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Relative Effects of Sleep Hygiene Behavior and Physical Exercise on Sleep Quality

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RELATIVE EFFECTS OF SLEEP HYGIENE BEHAVIOR AND PHYSICAL EXERCISE ON SLEEP QUALITY

by

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Abstract

Numerous studies have shown the relationship between sleep and overall health. A common measure of sleep is sleep quality which has been shown to be influenced by a variety of factors such as physical activity, diet, stress, social engagement, cognitive stimulating, and sleep hygiene behaviors. Data was analyzed from a previous study to determine whether trying to change one's sleep would improve sleep quality and if this was more effective than physical exercise. A group of 104 individuals, randomized to the treatment group, were asked to log their daily activities, via smartphone app, within these six behavioral domains for six months. Behavioral change scores were computed as the difference between six-month behavioral level and baseline behavioral level, for each of the six domains. Factor analysis that revealed that two latent factors explained the majority of the variance in behavioral change, with a "Physical Body Related behavior change" factor ("Physical") and a "Mental/Emotional" behavior change factor ("Mental"). In linear regression models, Physical significantly predicted sleep quality improvement over the six months ($p=.029$), but Mental did not ($p=.606$). In the middle aged adults in this study, the behavioral change pattern of increasing diet quality and physical activity, significantly predicted improvements in sleep quality. While efforts to improve one's cognitive and emotional well-being were not found to predict to sleep improvement, they still may be important for cognitive health overall. This information can prove useful as different interventions and programs are implemented to improve sleep in the population.

Acknowledgments

I would like to thank my faculty mentor Dr. Maria Norton, who led and guided me in writing this thesis. Without her, I would have had no idea where to begin or where to proceed. I also want to thank my wife for putting up with my many hours away from my family. I couldn't have done any of this without her love and support.

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Literature Review

The human body needs sleep for daily restorative purposes. Good quality sleep can improve physical (Faraut et al., 2011)(Fortier, Guerin, Williams, & Strachan, 2015) and mental (Uffelen et al., 2013) health, while poor sleep patterns can be associated with a greater chance of having chronic physical conditions (Sagayadevan et al., 2016) such as obesity (Cappuccio et al, 2008). A lack of sleep can even put people in physical danger by increasing the chance of having injuries at work (Uehli et al., 2014). A lack of sleep is found to be bidirectionally associated with a number of different mental health issues (Robotham, 2011) including depression (Sagayadevan et al., 2016)(Murphy & Peterson, 2015), anxiety (Leblanc, Desjardins, & Desgagne, 2015), and even Alzheimer's disease (Sharma, Sharma, Deshmukh, & Singh, 2015). Sleep can have an effect on health by acting as a mediator between relationship distress and self-rated health (Meadows & Arber, 2015). Despite all these consequences of sleep, and a great deal of literature on the consequences of sleep dysfunction, there is a dearth of literature describing the factors that contribute to sleep quality (Buysee, Grunstein, Horne, & Lavie, 2010).

One of the most studied aspects of sleep hygiene is sleep quality and the factors that contribute to it. There is substantial literature demonstrating links between physical activity and sleep quality in a variety of ways. In a study of 42 students, sleep and exercise were found to be related to each other in a number of ways. Those that participated in vigorous physical activity for greater than 20 minutes, 3 times per week, reported approximately 50% lower depression scores and a greater ability to cope with perceived stress (Gerber et al., 2014) which could have an effect on sleep (Hall et al., 2015). In addition to that, those who exercised had improved sleep patterns (Gerber et al., 2014) and had lower rates of obesity and sleep problems (Oksanen et al., 2013) (Hudgel, 2013). There seems to be a difference in efficacy of physical activity depending

on its intensity. In a 2x2 randomized controlled trial (RCT) of low vs. moderate-to-high physical activity and low vs. high cognitive training. The group found to have the greatest improvement in self-reported sleep quality was the combination of low intensity physical activity and low intensity cognitive training. This study claimed that its findings may have been in part due to the frequency the intervention as well as the age of the study's population (Pa et al., 2014). Another study found that while vigorous late night physical activity does not disturb participants' sleep quality, it may have effects on cardiac autonomic control (Myllymaki et al., 2011). This could eventually have an indirect effect on sleep because it was found that some heart related conditions such as hypertension can have an influence on sleep quality (Kaya et al., 2014).

