THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF KINESIOLOGY

sipIT Mini Worksite Study: Evaluating the Feasibility of the mini-sipIT Intervention for Modifying Office Worker Sedentary Behavior

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SPRING 2023

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Science
with honors in Kinesiology

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ABSTRACT

Sedentary time experienced by office workers has become one of the largest concerns among researchers and medical professionals, especially for the health outcomes that result. Although previous studies have been successful in reducing the amount of time that office workers spend at work, not all of these interventions are cost-effective and applicable in every office setting. The purpose of this study was to assess the feasibility of a stealth intervention using fluid intake to modify sedentary time in office workers. Thirty sedentary office workers were recruited to use the sipIT intervention for one month. Sedentary behavior was assessed for one week at baseline and follow-up with a thigh-worn accelerometer and inclinometer (activPAL) Participants were assigned the goal of consuming 8 fluid ounces/ hour during a 12-hour window of their choosing, and they received reminder messages when the hourly goal was not met. The sipIT tools were acceptable in our study sample, and modest increases were observed in step count and sit-to-stand transitions, and reductions in sitting time, time spent in sedentary bouts greater than 30 minutes and 60 minutes, and number of sedentary bouts greater than 30 minutes and 60 minutes. However, these changes were not statistically significant. Use of the intervention tools and results from the follow-up questionnaire demonstrate the acceptability of the intervention among this sample. This study established that the sipIT intervention is both feasible and acceptable to sedentary office workers. Clinical trials are needed to evaluate the effects of sipIT on fluid intake, hydration status, and sedentary behavior in at-risk office workers.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

Dr. David Conroy, thank you for taking me into your laboratory and for giving me the opportunity to conduct my Honors thesis with you. You took a chance on me, and I am very grateful for your patience, time, and effort you put into this project with me. I would also like to thank you for the faith you instilled in me as we overcame obstacles throughout this project.

Dr. Lacy Alexander, thank you for your assistance in helping me find laboratories that reflected my interests and introducing me to Dr. David Conroy. I would also like to thank you for your time in reviewing my thesis.

Deborah Brunke-Reese and Gabby Ryan, thank you both for your patience with me through the duration of this project. You both were so generous in providing me with assistance and advice when facing obstacles, and I am very grateful for the experience I had working with you both.

Jim Marks, thank you for your patience and time in getting me accustomed to using Hidrate and offering your time so generously to practice Zoom meetings with me to ensure I knew how to explain different functions of the app interface.

Andy from Hidrate, thank you for your time and generosity in creating participant Hidrate accounts at my request and for assisting me with any of my needs with the app.

I would like to thank Jing, Saran, Kennedy, Alex, Hannah, and Raquel for welcoming me in the Motivation Lab and offering me a helping hand with any of my needs.

Lastly, I would like to thank my family, friends, and fur friends for offering me their support and unconditional love throughout the process of conducting and writing my thesis.

Chapter 1

Information

Sedentary Behavior

In the last 60 years, the number of Americans working jobs that require light activity have increased by 23%, while those working jobs requiring high energy expenditure have decreased by 18% as of 2008 (Church et al., 2011). Office workers are particularly susceptible to prolonged sedentary behavior due to the nature of their work, as about 68% of their workday is spent sitting at their desks (Clemes et al., 2014). Sedentary behavior refers to "any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture," (Sedentary Behavior Research Network, 2017).

Sedentary behavior has been considered a growing risk factor for cardiometabolic diseases, such as type 2 diabetes, cardiovascular disease, and certain types of cancer (Keadle et al., 2017). Prolonged sedentary behavior also may be associated with decreased cognitive function and performance (Falck et al., 2017). Along with these health risks, office workers have reported dissatisfaction with their workstations, musculoskeletal discomfort, and exhaustion, which may be related to the time they spend seated at work (Daneshmandi et al., 2017). Office workers accumulate more sedentary time and less light physical activity on workdays than on non-working days, and those who spend the most time sedentary do not make up for this shortfall by increasing their physical activity outside of work (Clemes et al., 2014). Studies have also found that it may not be effective to encourage office workers to sit less as they may not be fully aware of the bouts they spend seated out of habit (Conroy et al., 2013).

Worksite Interventions to Reduce Sedentary Behavior

Current worksite interventions aiming to reduce office workers' sedentary time have implemented both light physical activity programs and sit-stand workstations (Buman et al., 2017). One review found that the implementation of sit-stand workstations reduced sitting time by 100 minutes/workday during short-term follow-up (95% CI -116, -84) and 57 minutes/workday during medium-term follow-up (96% CI -99, -15) (Shrestha et al., 2018). This review also identified reductions in time spent seated both inside and outside of the workplace by an average of 82 minutes/day (95% CI -124, -39) (Shrestha et al., 2018). Sit-stand workstations have previously been associated with reduced worker fatigue and musculoskeletal discomfort, such as significant reductions in lower back discomfort (95% CI -62.8, -0.9) (Thorp et al., 2014). However, sit-stand workstations can cost upwards of $1,000 and require organizational commitments that may not be possible in all office spaces.

