and Setting

Participants for this study were six adults employed in an office setting at a large Midwestern university between the ages of 18 to 65. Because of the ongoing COVID-19 pandemic, the setting was either the participant's workplace office (i.e., on campus), their home, or some combination thereof depending on their work schedule. Participants ranged in age from 31 to 60 years old (*M* = 42.8). Five of six participants (83.3%) identified as female. All six participants (100%) reported a Master's degree as their highest level of education. All six participants (100%) reported working from home because of the ongoing pandemic, with five of six participants (83.3%) reporting 95% or more of their job responsibilities as sedentary. More information regarding participant demographics is located in Table 1.

Recruitment

Participants were recruited via email. Specifically, I recruited participants through an email posting that was sent out to college and professional school's staff listservs announcing the opportunity to participate in the study (Appendix B). The email announcement contained general information about the purpose of the study, eligibility (i.e., inclusionary) criteria, and contact information for staff interested in participating.

Inclusionary Criteria

To participate in the study, prospective participants had to (a) be between the ages of 18 and 65 years; (b) complete the screening procedures; (c) be able to engage in brief periods of physical activity at a moderate intensity as determined by the screening questionnaires described below; (d) not currently use an activity tracker; (e) have access to the internet and a smartphone or tablet; (e) be able to read, receive, and send text messages; and (f) work 35 or more hours per week as part of their employment. Prospective participants were excluded from the study if any of these criteria are not met.

Materials

Participants wore a Fitbit Inspire 2® accelerometer. The Fitbit Inspire 2® accelerometer is a consumer-grade health tracking device that measures device acceleration (i.e., movement) along three axes (Fitbit, n.d.). It has the capability to track and record a variety of health metrics, including step counts, heart rate, and daily calorie expenditure among other features. This particular device also has the capability of being worn for up to 10 days between charges.

Participants were required to have access to a smartphone or tablet to sync data from the accelerometer to the Fitbit application or website. Prior to delivering the Fitbit device to participants, I created a Fitbit account and login information for each participant to use their respective Fitbit accelerometer. Each participant's relevant demographic information (e.g., height, weight, age, gender) was entered when setting up their account; this demographic information was important for calculating certain physiological indices collected and reported by the Fitbit. For example, the Fitbit uses height, weight, age, and gender along with heart rate when calculating daily calorie expenditure (i.e., the number of expended calories per day).

Response Measurement

The primary dependent variable was the number of hourly intervals where a step goal was met; this number was calculated daily by summing the total number of physically active intervals (i.e., intervals with ≥ 250 steps) during the workday. Because I was interested in physical activity during the workday, each day consisted of up to nine intervals (i.e., working hours); the hours in which performance was assessed were based on the participants self-reported work schedule. For example, if a participant reported their work schedule was Monday through

Friday from 8 am to 5 pm, then this information was used to determine which hourly intervals were assessed. Data for the primary dependent variable were collected and calculated Monday through Friday at the end of each workday for each participant.

All data were collected using permanent product recording. An hourly interval of *physical activity* was defined as an interval with a step count greater than or equal to 250 steps per hour; an hourly interval of *physical inactivity* was defined as an interval with a step count less than 250 steps per hour. The 250-step count criterion was chosen for several reasons. First, the 250-step count aligns with the standard, hourly step count reminder set by Fitbit. At approximately 50 minutes after the hour, the Fitbit accelerometer has an optional feature where a prompt can be provided to the wearer if they have not met their hourly step count goal (i.e., taken at least 250 steps). This, in turn, provides the wearer with a 10-min time frame to meet their hourly step goal. Second, approximately 100 steps-per-min has been shown to be a reasonable heuristic for meeting the criteria of physical activity at a moderate intensity (Aguiar et al., 2019; Tudor-Locke et al., 2019). Based on this heuristic, the 250-step count requires 2 to 3 min of walking per hour, thereby limiting its potential impact on work performance. Moreover, the time to meet the hourly target goal was an important variable for the current study because participants were asked to engage in brief periods of walking each hour throughout the workday.

The secondary dependent variable was the total number of steps taken during the workday. This number was calculated daily by summing the number of steps taken per hour for each of the hourly intervals during the workday. Daily step count totals were calculated Monday through Friday for each participant. In addition, I assessed goal achievement as a tertiary outcome. Goal achievement for each four-day block was calculated by dividing the total number of a days in a block a participant meets their target hourly interval goal by the total number of days in a block and converting this number into a percentage. Overall goal achievement was calculated by dividing the total number of a days a participant met their target hourly interval goal during the intervention by the total number of days in the intervention and converting this number into a percentage.

Data for each participant were reviewed and recorded daily, Monday through Friday. First, I reviewed each participant's data by accessing their activity log on the Fitbit website. Next, I recorded the data for a day's performance for the primary and secondary dependent variables within a GraphPad Prism file.

Interobserver Agreement

Interobserver agreement was collected for at least 33% of days during both baseline and intervention conditions. Each participant's data were independently reviewed by a second observer who calculated performance either by accessing their Fitbit account on the Fitbit website or viewing a video log of their performance captured from the Fitbit website. Agreement was collected on the primary and secondary dependent variables. Interobserver agreement for the primary dependent variable was calculated in two ways. First, interobserver agreement was calculated for the total number of physically active intervals per workday using a total count formula by dividing the smaller count by the larger count and converting this number to a percentage. Second, interobserver agreement was calculated on whether both observers record the same outcome for each hourly interval (i.e., whether the interval met the 250-step goal); this was done using an interval-by-interval formula by dividing the number of intervals with agreement over the total number of daily intervals and converting this number to a percentage. An agreement was scored when both observers recorded the same outcome for an hourly interval (i.e., whether the interval met the 250-step goal). A disagreement was scored when both observers did not record the same outcome for an hourly interval. Interobserver agreement for the secondary dependent variable (i.e., total steps taken during the workday) was calculated using a total count formula by dividing the smaller count by the larger count and converting this number to a percentage. Interobserver agreement for the total number of physically active intervals per workday was 100% (range, 100%). Interobserver agreement for the physically active hourly interval data (i.e., whether the interval met the 250-step goal) was 100% (range, 100%). Interobserver agreement for the secondary dependent variable, total steps taken during the workday, was 99.5% (range, 99.2%–99.9%).

Pre-Experimental Procedures

Email Screening

I initially screened participants by email to ensure they were eligible to participate in the study. This preliminary screening was completed when a prospective participant sent an email message to express interest in taking part in the study. During this preliminary screening I asked the prospective participant to confirm they were working as a non-student university employee and between the ages of 18 to 65. Upon meeting these criteria, I scheduled a follow-up time to meet with the prospective participant to complete a screening via videoconference.

Zoom Screening

I met with prospective participants using videoconferencing software (e.g., Zoom, version 5.4.6, 2021). The purpose of this meeting was threefold: (a) to obtain informed consent, (b) present the screening materials and demographic questionnaire to participants to complete during the meeting; and (c) to describe the purpose of the study. Regarding informed consent, I provided the prospective participant with an electronic copy of the informed consent document (Appendix C) via a Qualtrics survey. I instructed the prospective participant to independently read through the entire informed consent document. Upon reading through the consent form, I provided the prospective participant with an opportunity to ask any questions about the information discussed in the consent form or the study. Once all questions have been answered, I then asked the prospective participant to electronically sign the consent form and submit the Qualtrics survey with the signed consent form electronically. After the meeting, a PDF of the informed consent form was emailed to each participant for their records.

Next, the prospective participant was asked to complete three questionnaires for screening and demographic purposes. All three questionnaires were sent to the participant electronically and accessed via links to a Qualtrics survey. To screen for at-risk participants and to ensure that individuals are physically able to engage in physical activity at a moderate intensity, the participant was asked to complete the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+; Warburton et al., 2011; Appendix D) and the International Physical Activity Questionnaire-Short Form (IPAQ-SF; Craig et al., 2003; Appendix E). The PAR-Q+ is a 17-item self-report measure that assesses clearance to engage in physical activity. The questionnaire contains two sections—an initial section of seven questions and a supplemental section of 10 questions. If a participant answered "no" to all the first seven questions, then they met screening criteria to engage in physical activity for the purposes of this research. If a participant answered "yes" to any of the first seven questions, then they were asked to complete the 10 supplemental questions. If a participant answered "no" to all 10 questions, then they were able to engage in physical activity for the purpose of this research. The IPAQ-SF is a 7-item self-report measure that assesses time spent engaging in physical activity at a vigorous intensity, physical activity at a moderate intensity, walking, and sitting during the past 7 days. Although the IPAQ-SF is a commonly used measure because it is quick and easy to implement, research suggests mixed findings regarding its validity. Specifically, the measure tends to overestimate levels of physical activity when compared to objective measures (Lee et al., 2011). For more information on self-reported results, see Table 2.

The participant was also asked to complete the demographic questionnaire (Appendix F). The demographic questionnaire was a 17-item self-report measure with questions on age, height, weight, race, ethnicity, gender, income level, work schedule, and time spent sedentary at work. All three questionnaires were completed by filling out a Qualtrics survey; the participant was asked to complete each questionnaire in its entirety and submit each survey electronically. If all the inclusionary criteria are met, the participant moved to the Fitbit delivery and was asked to schedule a time to complete the Fitbit training. If any of the inclusionary criteria were not met, the prospective participant was excluded from the study and thanked for their time and interest in participating. Two potential participants were excluded from the study due to their self-reported answers on the PARQ+.

Delivery of Materials

Upon completion of the Zoom screening, the participant was provided with the Fitbit Inspire 2® accelerometer via contactless drop-off or mailing of the materials. In addition, the participant was also provided with one ClinCard, which is a reloadable debit card. The participant met the experimenter at a predetermined location for contactless delivery of the materials.

Fitbit Training

Prior to baseline, the experimenter met with the participant using videoconferencing software (i.e., Zoom). During the training, participants were shown how to use their Fitbit accelerometer along with other important features. The experimenter began by asking the participant to download the Fitbit application from the app store. The participant then logged in to their account using their smartphone. Although data from the Fitbit can automatically sync to the application when kept open in the background of the phone, the experimenter vocally stated that data can be synced by opening the application while connected to the internet as well as through the sync now option. The experimenter vocally stated to the participant that they should check to make sure their data had been synced at least once a day at a minimum—preferably at the end of the workday if only done once.

Next, the experimenter used behavioral skills training to teach the participant how to use other features of the Fitbit. Specifically, I provided the participant with vocal and written instructions as well as practice opportunities and feedback on how to charge their Fitbit, check the battery level, sync the Fitbit with their phone, and reset the Fitbit (if needed during the course of the study). The experimenter vocally stated to the participant that the Fitbit should be worn during all workday hours. Next, the experimenter asked the participant if they had any questions, answered any questions if asked, and confirmed with the participant they felt comfortable with each of the features reviewed. The experimenter ended the training session by thanking the participant for their time and letting them know that they could charge their Fitbit and begin wearing it starting on the next workday.

Experimental Design

I used a changing criterion design embedded within a nonconcurrent multiple baseline design across participants to evaluate the effects of the intervention on the number of physically active hourly intervals during the workday. All methods and procedures used in this study were approved by the university's institutional review board (approval #00146376).

Experimental Procedures

Baseline

The purpose of this condition was to assess participant performance on the number of physically active hourly intervals (i.e., intervals with ≥ 250 steps) and the number of steps taken during the workday prior to implementation of the intervention. Upon completing the Fitbit training, the experimenter initiated the beginning of the baseline condition by vocally asking the participant to begin wearing their Fitbit accelerometer during the next workday and all subsequent workdays. During this condition, the experimenter did not provide the participant with any feedback or programmed contingencies. However, the participant was able to self-monitor their step count. Intermittently, the experimenter contacted the participant via text message to ensure their self-reported work schedule for the week was still correct (i.e., to inquire about any schedule changes or time off). This condition lasted for at least five workdays (i.e., one workweek) and until stability was demonstrated via visual analysis (Sidman, 1960; Johnston & Pennypacker, 1993).

Intervention

During this condition, I implemented a packaged intervention consisting of a contingency (i.e., commitment) contract with monetary incentives, goal setting, textual prompts, and performance feedback.

Contingency Contract. The day or morning before the first day of the intervention, I met with the participant to (a) review the contingency contract, (b) answer any questions, and (c) have them electronically sign the contingency contract via a Qualtrics survey. The *contingency contract* (Appendix G) described the potential monetary incentives available and the conditions under which they could be earned. Each workday in the intervention, participants had the opportunity to earn $2 for meeting their daily target goal (i.e., the number of physically active hourly intervals with ≥ 250 steps). In addition, participants had the opportunity to earn an extra $3 bonus for meeting their daily target goal for all four days in a four-day block (i.e., four consecutive workdays). All money earned was delivered to participants using the ClinCard (i.e., reloadable debit card). Monetary incentives were added to a participant's ClinCard the day following the completion of a four-day block.

Goal Setting. Goal setting was assessed using a percentile schedule (Galbicka, 1994) over four-day blocks. The target goal was set each four-day block at the 75th percentile (i.e., the third-highest workday) from the previous four-day block's performance.

The target goal for the first four-day block of the intervention was based on a participant's baseline performance. For each participant, the mean from their previous five workdays was calculated and rounded up to the next whole number. Then, one hourly interval was added to that number. For example, if a participant's mean performance was 2.8, it would then be rounded up to 3. One additional hourly interval would be added, setting the target goal for the first four-day block at 4 physically active hourly intervals. All subsequent goals were based on the participant's performance during the previous four-day block. If the third-highest total from the previous block was *greater than* the target goal set for that four-day block, then the target goal for the next block was set to that hourly interval number. For example, if the participant's target goal was to meet their hourly step goal for 4 intervals and their third-highest total was 6 intervals, then their target goal for the next block was set at 6 intervals. If the third-highest total from the previous four-day block was *equal to* the target goal set for that block, then the target goal for the next block was set to the previous target goal plus one interval. For example, if the participant's target goal was to meet their hourly step goal for 4 intervals and their third-highest total was 4 intervals, then their target goal for the next block was set at 5 intervals. If the third-highest total from the previous four-day block was *less than* the target goal set for that block, then the target goal for the next block was set to the previous target goal. For example, if the participant's target goal was to meet their hourly step goal for 4 intervals and their third-highest total was 3 intervals, then their target goal for the next block was set at 4 intervals. Thus, the target goal could not decrease based on participant performance.

Performance Feedback. The experimenter provided performance feedback to the participant each evening via text message at a preferred time. The feedback consisted of textual information on their daily performance (i.e., whether they met their target goal for the day). Both positive and corrective feedback were provided (see Appendix H for an example). An example of a statement for positive feedback was, "Today (1/11) you reached your hourly step goal for 6/8 hours (75%), which means you met your goal of 6/8 hours (75%). You earned $2 because you met your goal." An example of a statement for corrective feedback was, "Today (1/11) you reached your hourly step goal for 4/8 hours (50%), which means you did not meet your goal of 6/8 hours (75%). You did not earn $2 because you did not meet your goal." To ensure receipt of the performance feedback, participants were asked to send a text message back to the experimenter indicating they received the feedback (e.g., "Sounds good."; "Thank you."; thumbs up emoji).

Textual Prompt. A textual prompt for the next day's target goal was also provided within the same text message as the performance feedback (see Appendix H for an example). An example of a textual prompt was, "Your target goal for Tuesday (1/12) is to meet your hourly step goal by taking at least 250 steps/hour during 6 of 8 work hours (75%)". To ensure receipt of the textual prompt, participants were asked to send a text message back to the experimenter indicating they received the prompt. Because both the performance feedback and textual prompt were delivered in the same text message, only one response back to the experimenter was required.

Barriers Assessment. If a participant's performance did not meet the criteria to increase their target goal for two consecutive four-day blocks, then the experimenter met with the participant after the second four-day block to complete the barriers assessment questionnaire (see Appendix I). The barriers assessment questionnaire was a five-question measure that asks about the self-reported barriers to meeting their target goals. The information that the participant reported was then used to identify potential solutions to troubleshoot the barriers reported in their environment.

Termination Criteria

I maintained the right to terminate participation in the study if the participant did not follow the study procedures or comply with consistent Fitbit usage. A participant would have been terminated from the study if they missed (a) two or more consecutive days of data collection or (b) four or more non-consecutive days of data collection resulting from participant misusage or non-usage of the Fitbit accelerometer (e.g., leaving the Fitbit at home, not charging the Fitbit, not wearing the Fitbit during work hours). This situation did not occur for any participants. With respect to baseline performance, a participant was terminated if their performance was at or above 87.5% (e.g., meeting the 250-step count goal for 7 out of 8 hourly intervals in a workday) for three or more days in their first 10 days of baseline. This situation occurred for one potential participant.

The intervention was terminated under four conditions: the participant (a) met the hourly step goal of 100% of intervals in a day (e.g., 8 out of 8 hourly intervals) for three days in a four-day block when the target goal was 100% of intervals, (b) met the hourly step goal of 87.5% or more intervals in a day (e.g., 8 out of 9 hourly intervals) for all four days in a block for two consecutive blocks (i.e., 8 days) when the target goal was 87.5% or more intervals, (c) met the target hourly step goal for two or fewer days in two consecutive four-day blocks following the barriers assessment, or (d) completed seven full workweeks in the intervention condition.

Intervention Acceptability

Following the intervention, participants completed an intervention acceptability questionnaire (Appendix J). The questionnaire contained 25 questions, including 12 Likert-type questions about the packaged intervention and each of its components, three Likert-type questions about the Fitbit, four Likert-type questions about the study, and six open-ended questions. All Likert-type questions were scored on a scale from 1 (strongly disagree) to 6 (strongly agree), with higher scores indicating higher acceptability. This questionnaire was completed electronically via a Qualtrics survey.

Procedural Integrity

Procedural integrity data were collected for each participant on intervention components using a procedural integrity checklist (Appendix K). Assessment of procedural integrity was collected by an independent observer. Specifically, integrity of the independent variable was collected for each participant on whether the experimenter (a) provided the participant with the contingency contract outlining the monetary incentives and the conditions under which they may be earned (verified via a participant's signature), (b) provided the participant with all the money earned during a four-day block (verified via payment logs), (c) calculated the target hourly step goal for each upcoming workday (verified via screenshots of read receipts), (d) provided the participant with feedback about their performance via text message (verified via screenshots of read receipts), and (e) provided the participant with a prompt with their target goal for the next workday via text message (verified via screenshots of read receipts). Procedural integrity was calculated by dividing the number of correctly implemented steps by the total number of steps and converting this number into a percentage. Procedural integrity was 100%.

If implemented, procedural integrity data were also collected on the extent to which the experimenter administered the barriers assessment questionnaire as described. An independent observer used the barriers identification integrity checklist (Appendix L) to collect procedural integrity data. Integrity of the barriers assessment was collected on whether the experimenter (a) asked the participant if there have been any barriers to meeting their move goal recently, (b) asked the participant to identify the top two barriers that have had the greatest impact on meeting their goal, and (c) discussed strategies to address the barriers along with asking what strategies the participant has tried thus far. If a participant did not identify any barriers, then the experimenter also asked if there was anything they could do differently to help the participant be more motivated to meet their target goal. Procedural integrity data were collected by listening to an audio recording of the conversation; integrity was calculated by dividing the number of correctly implemented steps by the total number of steps and converting this number to a percentage. Procedural integrity was 100%.