In addition to physical activity, it has also been found that diet quality has an effect on sleep. One study found that the relationship between high caloric diets and sleep quality is bidirectional. Those who were found to have a poorer sleep quality had a greater number of negative eating behaviors, while certain foods such as tryptophan were found to increase sleepiness (Chaput, 2014). In a mouse study, mice who were switched from a regular chow diet to a high-fat diet exhibited decreased wake time, increase in non-rapid eye movement (non-REM) sleep time and more sleep fragmentation, compared to mice who were switched from high-fat to regular chow diet (Perron, Pack, & Veasey, 2015). A number of studies found that poor diet quality can be associated with different sleep conditions such as sleep apnea (Tan et al., 2015) and that there are specific nutrients such as alpha-carotenes, vitamin D, and calcium that are associated with different aspects of sleep (Grandner, Jackson, Gerstner, & Knutson, 2014). In one study it was found that histidine (an amino acid found in foods such as apples, carrots, and meats) is associated with reduced daytime fatigue, increased working memory, and enhanced clarity of thought (Sasahara, Fujimura, Nozawa, & Sato, 2015). A healthy diet, made up of large

amounts of vegetables, seaweed, soy products, eggs, potatoes, and mushrooms, has also been found to be associated with a lesser difficulty falling asleep. (Kurotani et al., 2015). This emerging evidence shows that while some research has been completed on the relationship between sleep and diet, this is a relatively new line of inquiry with more research needed to make additional discoveries and to provide replication of these recent studies.

Beyond the health related behaviors of physical activity and diet quality which are related to the wellbeing of the physical body, several cognitive and psychosocial behaviors are also predictive of sleep quality. Among these additional behavioral domains is a range of behaviors specifically targeting sleep hygiene. There are many aspects to sleep hygiene and a number of them are associated with sleep quality such as avoiding alcohol and caffeine. One meta - analysis found that while consuming alcohol shortened your sleep onset latency it increased the amount of arousal as the night progressed. Caffeine was also found to disrupt sleep. The effects of both caffeine and alcohol however were found to have a level of tolerance with continued use (Irish, Kline, Gunn, Buysse, & Hall, 2014). In a RCT targeting improvement of sleep consolidation, subjects were randomized into a sleep hygiene group and a sleep hygiene with bed restriction group. The two groups receiving the sleep-hygiene education intervention were taught about sleep hygiene, the benefits of exercise and diet, and were instructed to pay attention to their sleeping environment. The subject with education only, upon waking in the morning, had a greater measure of well-being, and those who also had bed restriction were found to show improvements in sleep continuity as well as depth (Hoch et al., 2001).

Another area linked to sleep quality is stress management and behaviors that promote reduction of stress. Psychosocial stress has been associated with sleep disturbance (Hall et al, 2015) and workplace stress associated with greater sleep fragmentation (Pereria, Gross, &

Elfering, 2015). Occupational stress was also found to predict poorer sleep quality among paramedics, with high levels of social support buffering this effect (Pow, King, Stephenson, & DeLongis, 2016). While these studies do not directly focus on stress management behaviors, it is reasonable to conclude that when one successfully engages in behaviors that lower perceived stress, it would in turn promote better sleep quality. Not all studies however, found a connection between stress (or stress reduction) and sleep quality (Roth & Robbins, 2004).

Social engagement also is believed to play a role in sleep quality. In a longitudinal study of 942 university students, a bidirectional relationship was found between social ties (number of friends and satisfaction of social network) and sleep quality with emotional regulation being a mediating factor (Tavernier & Willoughby, 2015). Another study found that while social participation was positively correlated with better sleep, an enhancement of social participation didn't improve the person's quality of sleep (Chen, Lauderdale, & Waite, 2016). These few studies suggest the benefits to sleep quality of having a healthy social network.

There is an abundance of literature linking sleep quality to cognitive functioning, but much less literature demonstrating the reverse effect of cognitive stimulation on sleep quality. One study showed that while high intensity cognitive stimulation did improve sleep, low intensity had a greater effect (p=.001) (Pa et al., 2014). A limitation to this data however is that the participants while being cognitive stimulated were also being physically stimulated. This makes it difficult to determine which had the greater effect on the sleep quality. Thus, more studies are needed to examine the role of cognitive stimulation on sleep quality.

Given the wide range of behavioral domains involved in promotion of sleep quality, it may be helpful to discover whether there exists a set of latent factors that describe more holistically all such health-related behaviors with fewer variables. Only one study was found that

conducted exploratory factor analyses to identify the existence of similar latent behavioral factors previously mentioned. Said study showed that there was one latent factor among healthy behaviors for adolescents, comprised of seat belt use, hours of sleep, diet, physical activity, sedentary behavior, and toothbrushing (Donovan, Jessor, & Costa, 1993).

