# Impact of a smartphone-delivered sedentary behavior intervention on glucose metabolism in prediabetic adults

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## Abstract

This study investigates whether an 8-week lifestyle-based, smartphone-delivered intervention targeting reduction in sedentary behavior (i.e., sitting) significantly reduces objectively measured time spent sitting and improves fasting glucose and insulin. The incidence of type II diabetes has continued to increase in the United States and increases in sedentary behavior along with reductions in physical activity throughout the day have contributed to the increase of disease. There were 31 participants in the study and they started with a 3-week run-in period where a basic self-monitoring component was installed on their smartphone. After this run-in period, participants were randomly assigned to one of the eight experimental conditions. All participants received a basic self-monitoring with feedback component where they self-reported sleep, sedentary, and more active behaviors. Sitting time was measured with the activPAL3c, which is a device that they wore 24/7. Study visits occurred at week 0 (immediately after the 3-week run-in period), week 4, and week 8. Fasting glucose and insulin were measured at each of these visits. Participants logged approximately 60% of their sleep, sedentary, and exercise behaviors, which took 3–4 min/day to complete. The impact of the intervention was not significant, such that decreases in sedentary time in those assigned to the sedentary component did not significantly differ from those not assigned to the sedentary component at 8 weeks (beta (SE) = -1.19 (.32), p>0.05); however, the effect size was moderate (Cohen's d = 0.29). There was no significant impact on fasting glucose or insulin.

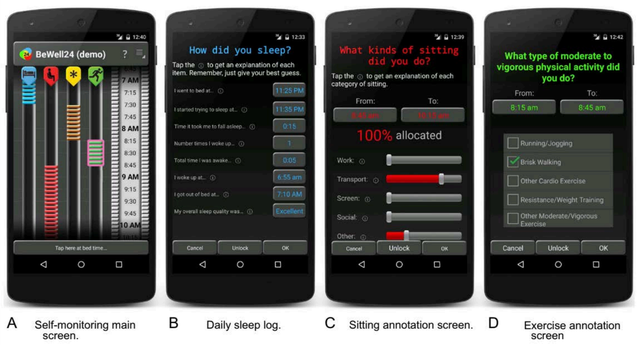


*Figure 1: Screenshots of BeWell24 self-monitoring component. a Self-monitoring main screen. b Daily sleep log. c Sitting annotation screen. d Exercise annotation screen*

## Introduction

The prevalence of type II diabetes is continuing to increase in our society. The NHANES III (1989-1994) and NHANES (1999-2004) studies showed an overall increase in type II diabetes from 5.8% to 7.0%. Many studies have found a significant correlation between sedentary behavior (i.e. sitting) and type II diabetes and metabolic syndrome. When sedentary behavior is quantified, the average American spends 7.67 hours per day sitting. In a study performed by Dr. Hu and his colleagues, they showed that sedentary behaviors, independent of exercise levels, were associated with significantly elevated risks of obesity and type 2 diabetes. Cell phone usage is a huge part of our current society with 90% of adults owning a cell phone and 77% using a smartphone. Although there is a limited amount of research on the effectiveness of mobile apps for health interventions, the existing literature shows great potential for the effectiveness of using apps to positively influence behaviors and health outcomes.

## Methods

There were a total of 31 participants in the study. Of those 31, 21 were from the Phoenix VA and the other 10 were recruited from ASU. Of the VA participants, 4 were lost to follow-up after randomization. There were no differences in demographics between these participants and those that completed the study. BeWell24 was designed into components that target three distinct behaviors: sleep, sedentary behavior, and physical activity (see Figure 1). To test the individual effects of each behavioral component (sleep, sedentary behavior, physical activity), we utilized the multiphase optimization strategy (MOST) design, conducting a 2x2x2 full-factorial experiment. After obtaining eligibility and consent, participants entered a 3-week run-in period where a basic self-monitoring component was installed on their smartphone. After this run-in period, participants were randomly assigned to one of the eight experimental conditions. All participants received a basic self-monitoring with feedback component where they self-reported sleep, sedentary, and more active behaviors. Sitting time was measured with the activPAL3c, which is a device that they wore 24/7. Study visits occurred at week 0, week 4, and week 8. Fasting glucose and insulin were measured at each of these visits.