Data Analysis

Visual analysis of the graphical data was used as the primary method for interpreting the experimental effects. Participant data were graphed and analyzed each workday. A phase change occurred after a participant demonstrated a stable level of responding for the primary dependent variable during the baseline condition. To measure this, I evaluated the variability (i.e., bounce) in the data. I also looked for trends (i.e., directionality) in the data. A decision to move to the intervention condition was made when there were sufficient data to support a steady state of behavior (Cooper et al., 2020; Sidman, 1960).

Results

Physically Active Hourly Intervals Per Workday

Figure 1 depicts the performance of all six participants in two multiple baseline designs. For each participant, the dotted gray lines in the intervention condition depict the target goal for a four-day block. The overall findings reveal systematic increases in the number of physically active hourly intervals (i.e., hours in which the ≥ 250 step goal was met) per workday during intervention for four of six participants (i.e., P1–P4). All four participants achieved mastery levels of responding (i.e., met the mastery termination criterion). The intervention was less effective for P5 and P6. Both P5 and P6 reached the termination criterion because they met their hourly step goal for two or fewer days in two consecutive four-day blocks following the barriers assessment.

During baseline, the average number of physically active hourly intervals for P1 was 2.8 (range, 2–4) of 8 intervals per day (35%). Her target goal during intervention for the first four-day block was set to 4 of 8 physically active hourly intervals per day (50%). During this block she exceeded her target goal on all four days, averaging 5.8 physically active hourly intervals per day (71.2%; range, 5–7). Based on her performance, her target goal for the next four-day block was set to 6 of 8 physically active hourly intervals per day (75%). During this block she met or exceeded her target goal on all four days, averaging 6.5 physically active hourly intervals per day (81.3%; range, 6–7). Her target goal for the next four-day block was then set to 7 of 8 physically active hourly intervals per day (87.5%). During this block she met or exceeded her target goal on all four days, averaging 7.8 physically active hourly intervals per day (96.9%; range, 7–8). Based on her performance, her target goal for the next four-day block was set to 8 of 8 physically active hourly intervals (100%). She met her target goal on four days, averaging 8 physically active hourly intervals per day (100%; range, 8).

During baseline, the average number of physically active hourly intervals for P2 was 5.1 (range, 3–7) of 9 intervals per day (57%). His target goal during intervention for the first four-day block was set to 7 of 9 physically active hourly intervals per day (77.8%). During this block he exceeded his target goal on all four days, averaging 8.5 physically active hourly intervals per day (94.4%; range, 8–9). Based on his performance, his target goal for the next four-day block was set to 9 of 9 physically active hourly intervals per day (100%). During this block he met his target goal two of four days, averaging 8.5 physically active hourly intervals per day (94.4%; range, 8–9). Because he did not meet the termination criterion, his target goal for the next four-day block remained at 9 of 9 physically active hourly intervals per day (100%). During this block he met his target goal on all four days, averaging 9 physically active hourly intervals per day (100%; range, 9).

During baseline, the average number of physically active hourly intervals for P3 was 5.3 (range, 2–7) of 9 intervals per day (58.7%). Her target goal during intervention for the first four-day block was set to 7 of 9 physically active hourly intervals per day (77.8%). During this block she met or exceeded her target goal on three of four days, averaging 7.25 physically active hourly intervals per day (80.6%; range, 6–8). Based on her performance, her target goal for the next four-day block was set to 8 of 9 physically active hourly intervals per day (88.9%). During this block she met or exceeded her target goal on all four days, averaging 8.5 physically active hourly intervals per day (94.4%; range, 8–9). Based on her performance, her target goal for the next four-day block was set to 9 of 9 physically active hourly intervals (100%). She met her target goal on three of four days, averaging 7.75 physically active hourly intervals per day (86.1%; range, 4–9).

During baseline, the average number of physically active hourly intervals for P4 was 2.4 (range, 1–5) of 8 intervals per day (30%). Her target goal during intervention for the first four-day block was set to 5 of 8 physically active hourly intervals per day (62.5%). During this block she met or exceeded her target goal on all four days, averaging 5.5 physically active hourly intervals per day (68.8%; range, 5–7). Based on her performance, her target goal for the next four-day block was set to 6 of 8 physically active hourly intervals per day (75%). During this block she met her target goal on all four days, averaging 6 physically active hourly intervals per day (75%; range, 6). Her target goal for the next four-day block was then set to 7 of 8 physically active hourly intervals per day (87.5%). During this block she met or exceeded her target goal on all four days, averaging 7.25 physically active hourly intervals per day (90.6%; range, 7–8). Based on her performance, her target goal for the next four-day block was set to 8 of 8 physically active hourly intervals (100%). She met her target goal on three of four days, averaging 7.75 physically active hourly intervals per day (96.9%; range, 7–8).

During baseline, the average number of physically active hourly intervals for P5 was 4 (range, 3–6) of 9 intervals per day (44.4%). Her target goal during intervention for the first four-day block was set to 5 of 9 physically active hourly intervals per day (55.6%). During this block she met or exceeded her target goal on two of four days, averaging 4 physically active hourly intervals per day (44.4%; range, 1–6). Because she did not meet the criterion to increase her goal, her target goal remained at 5 of 9 physically active hourly intervals per day (55.6%). During this block she met or exceeded her target goal on two of four days, averaging 4 physically active hourly intervals per day (44.4%; range, 2–6). Given that she did not meet her target goal for two consecutive four-day blocks, I conducted the barriers assessment. Her top reported barrier was multiple meetings each day that spanned the entire hour, making it difficult to meet the 250-step goal. Based on this barrier, potential solutions were provided that included walking around with her smartphone for phone-based meetings and turning off her camera and walking around the room during group videoconference meetings.

Her target goal for the four-day block following the barriers assessment remained at 5 of 9 physically active hourly intervals per day (55.6%). During this block she met her target goal on one of four days, averaging 3.3 physically active hourly intervals per day (36.1%; range, 2–5). Because she did not meet the criterion to increase her goal, her target goal for the next four-day block remained at 5 of 9 physically active hourly intervals (55.6%). During this block she met or exceeded her target goal on all four days, averaging 5.3 physically active hourly intervals per day (58.3%; range, 5–6). Based on her performance, her target goal for the next four-day block was set to 6 of 9 physically active hourly intervals (66.7%). During this block she met her target goal on zero of four days, averaging 4 physically active hourly intervals per day (44.4%; range, 3–5). Because she did not meet the criterion to increase her goal, her target goal for the next four-day block remained at 6 of 9 physically active hourly intervals per day (66.7%). She met her target goal on zero of four days, averaging 3.5 physically active hourly intervals per day (38.9%; range, 1–5). She met the termination criterion by meeting her target goal for two or fewer days in a four-day block for two consecutive blocks following the barriers assessment.

During baseline, the average number of physically active hourly intervals for P6 was 1.27 (range, 0–4) of 9 intervals per day (14.1%). Her target goal during intervention for the first four-day block was set to 3 of 9 physically active hourly intervals per day (33.3%). During this block she met or exceeded her target goal on all four days, averaging 3.3 physically active hourly intervals per day (36.1%; range, 3–4). Based on her performance, her target goal for the next four-day block was set to 4 of 9 physically active hourly intervals per day (44.4%). During this block she met her target goal on two of four days, averaging 2.8 physically active hourly intervals per day (30.6%; range, 0–6). Because she did not meet the criterion to increase her goal, her target goal for the next four-day block remained at 4 of 9 physically active hourly intervals per day (44.4%). During this block she met her target goal on two of four days, averaging 3.5 physically active hourly intervals per day (38.9%; range, 2–5). Because she did not meet her target goal for two consecutive four-day blocks, I conducted the barriers assessment. Her top reported barrier was multiple meetings each day that spanned the entire hour, making it difficult to meet the 250-step goal. Based on this barrier, potential solutions were provided that included walking around with her smartphone for phone-based meetings and turning off her camera and walking around the room during group videoconference meetings.

Her target goal for the four-day block following the barriers assessment remained at 4 of 9 physically active hourly intervals per day (44.4%). During this block she met her target goal on two of four days, averaging 3.5 physically active hourly intervals per day (38.9%; range, 3–4). Because she did not meet the criterion to increase her goal, her target goal for the next four-day block remained at 4 of 9 physically active hourly intervals per day (44.4%). She met her target goal on two of four days, averaging 4 physically active hourly intervals per day (44.4%; range, 3–6). She met the termination criterion by meeting her target goal for two or fewer days in a four-day block for two consecutive blocks following the barriers assessment.

Steps Taken Per Workday

Figure 2 depicts the number of steps taken per workday for each participant. The dotted gray lines depict the average number of steps taken per workday for baseline and for each four-day block. Overall, the number of steps taken per workday increased during intervention for each participant except P5. The average number of steps taken per workday for P1 increased from 2,100.8 (range, 1,356–4,360) during baseline to 2,984.3 steps (range, 2,580–3,238) during the final four-day block of intervention. For P2, the average number of steps taken per workday during baseline was 3,636.4 (range, 2,927–4,184). The average number of steps taken per workday increased during the final four-day block of intervention (*M* = 5,234.8; range, 4,375–6,709). The average steps taken per workday for P3 increased from 3,227 (range, 1,836–5,087) during baseline to 4,104 steps (range, 2,982–4,610) during the final four-day block of intervention. For P4, the average steps taken per workday during baseline was 2,632.1 (range, 865–10,325). The average number of steps taken per workday increased during the final four-day block of intervention (*M* = 5,228.3; range, 2,842–9,963). The average steps taken per workday for P5 decreased from 2,388 (range, 1,237–4,080) during baseline to 2,277.5 steps (range, 1,536–2,867) during the final four-day block of intervention. For P6, the average steps taken per workday during baseline was 1,059.1 (range, 281–2,477). The average number of steps taken per workday increased during the final four-day block of intervention (*M* = 1,839; range, 1,095–2,691).

Target Goals Met

Overall goal achievement for P1 was 100%, meeting her target goal on all workdays during the intervention. Overall goal achievement for P2 was 83.3%, meeting his target goal on 10 of 12 workdays. At the four-day block level, he met his target goal on 100%, 50%, and 100% of workdays during the first, second, and third blocks, respectively. During the second four-day block where goal achievement was 50%, he missed the target goal by one physically active hourly interval when the target goal was set at 100% of intervals. Overall goal achievement for

P3 was 83.3%, meeting her target goal on 10 of 12 workdays. At the four-day block level, she met her target goal on 75%, 100%, and 75% of workdays during the first, second, and third blocks, respectively. During the first four-day block where goal achievement was 75%, she missed the target goal by one physically active hourly interval when the target goal was set at 77.8% of intervals. During the third four-day block where goal achievement was 75%, she missed the target goal by five physically active hourly intervals when the target goal was set at 100% of intervals.

Overall goal achievement for P4 was 93.8%, meeting her target goal on 15 of 16 workdays. At the four-day block level, she met her target goal on 100%, 100%, 100%, and 75% of days during the first, second, third, and fourth blocks, respectively. During the fourth four-day block where goal achievement was 75%, she missed the target goal by one physically active hourly interval when the target goal was set at 100% of intervals. Overall goal achievement for P5 was 37.5%, meeting her target goal on 9 of 24 workdays. At the four-day block level, she met her target goal on 50%, 50%, 25%, 100%, 0%, and 0% of workdays during the first, second, third, fourth, fifth, and sixth blocks, respectively. Overall goal achievement for P6 was 60%, meeting her target goal on 12 of 20 workdays. At the four-day block level, she met her target goal on 100%, 50%, 50%, 50%, and 50% of workdays during the first, second, third, fourth, and fifth blocks, respectively.

Amount of Earned Incentives

Across all six participants, the average amount of monetary incentives earned by a participant was $30 (range, $21–$44) with an average daily cost per participant of $1.80. More information about the incentives earned by each participant is located in Table 3.

Intervention Acceptability

Table 4 presents the results of the intervention acceptability questionnaire for all six participants who completed the study. Participants reported high levels of satisfaction with the intervention and each of the intervention components. In general, results indicated that participants liked the use of all the intervention components, found all the intervention components to be helpful in increasing their physical activity during the workday, liked using the Fitbit, found the study fun and easy to participate in, and would be interested in participating in a similar study in the future.

Discussion

This study sought to evaluate the potential efficacy and feasibility of a technology-based CM intervention for increasing frequent, brief bouts of walking to decrease prolonged periods of sedentary behavior. A packaged intervention consisting of contingent monetary incentives, goal setting, performance feedback, and textual prompts was implemented with six office workers with predominantly sedentary job responsibilities. Overall, the packaged intervention increased the number of physically active hourly intervals (i.e., intervals with a step count $\geq$ 250 steps) during the workday. At the individual level, I observed an increase in the number of physically active hourly intervals for four of six participants during the intervention. All four participants for whom an increase was observed met the mastery criterion by reaching the hourly step goal of 100% of intervals in a day for at least three days in a four-day block when the target goal was 100% of intervals. For the remaining two participants, minimal changes in performance were observed during the intervention.

Contributions to the Literature

This study contributes to the existing literature in four important ways. First, this study extends the literature on interventions to decrease prolonged periods of sitting throughout the workday in general and in the workplace in particular. In the published behavior-analytic literature, mixed effects have been observed for interventions targeting prolonged periods of sitting, a type of sedentary behavior. Moreover, relatively few intervention components have been evaluated, with feedback and prompts as the primary intervention components assessed to date (Green et al., 2016; Green & Dallery, 2019). This study adds to the current literature by evaluating a packaged procedure that contained several novel intervention components, including the use of contingent monetary incentives and goal setting using shaping and percentile schedules, each of which will be discussed as its own contribution with its own implications.

Second, this was the first study to my knowledge to use a CM intervention to target prolonged periods of sitting as a dependent variable. The results of this study align with the results of previous research using CM with monetary incentives (Higgins et al., 2007; Petry et al., 2000; Silverman et al., 1999) and extend this literature by assessing a different aspect of a health-related behavior. Previous CM research, both in behavior analysis (e.g., Donlin Washington et al., 2016; Kurti & Dallery, 2013; Stedman-Falls & Dallery, 2020) and in the more extant literature (e.g., Finkelstein et al., 2016), has demonstrated the efficacy of contingent incentives for increasing physical activity. This study adds to the CM literature by extending its potential utility to reinforcing frequent, brief bouts of walking to disrupt prolonged periods of sitting.

In this study, earned incentives were added to the participant's reloadable debit card the day after the end of a four-day block. This procedure is like others used in several other behavior-analytic studies (e.g., Kurti & Dallery, 2013; Stedman-Falls & Dallery, 2020). However, other approaches have also been employed, including the delivery of monetary incentives at the end of the study in their entirety (Donlin Washington et al., 2016). One advantage of the current procedure is that it reduces the delay to the reinforcer delivery, a variable that has been shown to impact reinforcer efficacy (Lussier et al., 2006). In addition, the use of a reloadable debit card provides the opportunity for earned incentives to be added remotely, removing the need for any in-person interaction.

Performance feedback was provided to participants each workday on whether they earned the monetary incentive by meeting their target goal; thus, it is possible this information may have played a role in mediating the delay to the reinforcer delivery. During the intervention, feedback was provided to participants each evening via a text message after the end of their workday. This procedure differs from the feedback delivery procedure in the two published behavior-analytic studies examining sedentary behavior, where feedback was provided to participants via email at the start of the next workday (Green et al., 2016; Green & Dallery, 2019). As such, there were two notable differences between this study's feedback procedure and previous research: the feedback's timing and modality. Although speculative, it is possible that the two approaches to delivering feedback may have different underlying behavioral mechanisms. For instance, it is possible that the feedback in the current study may have functioned as a consequence as it was provided close to the end of the workday, whereas the feedback in previous studies may have functioned as an antecedent as it was provided at the start of the next workday. Regarding the efficacy of feedback timing, mixed findings have been observed in the organizational behavior management literature. For example, Aljadeff-Abergel et al. (2017) found that feedback delivered before performance produced better outcomes than feedback delivered after performance when teaching undergraduate students how to implement two behavior-analytic teaching procedures. However, Wine et al. (2019) and Henley and DiGennaro Reed (2015) found similar results for feedback delivered before and after performance, which suggests that the timing of the feedback did not meaningfully impact performance.

A third contribution of this study was that it extended the applications of a goal-setting procedure using shaping and percentile schedules of reinforcement to a different aspect of a health-related behavior. The current findings suggest that four-day observation blocks with a performance goal set at the 75^{th} percentile (i.e., third highest day of the four-day block) increased the number of physically active hourly intervals per workday for four of six participants. As such, this study's goal-setting procedure created a standardized approach for determining a participant's target goal that may be used in similar future research.

By setting goals using percentile schedules, each participant's target goal on the primary dependent variable (i.e., the number of physically active hourly intervals per workday) was individualized and determined by assessing recent performance (e.g., the last completed four-day block). Across participants, 13 of the 15 new target goals (86.7%) for a new four-day block were set to an increase of 1 physically active hourly interval per workday. On two occasions a target goal increased by a different number of physically active hourly intervals per workday; this occurred once for both P1 and P2, where a new target goal increased by 2 physically active hourly intervals for the next four-day block.

A fourth contribution of this study was that it was conducted entirely remotely using technology, thereby removing the need for any in-person interaction. Thus, there are several implications regarding the intervention's potential utility. One implication is that this intervention can remove geographic location as a barrier to participation (Dallery et al., 2015; Dallery et al., 2019). Because the intervention can be implemented without any in-person interaction, researchers may then be able to recruit from a broader, more diverse participant pool.

Researchers may also be able to target participants with certain demographics or health characteristics that may most benefit from an intervention. A fully remote intervention may also be advantageous under other conditions, including when in-person interactions might be restricted or even non-preferred by participants. For example, this study was able to be conducted in its entirety during the ongoing COVID-19 pandemic.

As a technology-based procedure, this study used both the internet and mobile phones to implement different aspects of the intervention. The internet was used for videoconference meetings as well as to access and complete the eligibility screening surveys and contingency contract. All other aspects of the study were completed using mobile phones (e.g., performance feedback, prompts for a daily target goal). A growing body of CM literature has demonstrated the efficacy of mobile-phone-based interventions for improving various health-related behaviors (Getty et al., 2019; Whittaker et al., 2019). Moreover, mobile-phone-based interventions may offer several advantages when compared to internet-based interventions, including the ability to expand access to a more diverse array of participants (Dallery et al., 2019), as it is estimated that 94% of U.S. adults own a mobile phone (Pew Research Center, 2019). Future research may extend the current procedure by identifying procedures for making the intervention entirely mobile-phone-based, which may further enhance the feasibility of implementation.

A second implication was that the remote procedures were minimally intrusive and required only a small amount of participant time each day. Specifically, the intervention required one meeting, which was completed remotely using videoconferencing software and lasted approximately five min. A second meeting was required only if the barriers assessment was implemented, which occurred for two participants. Daily, minimal time was needed from participants beyond walking to meet their daily target goal, in that the only requirement was to read and respond to a text message with information about their performance and the target goal for the next day. Moreover, intervention acceptability data indicated that participants strongly agreed with statements that the study was easy to participate in and did not require much time.