In summary, no study was identified that examined all 6 behavioral domains summarized in this literature review namely: physical activity, diet quality, sleep hygiene behaviors, stress management, social engagement, and cognitive stimulation. In addition, none of the studies used the derived latent factors to predict sleep quality. In the study reported herein, six health-related behaviors were subjected to factor analysis, and the effect of the resulting latent factors on improvement in perceived sleep quality was determined.

METHODS

Research Design

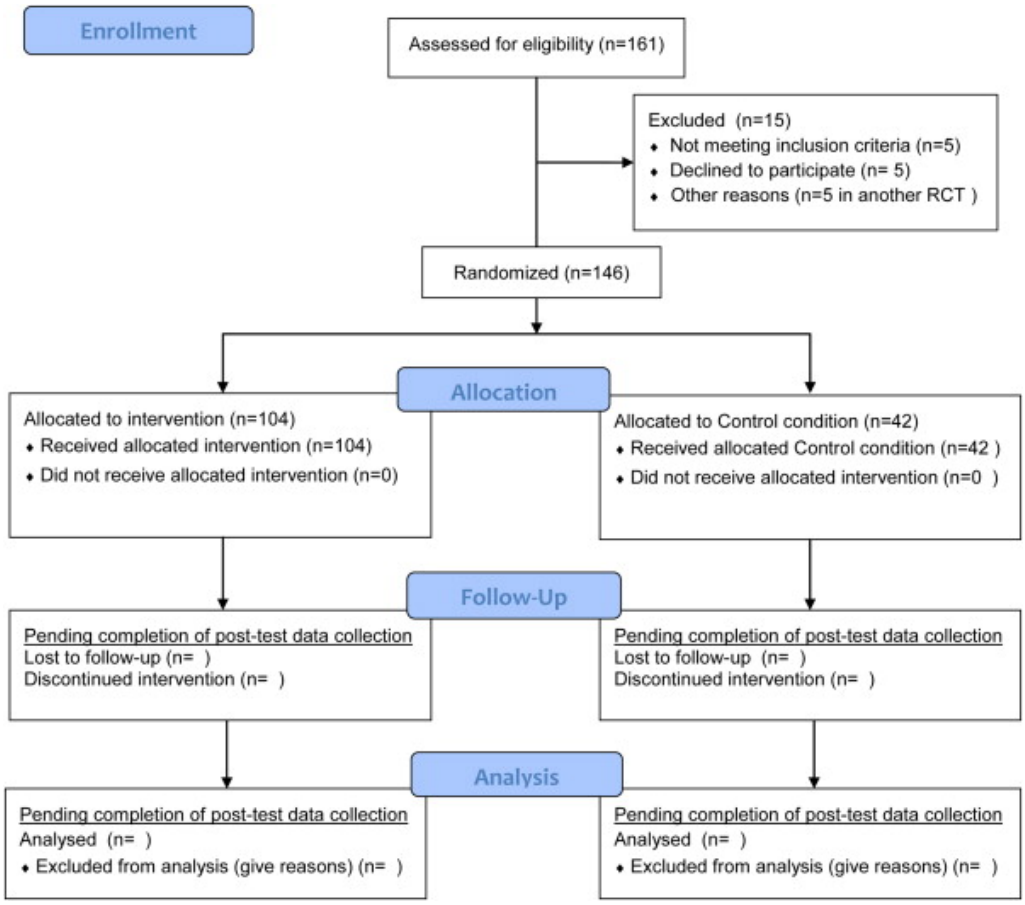
In the present study, data was obtained from an RCT of a healthy lifestyle intervention to reduce risk for later Alzheimer's disease in middle-aged participants. Once pretest data collection was completed, participants were randomly assigned into treatment or control group. The treatment group was given the freedom to choose what cognitive health-related behaviors they wanted to work to improve over the intervention period of six months. Out of the total number of participants two-thirds were assigned to the treatment group and one-third to the control using a binary random number generator in SPSS v. 21. The 2:1 ratio was used due to the nature of the study participants' ability to choose which behavioral domains they wanted to focus on. Having a large number of participants in the treatment group also allowed for analyzing the different subgroups of behavioral change separately. The baseline data was obtained in April,

2014 and posttest data collection began after six months of intervention. The present study only utilizes the treatment group because it was only in the treatment group that all six behavioral domains were reported.