Other worksite interventions have reduced sedentary time by incorporating small, frequent breaks during the workday via mobile and desktop prompting systems. One feasibility study identified acceptability in computer prompting systems, in addition with education, among office workers, where Cohen's d for total sitting time during intervention and follow-up were 0.172 and 0.472, respectively, compared to the education only group (O'Dolan et al., 2018). One similar study identified an average reduction of 10 minutes in computer activity ($p < 0.001$) and modest increases in physical activity upon prompt receipt (Van Dantzig et al., 2011). Another study found acceptability in computer prompting systems among office workers, who increased habit strength and self-regulation ($p=0.01$, $d=0.728$) of adhering to personalized break schedules (Luo et al., 2018). However, although acceptable, the prior study was unable to draw inferences in significance due to the small sample size, and the observed differences in sedentary time may

have been influenced by neighboring colleagues in separate groups (O'Dolan et al., 2018). Further, the Luo et al. study did not assess changes in sedentary behavior, and the observed increases in physical activity in the Van Dantzig et al. study were not statistically significant (2018; 2011). Interventions involving prompt systems have also been criticized due to the disruptions of productivity they may produce (Keadle et al., 2017).

A Stealth Intervention Approach

Given the limitations of existing worksite interventions for reducing sedentary behavior, a different approach may be needed to engage workers in modifying their activity behaviors. One possibility is to intervene indirectly with a stealth intervention. These interventions leverage motivation for other target behaviors to produce spillover effects on a desired behavior (Hekler et al., 2010). Rather than emphasizing the endpoint of an intervention, stealth interventions instead emphasize the experience of the intervention itself (Robinson, 2010). Highlighting process motivators rather than outcome motivators is believed to promote long-term changes in behavior, where the outcomes become "beneficial side effects" to the intervention (Robinson, 2010).

Prior studies have also employed fluid interventions among office workers, which have demonstrated success in promoting fluid intake. Most people, including office workers, do not consume enough water (Chiu et al., 2009). In attempting to increase fluid intake, one approach implemented a game-like simulator in which drinking more water would grow and nourish office workers' virtual tree. This approach resulted in an increase of 304 mL on average being consumed each day compared to baseline consumption, where those in the control group consumed an average of 43 mL less than their baseline consumption (Chiu et al., 2009). Another

study implemented a living plant interface in an office space, in which the health of the interface corresponded to how much water was being consumed (Zhou et al., 2021). This study received positive feedback from participants. However, neither of these studies investigated the effects of increasing office workers' fluid intake on sedentary behavior (Chiu et al., 2009; Zhou et al., 2021). These studies are also limited to producing their effects in the workplace and require an interest in attending to the interfaces described, which may not be a universal motive.

sipIT Fluid Intervention

The sipIT fluid intervention was developed to promote increased fluid consumption in patients with a history of kidney stones (Conroy et al., 2020). This intervention pairs a semi-automated tracking system with lapse-contingent reminders with follow-ups at 1 month and 3 months (Conroy et al., 2020). Results from this study display a significant increase in experienced automaticity of fluid consumption ($d=0.50$) at the 1 month follow-up visit compared to baseline, suggesting that the sipIT tools strengthened habits for fluid intake (Conroy et al., 2020).

Current Study

The purpose of this study aims to evaluate the feasibility of breaking up prolonged sedentary bouts experienced by office workers with a less expensive version of the sipIT fluid intervention called mini-sipIT (Streeper et al., 2023). This intervention uses two methods to track fluid intake: automated recordings from a connected water bottle and manual recordings in the companion app for the bottle. It does not use smartwatch-based drinking gesture detection as the

original sipIT intervention. Participants were assigned the goal to consume eight fluid ounces/hour and received text messages when they did not record enough consumption to meet that goal. Lapse-contingent reminders to drink were delivered via text messages instead of via app-based notifications. It was hypothesized that this stealth intervention will be feasible in promoting engagement with the sipIT tools. Feasibility in this study is measured by reaching at least 80% of the recruitment goal within 3 months, as well as having at least 85% of enrolled participants complete the study protocol. Acceptability in this study is measured by an average of at least 25 days with 1+ reports of Hidrate bottle use across enrolled participants, as well as an average score of at least 4 on the items marked by "**" and an average score of 2 or less on items marked by "***" in Table 4. defined as the degree to which the intervention could be implemented, and acceptability is defined as the tolerability of the intervention to the participants. The exploratory aim of this study is to assess the efficacy of this intervention in modifying sedentary time.

Chapter 2

Methods

Participants

Potential participants in the state of Pennsylvania were invited to complete a Qualtrics screening survey if they met the requirements of being between ages 30 and 60, working in an office, and having a smartphone. Participants were recruited through informational flyers in State College, posts on Facebook, Penn State University alumni groups, and Penn State's Health & Human Development Digest. Recruitment was open from October 4, 2022 until January 17, 2023. Participants were qualified to participate if they were employed full-time (40 hours per week) in an office setting, lived and worked in the state of Pennsylvania, reported sitting for at least seven hours during their workday, were capable of reading, speaking, and understanding English and of providing informed consent, did not have access to a standing or height-adjustable desk, owned an iPhone or Android smartphone and were willing to download the Hidrate app onto their smartphone, and were willing to wear an activPAL activity monitor for a week at the beginning and end of the study. Participants were excluded from this study if they were pregnant or planning to become pregnant within two months of the study, required an assistive device for mobility, worked remotely, worked inconsistent work weeks (i.e., less than five days of work per week), informed by a medical professional to restrict their fluid intake, and had catheters for urinary diversion.