Limitations and Future Directions

There were several limitations of the current study that future research should address. One limitation involves the use of monetary incentives as an intervention component. A substantive literature has found CM to be an efficacious intervention for improving numerous health-related behaviors (e.g., smoking cessation, substance abstinence, medication adherence; Dallery & Glenn, 2005; DeFulio & Silverman, 2012; Higgins et al., 2007; Rosen et al., 2007). Moreover, large treatment effects from CM interventions have been observed and reported within meta-analyses (Lussier et al., 2006). Although the literature has shown CM to be effective in changing various health-related behaviors, a frequently cited limitation is its cost (Petry, 2010). In the current study, participants could earn up to $11 every four days if they met their target goal each day of a four-day block (e.g., $2 a day and a $3 bonus for meeting all four goals).

The cost associated with providing monetary incentives is a barrier that may prevent widespread adoption or the scaling up of CM as a workplace intervention (e.g., with a greater number of participants, over more extended periods of time). However, there are a growing number of incentive programs among healthcare providers and organizations in which individuals can earn various incentives (i.e., putative reinforcers) for engaging in health-related behaviors. Several examples of programs from large healthcare providers include the UnitedHealthcare Motion® program and Humana Go365® program. For instance, within the UnitedHealthcare Motion® program, insured individuals can earn monetary incentives of up to

$4 per day by meeting different target goals, such as taking 10,000 steps in a day or walking 300 steps within a 5-min interval six times a day (UnitedHealthcare, 2020). These data are most commonly collected by accelerometers, which are oftentimes made available to insured individuals for free, with the earned incentives added to an individual's health saving account.

To extend this study's procedures, future research should evaluate the potential efficacy and feasibility of CM with deposit contracts as a way to decrease cost. Broadly, deposit contracts (also referred to as commitment contracts) involve a participant contributing towards the potential incentives they can earn during an intervention. Thus, a participant can earn back their monetary deposit by meeting target goals. As noted in my systematic review (see Appendix A), the incentive amount a participant is responsible for depositing can vary, from being responsible for a small amount of the earnings (e.g., 10%) to half of the earnings (50%; i.e., deposit matching) to the entirety of the earnings (i.e., 100%). In the behavior-analytic literature, two studies have evaluated deposit contracts as an intervention component (Donlin Washington et al., 2016; Stedman-Falls & Dallery, 2020). Donlin Washington (2016) compared a deposit-matching condition (i.e., participants contributing 50%) and a no deposit condition on the physical activity of 19 adults. Interestingly, the researchers observed similar step counts per day across the two conditions during the intervention, thereby providing preliminary support for deposit contracts as an equally efficacious yet more resource-efficient intervention. Stedman-Falls and Dallery (2020) compared technology-based deposit contracts and in-person deposit contracts wherein participants were responsible for depositing the entire incentive amount (100%). Overall, the researchers found similar efficacy and acceptability for both types of contracts. Taken together, these two studies suggest that deposit contracts in general, and technology-based deposit contracts in particular, warrant further examination as a potential approach to increase the resource efficiency with which CM interventions can be implemented to target aspects of sedentary behavior.

Another direction for future research is to examine the potential utility of technology-based deposit contracts for increasing the frequency of brief bouts of walking to disrupt prolonged periods of sitting. Researchers could conduct a parametric analysis by evaluating the proportion of the total incentives a participant must deposit. For example, future research might compare conditions where participants are responsible for contributing 0% (i.e., no deposit), 25%, 50% (i.e., deposit matching), 75%, and 100% of the total potential incentives available. These results could have several implications for both research and practice on the use of CM with deposit contracts. For example, results might help identify procedures that balance resource-efficiency and efficacy when seeking to improve a health-related behavior throughout the workday.

Support for the use of deposit contracts also extends beyond the empirical findings to date. As noted by Wolf (1978), one critical aspect of social validity is the acceptability of an intervention's procedures. In addition to the empirical literature supporting the efficacy and acceptability of deposit contracts as an intervention component, companies are providing services using them as well. Although circumstantial, this speaks at least in part to their potential acceptability among the general public. For example, two commercial services that use contingency contracts for health-related behaviors include StickK (2021) and StepBet (2021). With StickK, individuals identify a target goal and its parameters, then create and sign a commitment contract. Along with the commitment contract, StickK also provides several add-on services, including the use of financial deposits (i.e., deposit contracts) and to add a referee (i.e., individual that monitors and verifies progress). With respect to the deposit contracts, individuals decide on variables such as the amount and schedule, as well as where the money from unearned deposits is allocated, which could be to friends, a charity, or even an anti-charity.

A second limitation was that I was unable to evaluate the effects of each intervention component because a packaged intervention was implemented. Thus, the degree to which each intervention component impacted the results is currently unknown. Although the extant physical activity literature suggests greater efficacy for packaged interventions (Rhodes et al., 2017; see also Appendix A), it is possible that not all intervention components were needed to produce the observed effects. Moreover, it is possible that there are idiosyncratic differences regarding the efficacy and necessity of each of the intervention components when assessed across participants. When compared to the existing behavior-analytic literature that has targeted sedentary behavior, there were two novel components included in this packaged intervention: the provision of contingent monetary incentives and goal setting using percentile schedules. To evaluate the potential impact of each of these novel intervention components and address this limitation, future researchers may seek to conduct an experimental analysis of the variables controlling performance. One procedure would be to conduct a component analysis where each intervention component as well as combinations of components are introduced systematically. Researchers could evaluate each intervention component using a within-subjects design by introducing each component and combinations over time, or by using a between-subjects design where different groups of participants are assigned to different conditions (e.g., factorial design).

Another limitation was that the total amount of monetary incentives a participant could earn was not equal across participants. Therefore, it was possible for some participants to earn more incentives than others. The variable that most affected the potential incentives available to a participant was their baseline performance. For example, a participant with a higher baseline (e.g., P2) would have a higher initial target goal as well as fewer target goals, thereby leading to fewer days in intervention to earn the incentives.

This study did not collect maintenance data, which may also be viewed as a limitation. Because of the novelty of several of the intervention components and the mixed effects found in the behavior-analytic literature to date, the purpose of this study was to evaluate whether a packaged CM intervention would be efficacious and feasible for increasing frequent, brief bouts of walking. In general, the results of this study support this conclusion. An important next step for future research is to address this limitation by evaluating performance over more extended periods of time. In doing so, researchers might also identify ways to thin the schedule of reinforcement. One potential approach would be to thin the schedule of reinforcement by systematically reducing how often monetary incentives and feedback are provided (Andrade et al. 2014). Future research could also employ a lottery-based CM procedure, which has been shown to be effective for improving other health-related behaviors (Petry et al., 2010) as well as physical activity (Donlin Washington et al., 2014).

Another limitation involves the fidelity of the participant's receipt of performance feedback and textual prompt. Although participants were asked to send a text message indicating they received the performance feedback and prompt, I was unable to verify that participants had in fact read the entirety of the message. Future research may look to mitigate this limitation by asking participants to report back their daily performance and the next day's target goal in their confirmation text message back to the experimenter.

In sum, the findings of the current study provide preliminary evidence that a technology-based CM intervention can increase the total number of physically active intervals (i.e., intervals with ≥ 250 steps) during the workday amongst office workers with predominantly sedentary job responsibilities. For adults with full-time employment, approximately 8.5 hours a day are spent at the workplace during the workweek (Bureau of Labor Statistics, 2019). Given the substantial amount of time an individual spends in the workplace, it may be argued this environment plays an important role in one's health more broadly. Identifying effective interventions that target physical inactivity and sedentary behavior is an important area of scientific inquiry, with myriad implications spanning from the individual to societal level. Future research efforts should therefore be directed towards identifying effective, sustainable interventions that target these behaviors in the workplace as one way to help improve individual health and wellbeing.

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Table 1

Participant Characteristics

Participant	Age	Gender	Education Level	Income	Workplace Setting	% Work Sedentary
P1	41	Female	Master's Degree	$50,001-$75,000	Home	95
P2	60	Male	Master's Degree	$100,001-$150,000	Home	95
P3	40	Female	Master's Degree	$75,001-$100,000	Home	100
P4	31	Female	Master's Degree	$100,001-$150,000	Home	100
P5	35	Female	Master's Degree	$40,001-$50,000	Home	66
P6	50	Female	Master's Degree	$40,001-$50,000	Home	100

Table 2

International Physical Activity Questionnaire-Short Form Results

Participant	Vigorous Activity	Moderate Activity	Walking	Sitting
P1	None	3 days; 1 hr/day	None	5 hr/day
P2	None	3 days; 30 min/day	5 days; 25 min/day	10 hr/day
P3	4 days; 45 min/day	None	3 days; 10 min/day	12 hr/day
P4	4 days; 45 min/day	None	7 days; 45 min/day	12 hr/day
P5	3 days; 45 min/day	5 days; 2 hr/day	2 days; 30 min/day	4 hr/day
P6	None	None	2 days; 30 min/day	16 hr/day

Note. Self-reported time spent engaging in each activity over the last 7 days.

Table 3

Earned Incentives Per Participant

Participant	Days in Intervention	Total Incentives Earned	Average Incentive/Day
P1	16	$44	$2.75
P2	12	$26	$2.17
P3	12	$23	$1.92
P4	16	$39	$2.44
P5	24	$21	$0.88
P6	20	$27	$1.35
Total	100	$180	$1.80

Table 4

Intervention Acceptability Results

Question	Mean	Range
I liked the use of monetary incentives.	5.17	4–6
I found the monetary incentives helpful in increasing my physical activity during the workday.	5	3–6
I liked the use of target goals.	5.5	3–6
I found the target helpful in increasing my physical activity during the workday.	5.5	4–6
I liked the use of daily feedback about my performance	5.67	5–6
I found the daily feedback about my performance helpful in increasing my physical activity during the workday.	5.83	5–6
I liked the use of text message prompts for the next day's target goal.	5.83	5–6
I found the text message prompts helpful in increasing my physical activity during the workday.	5.83	5–6
I liked the procedures used to increase my physical activity throughout the workday.	5.67	5–6
The intervention was effective at increasing my physical activity throughout the workday.	4.83	1–6
Most individuals would find this intervention helpful for increasing their physical activity throughout the workday.	5.67	5–6
I would recommend this intervention to others interested in increasing their physical activity throughout the workday.	5.83	5–6
I found the Fitbit easy to use.	5.17	4–6
I found the Fitbit helpful for increasing my physical activity throughout the workday.	5.67	5–6
I found the Fitbit to be an acceptable way to increase my physical activity throughout the workday.	5.67	5–6
The study was fun to participate in.	5.67	5–6
The study was easy to participate in.	5.83	5–6
Participation in the study did not require much time.	5.33	5–6
I would be interested in participating in a similar study in the future.	5.83	5–6

Note: 1 (*strongly disagree*) to 6 (*strongly agree*)

Figure 1

Multiple Baseline Design Across All Six Participants

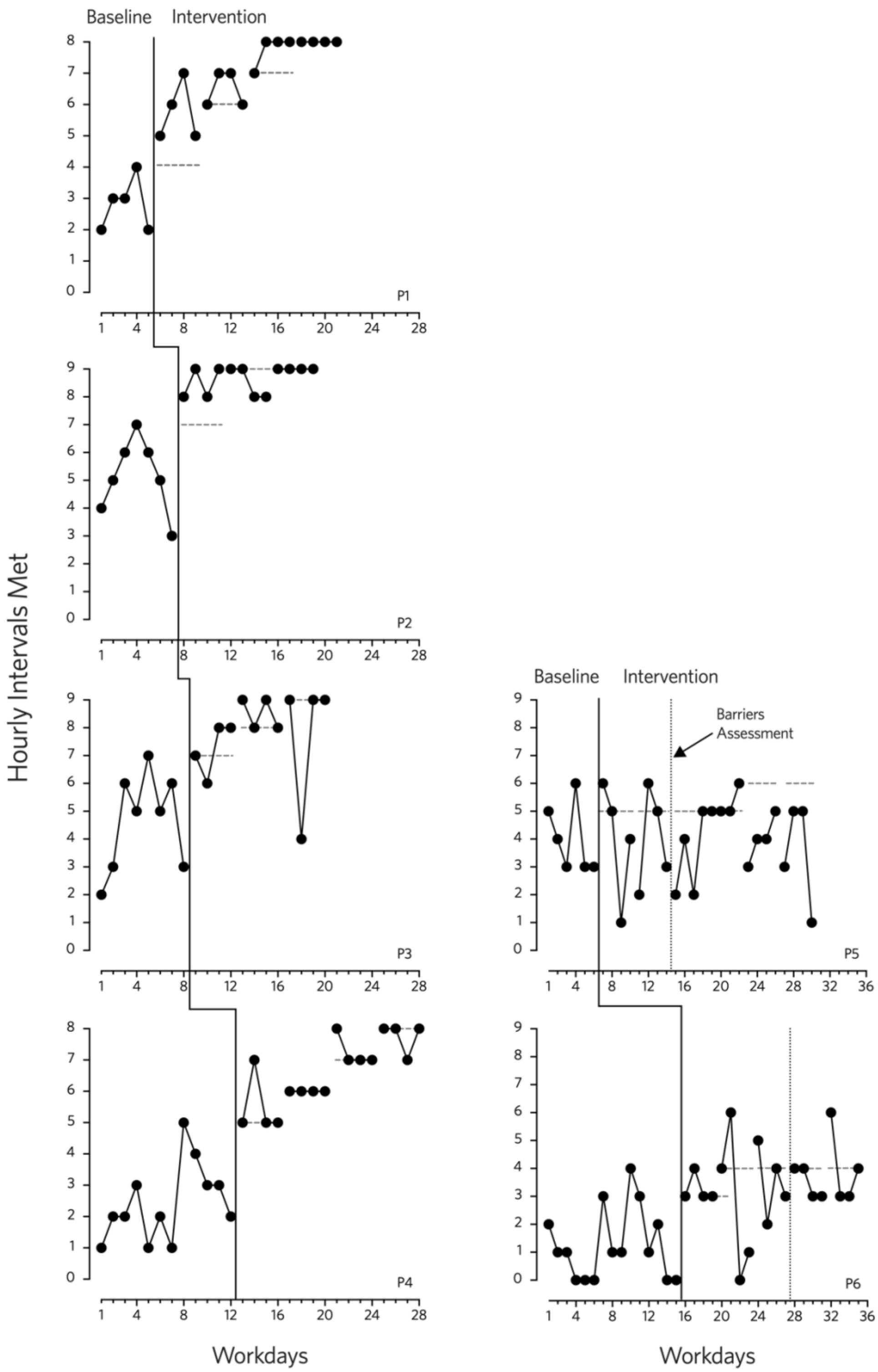
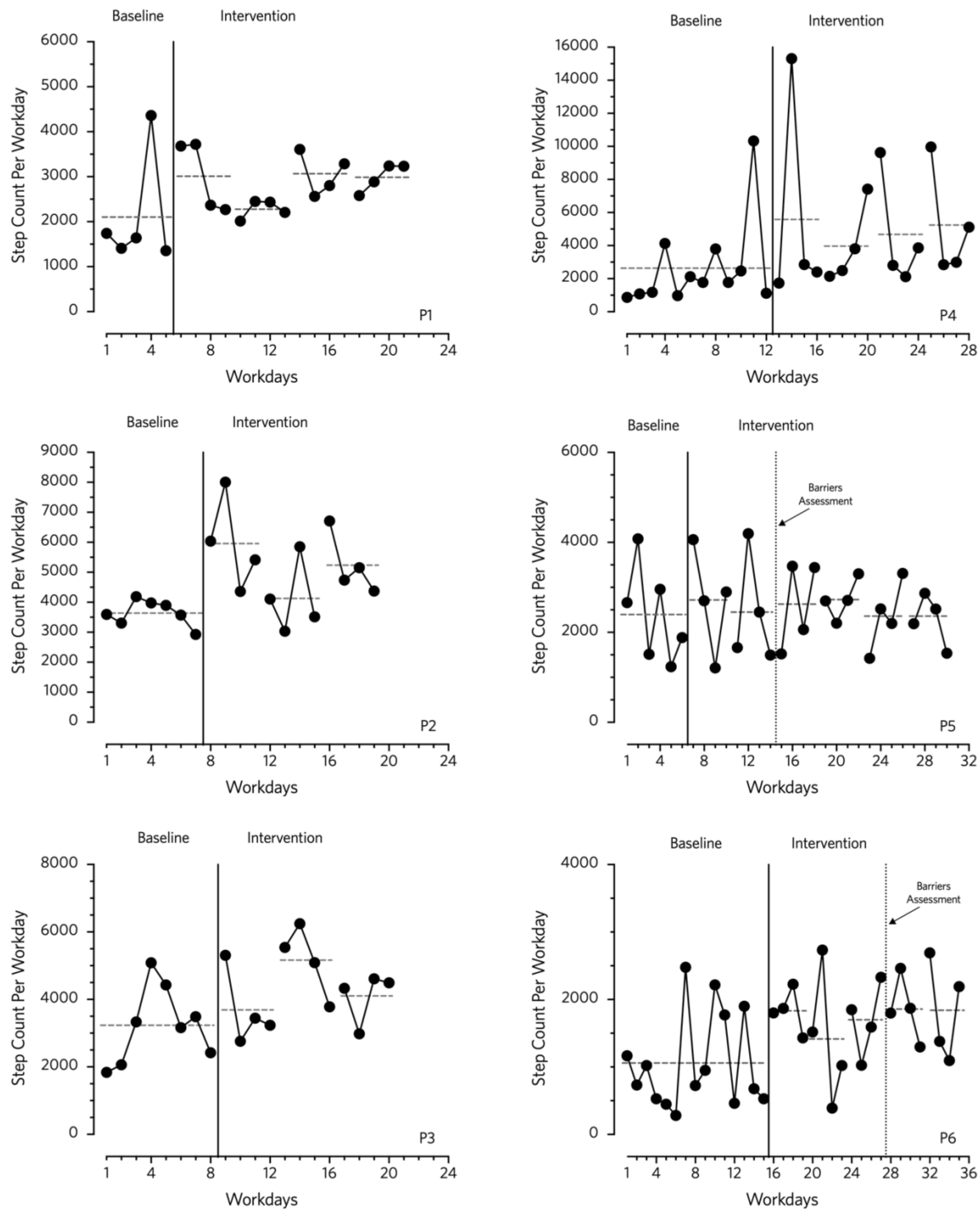


Figure 2

Step Counts Per Workday by Participant



Appendix A

Comprehensive Review Manuscript

A Systematic Review of Behavior-Analytic Interventions Targeting Physical Activity and Sedentary Behavior with Adults

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Abstract

Developing effective interventions to address physical inactivity and sedentary behavior is a socially significant area of research. With its rich history identifying effective interventions to produce meaningful behavior change, behavior analysis has much to offer in this respect. The purpose of this review is to highlight research published in behavior-analytic journals examining physical activity and sedentary behavior with adults. In doing so, I review (a) the different types of intervention components and how they have been implemented; (b) measurement apparatuses and how target behaviors have been measured; (c) the types of experimental designs employed; and (d) other important variables, including the assessment of social validity and maintenance. Implications of these findings are discussed, along with potential directions for future research.