Participants

A convenience sampling approach was taken to obtain participants for this lifestyle intervention. Efforts to obtain participants included flyer distribution, local health fairs, and county health department liaisons. Those who were interested in participating in the study were required to complete a pre-screening eligibility survey. One-hundred and forty-six participants were enrolled upon reaching the eligibility criteria, and after the participants were randomized, 12 married couples were placed in the same group in order to avoid contamination of the control group and vice-versa. The final groups consisted of 104 participants within the treatment group and 42 in the control group (Figure 1).

The criteria used to determine a participant's eligibility included: (1) age between 40 and 64 years of age, (2) body mass index no higher than 41, (3) ownership of a smartphone or tablet (iOS or Android), (4) fluency in the English language, (5) residence in Cache County, Utah, and (6) no exclusionary medical conditions including: pregnancy, dementia, unmanaged diabetes, or untreated major depression. Although a dementia diagnosis was exclusionary, persons with mild cognitive impairment were included.



Procedures

The intervention aimed to study six behavioral domains that are commonly associated with Alzheimer's disease, namely: physical activity, diet quality, sleep hygiene, stress management, social engagement, and cognitive stimulation.

A "kickoff event" occurred near the beginning of the study and different educational tips were taught during follow up "booster events" during the six-month intervention. These smaller events were used to teach the relationship between the domains that the participants were working on and Alzheimer's risk. It also gave the participants additional chances to experiment with different domains that they may not be working on up to this point. Some examples might be learning mindfulness techniques, cooking classes for cooking vegetables, and instruction on

crossfit and yoga. The participation for these activities ranged from 5% to 25% at any given activity.

A workbook was additionally provided in order to help participants improve the quality of their social engagement. This workbook provided lists of activities that could be implemented, as well as areas that allowed goal setting, and reflection.

A smartphone application ("app") designed for both iOS and Android devices, was given to each participant and had three uses. *Information:* Selecting an area of the app allowed participants to learn a "daily fact." These facts included references to studies of Alzheimer's disease prevention as well as a short summary of the findings found. *Accountability*: The app also allowed for participants to log daily, activities related to the six behavioral domains. Ten questions were used for this, and they included questions such as "How many minutes of vigorous activity did you complete today." The participants would then use a slider bar mechanism to designate their answers. *Feedback:* The app was also used to show daily and weekly summaries of the answers given to help participants track their progress over time.

In addition to the fact located on the app, a website was created with information on the six behavioral domains. This website was shared with the participants in hopes that they would be able to use it as a tool to gain more knowledge. It also included links to other sites included in the web page, as well as contact information to submit questions to the research team.

The Institutional Review Board at Utah State University approved both the intervention and the current study. Written informed consent was also obtained from all participants.

Participants completed an online questionnaire described below to assess sleep quality at baseline and again at six-month post intervention. The treatment group was encouraged to start making behavioral changes in line with the six behavioral domains listed previously. They were

not required to maintain any schedule of sorts in order to better simulate real world results. This resulted in the participants having a choice as to how many, and what combination of behavior domains that they worked on. All participants understood that the intervention was to study lifestyle behaviors that are commonly associated with AD risk.

Measures

To measure perceived sleep quality and other sleep related variables such as sleep-latency, sleep efficiency and sleep duration, the Pittsburg Sleep Quality Index (PSQI) was used. The PSQI contained 16 total questions; four related to the amount of sleep, and 12 relating to difficulty sleeping and treatments that may currently be implemented. An example question includes “During the past month, how often have you taken medicine (prescribed or “over the counter”) to help you sleep?” with the options of “Not during the past month, Less than once a week, Once or twice a week, Three or more times a week” as possible responses. Sleep components using this measure include: Subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The 16 questions were combined in specific algorithms to generate the seven component scores each ranging from 0 to three. The seven components were then summed to generate an overall global sleep quality score (hereafter referred to as sleep quality) that ranged from 0 to 21. The PSQI was found to have a Cronbach alpha internal consistency reliability of 0.83. (Buysse, Reynolds, Monk, Berman, & Kupfer, 1988). For a full list of the questions in the PSQI see appendix A.

The smartphone app used was crucial to the study as well because it provided a way of measuring the amount of effort participants were placing in each of the six domains previously mentioned. Twelve questions were asked daily, but only 10 of them are of use to this particular

study. The chosen ten questions had been previously grouped based on their different aforementioned behavioral domains. After the responses had been obtained, the daily results were then averaged into monthly averages of daily behavior. Physical activity was computed as the sum of the following two questions, “How many minutes of "moderate" physical activity did you do today?” and “How many minutes of "vigorous" physical activity did you do today?” Three diet quality questions were first converted into ounces and then summed for an overall diet quality score. Cognitive activity was computed as the sum of the following two questions, “How many minutes did you spend today doing "novel mental exercises"?” and “How many minutes did you spend today doing "cognitively stimulating activities"?” Sleep quality, stress management, and social engagement were each captured with a single behavioral questions per domain. The scores for these measures were open ended with the potential for zero value and no upper limit restriction. The scores for these measures consisted of different units of measurement (e.g. ounces, minutes, etc..). Month six and month zero behavioral scores were subtracted within each domain to compute behavioral improvements across the intervention period. For a full list of the questions used, see Appendix B.