Measures

ActivPALs were initialized using PALconnect software (version 8.11.7.95) using aP4 ([20.4], 10bit 20Hz +/-4g) default recording mode. ActivPALs were set to record for twenty days, beginning immediately after initializing. PALconnect was used to download activPAL data, and PALanalysis software (version 8.11.8.75) was used to generate daily summary profiles for each day of wear by the participants. For participants with five or more days with 10 or more hours of wear time, scores were aggregated across days to estimate average daily sedentary time, step counts, time spent in sedentary bouts greater than 30 minutes, time spent in sedentary bouts greater than 60 minutes, number of sedentary bouts greater than 30 minutes, number of sedentary bouts greater than 60 minutes, and sit-to-stand transitions.

Engagement with intervention tools was obtained via the sipIT server for each participant. Each participant's Hidrate water bottle was synced to the companion app on their smartphone with a unique email linked to the sipIT server. Data was downloaded and aggregated across days of bottle use to estimate volume consumed (by bottle, manual entry, and combined), frequency of reports (by bottle, manual entry, and combined), number of days with at least one report, and number of reminders received.

Two online Qualtrics questionnaires were developed and participants were given a unique participant identification number to use when completing questionnaires. Demographic characteristics assessed on the baseline questionnaire included age, sex, identifying gender, and racial/ethnic background. Participants provided details on their typical workdays, work hours, and if they worked the same hours each day. Descriptions of office layout, perceived office climate and comfort, and printer location were obtained.

The post-intervention questionnaire assessed user satisfaction and user experience. User satisfaction was assessed with the net promoter score (DasMahapatra et al., 2017). Three questions were presented to measure how likely participants were to recommend the sipIT tools, on a scale from 0 (‘not likely to recommend’) to 10 (‘extremely likely to recommend’) for increasing fluid intake, improving cognitive performance, and to break up long periods of sitting. User experience was assessed with eighteen statements regarding the sipIT tools, reminder text messages, and the intervention as a whole. Participants rated each statement on a scale ranging from strongly agree (1) to strongly disagree (5).

Procedures

Screening

Potential participants were screened via a Qualtrics survey to assess their eligibility. Eligible participants were contacted and asked to provide their mailing address, availability for the first Zoom visit, and brand of smartphone. Prior to the first virtual visit, participants were mailed an activPAL activity monitor, a study information sheet, a copy of the consent form, and participant guide. In the first Zoom visit, participants were informed of the study details and then provided informed consent. Participants completed a Qualtrics questionnaire regarding their demographic and workplace characteristics. Participants were then trained on how to apply the activPAL and wore the monitor for one week. The participants mailed back the monitor using a pre-paid envelope.

Intervention

Participants engaged in at least seven hours during workdays were eligible to continue in the study. These participants were mailed a Hidrate water bottle. During the second Zoom visit, participants were instructed to download the Hidrate Spark Smart Bottle application onto their smartphone and were given an email and password generated for study purposes. When prompted by the app, participants were instructed to provide their sex and year of birth, and input their birth date as January 1, their height as 6-foot, and their weight as 150 pounds. Participants were instructed to prohibit the app's ability to track their activity across other apps and to not share their location with the app. Participants synced their smartphone to their Hidrate water bottle via Bluetooth. Participants were informed to keep their Hidrate water bottle and smartphone near them for the next 28 days, where they were prompted to meet the goal of consuming eight fluid ounces/hour. If this goal was not met, they would receive a text message reminder during the twelve-hour window of their choice to consume more water from the sipIT Trial Database.

Follow-up

Prior to the last week of the intervention, participants were mailed a second activPAL activity monitor and instructed to wear the monitor for the final week of the study while continuing to use their Hidrate water bottle and receive text message reminders. On the final day of the study, participants were emailed the link to the final Qualtrics questionnaire regarding their opinions on the intervention and how it could be improved. Participants that completed the intervention received a $35 Amazon e-gift card.

Data Analysis

Data from sipIT engagement and baseline and follow-up wear of the activPAL for each participant were compiled into an Excel file for data processing. Descriptive statistics were estimated using the Statistical Package for the Social Sciences (version 28.0.1.0) by creating event-level records for each participant. ActivPAL data were analyzed by selecting days with at least 20 hours of wear time and averaging each variable of interest across valid days. Paired-sample t-tests were conducted to evaluate changes from baseline to follow-up wear, and effect sizes were calculated using standardized mean differences (Cohen's d). Engagement data were aggregated across days and represented as daily averages.

Chapter 3

Results

Figure 1 summarizes participant flow for this feasibility study. Of the 361 respondents of the initial screen, 63 (17%) were eligible to participate in the study. A total of 29 participants enrolled in the study (54%). Three participants were ineligible after baseline activPAL wear and communication was lost with two participants. One participant dropped out due to their work schedule and time constraints. The majority of study participants were White (n=25, 86%) and female (n=26, 89%) (Table 1). None of the participants were of Hispanic/Latinx origin.

Table 2 describes participant engagement with the 3-component mini sipIT intervention: the HidrateSpark Smart water bottle, its companion app, and lapse-contingent reminder text messages. On average (M ± SD), participants consumed 2.7 ± 1.2 liters of fluid each day of the 28-day intervention. An average of 1.6 ± 0.9 liters were recorded automatically via the bottle, and 1.1 ± 0.8 liters were recorded manually on the Hidrate app. Additionally, an average of 19.5 ± 14.8 reports/day were recorded by the bottle and 2.5 ± 1.8 reports/day were manually recorded using the Hidrate app. Through the duration of the intervention, participants received an average of 10.4 ± 1.1 reminder text messages each day.