Keywords: *physical activity*, *sedentary behavior*, *adults*

A Systematic Review of Behavior-Analytic Interventions Targeting Physical Activity and Sedentary Behavior with Adults

Physical Activity

Physical activity refers broadly to any movement of the body that results in energy expenditure (Casperson et al., 1985; World Health Organization [WHO], 2020). Current federal guidelines recommend that adults engage in at least 150 min of physical activity at a moderate intensity or 75 min of physical activity at a vigorous intensity per week (Centers for Disease Control and Prevention [CDC], 2020; U.S. Department of Health and Human Services, 2018; WHO, 2020). The WHO (2020) defines intensity as “the rate at which the activity is being performed or the magnitude of the effort required to perform an activity or intervention”. The intensity of energy expenditure is measured as the metabolic equivalent of task (MET), which is the rate of energy expended during an activity over the rate of energy expended at rest (Piercy et al., 2018; U.S. Department of Health and Human Services, 2018). Thus, a MET score of 2 would mean that an activity’s energy expenditure is double the amount of energy expenditure at rest. For physical activity to be considered of moderate intensity, it must have an activity score between 3–6 METs and a target heart rate of 50% to 70% of one’s maximum heart rate. Examples of activities of moderate intensity include walking at a moderate-to-brisk pace (i.e., 3–4.5 miles per hour), yoga, water aerobics, and using a rowing machine or stationary bike at medium effort. Vigorous intensity includes activities with a score of 6 METs or higher and a target heart rate of 70% to 85% of one’s maximum heart rate. Example of vigorous activities include running, aerobic dancing, and using a rowing machine or stationary bike at high effort.

The benefits of regular physical activity are well established (Kannel et al., 1979; Reiner et al., 2013; Warburton et al., 2006; Warburton & Bredin, 2017) and have been shown across the age continuum, from children to geriatric populations (Janssen & LeBlanc, 2010; Vogel et al., 2009). As a behavior, physical activity can help prevent the occurrence of a disease (i.e., primary prevention), as well as minimize the effects of a disease after its onset (i.e., secondary prevention; Warburton et al., 2006). With respect to primary prevention, regular physical activity has been associated with a decreased risk for various noncommunicable diseases (e.g., cardiovascular, cancer) and premature mortality (Lee et al., 2012; Warburton et al., 2006). Regular physical activity has also been shown to be effective as a type of secondary prevention by attenuating the risk of premature mortality from various noncommunicable diseases (e.g., cardiovascular disease, type 2 diabetes) that have already developed (Warburton, et al., 2006).

Unfortunately, 76.8% of adults in the U.S. do not meet the recommended physical activity guidelines (Carlson et al., 2010; CDC, 2020; Piercy et al., 2018). Moreover, up to 26.6% of adults report no engagement in leisure-time physical activity (i.e., activity not essential to daily living, performed at the discretion of an individual; Carlson et al., 2010; CDC, 2020; Moore et al., 2012). When translated into a monetary cost to society, inadequate physical activity is estimated to account for approximately 8.7% of all health care expenditures annually, or from approximately $79 billion to $117 billion a year (Carlson et al., 2015; CDC, 2020).

Physical inactivity is the fourth leading cause of preventable death in the U.S. (Danaei et al., 2009; Kohl et al., 2012) and is related to a myriad of negative health outcomes, including increased risk of obesity, cardiovascular disease, cancer (e.g., breast, colon), hypertension, and type 2 diabetes, among others (Owen et al., 2010; Warburton & Bredin, 2017). Moreover, physical inactivity has been estimated to be responsible for 6% to 10% of all non-communicable diseases, as well as 9% of premature deaths (Lee et al., 2012). The WHO (2009) has prioritized physical inactivity as one of its top four modifiable risk factors—that is, risk factors that can be reduced in probability through intervention (i.e., behavior change)—indicating a need for the expertise of behavior analysts.

Sedentary Behavior

Sedentary behavior has been defined as “any waking behavior characterized by an energy expenditure less than or equal to 1.5 METs, while in a sitting, reclining or lying posture” (Tremblay et al., 2017). Several illustrative examples of sedentary behavior include working at a desk, watching television, or reading a book. Similar to physical inactivity, research suggests excessive and prolonged periods of sedentary behavior may have similar adverse implications for metabolic heath, including increased risks for various noncommunicable diseases (e.g., cardiovascular disease, type 2 diabetes, colon cancer, lung cancer) and an increased risk of cardiovascular disease mortality and all-cause mortality (Diaz et al., 2017; Piercy, 2019; Rosenberg et al., 2015; Katzmarzyk et al., 2009; Thorp et al., 2011; U.S. Department of Health and Human Services, 2018).

Physical inactivity and sedentary behavior have recently been discussed as two distinct yet related risk factors (i.e., independent variables; Ekelund et al., 2020; Rosenberg et al., 2015; U.S. Department of Health and Human Services, 2018; WHO, 2020). For example, in a recent update to the WHO’s (2020) guidelines on physical activity and sedentary behavior, the empirical evidence on physical activity is now separate from the evidence on sedentary behavior, in addition to sedentary behavior being added to its title (Bull et al., 2020; WHO, 2020).

An emerging body of research has sought to examine the impact of sedentary behavior on various health indices. Given its relatively recent emergence, no well-established consensus exists regarding the independent and combined effects of sedentary behavior and physical inactivity on various health-related outcomes (Bull et al., 2020; WHO, 2020). However, in a review of the literature, the U.S. Physical Activity Guidelines Advisory Committee concluded that strong empirical evidence exists regarding a significant relation between higher sedentary time and higher all-cause mortality (U.S. Department of Health and Human Services, 2018).

Several meta-analyses have been conducted to evaluate the impact of sedentary behavior on an individual's health. For example, Biswas et al. (2015) conducted a meta-analysis to evaluate the association between sedentary behavior and various health outcomes. In doing so, the researchers examined the impact of sedentary behavior, both as an independent risk factor and when combined with physical activity, on all-cause mortality, cardiovascular disease, cancer, and all-cause hospitalizations. All the studies included in Biswas et al. were based on data collected via self-report. Overall, results indicated that sedentary time was an independent risk factor, with higher (i.e., prolonged) rates of sedentary time associated with increased risk for cardiovascular disease, all-cause mortality, type 2 diabetes, and cancer incidence and mortality (Biswas et al., 2015).

Ekelund et al. (2019) conducted a meta-analysis to understand the dose-response relation between physical activity and sedentary behavior on all-cause mortality. Across eight studies included in their analysis, which comprised approximately 36,000 middle- and older-age adult participants, the researchers found that higher rates of physical activity and lower rates of sedentary behavior were associated with a decreased risk for premature mortality. Interestingly, this finding was observed irrespective of the intensity of the physical activity. These results suggest that physical activity—even at a lower intensity—and less sedentary time may help to mitigate the risk for premature mortality.

Ekelund et al. (2020) conducted a follow-up meta-analysis to examine the relation between physical activity and sedentary behavior on all-cause mortality. Nine studies involving approximately 44,000 participants were included in the analysis. This meta-analysis extended Ekelund et al. (2019) in two ways: (a) measurement of physical activity and sedentary behavior via accelerometers as opposed to self-report and (b) stratification of participants into nine groups based on their rates of moderate-to-vigorous physical activity and time spent sedentary (i.e., three groups each; high, medium, low). The researchers found that both physical activity and sedentary behavior significantly impact all-cause mortality (U.S. Department of Health and Human Services, 2018), with lower rates of physical activity and higher sedentary time associated with a higher risk for premature mortality—a finding similar to previous meta-analyses (Biswas et al., 2015; Ekelund et al., 2016; Ekelund et al., 2019).

Ekelund et al. (2020) extended the literature on the relation between physical activity and sedentary behavior in two important ways. First, their results suggest a relation between sedentary behavior, physical activity, and mortality, in that individuals who have high rates of sedentary time and engage in low rates of moderate-to-vigorous physical activity have a higher risk for premature mortality (Keadle et al., 2015). Second, their results suggest that high rates of moderate-to-vigorous physical activity may minimize the risk for premature death regardless of the amount of time spent sedentary. That is, even with high rates of sedentary time, approximately 30 to 40 min of moderate-to-vigorous physical activity per day may be sufficient to minimize the risk of premature mortality.

Taken together, the results of these meta-analyses suggest several implications for sedentary behavior, both in general and as it relates to the literature to date. The first implication is that the data across meta-analyses suggest several similar (i.e., convergent) findings. However, the majority of this literature—and thus, its implications—is based on data collected via participant self-report, with one exception being the meta-analysis by Ekelund et al. (2020). The second implication is that the results from Ekelund et al. (2020) suggest that approximately 34 min per day (range, 30–40 min) of moderate-to-vigorous physical activity may be sufficient to mitigate the negative health implications of prolonged sedentary time. This finding differs from the results of previous studies on physical activity and sedentary time, which suggest a minimum threshold of 60 min to 70 min of physical activity per day based on data collected via self-report (Diaz et al., 2017; Ekelund et al., 2016). Thus, more research is needed that measures observable behavior in the natural environment. Second, although multiple meta-analyses have examined the role of sedentary behavior, a primary focus has been on evaluating its relation to all-cause mortality, with less known about its impact on other health indices. More research is therefore needed to better understand the relation between sedentary behavior and physical activity on other health-related indices.

Role of Behavior Analysis

In the extant literature, physical activity and, to a lesser extent, sedentary behavior, are multidimensional areas of scientific investigation, with research that spans a wide range of scientific disciplines—ranging from biology to exercise science to cardiology to applied psychology, among others (Booth et al., 2008; Casperson, 1989; Fletcher et al., 1996; Toker & Biron, 2012). Situated within this continuum is a body of behavioral research examining interventions to increase physical activity and decrease sedentary behavior. As part of a review of empirical reviews, Rhodes et al. (2017) conducted a narrative analysis of the types of behavioral interventions found within the physical activity literature. In doing so, the authors note two primary outcomes from their findings. First, the current evidence for various behavioral interventions is inconclusive, with more research needed to evaluate their efficacy. Second, the researchers note that, although preliminary, the evidence to date suggests that (a) multicomponent behavioral interventions are more effective than single-component interventions and (b) interventions including goal setting, performance feedback, and self-monitoring show promise for increasing physical activity and improving health outcomes.

Research examining physical inactivity and sedentary behavior is an important area for scientific investigation, as it is a socially significant topic (Baer et al., 1968) with consequences at both the individual and societal level. Approximately 42.5% of U.S. adults are now considered obese and another 31.1% are considered overweight, thereby bringing the total percentage of U.S. adults who are overweight or obese to 73.6%—approximately 3 out of every 4 adults (CDC, 2021). Thus, it may be argued that behavioral interventions to improve physical health are not only timely, but also needed now more so than ever before. Given their expertise in behavior change, behavior analysts may be uniquely suited for identifying behavioral interventions to address physical inactivity and sedentary behavior. Within the field, a growing body of evidence demonstrates the effectiveness of behavioral interventions for increasing physical activity (Kurti & Dallery, 2013; Normand, 2008; Zarate et al., 2019) and decreasing sedentary behavior (Green et al., 2016) with adults. However, there is no systematic review of the literature to date.

A review of studies in behavior analysis is important, as it may provide useful information regarding the efficacy of various behavioral interventions. By synthesizing the current literature and elucidating the ways in which interventions have been implemented, there are also implications for both researchers and practitioners who are interested in improving adult physical health and wellbeing. Moreover, a systematic review of the behavior-analytic literature could help identify potential gaps within the literature, as well as areas to direct future research efforts. To my knowledge, no review has been conducted to date that examines interventions targeting physical activity and sedentary behavior with adults in the field of behavior analysis. Thus, this is the primary purpose of this review.

Method

Literature Search Methods

A systematic search of interventions targeting physical activity and sedentary behavior in behavior analysis was conducted using a procedure based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher et al., 2009). The search was conducted from June 2020 to December 2020, with articles published through 12/12/2020 included in the review. Appendix A contains information on the search (e.g., search terms) and screening procedures, including two full Boolean searches. Figure 1 provides a visual overview of the search procedure.

Articles were identified via an electronic search of two scholarly databases: PsycINFO and Web of Science. These searches yielded a total of 274 articles. An initial screening of articles was conducted by applying specific filters to the obtained search results. These filters included the following inclusionary criteria: (a) published in a scholarly journal (b) peer-reviewed, (c) written in English, and (d) inclusion of adult participants (i.e., 18+ years of age). This screening procedure—which also included the removal of duplicate records—excluded 201 articles.

A review of the remaining 73 articles was then conducted to determine whether each article met further inclusion criteria: (a) assessment of physical activity or sedentary behavior as a dependent variable, (b) measurement of an overt form of behavior (i.e., no self-report or survey) using a validated measurement tool (e.g., Fitbit accelerometer, pedometer), (c) inclusion of a behavioral intervention as an independent variable, (d) inclusion of adult participants[1] (i.e., 18+ years of age), (e) use of single-subject design methodology, and (f) published in a behavior-analytic journal (see Table 1 for a list of the journals and number of articles). This screening removed 57 articles, yielding a total of 16 articles and 17 studies that were included in the current review; Kurti and Dallery (2013), contained two experiments and was therefore coded as two studies.

Study Coding

Each study was coded for reported demographics and methodological features (see Appendix B). Specifically, each study was coded for (a) participant demographics, (b) experimental design, (c) dependent variable(s), (d) measurement apparatus, (e) independent variable(s), (f) measurement of social validity, and (g) measurement of maintenance. More information regarding each of these components for each study is located in Table 2.

Results

Participant Characteristics

All participants included in this review were adults (i.e., ≥18 years old). The majority of participants were identified as female: 128 of 160 participants (80%). Across the studies, participants ranged in age from 18 to 71 years old. With respect to other participant characteristics, I created categories based on the demographic information provided by the authors. The most frequently reported participant characteristics across studies were participants who were (a) sedentary adults (*n* = 5 studies; Andrade et al., 2014; Donlin Washington et al.,

[1] Although the "only adult populations" filter was selected in the initial screening procedure, not all appropriate studies were excluded. Thus, this inclusion criterion was also applied in the review procedure.

2016; Green & Dallery, 2019; Kurti & Dallery, 2013, studies 1 & 2), (b) college students (*n* = 4 studies; Donlin Washington et al., 2014; Junaid et al., 2020; Stedman-Falls & Dallery, 2020; Wack et al., 2014), adults who were overweight (*n* = 3 studies; Nastasi et al., 2020; Valbuena et al., 2015; Van Wormer, 2004), adults who were healthy (*n* = 2 studies; Normand, 2008; Zarate et al., 2019), office workers (*n* = 2 studies; Green & Dallery, 2019; Green et al., 2016), and adults with intellectual or developmental disabilities (*n* = 2 studies; Li et al., 2019; Nastasi et al., 2020).

Dependent Variables and Measurement Apparatuses

Of the 17 studies included in this review, 15 (88.2%) focused on measuring physical activity and 2 (11.8%) focused on measuring sedentary behavior.

Physical Activity

Fifteen of 15 studies (100%) evaluating physical activity assessed step counts as a primary dependent variable. Across all the studies, step counts per day was the most frequently used dependent measure, used in 13 studies (76.5%; Andrade et al., 2014; Donlin Washington et al., 2014; Donlin Washington et al., 2016; Junaid et al., 2020; Kurti & Dallery, 2013, studies 1 & 2; Li et al., 2020; Nastasi et al., 2020; Normand, 2008; Sofis et al., 2017; Stedman-Falls & Dallery, 2020; Valbuena et al., 2015; Van Wormer, 2004;). Three other derivatives of step counts were also employed by researchers, including the percentage of days with greater than 10,000 steps (Andrade et al., 2014), running distance which was measured in miles (Wack et al., 2014), and the number of intense steps per week (i.e., greater than 400 steps in a 5-min interval; Zarate et al., 2019).

Sedentary Behavior

Two studies assessed sedentary behavior as the primary dependent variable (Green et al., 2016; Green & Dallery, 2019). Across both, sedentary behavior was, broadly, measured by the duration of time an individual was stationary (i.e., engaged in little to no physical activity). Green et al. (2016) measured sedentary behavior as the number of bouts (i.e., intervals) of sitting for 31 min or more without disruption. Green and Dallery (2019) measured sedentary behavior as the percentage of active bouts per day; each bout was a 30-min interval, with an active bout consisting of 100 or more steps in the 30-min interval.

Measurement Apparatuses

All 17 studies (100%) used permanent product recording (Cooper et al., 2020). A Fitbit accelerometer was the most frequently worn measurement device, used in 12 studies (70.1%; Donlin Washington et al., 2014; Donlin Washington et al., 2016; Green & Dallery, 2019; Junaid et al., 2020; Kurti & Dallery, 2013, studies 1 & 2; Li et al., 2020; Nastasi et al., 2020; Sofis et al., 2017; Stedman-Falls & Dallery, 2020; Valbuena et al., 2015; Zarate et al., 2019). Fitbit accelerometers are consumer-grade activity trackers that measure device acceleration (i.e., movement) along three axes (Fitbit, n.d.). Data from the device are uploaded wirelessly through Bluetooth by pairing and syncing the device with the Fitbit mobile application. Fitbit accelerometers can track and calculate a variety of health metrics, including step counts, distance traveled, and the number of calories burned, among others (Fitbit, n.d.). In general, Fitbit accelerometers have been shown to be a reliable and valid measurement device (Van Camp & Berth, 2018).

A pedometer (i.e., activity tracker that calculates step counts and estimates distance walked by measuring vertical movement from the hip) was the second most frequent device (n = 3 studies; 17.7%; Andrade et al., 2014; Normand, 2008; Van Wormer, 2004). Finally, one study (5.9%) used an Actigraph accelerometer (i.e., an accelerometer that measures acceleration across three axes; Green et al., 2016) and one study (5.9%) used a Nike SportKit with a supplemental sensor (i.e., an activity tracking device based on pedometer technology; Wack et al., 2014).

Intervention Components

Across the 17 studies, 16 (94.1%) employed a multicomponent, packaged intervention containing at least three intervention components (range, 3–6 components). Figure 2 depicts the intervention components used in each study. Because a multicomponent intervention was used in approximately 94% of studies, the efficacy of each intervention component—and the degree to which it is responsible for the reported behavior change—is unknown. Thus, for the purposes of this review, intervention components have been classified into two broad categories: incentive-based interventions (e.g., monetary incentives) and non-incentive-based interventions.

Incentive-Based Intervention Components

Seven of 17 studies (41.2%) used an incentive as part of their intervention package (Andrade et al., 2014; Donlin Washington et al., 2014; Donlin Washington et al., 2016; Kurti & Dallery, 2013; Li et al., 2019; Nastasi et al., 2020; Stedman-Falls & Dallery, 2020). I have categorized the results based on the type of incentive procedure employed. However, it is important to note that all seven studies using an incentive-based component were part of a packaged intervention that contained two or more intervention components.

Prize Draws. Three studies (17.7%) used a prize-draw-based incentive (Andrade et al., 2014; Donlin Washington et al., 2014; Li et al., 2019). In each study, the prize draw consisted of a probabilistic, incentive-based procedure wherein participants could earn entries into a lottery for rewards of varying magnitudes contingent upon meeting a target goal. For example, Donlin Washington et al. (2014) evaluated the effects of a prize-draw intervention to increase the physical activity of 15 college students. The researchers made prize-draw entries contingent on either wearing the Fitbit (phase A) or meeting a performance-based criterion (i.e., having a step count greater than the 5th highest day from preceding 7 days; phase B). Overall, the researchers found the prize-draw intervention was effective at increasing physical activity, with eight participants demonstrating moderate to strong effects based on visual analysis. Moreover, the prize draw and pool of potential consequences—which consisted of praise (50%), small prizes (worth up to $5; 42%), medium prizes (worth up to $15; 5%), large prizes (worth up to $50; 2%), and a jumbo prize (worth up to $120; 1%)—was found to be a low-cost intervention, totaling $126 (i.e., $12.60 per person).