| Experimental condition number | Intervention components | | |
|---|---|---|---|
| | Physical activity component | Sedentary behavior component | Sleep component |
| 1 | No | No | No |
| 2 | No | No | Yes |
| 3 | No | Yes | No |
| 4 | No | Yes | Yes |
| 5 | Yes | No | No |
| 6 | Yes | No | Yes |
| 7 | Yes | Yes | No |
| 8 | Yes | Yes | Yes |

All participants were encouraged to use the self-monitoring component throughout the intervention

*Table 1: Multiphase optimization strategy design for BeWell24*

## Results: Sedentary Time

On average, participants self-monitored about 60% of the 24-hr day and this monitoring took 3–4 min per day to complete. Peak usage occurred during week 2 of the intervention for both the sleep and sedentary components, but on average steadied at around 30-min/ week for these two components. Usage of the exercise component remained lower than the sleep and sedentary components throughout the intervention period. There were 18 participants who received the sedentary component of the intervention and 13 participants who did not. All results control for the MOST design (assignment to sleep and physical activity components). The sedentary intervention arm had 972.45 ± 62.54 min per 16 hour day of sedentary time at baseline, 919.23 ± 55.42 min per 16 hour day at 4 weeks, and 924.12 ± 61.93 min per 16 hour day at 8 weeks. The non sedentary intervention arm had 964.23 ± 59.63 min per 16 hour day of sedentary time at baseline, 971.87 ± 68.92 min per 16 hour day at 4 weeks, and 952.49 ± 63.42 min per 16 hour day at 8 weeks (see Figure 2). The impact of the intervention was not significant, such that decreases in sedentary time in those assigned to the sedentary component did not significantly differ from those not assigned to the sedentary component at 8 weeks (beta (SE) = -1.19 (.32), p>0.05); however, the effect size was moderate (Cohen's d = 0.29).

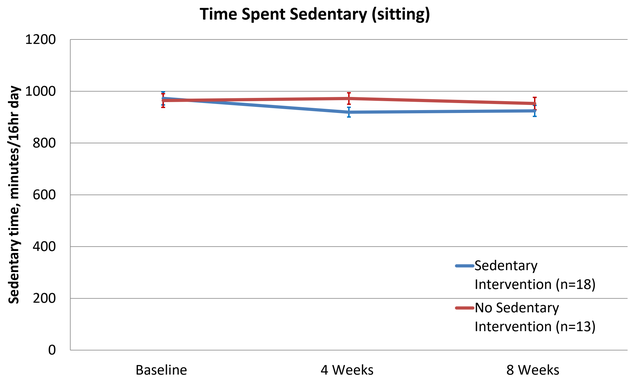


*Figure 2: Comparison of time spent sitting between the groups that either did or did not receive the sedentary intervention component of the app*

## Results: Biomarkers

There was no significant impact on fasting glucose and insulin (not shown).

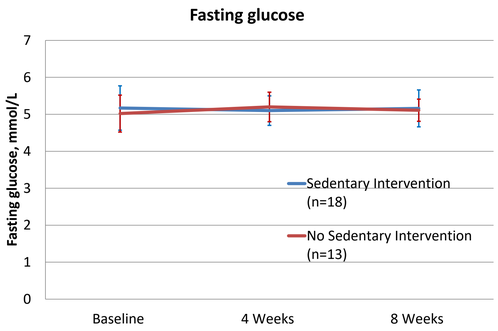


*Figure 3: Comparison of changes in fasting glucose between the groups that either did or did not receive the sedentary intervention component of the app*

## Discussion and Conclusions

Although the impact of the intervention was not significant in its effect on sedentary time or fasting glucose and insulin, the effect size was moderate and sedentary behavior reduction of this magnitude has been shown to elicit clinically meaningful cardiometabolic improvements in larger studies. This population was not generalizable to the population as a whole since it was conducted at the Phoenix VA and participants were primarily men (85%) and Caucasian (73%). Appropriate follow up to the study would include a study with a larger sample size and a more diverse population. It would also be useful to follow the subjects over a longer time period to see if the effects are significant if behaviors continue to follow the trend that was established during the 8 week time period.

## Acknowledgements

I wish to thank my mentor Dr. Matthew Buman and his research coordinator Monica Gutierrez. I would also like to thank the other research assistants: Meynard Toledo, Boyd Lanich and Jake Duncan for their contributions to the project.