Table 3 captures behavior change as recorded through activPAL wear. During baseline recording, participants took an average of 6,828.9 ± 2,777.3 steps/day. Participants sat for an average of 504.9 ± 71.9 minutes/day. Further, participants spent an average of 278.5 ± 94.5 minutes/day in sitting bouts greater than 30 minutes and an average of 139.2 ± 81.6 minutes/day in sitting bouts greater than 60 minutes. On average, participants completed 53.4 ± 14.2 sit-to-stand transitions each day. Participants experienced an average of 4.8 ± 1.4 sitting bouts greater than 30 minutes and an average of 1.5 ± 0.8 sitting bouts greater than 60 minutes.

Post-intervention values are summarized in Table 3. No significant changes were observed in step count, sedentary time, number of sit-to-stand transitions, time spent in sedentary bouts greater than 30 minutes and 60 minutes, or number of sitting bouts greater than 30 minutes and 60 minutes.

After using mini-sipIT for one month, participants reported an average net promoter score of 8.38 (± 2.04) in likelihood to recommend the sipIT tools to a friend or coworker wishing to increase their fluid intake. On the same scale, participants reported an average of 6.59 (± 3.09) and 5.97 (± 3.03) in likelihood to recommend the sipIT tools to a friend or coworker wishing to break up sedentary bouts and improve their cognitive performance, respectively. The net promoter score for increasing fluid intake was significantly higher than the net promoter scores for breaking up sedentary bouts ($p < 0.001$, $d = 0.718$, $t = 3.865$) and for improving cognitive performance ($p < 0.001$, $d = 0.883$, $t = 4.757$).

Table 4 summarizes ratings of intervention acceptability. The provided statements were sorted into ‘desirable’ and ‘undesirable’ categories. Participant responses were recoded so that higher scores represented stronger agreement with the desirable statements, and lower scores represented stronger disagreement with the undesirable statements (i.e., higher scores correspond with more favorable evaluations of acceptability in both cases). On average, the participants most strongly agreed that using the Hidrate bottle and companion app were simple and enjoyable to use. Additionally, the participants agreed that they wanted to drink more, felt that they sat for shorter periods between breaks, and used the restroom more frequently while using the sipIT tools. The participants indicated neutrality in enjoyableness and helpfulness of the reminder messages. In the ‘undesirable’ category, participants most strongly disagreed that tracking their fluid intake was complicated, distracting from work, and took too long. Participants also

disagreed that using the sipIT tools were disruptive, inconvenient (by keeping the Hidrate bottle nearby), and that the reminder messages were distracting from work. Participants felt neutral regarding the difficulty in consuming 8 ounces of water every hour and slightly agreed that the reminder messages were sent too frequently.

Participants were given the opportunity to provide open-ended feedback on the Hidrate bottle and app, reminder messages, and intervention as a whole. Table 5 summarizes participants' feedback on each of these elements. Regarding the Hidrate bottle and app, respondents indicated that the tools were easy (n = 3) and enjoyable (n = 2) to use, felt motivated in meeting their goals (n = 2), and experienced positive effects (n = 3). Participants provided feedback on inaccurate syncing (n = 2), irritation with logging drinks (n = 3), difficulty in reaching the hourly goal (n = 2), and feeling sick due to the amount drank (n = 1). Regarding the reminder messages, some respondents expressed that they were too frequent (n = 5), were ineffective (n = 5), or that they disliked them (n = 7). Some participants indicated that they felt the reminder messages helpful (n = 3) and "cute" (n = 2). One participant expressed a desire to adjust the time schedule themselves. Regarding general feedback on the intervention, four respondents indicated positive experiences with the intervention. Respondents also indicated a wish for push notifications on the app (n = 2) and for personalized reminder messages (n = 1). One participant expressed skin irritation due to the tape of the activity monitor, and one participant indicated the desire for 2-hour goals as opposed to the 1-hour goals.