Andrade et al. (2014) evaluated the effectiveness of a probabilistic reinforcement-thinning schedule on maintaining increased levels of walking per day. Prior to the primary experimental manipulation, participants took part in an initial fixed-interval monitoring-plus-reinforcement condition for three weeks. During this condition, participants had the opportunity to earn one probabilistic prize draw for each day they walked more than 10,000 steps, along with bonus draws contingent on meeting consecutive target step goals. Following this condition, 61 adults were assigned to either a monitoring-only (n = 30) or monitoring-plus-reinforcement-thinning condition (n = 31). Whereas the monitoring-only condition consisted primarily of a $5 gift card for attending meetings, in the reinforcement-thinning condition participants could also earn prize draws for walking more than 10,000 steps daily; the reinforcement-thinning component consisted of reducing the probability of scheduling a meeting to review their performance by 50% every 4 weeks. In general, results showed greater walking and a higher percentage of days meeting the daily target goal of 10,000 steps for participants in the reinforcement-thinning group (82.6%) when compared to the monitoring-only group (55.3%)

over the 12-week intervention period. Both groups, however, were found to have similar daily step counts at a 24-week follow-up.

Token Economy. Two studies (11.8%), both of which were conducted with adults with intellectual and developmental disabilities, employed a token economy wherein tokens earned for meeting a target goal could be exchanged for tangible rewards (Li et al., 2019; Nastasi et al., 2020,. In Nastasi et al. (2020), for example, participants could earn tokens that were exchangeable for various items, including a lunch at a restaurant, shopping outings, or a trip to an amusement park. The researchers found an increase in the target behavior of daily step counts for three of four participants, with step count increases ranging from 88% to 168% above baseline averages. This is similar to the findings of Li et al. (2019), where the researchers observed an increase in daily step counts for three of four participants during the prize draw and token economy intervention conditions.

Monetary Reinforcement. Three studies (17.7%) evaluated the effects of monetary incentives on physical activity (Donlin Washington et al., 2016; Kurti & Dallery, 2013, study 1; Stedman-Falls & Dallery, 2020). All three studies used a contingency-management procedure where earning the incentive was contingent on meeting a target goal. Although all three studies used monetary incentives, each study differed in the putative function of the monetary incentive. Specifically, there was variation regarding how each study arranged for the incentive to function, that is, as a positive or negative reinforcer.

Kurti and Dallery (2013) evaluated the effects of monetary incentives as a component of a broader, internet-based packaged intervention that also included self-monitoring, goal setting, and feedback. The primary experimental manipulation was the inclusion of monetary incentives—a putative positive reinforcing consequence—for meeting target goals, which was only included in study 1. In this study, the magnitude of the incentive varied based on the target goal and participant performance. Specifically, the amount of the monetary incentive was titrated to the target goal, wherein the dollar amount was equated to the target step goal as measured by steps in the thousands (e.g., meeting a step goal set between 2,000 to 2,999 steps resulted in $2). In addition, participants could earn a $3 bonus by meeting the performance criterion to advance to a new goal. Overall, the internet-based intervention was successful in increasing daily step counts, both as a stand-alone intervention (study 2) and when combined with a monetary incentive (study 1). However, the monetary incentive produced a larger effect (i.e., an 80%–256% increase) than no monetary incentive (i.e., an 8%–186% increase) when compared to baseline averages of step counts per day.

The remaining two studies using monetary incentives included deposit contracts as part of their intervention (Donlin Washington et al., 2016; Stedman-Falls & Dallery, 2020). Stedman-Falls and Dallery (2020) evaluated the effects of two modalities of deposit contracts—technology-based versus in-person—on participant performance. Across both conditions, participants were asked to deposit 100% of the potential earnings (i.e., the entire deposit contract amount). All deposits were provided by participants on a weekly basis. In the technology-based deposit condition, participants deposited $10 electronically via PayPal using a smartphone. In the in-person condition, participants deposited $10 in cash as part of an in-person meeting. Both deposit-contract procedures increased daily step counts by over 2,400 steps per day, with minimal differences in the efficacy and acceptability between the two deposit modalities.

Donlin Washington et al. (2016) evaluated deposit matching as one way to enhance resource efficiency. To do so, 19 participants were randomly assigned to one of two conditions, either a no-deposit or deposit-matching condition. All participants had the opportunity to earn up to $50 throughout the intervention. However, those in the deposit-matching group had to provide half of the total potential earnings (e.g., $25). Thus, the net total that a participant could earn in the no-deposit condition and deposit-matching groups was $50 and $25, respectively. The procedures and experimental design were the same across both groups—an ABA (i.e., reversal) design with the B phase being the intervention that consisted of daily goal setting and daily monetary incentives. Across both groups, participants could earn $1.50 per day by meeting their target goal and a bonus of $2.65 for meeting their target goal on three consecutive days. The researchers found similar results across both the no-deposit and deposit-matching groups. Moreover, the intervention increased physical activity for the majority of participants, with 14 participants increasing their average daily step count by at least 2,500 steps during the intervention across both experimental conditions.

Non-Incentive-Based Components

Seventeen studies (100%) used a non-incentive-based component as part of their intervention package. Of the non-incentive-based intervention components, three were used in a majority of studies included in this review: feedback, goal setting, and self-monitoring. The most frequently implemented intervention package was a combination of self-monitoring, goal setting, and feedback, which was used in 10 studies (58.8%; Donlin Washington et al., 2016; Junaid et al., 2020; Kurti & Dallery, studies 1 & 2; Li et al., 2020; Normand, 2008; Stedman-Falls & Dallery, 2020; Valbuena et al., 2015; Van Wormer, 2004; Zarate et al., 2019). The six remaining studies (35.3%) used a packaged intervention that included some combination of these three components (e.g., self-monitoring and feedback, goal setting and feedback; Andrade et al., 2014; Donlin Washington et al., 2014; Green & Dallery, 2019; Green et al., 2016; Nastasi et al., 2020; Wack et al., 2014).

Feedback. The most commonly implemented intervention component across studies was feedback, which was used in 15 studies (88.2%; Andrade et al., 2014; Donlin Washington et al., 2016; Green & Dallery, 2019; Green et al., 2016; Junaid et al., 2020; Kurti & Dallery, 2013, studies 1 & 2; Li et al., 2019; Nastasi et al., 2020; Normand, 2008; Stedman-Falls & Dallery, 2020; Valbuena et al., 2015; Van Wormer, 2004; Wack et al., 2014; Zarate et al., 2019). In general, feedback refers to providing an individual with information about their performance that allows them to adjust their performance in the future (Alvero et al., 2001; Daniels & Daniels, 2009; Prue & Fairbank, 1981). Across the studies, the type and dimensions of feedback varied, most notably, with respect to the feedback type (e.g., graphical, textual), modality (e.g., text message, email; in person), and frequency (e.g., daily, weekly). Of the feedback combinations, one employed commonly was the delivery of textual information on a daily schedule via text message. Donlin Washington et al. (2016), for example, provided participants with the opportunity to select their preferred feedback modality among three options: email, text message, and phone call. Of the 19 participants, the 16 chose text messaging, followed by email ($n = 2$) and a phone call ($n = 1$). The content of this feedback consisted of textual information regarding whether the daily step goal was met and the amount of money a participant did or did not earn based on their performance.

Two studies also delivered more than one type of feedback, each of which may or may not have been delivered on different feedback schedules (Normand, 2008; Wack et al., 2014). For example, Normand (2008) provided participants with two different types of feedback. The first type was daily textual feedback, delivered via email, in which information was provided on whether a target goal was met (i.e., goal attainment). The second type was weekly vocal and graphic feedback, delivered in-person, during a meeting to review performance.

Goal Setting. Goal setting was a frequently implemented intervention component found in 14 studies (82.4%; Donlin Washington et al., 2014; Donlin Washington et al., 2016; Green et al., 2016; Junaid et al., 2020; Kurti & Dallery, 2013, studies 1 & 2; Li et al., 2020; Nastasi et al., 2020; Normand, 2008; Stedman-Falls & Dallery, 2020; Valbuena et al., 2015; Van Wormer, 2004; Wack et al., 2014; Zarate et al., 2019). In general, three different types of goal setting procedures were implemented: goal setting using percentile schedules, goal setting via a standardized percentage increase, and goal setting using a predetermined performance criterion.

Goal setting using percentile schedules was implemented in six studies (Donlin Washington et al., 2014; Donlin Washington et al., 2016; Kurti & Dallery, 2013, studies 1 & 2; Nastasi et al., 2020; Valbuena et al., 2015). Broadly, this procedure involved creating a target goal based on performance during a predetermined observation period (e.g., a four-day block of observations), along with using a predetermined percentile benchmark (Donlin Washington et al., 2016). In addition, there may have also been a requirement to meet the target goal on a set number of days in the observation period. Across studies, the number of days in an observation block varied, ranging from 5 days to 10 days. With respect to the percentile benchmark, a frequently used metric was to approximate the 70^{th} percentile, which has been recommended as a percentile goal that is both achievable and likely to increase the target behavior (Donlin Washington et al., 2016; Galbicka, 1994). For example, Kurti and Dallery (2013) implemented a 5-day observation period wherein participants had to meet or exceed their target step goal on at least three of those days. Target step goals were set to either the fourth-highest step count (i.e., 80^{th} percentile) or a 1,000 step increase from the previous observation block. This goal-setting procedure was implemented until a participant achieved the terminal goal of 10,000 steps per day for at least three of five days in two 5-day observation blocks.

Four studies implemented a goal setting procedure wherein target goals were set using a standardized percentage increase (Junaid et al., 2020; Li et al., 2020; Zarate et al., 2019) or via an averaging of performance (Normand, 2008). Across all studies, a performance average was calculated over a preset observation period, which ranged in length from 2 days to 7 days. Then, a new target goal was set for the next observation period, either to the average from the previous observation period (Normand, 2008) or to a predetermined percentage increase above that average (e.g., 10% increase for current observation period; Junaid et al., 2020; Li et al., 2020; Zarate et al., 2019). For example, to determine the target distance for a weekly observation period during intervention, Zarate and colleagues (2019) calculated the mean from the previous two weeks and set a new target goal at a 10% increase from that mean. Finally, one study (Stedman-Falls & Dallery, 2020) used a predetermined performance criterion as their target step goal wherein the target goal was set at 2,000 steps higher than a participant's average baseline performance.

Self-Monitoring. Thirteen studies (76.5%) included self-monitoring as an intervention component (Andrade et al., 2014; Donlin Washington et al., 2014; Donlin Washington et al., 2016; Green & Dallery, 2019; Junaid et al., 2020; Kurti & Dallery, 2013, studies 1 & 2; Li et al., 2019; Normand, 2008; Stedman-Falls & Dallery, 2020; Valbuena et al., 2015; Van Wormer, 2004; Zarate et al., 2019). Although the way in which self-monitoring was implemented varied, there were two commonly used procedures. One procedure was to directly manipulate self-monitoring as an independent variable, which occurred in four studies (Normand, 2008; Valbuena et al., 2015; Van Wormer, 2004; Zarate et al., 2019). To restrict the opportunity to self-monitor during baseline, researchers covered the accelerometer or pedometer with tamperevident tape. This tape was subsequently removed during the intervention, thereby providing the participants with the opportunity to self-monitor their behavior.

The second approach, which was used in seven studies, had participants record or report their step count data (Andrade et al., 2014; Donlin Washington et al., 2014; Donlin Washington et al., 2016; Junaid et al., 2020; Kurti & Dallery, 2013, studies 1 & 2; Li et al., 2019). Among these, several studies asked participants to record their step count at the end of the day, then report this step count to the experimenter. For example, as part of their self-monitoring procedure, Kurti and Dallery (2013) had participants submit a daily step count total both textually and via a video submission. Other studies asked participants to report their daily step count total, either via text message or email (Donlin Washington et al., 2014; Donlin Washington et al., 2014; Normand, 2008). Finally, Junaid et al. (2020) implemented a self-monitoring procedure in which participants completed two components—recording their daily performance in an activity log and graphing their performance on a standard celeration chart.

Experimental Designs

Figure 3 depicts the types of, and aggregated totals for, each type of experimental design employed. Because a study could use more than one type of component in its experimental design, these data are discussed in relation to the most frequently implemented design components. Across studies, the most frequently implemented experimental design was a multiple baseline design across participants, which was implemented in eight studies (Green & Dallery, 2019; Green et al., 2016; Junaid et al., 2020; Normand, 2008; Sofis et al., 2017; Valbuena et al., 2015; Wack et al., 2014; Zarate et al., 2019), followed by seven studies employing a changing criterion design (Kurti & Dallery, 2013, studies 1 & 2; Nastasi et al., 2020; Wack et al., 2014; Washington et al., 2014; Washington et al., 2016; Zarate et al., 2019) and seven studies employing a reversal design (Junaid et al., 2020; Li et al., 2019; Normand, 2008; Stedman-Falls & Dallery, 2020; Van Wormer, 2004; Washington et al., 2014; Washington et al., 2016). Analysis of the experimental methods also indicated that a plurality of studies (*n* = 11; 61.1%) used a combination of design components. For example, of the eight studies that used a multiple baseline design, four (50%) also included at least one additional methodological component in their experimental designs, such as a changing criterion (*n* = 2) and a reversal (*n* = 2) component.

Social Validity

Ten studies (58.8%) collected social validity data (Green & Dallery, 2019; Junaid et al., 2020; Kurti & Dallery, 2013, studies 1 & 2; Li et al., 2019; Normand, 2008; Stedman-Falls & Dallery, 2020; Valbuena et al., 2015; Wack et al., 2014; Zarate et al., 2019). In general, social validity was assessed in two ways—intervention acceptability (i.e., appropriateness of the procedures) and intervention effectiveness (i.e., importance of treatment effects; Wolf, 1978). In addition, researchers also solicited participant feedback on the activity tracker (e.g., acceptability, ease of use) and the time required to participate in the study. With respect to social validity modalities, all ten studies collected data via questionnaires; these ranged in length from four to 16 questions and used various question types, including yes/no questions, Likert-type (e.g., 1-5, disagree to agree) questions, and open-ended questions. The most frequently implemented question type was a Likert-type question, which was used in eight studies.

Maintenance

Two of the 17 studies (11.8%) included in this review assessed maintenance of the behavior over time (i.e., follow-up; Andrade et al., 2014; Van Wormer, 2004)). Follow-up step count data in Van Wormer (2004) were collected for one day, approximately six months after the end of the study. At this follow-up, performance of two of three participants was observed to be similar to their performance during the intervention, and thus, suggestive of maintenance of the intervention effects over time. In Andrade et al. (2014), evaluating maintenance was a primary purpose of the study; specifically, the researchers evaluated the degree to which a reinforcement-thinning schedule impacted performance at follow-up probes conducted approximately 9 weeks after the end of the intervention. When comparing follow-up performance between the two groups (i.e., self-monitoring only vs. self-monitoring plus reinforcement thinning), the researchers found no statistically significant difference in performance; this finding differed from the results during the intervention (i.e., randomization) condition, where a difference between the two groups was observed (both statistically and via visual inspection) at the aggregate level.

Discussion

Developing effective interventions to address physical inactivity and sedentary behavior is a socially significant area of research. Behavior analysis, with its rich history identifying effective interventions to produce meaningful behavior change, has much to offer in this respect. The purpose of this review has been to highlight research published in behavior-analytic journals examining physical activity and sedentary behavior with adults. In doing so, I have sought to describe (a) the different types of intervention components and how they have been implemented across studies; (b) target behaviors and how they are measured; (c) the various types of experimental designs; and (d) other significant variables, including the assessment of social validity and long-term maintenance. To my knowledge, this is the first review to systematically evaluate interventions targeting physical activity and sedentary behavior with adults within behavior analysis.

The last decade has seen an increase in the number of published studies targeting physical activity and sedentary behavior in behavior-analytic journals (see Figure 4). Although speculative, this growth corresponds with technological advancements in wearable technologies and, more specifically, the opportunity to collect overt measures of behavior in real-world (i.e., free living) settings. During this time, wearable technologies have progressed from pedometers with limited features and storage capabilities (e.g., a memory storage of 7 days; Normand, 2008) to the accelerometers and smart watches on the consumer market today (e.g., Fitbit Charge 4®, Apple Watch® series 6). This transition from pedometers to more sophisticated wearable technologies can also be seen across studies when assessing device type by publication year (see Table 2). Specifically, pedometers were used in some of the earlier studies (e.g., Normand, 2008; Van Wormer, 2004) included in this review, with 13 of 15 studies since 2013 using an accelerometer-based device (e.g., Fitbit, Actigraph).

Approximately 21% of adults in the U.S. now regularly use a wearable activity tracker (e.g., smart watch, Fitbit; Pew Research Center, 2020). Moreover, the market for consumer-grade activity trackers is projected to continue to see double-digit growth each year through 2024, as it did from 2019 to 2020 when there was an increase from 346 million units sold to 396 million units sold, respectively (International Data Corporation, 2020). Prior to the advent of wearable technologies, the majority of the extant literature examining physical activity was collected via self-report (Dowd et al., 2018; Sallis & Saelens, 2000). As such, there may be questions regarding these findings and their implications, given the potential threats to validity and reliability of data collected via self-report (Ainsworth et al., 1994). The relatively recent emergence of wearable activity trackers may also explain the paucity of research published in behavior-analytic journals prior to the last two decades. Specifically, although no restriction was placed on publication year, the earliest study that met all the inclusionary criteria for this review was published in 2004.

As an alternative to self-report, activity trackers allow for data to be collected in real-time, remotely, and in a non-obtrusive way (i.e., via a device that is commonly worn either on the wrist or hip). When combined with technology- or internet-based interventions, it is then possible for all aspects of the study to be conducted remotely (Dallery et al., 2015). This may remove geographic barriers to participation, which would be advantageous both to researchers and potential participants. For example, a remote intervention opens the opportunity for participation from a broader participant pool. In addition, it may also enhance the ability for researchers to improve physical activity and sedentary behavior when in-person interactions might be restricted, limited, or non-preferred by participants, such as during the COVID-19 pandemic. However, there are still potential threats to the validity and reliability of data collected via wearable activity trackers. For example, one potential threat to validity is participant verification (i.e., user authentication; Donlin Washington et al., 2014; Kurti & Dallery, 2013). Although unlikely, unless verified, a participant could provide their activity tracker to another individual. In addition, most studies are conducted in the natural environment, which may limit the types of procedural checks that can be used to help control for this potential threat (e.g., periodic check-ins; video logs). As such, researchers must seek to balance threats to validity, while also taking into consideration variables like intrusiveness and how the procedures might impact the independent variable under investigation.

With respect to the findings of this review, feedback was the most frequently implemented intervention component, employed in 15 of 17 studies (88.2%). Across studies, feedback varied in its characteristics (Alvero et al., 2001), including how it was delivered (i.e., medium; e.g., textual, verbal), how often it was delivered (i.e., frequency; e.g., daily, weekly), and the modality in which it was delivered (e.g., text message, email). One manipulation of feedback less-frequently discussed, however, was the feedback source (i.e., who or what delivered the information to the participant; Alvero et al., 2001). Interestingly, the results of Valbuena et al. (2015) showed a greater increase in daily step counts when tailored feedback was provided by a behavioral coach as part of a weekly coaching meeting than automated feedback provided by the Fitbit device. Thus, one potential area of investigation for future researchers is to assess the role of the feedback source on participant performance. Ensuring that the feedback was received by the participant is another important variable when evaluating the efficacy of an intervention (e.g., Green & Dallery, 2019), especially when the feedback is a key component of the intervention. As such, future researchers might also evaluate the degree to which requiring a participant response to the feedback impacts performance, particularly when delivered in an electronic format (e.g., text message, email). Such a requirement might be advantageous, as it may better ensure that the feedback was received by the participant (i.e., implemented as intended), and thus, promote intervention integrity.

Goal setting was the second most frequent intervention component employed, used in 14 studies (82.4%). The findings of this review suggest goal setting is an integral intervention component for producing behavior change when targeting physical inactivity and prolonged or excessive sedentary time. This finding is convergent with studies outside the behavior-analytic literature, where goal setting is also a commonly used intervention. In fact, the National Institute for Health and Care Excellence (2014) recommends that, given its efficacy, goal setting be used in all behavioral interventions. In a meta-analysis evaluating goal setting for physical activity, McEwan et al. (2016) found a medium-sized effect (d = .55) for goal setting when used in a multicomponent intervention. Specifically, the researchers found a positive effect for goal setting regardless of the type of goal (i.e., absolute [e.g., 10,000 steps per day] and relative [e.g., 10% increase]) or the source of the goal (e.g., experimenter, participant), as well higher efficacy for daily target goals when compared to weekly target goals.

The two most common goal-setting procedures used across studies were shaping using percentile schedules and a standardized percentage increase, with both shown to be a part of effective intervention packages. Both goal-setting procedures provide a mechanism for identifying goals that are feasible and likely to improve performance, whether to increase the rates of a desirable behavior (i.e., physical activity) or decrease the rates of an undesirable behavior (i.e., sedentary time). In addition to the type of goal-setting procedure, the length of the observation block (i.e., goal setting period) is another important variable that may impact efficacy. Across studies, a typical observation block was approximately five days; however, different lengths of observation blocks were also employed, ranging from two to 10 days. Taken together, these results suggest various combinations of goal-setting procedures and block lengths for potential use. One direction for researchers might be to expand upon these findings by identifying best practices for goal-setting procedures and the conditions under which each type of procedure may be most effective (i.e., when to use a percentage increase or a percentile schedule). These results also align with the recommendations of Hartmann and Hall (1976) regarding effective implementation of a changing criterion design, within which goal setting is of the utmost importance. Specifically, Hartmann and Hall note how researchers must be flexible and adapt their procedures to allow for effective demonstrations of experimental control, while also considering the myriad of critical variables (e.g., response variability, magnitude of behavior change, length of treatment phase) upon which it is impacted.

Self-monitoring was included as an intervention component in 13 studies (76.5%). As noted by Cooper et al. (2020), self-monitoring is most often included as part of a multicomponent intervention package along with some combination of feedback, goal setting, and reinforcement, as opposed to being used a standalone intervention; this corresponds with findings of this review. The two most frequent types of self-monitoring procedures found across studies were the direct manipulation of the opportunity to observe one's own behavior—via feedback from the activity tracker—and the self-reporting of one's behavior. Activity trackers seem to be particularly well-suited for self-monitoring physical activity and sedentary behavior, as they are simple to use, independently collect data on important dimensions of various target behaviors (e.g., step counts, calories burned), and allow for each occurrence of the behavior to be recorded via permanent product recording (Cooper et al., 2020). More broadly, research on the efficacy of self-monitoring to improve physical activity as a standalone intervention is mixed, with some studies finding an intervention effect, others finding no intervention effect, and others finding a transient (i.e., short-term) effect (Cadmus-Bertram et al., 2015; Page et al., 2020). Nonetheless, self-monitoring may be a particularly advantageous intervention component to include when measuring physical activity and sedentary behavior via activity trackers, as it requires minimal response effort and may improve performance, even if only in the short-term (Cadmus-Bertram et al., 2015).

The results of this review suggest that providing monetary incentives to meet a target goal is an effective intervention component when included as part of a multicomponent intervention package. Of the studies using a monetary incentive, only two, Kurti and Dallery (2013) and Washington et al. (2016), evaluated the impact of different incentive arrangements on participant performance. Kurti and Dallery (2013) examined the impact of monetary incentives by providing incentives in study 1 and not in study 2; as such, this was the only study to assess the delivery and non-delivery of an incentive of those included in this review. In doing so, the researchers observed a larger intervention effect for participants who earned a monetary incentive (study 1) than those who did not (study 2), with a median increase of 182% (range, 80%–256%) and 108% (range, 8%–186%), respectively, when compared to baseline averages. When evaluating incentives delivered with and without a deposit matching component, Donlin Washington et al. (2016) found a small—but not statistically significant—difference for meeting step count goals between the two conditions. Although effective, one limitation of providing monetary incentives is their cost. Thus, the adoption of monetary incentives as an intervention component in real-world settings may be limited.

There are, however, several potential ways to decrease the cost of providing monetary incentives, including through the use of deposit contracts. In this review, two studies (Donlin Washington et al., 2016; Stedman-Falls & Dallery, 2020) included deposit contracts wherein participants were responsible for contributing all or some of the potential earnings they could earn throughout the intervention. In both, the deposit contract involved the presentation of a reinforcing consequence (i.e., money) that was delivered contingent on meeting a target goal. Broadly speaking, a deposit contract may vary in its function, depending on how it is implemented. That is, although a deposit contract involves the delivery of a putative reinforcing consequence, the function of the behavior (e.g., meeting a target goal) may vary under different conditions. For example, a deposit contract may vary in the degree to which the participant is responsible for contributing to the deposit contract amount, from being responsible for a small amount of the total potential earnings (e.g., 5%) to being responsible for depositing half of the potential earnings (i.e., deposit matching; 50%) to being responsible for depositing the entirety of the potential earnings (e.g., 100%). Thus, under the latter context for example, a participant may hypothetically be working to meet a target goal to avoid the loss of a reinforcer, as opposed to strictly gaining access to a positive reinforcer.

The results of Donlin Washington et al. (2016) and Stedman-Falls and Dallery (2020) suggest that deposit contracts and deposit matching may be one way to enhance financial resource efficiency when using monetary incentives. However, more research is needed that replicates and extends the generality of these findings. One interesting line of research might be to evaluate varying levels of deposit contracts in a parametric analysis and their effects on physical inactivity and sedentary behavior. For example, future researchers may evaluate deposit contracts where participants are responsible for a small amount (e.g., 10%), half the amount (50%), and the full amount (100%) of potential earnings. Such a line of investigation may be of particular importance to applied research that seeks to balance meaningful behavior change and resource efficiency.

An interesting finding of this review was that only two studies (11.8%) collected and reported data on the maintenance of intervention effects. This suggests the need for more research examining the long-term follow-up of all the intervention components and packages discussed herein. Future researchers interested in extending this body of research and assessing performance over extended periods of time may look to other areas of the behavior-analytic literature to identify potential maintenance procedures. For example, researchers could thin the schedule of reinforcement (Andrade et al., 2014) by systematically reducing a dimension of the reinforcer over time. In doing so, researchers could use probabilistic rewards, wherein the probability of obtaining an incentive is systematically reduced while still maintaining performance. Future researchers might also evaluate lottery- or prize-based contingency management procedures, which have been shown to be effective and also help reduce costs (Donlin Washington, 2014). Finally, researchers might employ a dynamic fading procedure (DiGennaro et al., 2005), wherein reinforcement could not only be thinned when performance maintains, but also return to a previous schedule if a performance decrement is observed.

The finding that few studies collected maintenance data also corresponds with the extant physical activity literature, where there is support for the short-term efficacy of behavioral interventions, but less support for long-term maintenance (Murray et al., 2017). Although similar in many respects, one notable difference between these two bodies of literature is their theoretical orientation—that is, the conceptual underpinnings through which behavior change is evaluated—which may be a variable that directly impacts maintenance. For example, much of the extant physical activity literature is based on a social cognitive framework (Bandura, 1991). As such, maintenance of a behavior or the lack thereof may be attributed to a deficit in intrinsic motivation or self-regulation (Anderson et al., 2006). This differs from a behavior-analytic framework, where maintenance would be discussed in relation to the environmental variables controlling behavior (i.e., its antecedents and consequences; Skinner, 1953). Thus, the former may implement an intervention to teach self-regulation skills (e.g., action planning), whereas the latter may look to identify the contingencies controlling behavior and design an intervention to address those environmental barriers (e.g., generalization to natural maintaining contingencies; Stokes & Baer, 1977).

From a behavior-analytic perspective, physical inactivity and sedentary behavior may be conceptualized as a behavioral deficit (i.e., too little of a behavior) and as a behavioral excess (i.e., too much of a behavior), respectively. Using this conceptualization, it is possible to (a) identify the function of the behavior and (b) design an intervention to alter the environmental conditions (e.g., stimuli) surrounding it, either before its occurrence (i.e., an antecedent manipulation), after its occurrence (i.e., a consequence manipulation), or in some combination thereof. In addition, a behavior-analytic approach corresponds with the findings of the extant literature on interventions to address physical activity, which has shown (a) behavior-based interventions (e.g., goal setting, rewards) to be more effective than cognitive-based interventions (e.g., health education) and (b) individual-level interventions to be more effective than community-level interventions (Conn et al., 2011). This is similar to the findings of Rhodes et al. (2017), where goal setting, performance feedback, and self-monitoring were shown to be among the most promising intervention components. Thus, the extant literature suggests convergent findings to those of this review and the behavior-analytic literature more broadly, where behavioral interventions (e.g., goal setting, performance feedback) have been shown to have a robust and positive effect on a wide range of behaviors.

One potential limitation of this review is its inclusionary criterion of only examining studies conducted with adult populations. Because the participant sample was restricted to this population, the current findings and their implications may not be representative of all the types of interventions used to target physical activity and sedentary behavior within the field of behavior analysis. Thus, one direction for future researchers is to conduct a review of studies in behavior analysis targeting physical activity and sedentary across the age continuum. In doing so, researchers may also be able to examine how the results of this review compare to those conducted with child and adolescent populations.

Another limitation is the relatively limited scope of potential journals from which articles were reviewed. The primary purpose of this review was to better understand the literature within behavior analysis, by specifically evaluating the research published in behavior-analytic journals.

As such, this review is not intended to be a comprehensive review of the entire physical activity and sedentary behavior literature. Finally, 94% of studies included in this review employed packaged interventions, thereby limiting the opportunity to quantify the efficacy of individual intervention components. Although speculative, this finding may be a result of multicomponent interventions being more effective the single-component interventions; if so, then this result would correspond with the findings and recommendations of the extant physical activity literature regarding the use of multicomponent interventions (e.g., Rhodes et al., 2017).

In this review I have sought to summarize the behavior-analytic literature regarding interventions—as well as their respective variations—for increasing physical activity and decreasing sedentary behavior with adults. By better understanding the current state of the literature, future research might expand upon these findings to create powerful, socially significant interventions that improve the lives of individuals and their physical health.

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Table 1

Behavior-analytic journals included in the review, and the number of articles published by each journal

Journal Title	*# of Articles (n)*
Journal of Applied Behavior Analysis	*7*
Perspectives on Behavior Science	*0*
Behavior Analysis in Practice	*2*
Journal of Organizational Behavior Management	*1*
Behavior Modification	*1*
Behavior Analysis: Research and Practice	*1*
Behavioral Interventions	*3*
Journal of the Experimental Analysis of Behavior	*0*
Behavioral Processes	*0*
Behavior and Social Issues	*0*
The Psychological Record	*0*
Translational Issues in Psychological Science	*1*

Table 2

Study characteristics for each article, organized alphabetically

Study	Participants	Design	Dependent variable	Measurement Tool	Intervention	Maint enance	Social Validity	Results
Andrade, Barry, Litt, & Petry (2014)	61 adults (55 female; 6 male)	Multiple treatments comparison design	Percentage of days walked with ≥ 10,000 steps; step counts/day	Pedometer (device not listed)	Part 1 - fixed interval monitoring plus monetary reinforcement; Part 2 - comparison of self-monitoring (n = 30) to self-monitoring plus reinforcement thinning on a variable interval schedule (n = 31)	Yes	No	The self-monitoring plus reinforcement thinning condition was shown to produce, on average, a higher percentage of days meeting the 10,000-step count/day goal (82.6%) than the self-monitoring only (55.3%) condition during maintenance. However, no difference was observed between the groups at a 24-week follow up (i.e., 9 weeks post-intervention).
Donlin Washington, Banna, & Gibson (2014)	10 adults (6 female; 4 male)	ABA reversal with a changing criterion	Daily step count totals (i.e., step counts/day); number of target goals met	Fitbit accelerometer (device not listed)	Goal setting, prompts, and prize draws; prize draws (100 raffle tickets) via lottery; Conditions: (1) baseline - 50% tickets with verbal praise and 50% of tickets for prize < $5; (2) intervention - (a) goal setting using percentile schedule, (b) prize draws with 50% praise, 42% small prize, 5% up to $15, 2% up to $50, 1% up to $120	No	No	Per the author's visual analysis, 4 participants demonstrated a clear increase in daily step count during the intervention, with an average increase of 4,387 steps/day; 4 additional participants showed a moderate improvement in daily step count, with an average increase of 2,845 steps/day.

Donlin Washington, McMullen, & Devoto (2016)	19 sedentary adults (16 female; 3 male)	ABA reversal with a changing criterion; B condition: 2 groups (incentive vs. deposit contract)	Daily step count totals (i.e., step counts/day); goal achievement	Fitbit 1 accelerometer	Goal setting, prompts, performance feedback, and incentives; Incentives: $1.50 per day for meeting step goal and $2.65 bonus for meeting step goal 3 consecutive days; conditions: (1) monetary incentives - opportunity to earn $50; (2) deposit contract - opportunity to earn $50, deposit 50% ($25) of potential earnings	No	No	Overall, participants increased their daily step counts by 47% (3,050 steps/day); 14 participants increased step counts/day by 2,500 steps. Per the author's visual analysis, 6 participants demonstrated a clear increase in daily step count in the no-deposit condition, meeting 77.7% of target step goals during the intervention; 5 participants demonstrated a clear increase in daily step count in the deposit condition, meeting 70.9% of target step goals during the intervention.
Green & Dallery (2019)	8 office workers (6 female; 2 male)	Multiple baseline design across participants	Bouts of physical activity (i.e., 30 min intervals with >100 steps); measured as a percentage of intervals	Fitbit Zip	Baseline: education and self-monitoring; intervention: performance feedback, performance feedback plus task clarification	No	Yes	Per the author's visual analysis, an intervention effect was observed for 4/8 participants. One participant met the termination criteria of >80% active bouts over a 5-day period.
Green, Sigurdsson, & Wilder (2016)	3 office workers (3 female)	Concurrent multiple baseline design across participants	Bouts of prolonged sitting (i.e., intervals of sitting > 31 min); each 30 min scored as additional bout	Actigraph GT3X+	Intervention conditions: (1) information about moving; (2) tactile prompt; (3) tactile prompt, performance feedback, and goal setting	No	No	Compared to baseline, all three intervention conditions decreased the number of bouts of prolonged sitting. The tactile prompt, feedback, and goal setting was the most effective condition, decreasing bouts by an average of 41.3% (range, 33%-47%).

Junaid, Bulla, Benjamin, Wind, & Nazaruk (2020)	4 adults (4 female)	Multiple baseline design across participants with ABAB reversal component	Daily step count totals (i.e., step counts/day)	Fitbit Ace	Self-monitoring, goal setting, social media, social feedback, and weekly meetings	No	Yes	An effect was observed for 3 of 4 participants, whose daily step count increased during intervention. The intervention increased daily step counts to > 10,000 steps for 2 participants, and to 8,441 for another participant.
Kurti & Dallery (2013) study 1	6 sedentary adults (5 female; 1 male)	AB design with changing criterion	Daily step count totals (i.e., step counts/day)	Fitbit accelerometer (device not listed)	Goal setting, self-monitoring, feedback, and monetary incentives; changing criterion: steps assessed over 5-day blocks, had to exceed goal on 3/5 days to advance; monetary incentives: approximately $1 for every 1,000 steps/day, $3 bonus for meeting new goal	No	Yes	All 6 participants increased their daily step count during intervention. Participants earned between $56.00 and $102.50. Most participants step count increases were based on the 1,000-step increase. Participants increased steps by a median of 182.2% (range, 80%-255.7%). Participants, on average, met 91% of their goals.
Kurti & Dallery (2013) study 2	6 sedentary adults (5 female; 1 male)	AB design with changing criterion	Daily step count totals (i.e., step counts/day)	Fitbit accelerometer (device not listed)	Goal setting, self-monitoring, and feedback; changing criterion: steps assessed over 5-day blocks, had to exceed goal on 3/5 days to advance	No	Yes	Five of 6 participants increased their daily step count during intervention. Most participants step count increases were based on the 1,000-step increase. Participants increased steps by a median of 108.2% (range, 8.3%-186%). Participants, on average, met 63.3% of their goals.
Li, Curiel, Ragotzy, & Poling (2019)	4 adults with developmental disabilities (2 female; 2 male)	Within-subject reversal design	Daily step count totals (i.e., step counts/day)	Fitbit Zip	Goal setting, changing criterion, feedback, and prize draws via lottery; goal setting of 10% higher than average during baseline and 10% higher than mean of last 2 days where step goal was met	No	Yes	An effect was observed for 3 of 4 participants, whose daily step count increased during intervention.

Nastasi, Sheppard, & Raiff (2020)	4 adults with developmental disabilities (2 female; 2 male)	AB design with changing criterion	Daily step count totals (i.e., step counts/day)	Fitbit Flex	Goal setting, prompting, feedback; token economy; changing criterion: steps assessed over 5-day blocks, had to exceed goal on 3/5 days to advance	No	No	An effect was observed for 3 of 4 participants, whose daily step count increased during intervention. These 3 participants increased their steps by 88%-168% from baseline averages.
Normand (2008)	4 adults (1 female; 3 male)	Multiple baseline design across participants with ABAB reversal component	Daily step count totals (i.e., step counts/day); body weight (i.e., pounds)	New Lifestyles (NL)-2000 pedometer	Goal setting, self-monitoring, and performance feedback; goal setting: daily average from previous week, had to meet target goal for 4 days during week	No	Yes	Three of 4 participants showed an increase in daily step counts during intervention; all 3 of these participants increased steps by > 2,500 steps/day. All 4 participants maintained a similar weight during the course of the study.
Sofis, Carrillo, & Jarmolowicz (2017)	4 adults	Concurrent multiple baseline design across participants	Daily step count totals (i.e., step counts/day)	Fitbit Charge HR	Effort-based physical activity intervention; behavioral coaching	No	No	All four participants increased their daily step count during intervention. The average increase in steps was 1,574 per day, which equated to an average improvement of 18%.
Stedman-Falls & Dallery (2020)	12 adults (9 female; 3 male); 9 adults completed full study (6 female; 3 male)	Within-subject reversal design with an alternating treatments component	Step counts/day; step count goal >2,000 steps/day over baseline	Fitbit Zip	Goal setting, self-monitoring, performance feedback, and monetary deposits; conditions - (1) mobile deposit condition: deposit payment and payment submitted via Paypal; (2) In-person condition: deposit payment and payment submitted in cash in-person	No	Yes	Technology-based deposits were similar in efficacy to in-person deposits, with similar treatment adherence. Technology-based deposits increased steps by an average of 2,490 steps/day over baseline; in-person deposits increased steps by an average of 2,437 steps/day. Participants found both modalities acceptable, with minimal difference between the two modalities.