Figure 1: Participant consort flow diagram

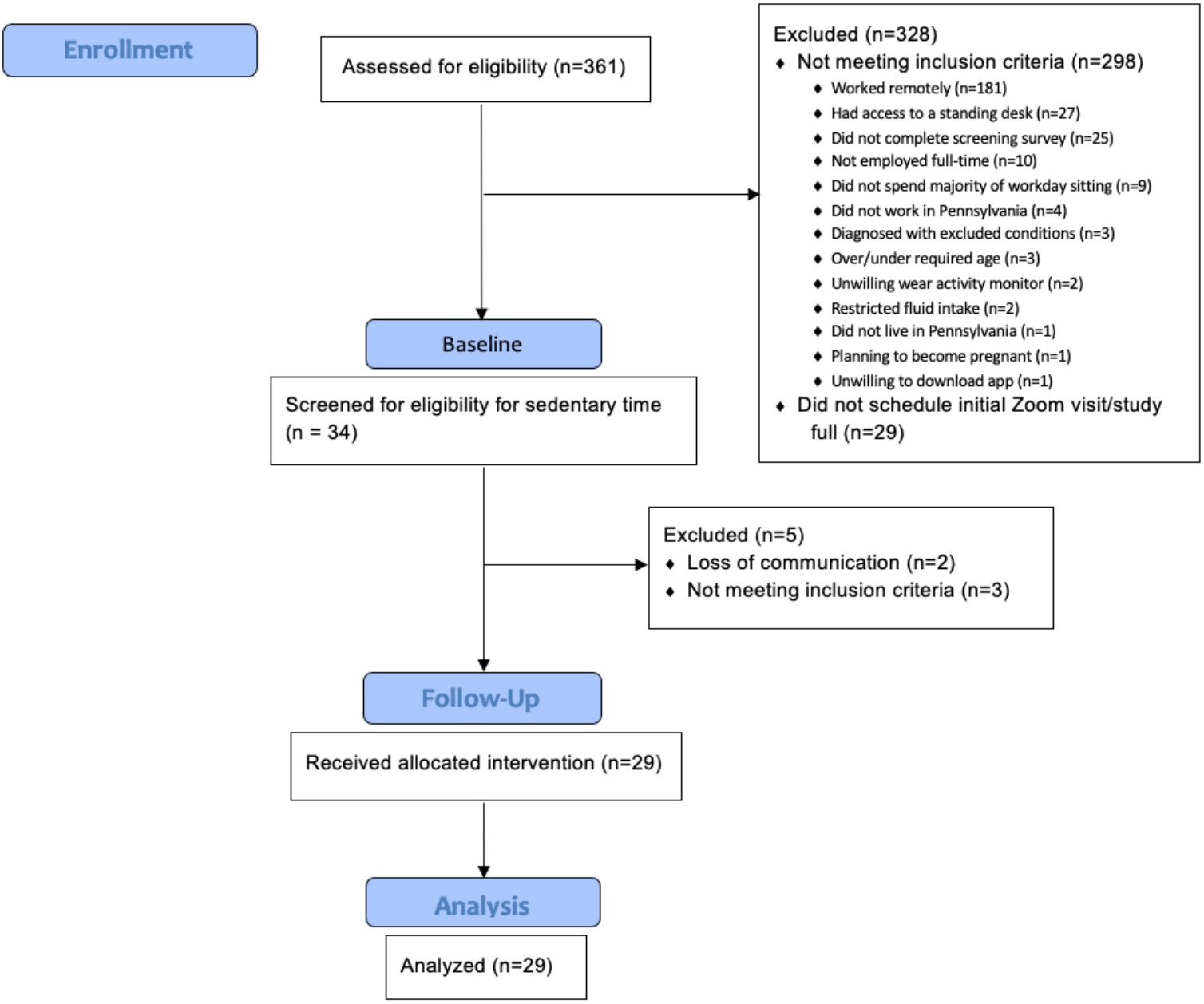

Table 1: Participant characteristics

Characteristic		N	Percent
Sex			
	Male	3	10.3
	Female	26	89.7
	Did not respond	0	0
Age			
	30–40	12	41.4
	41–50	8	27.6
	51–60	9	31.0
Race			
	American Indian or Alaska Native	0	0
	Asian	0	0
	Native Hawaiian or Other Pacific Islander	0	0
	Black or African-American	4	13.8
	White	25	86.2
	Two or more races	0	0
	Other	0	0
Ethnicity			
	Of Hispanic, Latinx, or Spanish origin	0	0
Work layout			
	Private office	14	48.3
	Cubicle (partitions exist)	7	24.1
	Open plan (no partitions exist)	8	27.6
	Other	0	0
Office climate control			
	Never	1	3.4
	Sometimes	0	0
	About half the time	3	10.3
	Most of the time	4	13.8
	Always	21	72.4

Office temperature			
	Too hot	6	20.7
	Just the right temperature	13	44.8
	Too cold	10	34.5

Table 2: Daily engagement with intervention tools

Engagement indicator	M	SD	Min	Max
Avg volume consumed (bottle and self-report, L)	2.69	1.24	0.10	6.02
Avg volume consumed by bottle, L	1.60	0.87	0.10	3.68
Avg volume consumed by self-report, L	1.09	0.83	0.00	3.11
Frequency (bottle and self-report)	35.36	15.02	12.93	88.00
Frequency (bottle)	19.52	14.77	0.10	74.21
Frequency (self-report)	2.45	1.75	0.00	7.38
Days with 1+ reports (bottle and self-report)	27.62	5.12	5.00	36.00
Reminders received	10.42	1.13	7.96	11.93

Table 3: Behavior change

	Baseline		Follow Up				
Variable	M	SD	M	SD	d	T	p
Step count	6,828.94	2,777.32	7,002.31	3,361.39	0.093	0.486	0.631
Sedentary time	504.88	71.87	495.40	78.87	-0.140	-0.726	0.474
Sit > 30 min.	278.45	94.49	246.97	90.52	-0.392	-2.037	0.052
Sit > 60 min.	139.21	81.58	117.31	80.02	-0.383	-1.990	0.057
Number of sitting bouts > 30 min.	4.80	1.37	4.49	1.32	-0.243	-1.265	0.217
Number of sitting bouts > 60 min.	1.49	0.78	1.31	0.83	-0.305	-1.585	0.125
Sit-to-stand transitions	53.36	14.24	56.39	16.94	0.341	1.774	0.088

Table 4: User experience*

Feature of sipIT		M	SD	95% CI
Desirable				
	“I consumed more water while using the sipIT tools.”	4.54	0.96	4.16 - 4.91
	“I found myself siting for shorter periods between breaks while using the sipIT tools.”	3.62	1.32	3.12 - 4.12
	“I wanted to drink more water while using the sipIT tools.”	3.83	1.39	3.30 - 4.36
	“I enjoyed using the Hidrate bottle.”	4.48	0.95	4.12 - 4.84
	“I enjoyed using the Hidrate app.”	4.45	0.78	4.15 - 4.75
	“I enjoyed the text message reminders to drink.”	2.86	1.30	2.37 - 3.36
	**"The Hidrate bottle was easy to use.”	4.72	0.80	4.42 - 5.00
	**"The Hidrate app was easy to use.”	4.69	0.85	4.37 - 5.00
	“Using the sipIT tools (bottle, app, reminder messages) caused me to use the restroom more frequently at work.”	4.07	1.13	3.64 - 4.50
	"I found the reminder messages helpful in reaching my fluid consumption goals.”	3.07	1.25	2.59 - 3.55
Undesirable				
	“It took too long for me to record my fluid intake with the Hidrate app.”	1.62	1.05	1.33 - 2.02
	***“Tracking my fluid intake distracted me from my work.”	1.72	1.19	1.27 - 2.18
	***“Recording my fluid intake with the Hidrate app was complicated.”	1.59	1.18	1.14 - 2.04
	***"Using the sipIT tools (bottle, app, reminder messages) disrupted my work.”	1.79	1.15	1.36 - 2.23

	"Keeping my Hidrate bottle with me throughout my workday was inconvenient."	1.66	0.94	1.30 - 2.01
	"I found it difficult to meet my hourly goal to consume 8 ounces of water."	3.10	1.35	2.59 - 3.62
	"I thought the reminder messages were sent too frequently."	3.72	1.22	3.26 - 4.19
	"The reminder messages distracted me from work."	2.45	1.38	1.92 - 2.97

*Items were reverse scored so that "strongly agree" is 5 and "strongly disagree" is 1.

**Scores of at least 4 on these items may suggest acceptability of the intervention.

***Scores of 2 or less on these items may suggest acceptability of the intervention.

Table 5: Participant feedback

Component	Participant ID#	Participant feedback
Hidrate bottle and app		
	720	"Personally, I drink Bubly or AHA water throughout the day and do not typically drink regular tap or bottled water. If this bottle allowed for the use of carbonated beverages, I would've used the bottle. I wish the app would've stopped messaging me if I was ahead of my goal for the day because at times, it was very distracting at work."
	731	"was easy to manually add liquid. App has limited beverages. Was easy to meet daily goal, but hourly was difficult to always meet, especially around lunch time and commute time"
	704	"Easy to use and motivational"
	707	"I wish that there was a preset in the app for carbonated water like they had for coffee"
	730	"One thing that I didn't expect was not only getting up more to use the restroom, but also to refill my bottle. I previously used a large bottle that lasted throughout the day, but with sipit needed filled more frequently and I was more motivated to refill it because of the tracking"
	713	"I wish there was a way to record specifically what time of day you consumed something. I found myself, especially on the weekends, recording intake at the end of the day instead of throughout the day because it was inconvenient."
	728	"I enjoyed participating with this study."
	721	"synching seemed to not always be accurate" (sic)
	722	"Just a big thank you to Madison for all of her help and patience when working with me to get started"
	714	"the bottle had a positive influence on fluid consumption"
	729	"At work was the easy part. The harder part was actually outside of work. First off, carrying the bottle when out and about was difficult and there wasn't always somewhere to set it down to make sure it recorded. I also found that I was waking in the middle of the night to use the bathroom instead of going more frequently during the day, even when I was on track during work. Not ideal."

	719	“I found that I wouldn't be able to drink 8 oz per hour but I might drink 30+ oz in one hour and then nothing for another hour or two.”
	716	“I suffer from migraines and have not had one since starting this study. It makes me think that dehydration may have played a part in my headaches. Due to this, I will be continuing to take in the same amount of water each day in the hopes that my migraines become a thing of the past!”
	718	“drinking this amount of water per hour made me feel almost sick most days of the study”
	709	“This really made me more aware of my water intake and also reminded me to stand up and move. I will definitely continue to monitor and use my sipit bottle and app”
	708	“I found the app very simple and quick to use. No complaints at all.”
	711	“It was annoying that i had to open the app to log the water. Ialways reopened the app after emptying the bottle and refilling to make sure it was still correct.” (sic)
	712	“This was interesting but did not motivate me enough to continue with the increased water consumption and really did not impact my amount of sitting other than to frequently go to the bathroom”
	710	“I didn’t think 100 ounces was a lot until doing it. I had a hard time meeting goals but enjoyed it”
	701	“Thank you :)"
Reminder messages		
	720	“The reminder messages could be distracting at times and I didn't like the fact that if I were ahead of my intake goal for the day, it would continue alerting me. This was distracting, at times, for me.”
	731	“often did not see them right away.”
	726	“I run long distances and the messages while running were annoying. Should be able to shut them off.”
	704	“Motivational and necessary”
	707	“I get a lot of text messages and app alerts so it became a little bit like white noise. Seeing the bottle was a better reminder for me.”
	724	“Too frequent”
	730	“When they were less frequent, I did not always drink as frequently”