Valbuena, Miltenberger, & Solley (2015)	7 adults who were overweight (i.e., BMI >25) (6 female; 1 male)	Multiple baseline design across participants	Daily step count totals (i.e., step counts/day); daily body weight (i.e., pounds)	Fitbit one	Conditions: (1) Fitbit web-based program on exercise and weight loss (included self-monitoring, goal setting, feedback, and social support); (2) Fitbit plus behavioral coaching (i.e., video conference 1x per week; goal setting using percentile schedule)	No	Yes	Three of 7 participants increased daily step counts in the Fitbit condition (range, 48.4%-65.6%). However, performance at the end of this condition was on a decreasing trend for 2 participants. All 6 remaining participants increased their daily step count with the incorporation of behavioral coaching and goal setting (range, 10.2%-89.1%).
Van Wormer (2004)	3 adults who were overweight (2 female; 1 male)	Within-subject reversal design with an alternating treatments component	Daily step count totals (i.e., step counts/day); weekly body weight (i.e., pounds)	Yamax Digi-Walker Model SW-200 pedometer	Conditions: (1) self-monitoring; (2) self-monitoring plus e-counseling (step review, goal setting, performance feedback)	Yes	No	All 3 participants increased their daily step count by varying levels, with a mean increase of 93% (range, 14%-144%). Two participants maintained performance at a 1-day 6-month follow-up.
Wack, Crosland, & Miltenberger (2014)	5 adults (5 female)	Multiple baseline design across participants with a changing criterion	Running distance (measured by miles)	Nike SportKit plus sensor pouch	Conditions: (1) daily goal setting plus performance feedback on weekly running distance; had to run 3x per week (2) weekly goal setting plus performance feedback on weekly running distance	No	Yes	Running distance increased for all 5 participants; 2 participants increased their running distance during intervention condition 1. The remaining 3 participants increased their miles run/week when the contingency was changed to intervention condition 2 (i.e., weekly goal setting).

Zarate, Miltenberger, Valbuena (2019)	4 adults (1 female; 3 male)	Multiple baseline design across participants with a changing criterion	Number of intense steps per week (i.e., > 400 steps in a 5-min interval)	Fitbit flex	Goal setting, textual feedback, and prompts; goal setting was set at 10% higher than previous week's mean distance; textual feedback about whether target goal for the week was met; prompt for goal for next week	No	Yes	Per the author's visual analysis, all 4 participants increased their number of intense steps per week during the intervention. Overall, participants met their target goal for a total of 37 times out of 58 opportunities (64%).

Figure 1

Systematic review flow diagram

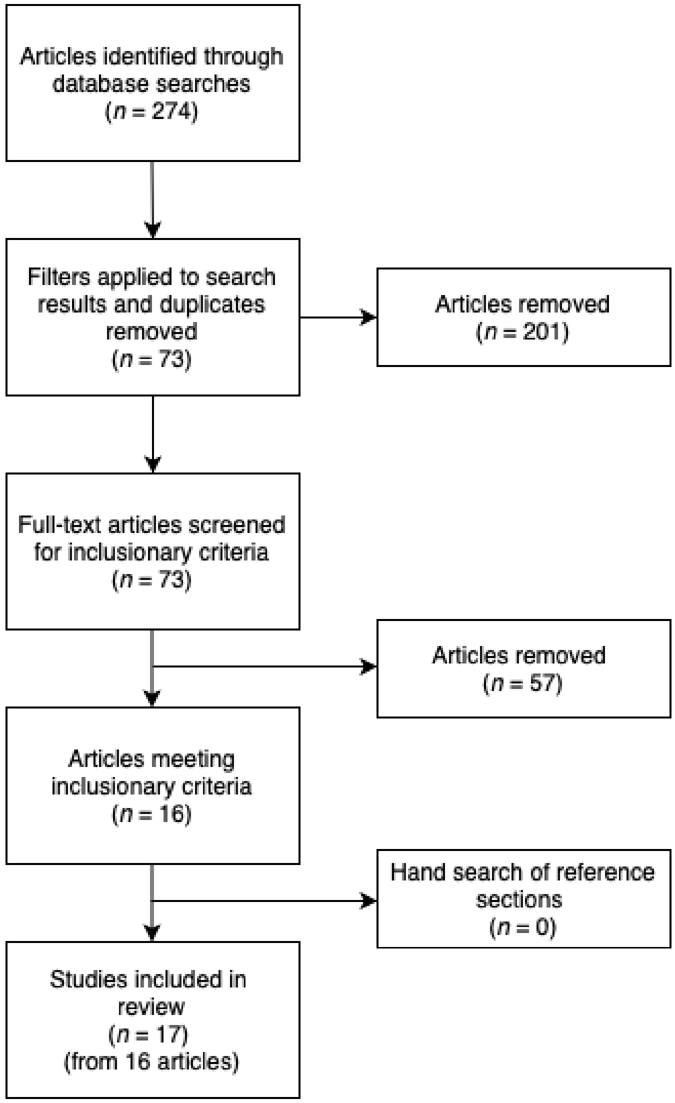


Figure 2

Intervention components included in each study

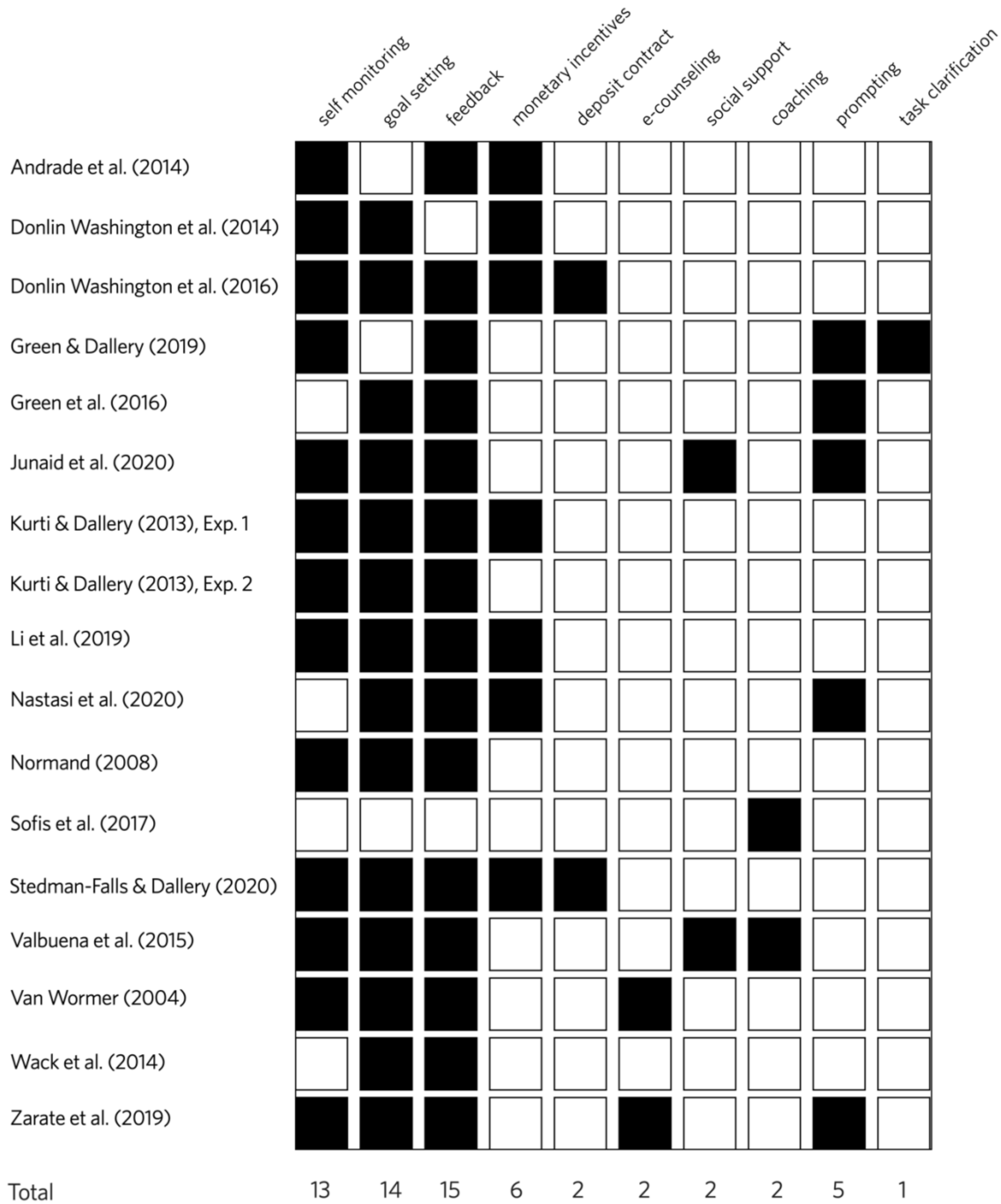


Figure 3

Aggregate totals for each type of experimental design

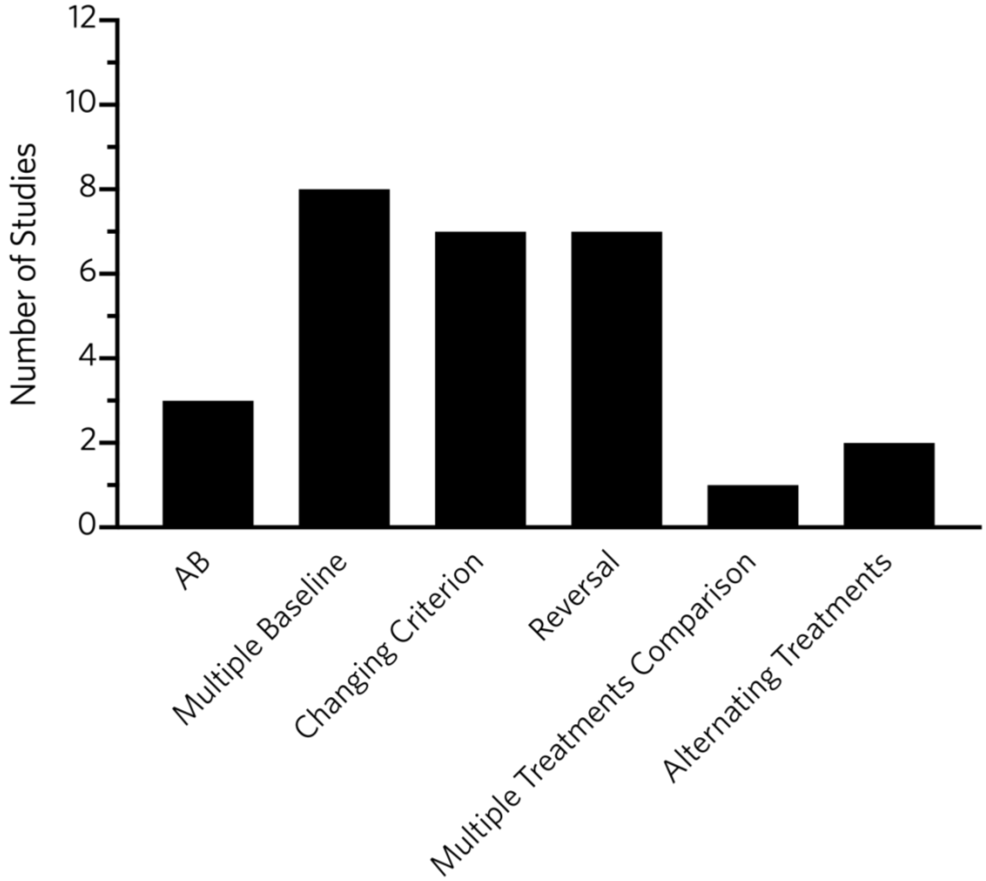
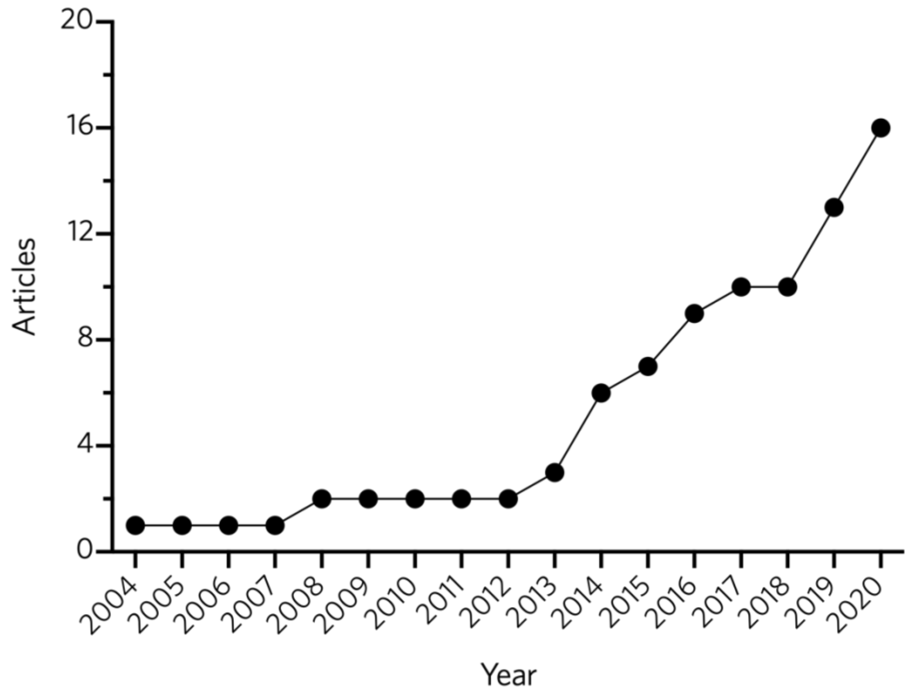


Figure 4

Cumulative number of studies by year



Literature search procedures

Search conducted on 12/12/2020
Database searches

PsycINFO Boolean search:
(physical activity OR sedentary behavior) AND pub.Exact("The Behavior Analyst" OR "Behavior Analysis in Practice" OR "Perspectives on Behavior Science" OR "Journal of Applied Behavior Analysis" OR "Journal of Organizational Behavior Management" OR "Behavior Modification" OR "Behavior Analysis: Research and Practice" OR "Behavioral Interventions" OR “Journal of the Experimental Analysis of Behavior” OR “Behavioral Processes” OR “Behavior and Social Issues” OR “The Psychological Record” OR “Translational Issues in Psychological Science”)

n = 171 articles

Web of Science Boolean search:
TS=(physical activity OR sedentary behavior) AND SO=("The Behavior Analyst" OR "Behavior Analysis in Practice" OR "Perspectives on Behavior Science" OR "Journal of Applied Behavior Analysis" OR "Journal of Organizational Behavior Management" OR "Behavior Modification" OR "Behavior Analysis: Research and Practice" OR "Behavioral Interventions" OR “Journal of t he Experimental Analysis of Behavior” OR “Behavioral Processes” OR “Behavior and Social Iss ues” OR “The Psychological Record” OR “Translational Issues in Psychological Science”)

n = 103 articles

Screening procedure, part 1

- Filters applied to the search results
    - Scholarly journal
    - Adult population
    - Peer reviewed
    - English

n = 73 articles

Screening procedure, part 2

- All 73 articles were screened based on the following inclusionary criteria:
    - Must assess physical activity or sedentary behavior as a dependent variable
    - Must measure an overt form of behavior using a validated measurement tool (i.e., no self-report, no survey)
    - The independent variable must include a behavioral intervention
    - Participants must be adults (e.g. 18+ years of age)

n = 16 articles (17 studies)

Study Coding Data Sheet

Article:_________________________

Participant type (check all that apply):

______ College student ______ Worker/workplace
______ Sedentary ______ Healthy (non-obese)
______ Individual with I/DD ______ Overweight
______ Other/not listed (specify):______________________

Independent variable(s) (check all that apply):

______ Self-monitoring ______ Goal setting ______ Feedback
______ Monetary Incentive ______ Deposit contract ______ E-counseling
______ Social support ______ Coaching ______ Prompting
______ Task clarification ______ Other (specify):______________________________

Experimental design

______ Multiple baseline ______ Changing Criterion ______ Reversal
______ AB ______ Mult. Tx ______ Alt. Tx
______ Other (specify):______________________________

Dependent Variable

______ Physical activity (how):______________________________
______ Sedentary behavior (how):____________________________
______ Other (how):___________________________

Measurement Apparatus

______ Fitbit (type if listed):__________________________
______ Pedometer (type if listed):____________________________
______ Other:__________________________

Measured social validity?

______ Yes
______ No

Measured maintenance (i.e., follow-up)?

______ Yes
______ No

Appendix B

Email Recruitment Script

Do you spend most of your workdays sitting at a desk? Are you interested in becoming more active throughout the workday? Have you thought about using a Fitbit or another electronic activity tracker?

We are researchers in the Department of Applied Behavioral Science at the University of Kansas and are conducting a study to evaluate physical activity during the workday. We are recruiting employees who might be interested in using an electronic activity tracker and becoming more physically active throughout the day. As part of your participation, you may have the opportunity to earn monetary compensation. You may also learn about strategies to help you increase your physical activity and decrease your sedentary time throughout the day. Your participation in the study may be for up to, but no more than, 10 weeks. There is minimal risk to participation in this study; it involves no more risk than what is associated with daily life.

To participate in the research study, you must: (1) be between the ages of 18 and 65; (2) be able to engage in brief periods of walking; (3) not currently use an electronic activity tracker (ex. Fitbit, Apple watch); (4) have access to the internet and a smartphone; (5) be able to read, receive, and send text messages; and (6) work 35 or more hours per week as part of your employment.

If you are interested in learning more or participating in the study, please contact the principal investigator at erathtg@ku.edu.

Best,

Tyler G. Erath, M.A.
Principal Investigator
erathtg@ku.edu

Florence D. DiGennaro Reed, Ph.D., BCBA-D
Faculty Supervisor
fdreed@ku.edu

Appendix C

Informed Consent Statement

INFORMED CONSENT STATEMENT

TITLE OF STUDY

The effects of incentives and support procedures on physical activity

KEY INFORMATION

- This project is studying the effects of incentives and support procedures on physical activity.
- Your participation in this research project is completely voluntary.
- Your participation may take up to, but no longer than, 10 weeks.
- You will be asked to do the following procedures: walk for brief periods of time. More detailed information on the procedures can be found below.
- There is minimal to no risk from participating in the study.
- By participating you may learn about ways to increase your physical activity and decrease your time sitting for extended periods without moving, both of which may improve your physical health.
- Your alternative to participating in this research study is not to participate.
- Your employment will not be affected if you decide to not participate or withdraw.
- It is possible, however, with internet communications, that through intent or accident someone other than the intended recipient may see your response.