	713	“I didn't like the text messages. I didn't mind the bottle glowing as a reminder because it usually caught my attention and was much more subtle.”
	728	“hourly messages was a lot”
	721	“din't find messages helpful, color lights of bottle sufficient” (sic)
	722	“Reminder messages helped me drink more water it was great to get those reminders”
	714	“they were easier to ignore than push notifications”
	729	“I didn't always open them right away, but just seeing my phone light up, I would assume it was a reminder, and take a sip.”
	719	“I found the texts to be very distracting and found myself ignoring them very quickly.”
	718	“i didn't really look at the messages as much as when the bottle would glow to remind me”
	709	“Thank you for allowing me to take part I will definitely continue to use my Sipit bottle and app as it has helped me be more aware of my water intake and the need to stand and move”
	708	“I wish I was able to adjust the time schedule myself but otherwise no complaints.”
	711	“Most of the time i just swiped the reminders.”
	712	“I found the messages a bit annoying after a while”
	705	“Cute pictures”
	703	“They came too often. They quickly began to annoy me, and I felt like I was being bothered”
	702	“The messages were cute and fun, but too frequent.”
	701	“Reminder messages -there were too many”
General		
	720	“The plastic around the step tracker is sharp and irritating. I had to try and fold over the excess to get it in a comfortable spot for it to stop giving me cuts. I also think that the strips are not large enough, especially if you are a woman who wears jeggings or leggings. By mid-day, the tracker would be falling off. I think extra strips should be sent out, as I received 6. With the monitor falling off/peeling back and as someone who showers twice a day, I didn't enjoy the soggy tape. Tape is also very irritating and left rashes/blister like marks on my legs where the tape had been.”

731	“2 hour goals instead of 1 hour goals. I've stopped drinking 5 diet sodas a day at work and now rarely even have one. I thought more water would help with winter dry skin - it did not.”
704	“The use of this bottle and app will benefit me long term as I continue to increase my intake of water which improves my energy, attention, and mood. Thankful to participate in this study.”
707	“Potentially personalizing the text messages so they don’t seem as generic”
713	“Overall I think it made more more aware of how little water I consume during the day and how litle I'm active, especially on work days. Coupled with the Apple Watch reminders to get up and move every hour, I think it could really help me and others.” (sic)
722	“Could not see any other way to improve it. Glad I was able to participate”
719	“I think it would have been good to get a baseline for liquid consumption. I also think you might want do differentiate liquids that are hydrating (e.g., water, milk) versus diuretics (e.g., coffee, alcohol)”
708	“It would be nice if the bottle lit up at the same time that texts come to remind you to drink. Push notifications on the app would be helpful too with reminders.”
712	“It motivated me to drink more water but did not really impact my sitting time”
710	“A notification when your battery is dead. I didn’t realize it until I already started drinking at times”
702	“Only that a reminder message be sent when you are behind instead of at regular intervals”
701	“Put a diet plan on here also :)"

Chapter 4

Discussion

The goal of this study was to measure the acceptability of a fluid intervention for breaking up sedentary bouts in office workers. The results from the 1-month trial indicated that the Hidrate app and bottle were accepted by this sample of participants, and the reminder text messages were thought to be sent too frequently, as indicated by the majority of participants.

This study offers three major contributions. The first contribution provided was that this stealth intervention using fluid intake to break up sedentary behavior was both acceptable and feasible in sedentary office workers. Net promoter scores and user experience feedback both suggest that the participants found the intervention most favorable in increasing fluid intake. Feasibility of this study was demonstrated, as over 80% of the recruitment goal was met within 3 months of implementation and over 85% of enrolled participants completed study protocol. Acceptability in this study was also demonstrated, as the mean scores of the indicated items in Table 4 met the determined measures. These findings suggest that office workers may be willing to use the mini-sipIT tools, and its impacts on sedentary behavior could be assessed in future studies.

Based on these results, future research could market sipIT as a fluid intake intervention without appealing to potential impacts on sedentary behavior or cognitive function. Future studies may be able to build upon this study by utilizing a larger sample size.

Prior efforts to reduce sedentary time in office workers have attempted to do so through the implementation of sit-stand desks and promotion of movement and breaks in the workplace. One study assessed previous interventions that aimed to reduce sedentary time in office workers (Shrestha et al., 2018). This study identified no significant effects on sedentary time when

workplace policies were altered (Shrestha et al., 2018). Significant differences in sedentary time were identified when information/counseling and computer prompts were implemented and assessed at medium-term follow-up by an average of 55 minutes/eight-hour workday (95% CI -96, -14) (Shrestha et al., 2018). This study also identified an average reduction of 100 minutes/eight-hour workday (95% CI -116, -84) in sitting time when sit-stand desks were implemented (with and without information/counseling) were implemented (Shrestha et al., 2018).

Another study assessed the feasibility of hourly prompts on sitting time, stepping time, and sit-to-stand transitions (Júdice et al., 2015). This study obtained a sample of ten participants who wore an activPAL for one week while receiving hourly computer prompts to break up siting time at work and sitting-reduction strategies via daily text messages during time at home (Júdice et al., 2015). This study also included a control week to capture baseline sitting times, stepping times, and sit-to-stand transitions (Júdice et al., 2015). Results from this study displayed significant reductions in sitting time and significant increases in step count, stepping time, and number of bouts spent stepping for ≤ 4 minutes and 5-9 minutes (Júdice et al., 2015). One current study is seeking to utilize a multi-level movement intervention with and without sit-stand desks (Buman et al., 2017). This study includes 270 office workers across 24 different worksites, and interventions include either the "MOVE+" intervention, which attempts to increase light physical activity in the workplace, and the "STAND+" intervention, which also attempts to increase light physical activity at work alongside the implementation of sit-stand desks (Buman et al., 2017). The primary outcome this study seeks to assess is changes in sedentary behavior at 12 months of intervention with 3 month follow-ups until 24 months to assess the sustainability of the interventions on this behavior change (Buman et al., 2017).

Interventions that can modify sedentary behavior may have downstream effects of biomarkers of cardiometabolic risk. In one study of 739 participants selected from the Australian Diabetes, Obesity, and Lifestyle study, activPALs were worn for one week and fasting cardiometabolic samples were obtained at the designated testing center (Bellettiere et al., 2017). Adults who sat for greater periods of time exhibited significantly ($p < 0.001$) higher BMI, waist circumference, triglycerides, and reductions in high-density lipoprotein (HDL) cholesterol levels (Bellettiere et al., 2017). Low number of sit-to-stand transitions were also associated with significantly higher BMI and waist circumference (Bellettiere et al., 2017). In a separate study, 678 participants were invited from the Australian Diabetes, Obesity, and Lifestyle Study for the assessment of changes in cardiometabolic factors following sedentary behavior interventions (Healy et al., 2015). Participants were randomly allocated to either sitting-to-standing or sitting-to-stepping interventions for two hours each day (Healy et al., 2015). The findings indicated significant reductions ($p < 0.05$) in fasting plasma glucose, triglycerides, and total/HDL cholesterol for both the sitting-to-standing or sitting-to-stepping reallocations (Healy et al., 2015). These findings further emphasize the importance of reducing sedentary bouts in those dedicating large portions of their time sitting and the need for more attention on this research field.

The third contribution this study provides to the field is the finding that the participants may have preferred automatic fluid intake tracking over manual fluid intake tracking. This detail is provided in Table 2 and may be useful in guiding further studies seeking to utilize the Hidrate bottle. One 12-week study aimed to encourage overweight or obese participants to self-monitor eating habits and body weight (Patel et al., 2020). 105 participants were randomly assigned to one of three interventions, including tracking daily dietary intake on the MyFitnessPal app alone,

delayed daily tracking of diet to better self-regulatory skills, or in combination with body weight tracking and behavior change techniques (Patel et al., 2020). Follow-up visits were conducted at the 1 month, 3 month, and 6 month mark (Patel et al., 2020). Consistent trackers were characterized as reporting eating habits at least 6 of 7 days of the week, and only a quarter of the participants were considered consistent trackers (Patel et al., 2020). This study also demonstrated that those who more consistently tracked their dietary intake had significantly greater reductions in weight ($p=0.03$, $d=0.57$) and BMI ($p=0.009$, $d=0.66$) at 6 months compared to baseline measures (Patel et al., 2020). These findings suggest the need for simplicity in self-monitoring techniques to promote behavior change.

This study had several limitations. The small sample was comprised of White and female adults and may not represent the broader population of adults. Participants indicated in their evaluations that the Hidrate water bottle lagged in updating their fluid amount, and some indicated that the amount that appeared on the app was inaccurate to what they had consumed. However, this aspect did not have any influence on the observed behavior change as exhibited by the activPAL wear. Another limitation in this study is that the hourly goal of 8 ounces over a 12-hour timeframe may not universally meet hydration goals for each participant, but again, this aspect did not influence behavior changed exhibited by the participants.

Future research may find more success in obtaining a larger, more diverse sample size and a longer time frame. A larger sample of more diverse participants may produce results that are more applicable to the population of office workers, and a longer timeframe would allow for participants to become more accustomed to the fluid intervention. Further, future studies should tailor the hourly fluid consumption goal to each participants needs, which could be based on height, weight, age, and regular activity level. Obtaining these parameters would ensure that each

participant is consuming an adequate amount of fluid and would assist in avoiding the risk of overconsumption. The reminder text messages also appeared to quickly become bothersome to the participants, as indicated by the evaluations; further studies could limit reminder message sending to an 8-hour window, as opposed to the 12-hour window in this study, where participants would only be receiving these reminder messages during work hours.

This study offers to the field of research on sedentary time reduction techniques in office workers the unique benefit that is cost-effectiveness. The administration of the Hidrate Spark Smart Bottle is significantly less expensive and acceptable in every office space, as opposed to sit-stand workstations. Further, as the first of its kind to utilize a fluid intervention in attempt to indirectly reduce time spent in sedentary bouts, this study exhibits that the Hidrate water bottle and app were acceptable among the study sample. Participant evaluation of the intervention provides additional guidance on which aspects of the study were acceptable and what could be altered in potential future studies. In comparison to previous literature, results from this study did not produce significant effects, but offers useful data and information that could guide future studies.

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ACADEMIC VITA

Madison Kuzmich

Work Experience

May 2022 - Present

Heritage Valley Health Systems – Beaver Campus – *Pharmacy Technician*

- Counted and obtained patient medications
- Transported medications to hospital units
- Mixed IV bags to order, prepared compounded medications and vaccines

May 2021 – May 2022

Hand and Shoulder Surgery Center, Center Township - *Clinical Aid*

- Assisted medical professionals with patient care
- Maintained sanitary working conditions
- Instructed patients on how to perform optimal therapy techniques according to therapist orders

July 2020 - January 2021

CVS Pharmacy, Aliquippa - *Pharmacy Technician*

- Counted and prepared medications
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- Obtained prescription scripts

Education

August 2019 - Present

Pennsylvania State University Schreyer Honors College, State College - *Biobehavioral Health, Kinesiology minor*

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Central Valley High School, Monaca, PA

Research Experience

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Motivation Lab, Pennsylvania State University, State College - *Research assistant*

Awards

- Schreyer Honors Scholar *(2019 - Present)*
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