INTRODUCTION

The Department of Applied Behavioral Science at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with this unit, the services it may provide to you, or the University of Kansas.

PURPOSE OF THE STUDY

The purpose of the current study is to evaluate the effects of incentives and other support procedures on physical activity.

PROCEDURES

By participating in this study, you will first be asked to meet using Zoom. This meeting will be approximately 20-25 minutes, which includes the time it will take to complete several surveys. The zoom meeting will begin by obtaining informed consent and describing the purpose of the study; you will also be able to ask any questions. After informed consent has been obtained, you will be asked to complete a demographic survey and several screening procedures. The demographic survey and screening procedures will be completed online via a Qualtrics survey. The zoom meeting will conclude by discussing Fitbit pickup and a date and time to do so. Next, you will receive a Fitbit accelerometer via contactless pickup. Contactless dropoff/pickup will take approximately 30 seconds to 1 minute to complete. This meeting will occur outside in lot #61 on campus (near the Dole Human Development Center) with social distancing and safety guidelines in place. There will be no direct contact and 8 or more feet of radius maintained at all times. Both the experimenter and the participant will wear a mask and gloves. The experimenter will place the research kit outside in an empty parking space, reenter his car, then signal to the participant they can pick up the kit and once picked up, return to their car. You will be asked to wear the Fitbit during all waking hours and throughout the entirety of the day. During parts of the study, you will have the opportunity to earn money for meeting certain walking activity goals, which will be known to you in advance. The experimenter will discuss these goals and the times they are available with you over text message prior to when the goals become available. This discussion should take no longer than 5 minutes and will only occur once. You will have the opportunity to earn up to $13 each week by meeting daily and weekly activity goals. All money earned will be added to a reloadable debit card provided to you. Payment will be provided to you on a weekly basis. Should you withdraw at any time, you will keep all money earned. Depending on your performance, you may earn up to $91 participating in this study. Activity goals that will be looked at may include the number of steps taken in a day, daily distance, and the number of hours where a step goal is met. This data will be collected by the experimenter by accessing the online Fitbit website. Other than the meetings described above, the time commitment for you to participate in the study will be minimal and brief on a daily and weekly basis. Daily, there may be days where you are asked to respond to a text message with a brief response, which should take no longer than 30 seconds to a minute to complete. Weekly, you may be informed by text message about how much money you earned and to let you know that this money had been added to the reloadable debit card, which should take no longer than 30 seconds to a minute to read through. Your participation in the study itself may be up to, but no longer than, 10 weeks.

RISKS

Minimal risks are anticipated with participation in this study. You will be asked to wear a Fitbit accelerometer. The Fitbit may cause skin irritation.

BENEFITS

By participating you may learn about ways to increase your physical activity and decrease your time sitting for extended periods without moving, both of which may improve your physical health.

PAYMENT TO PARTICIPANTS

You will have the opportunity to receive monetary compensation for your performance, which will be provided to your ClinCard (which can be used like a debit card) at the end of each week when the money is available. The maximum amount of money you can earn is $91. Each workday of the intervention, you will have the opportunity to earn $2 for meeting your daily hourly interval goal. You will also have the opportunity to earn an additional $3 bonus for meeting your daily target goal for each day in a week (i.e., five consecutive workdays). In the event that your performance is too high initially to remain in the study, you will be thanked for your time and participation. In addition, you will receive $10 for participating in the study, which will be added to your Clincard account. Investigators may ask you to enter your social security number directly into the ClinCard website to comply with federal and state tax and accounting regulations.

PARTICIPANT CONFIDENTIALITY

Your name will not be associated in any publication or presentation with the information collected about you or with the research findings from this study. Instead, the researcher will use a participant number or a pseudonym. Your identifiable information will not be shared unless required by law or you give written permission.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from the University of Kansas or to participate in any programs or events of the University of Kansas. However, if you refuse to sign, you cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to participate in this study at any time. You also have the right to cancel your permission to use and disclose further information collected about you, in writing, at any time, by sending your written request to: Florence DiGennaro Reed, PhD, 1000 Sunnyside Avenue Room 4001 Dole Human Development Center, Lawrence, KS 66045.

If you cancel permission to use your information, the researchers will stop collecting additional information about you. However, the research team may use and disclose information that was gathered before they received your cancellation, as described above.

QUESTIONS ABOUT PARTICIPATION should be directed to:

Tyler Erath, MA
Graduate Student
Department of Applied Behavioral Science
4001 Dole Human Development Center
University of Kansas
1000 Sunnyside Avenue
Lawrence, KS 66045
erathtg@ku.edu

Florence DiGennaro Reed, PhD
Associate Professor and Chairperson
Department of Applied Behavioral Science
4001 Dole Human Development Center
University of Kansas
1000 Sunnyside Avenue
Lawrence, KS 66045
fdreed@ku.edu

If you have any questions about your rights as a research participant you may contact the Human Research Protection Program (HRPP) office at (785) 864-7385, write the Human Research Protection Program (HRPP), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7568, or email *irb@ku.edu*.

PARTICIPANT CERTIFICATION:

If you agree to participate in this study, please sign where indicated. You may download a copy of the informed consent for your records.

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study and the use and disclosure of information about me for the study.

I agree to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

Print Participant's Name

Date

Participant's Signature

Appendix D

Physical Activity Readiness Questionnaire for Everyone (PARQ+)

2020 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ________	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ________	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ________	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow Global Physical Activity Guidelines for your age (https://apps.who.int/iris/handle/10665/44399).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION

If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ____________________ DATE ____________

SIGNATURE ____________________ WITNESS ____________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ____________________

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

01-11-2019

2020 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c — If **NO** ☐ go to question 2

1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	YES ☐ NO ☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	YES ☐ NO ☐

2. Do you currently have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b — If **NO** ☐ go to question 3

2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?	YES ☐ NO ☐
2b.	Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)?	YES ☐ NO ☐

3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm

If the above condition(s) is/are present, answer questions 3a-3d — If **NO** ☐ go to question 4

3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	YES ☐ NO ☐
3c.	Do you have chronic heart failure?	YES ☐ NO ☐
3d.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	YES ☐ NO ☐

4. Do you currently have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b — If **NO** ☐ go to question 5

4a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
4b.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)	YES ☐ NO ☐

5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes

If the above condition(s) is/are present, answer questions 5a-5e — If **NO** ☐ go to question 6

5a.	Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?	YES ☐ NO ☐
5b.	Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.	YES ☐ NO ☐
5c.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet?	YES ☐ NO ☐
5d.	Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?	YES ☐ NO ☐
5e.	Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?	YES ☐ NO ☐

2020 PAR-Q+

6.	**Do you have any Mental Health Problems or Learning Difficulties?** This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome If the above condition(s) is/are present, answer questions 6a-6b	If **NO** ☐ go to question 7
6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
6b.	Do you have Down Syndrome **AND** back problems affecting nerves or muscles?	YES ☐ NO ☐
7.	**Do you have a Respiratory Disease?** This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure If the above condition(s) is/are present, answer questions 7a-7d	If **NO** ☐ go to question 8
7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
7b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES ☐ NO ☐
7c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES ☐ NO ☐
7d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES ☐ NO ☐
8.	**Do you have a Spinal Cord Injury?** This includes Tetraplegia and Paraplegia If the above condition(s) is/are present, answer questions 8a-8c	If **NO** ☐ go to question 9
8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
8b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES ☐ NO ☐
8c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES ☐ NO ☐
9.	**Have you had a Stroke?** This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event If the above condition(s) is/are present, answer questions 9a-9c	If **NO** ☐ go to question 10
9a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
9b.	Do you have any impairment in walking or mobility?	YES ☐ NO ☐
9c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES ☐ NO ☐
10.	**Do you have any other medical condition not listed above or do you have two or more medical conditions?** If you have other medical conditions, answer questions 10a-10c	If **NO** ☐ read the Page 4 recommendations
10a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES ☐ NO ☐
10b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES ☐ NO ☐
10c.	Do you currently live with two or more medical conditions?	YES ☐ NO ☐
	PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE:	

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

2020 PAR-Q+

If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:
You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ____________________ DATE ____________________

SIGNATURE ____________________ WITNESS ____________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ____________________

For more information, please contact
www.eparmedx.com
Email: eparmedx@gmail.com

Citation for PAR-Q+
Warburton DER, Jamnik VK, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health & Fitness Journal of Canada 4(2):3-23, 2011.

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

Key References

1. Jamnik VK, Warburton DER, Makarski J, McKenzie DC, Shephard RJ, Stone J, and Gledhill N. Enhancing the effectiveness of clearance for physical activity participation; background and overall process. APNM 36(S1):S3-S13, 2011.
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11-01-2019

Appendix E

International Physical Activity Questionnaire-Short Form (IPAQ-SF)

YOUTHREX Research & Evaluation eXchange

Evaluation Measures

International Physical Activity Questionnaire - Short Form

OVERVIEW

- This measure assesses the types of intensity of physical activity and sitting time that people do as part of their daily lives are considered to estimate total physical activity in MET- min/week and time spent sitting.

SUBSCALES

- None
- Sample items from the scale:
  - » During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

STEPPING UP THEME(S) & OUTCOME(S)

- **Health & Wellness**
  - » Youth are physically healthy

TARGET POPULATION

- Youth 15 years of age and older

LENGTH & HOW IT IS MEASURED

- 7 items
- Open-ended questions surrounding individuals' last 7-day recall of physical activity
- Self-report, paper- pencil version or orally
- Available in: English and many other languages

DEVELOPER

- International Physical Activity Questionnaire, 1998

GOOD TO KNOW

- Used by the Ontario Trillium Foundation
- Click here for Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) - Short Form

PSYCHOMETRICS

- **Reliability**

  Test-rest reliability indicated good stability

  High reliability (α <.80)

- **Validity**

  Predictive validity

  Concurrent validity

  Convergent validity

  Criterion validity

  Discriminant validity

LEARN MORE

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- van Poppel MNM, Chinapaw MJM, Mokkink LB, van Mechelen W, Terwee CB: Physical activity questionnaires for adults: A systematic review of measurement properties. Sports Medicine. 2010, 40: 565-600. 10.2165/11531930-000000000-00000.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (August 2002)

SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ
The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation
Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective.* Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

Appendix F

Demographic Questionnaire

Demographic Questionnaire

What is your age?________
What is your date of birth (mm/dd/yyyy)? ________________

Height:

Weight:

To which gender do you most identify?

- ☐ Female
- ☐ Male
- ☐ Transgender Female
- ☐ Transgender Male
- ☐ Non-Binary/Gender Variant/Gender Fluid
- ☐ Other/Not Listed: ____________________
- ☐ Prefer Not to Answer

Are you of Hispanic, Latino, or Spanish origin?

- ☐ Yes
- ☐ No
- ☐ Prefer not to answer

What is your race (*check all that apply*)?

- ☐ Arab/West Asian
- ☐ Black or African American
- ☐ Chinese
- ☐ Filipino
- ☐ Japanese
- ☐ Korean
- ☐ Middle Eastern
- ☐ Native American or Alaskan native
- ☐ Native Hawaiian or Pacific Islander
- ☐ Mixed race
- ☐ South Asian
- ☐ White/Caucasian
- ☐ Other: __________________
- ☐ Prefer not to answer

What is your highest level of education?

- ☐ Less than High school/GED
- ☐ High school/GED
- ☐ Some college, but did not obtain a degree

☐ Associate's degree
☐ Bachelor's degree
☐ Master's degree
☐ Doctorate

If you obtained a degree, what was your major or field of study?

What is your income level? (*check one*)
☐ $0 to $20,000
☐ $20,001 to $30,000
☐ $31,001 to $40,000
☐ $40,001 to $50,000
☐ $50,001 to $75,000
☐ $75,001 to $100,000
☐ $100,001 to $150,000
☐ $150,001 to $200,000
☐ $200,000 or more

Number of hours of paid employment per week from the University of Kansas: ______________

What is your weekly work schedule (ex. 8 am – 5 pm, Monday through Friday)?

Currently, what location best describes your primary workplace?
☐ Work from home
☐ Office setting
☐ Other: ________________

Describe your workplace setting? (ex. size, how much space to walk move/around, stairs, access to outside, etc.)

Approximately how much of your work time is spent sedentary (ex. working at computer, sitting in a meeting)?
Hours per day: _____
Percentage: _____

Approximately how much of your work <u>must</u> be completed in a sedentary position (ex. working at computer, sitting in a meeting)?
Hours per day: _____
Percentage: _____

Do you own or have access to a standing desk?

- ☐ Yes
- ☐ No

Appendix G

Commitment Contract

Commitment Contract

The below information describes the opportunities for you to earn money by meeting your daily physical activity target goal. Each workday your target goal will be a predetermined number of hours for you to meet the Fitbit hourly step goal of 250 steps per hour.

This information outlines how much money you can earn (per day and per week) by meeting your physical activity target goals. Your physical activity target goals will be discussed with you each workday—specifically, after the end of the workday and at a preferred time in the evening via text message. Money you earn will be added to your reloadable debit card after the end of a four-day block.

- Each day you meet your physical activity target goal = $2.00
- Bonus for meeting each physical activity target goal for the previous 4 workdays = $3.00
- Total potential amount of money that could be earned each workweek = $16.00

By signing below, I agree to these procedures and conditions.

Participant

Signature: ____________________

Date: ____________

Researcher

Signature: ____________________

Date: ____________

Appendix H

Text Message Feedback Script

Text Message Feedback

Positive Feedback (step goal met) and prompt

Hey there. Today (*insert* date) you reached your hourly step goal for 5/8 hours (63%), which means you met and surpassed your goal of 4/8 hours (50%). You earned $2 because you met your goal.

Your target goal for tomorrow (*insert date*) is to meet your hourly step goal (by taking at least 250 steps per hour) during 4 of 8 work hours (50%).

Bonus component
Potential to add to part 1 for bonus – In addition, you met your goal for four consecutive days, which means you also earned a $3 bonus. A total of $11 will be added to your debit card tomorrow for this 4-day block.

Corrective Feedback (step goal not met) and prompt

Hey there. Today (*insert date*) you reached your hourly step goal for 5/8 hours (63%), which means you did not meet your goal of 6/8 hours (75%). You did not earn $2 because you did not meet your goal.

Your target goal for tomorrow (*insert date*) is to meet your hourly step goal (by taking at least 250 steps per hour) during 6 of 8 work hours (75%).

Appendix I

Barriers Assessment

Barriers Assessment

Script: I hope you're settling into the new semester! Thanks again for finding a time to meet. I wanted to schedule this meeting to discuss your move goal. As you know from my text-message feedback, you haven't met your target move goal the past few workdays. I was hoping to ask you a few questions about this so we can figure out a way to help you be more successful. Transition to Q1.

1. Have there been any barriers that have prevented you from meeting your move goal the past few days? (summarize the barriers shared; is there anything else?)
2. Of those you shared, what are the top two barriers or the ones you think are having the greatest impact on you moving throughout the day?
3. Let's discuss strategies you can adopt to address those barriers. What have you tried already? (Propose solutions in the moment)
4. I'm going to think more about these and read a bit to see if I have any additional recommendations. Is it okay if I text you later if I come up with something else?

If the participant does not identify any barriers:

5. Is there something I could do differently to help you be more motivated?

Appendix J

Intervention Acceptability Questionnaire

Intervention Acceptability Questionnaire

Please provide your opinion about the intervention: (e.g., Monetary incentives, Goal setting, Performance feedback, Textual prompts)

Please circle the number which best describes your agreement or disagreement with each statement.

1- strongly disagree 2-disagree 3-slightly disagree 4-slightly agree 5-agree 6-strongly agree

1. I liked the use of monetary incentives.
   1 2 3 4 5 6

2. I found the monetary incentives helpful in increasing my physical activity during the workday.
   1 2 3 4 5 6

3. I liked the use of the weekly target goals.
   1 2 3 4 5 6

4. I found the weekly target goals helpful in increasing my physical activity during the workday.
   1 2 3 4 5 6

5. I liked the use of daily feedback on my performance.
   1 2 3 4 5 6

6. I found the daily feedback on my performance helpful in increasing my physical activity during the workday.
   1 2 3 4 5 6

7. I liked the use of text message prompts for the next day's goal.
   1 2 3 4 5 6

8. I found the text message prompts helpful in increasing my physical activity during the workday.
   1 2 3 4 5 6

9. I liked the procedures used to increase my physical activity throughout the workday.
   1 2 3 4 5 6

10. This intervention was effective at increasing my physical activity throughout the workday.
    1 2 3 4 5 6

11. Most individuals would find this intervention helpful for increasing their physical activity throughout the workday.
    1 2 3 4 5 6

12. I would recommend this intervention to others interested in increasing their physical activity throughout the workday.
    1 2 3 4 5 6

Please provide your opinion about the Fitbit:

1. I found the Fitbit easy to use.
   1 2 3 4 5 6

2. I found the Fitbit helpful for increasing their physical activity throughout the workday.
   1 2 3 4 5 6

3. I found the Fitbit to be an acceptable way to increase my physical activity throughout the workday.
   1 2 3 4 5 6

General questions

1. The study was fun to participate in.
   1 2 3 4 5 6

2. The study was easy to participate in.
   1 2 3 4 5 6

3. Participation in the study did not require much time.
   1 2 3 4 5 6

4. I would be interested in participating in a similar study in the future.
   1 2 3 4 5 6

Free Response questions

1. What components of study did you like the most?

2. What components of study did you like the least?

3. What were the most common barriers you experienced when working to meet your target goals?

4. What component of the intervention did you find the most helpful?

5. What component of the intervention did you find the least helpful?

6. Additional comments

Appendix K

Procedural Integrity Checklist

Procedural Integrity Checklist

Participant #

Treatment Integrity Score:

Scoring:
Correct = +
Incorrect = -

<u>Intervention</u>

Contingency contract with monetary incentives

1. Experimenter provides the participant with the contingency contract (via Qualtrics survey)
   \+ -

2. Experimenter provides the participant with all money earned for meeting target goals every 4-day block (via Clincard)
   \+ -

Goal setting

3. Experimenter calculates the target hourly step goal using 75th percentile
   \+ -

Performance feedback

4. Experimenter provides the participant with textual feedback (positive and/or corrective) about performance daily (via text message)
   \+ -

Textual prompt

5. Experimenter provides the participant with textual feedback about target goal daily (via text message) in the evening after the completion of the workday
   \+ -

Appendix L

Barriers Assessment Integrity Checklist

Barriers Assessment Integrity Checklist

Experimenter behavior:

1. Experimenter asks: Have there have there been any barriers that have prevented you from meeting your move goal the past few days?
   \+ -
2. Experimenter asks: Of those you shared, what are the top two barriers or the ones you think are having the greatest impact on you moving throughout the day?
   \+ -
3. Experimenter discusses strategies with participant to address those barriers and asks what they have you tried already.
   \+ -

If the participant does not identify any barriers:

4. Experimenter asks: Is there something I could do differently to help you be more motivated?
   \+ -