All data analysis was completed by using SPSS v. 23. Exploratory factor analysis was conducted to identify a set of latent factors that influence the six behavioral improvement scores. Principal components was the extraction method used, with varimax (orthogonal) rotation. Derived factor scores were retained if their eigenvalues exceeded one. Resulting factors were identified and labeled and factor scores were computed using a regression approach to create new variables describing the latent factors. Finally, a general linear model with repeated measures was computed to test for the association between the behavioral latent factors and change over time in sleep quality.

RESULTS

Out of the original 146 participants included in the original study, only 104 were participants in the treatment group. Out of these, 98 provided month 0 data, month 6 data, or both time points (regarding completeness of behavioral data from the smartphone app in the six domains, subjects either provided all six or none). Sixty-nine provided month 0 and month 6 sleep quality data (dependent variable), and of these, 56 also provided longitudinal behavior change data on the app (independent variable). Of the final sample of 56 subjects, 66.1% were female; 83.9% were currently married, 7.1% divorced, and 8.9% never married. All subjects completed high school, with 21.4% also completing some college or vocational training, 35.7% completing a bachelor's degree, and 42.9% completing a graduate or professional degree. Minimum age was 40, the maximum 64 (M= 54.84, SD= 6.6).

Factor analysis results revealed the presence of two latent factors that explained the majority of the variance in the six behavioral domains. The first factor explained 40.0% of the variance and had high loadings on cognitive stimulation, sleep quality, stress management, and social engagement, and thus this factor was labelled "Social/Emotional Related Behaviors". The second factor explained an additional 21.6% of the variance and had high loadings on the other behavioral domains namely, physical activity and diet quality. This factor was labelled "Physical Body Related Behaviors." Factor loadings for these two derived factors are given in Table 1.

Table 1: Principal Components Factor Analysis Results of Six Behavioral Change Scores Over a Six Month Intervention Period

	Component	
	1	2
Sleep Hygiene Promotion	0.609*	0.161

Physical Activity	0.095	0.826*
Cognitive Stimulation	0.766*	-0.044
Stress Management	0.841*	0.069
Diet Quality	0.086	0.847*
Social Engagement	0.751*	0.147

The remaining factors had eigenvalues less than one with small proportion of explained variance and were not retained in the rotated factor solution. Factor scores were computed via regression method for the two identified latent factors.

The two latent factors were then tested for prediction of change in sleep quality over the intervention period and the physical body factor was a significant predictor while the social/emotional factor was not (Table 2).

Table 2: Linear Regression Analysis of Improvement in Sleep Quality Regressed on the Social/Emotional Behavioral Factor and Physical Body Behavioral Factor Before Adjusting for Covariates.

	Unstandardized Coefficients		Standard Coefficients	t	Sig.
	B	Std. Error	Beta		
Mental/Emotional Behavioral Factor	0.154	0.297	0.068	0.52	0.606
Physical Body Behavioral Factor	-0.665	0.297	-0.294	-2.241	0.029

Because the social/emotional factor was not significant it was removed from subsequent models. The next regression model added in the covariates in order to determine the robustness of the physical body behavioral factor on sleep quality after adjustment for these sociodemographic variables. Higher scores on the physical body factor predicted significant

reduction in global sleep quality score, i.e. significant reduction in sleep problems, after controlling for all covariates (Table 3).

Table 3: Linear Regression Analysis of Improvement in Sleep Quality Regressed on the Social/Emotional Behavioral Factor and Physical Body Behavioral Factor After Adjusting for Covariates.

	Unstandardized Coefficients		Standard Coefficients	t	Sig.
	B	Std. Error	Beta		
Married	-0.004	0.782	-0.001	-0.005	0.996
What is your gender?	-0.373	0.651	-0.078	-0.573	0.569
What is your age in years?	-0.01	0.044	-0.032	-0.238	0.813
Varimax REGR Factor Score Physical Body Behavioral Change	-0.666	0.303	-0.294	-2.257	0.028*

After performing bivariate correlations, results showed that there were seven bivariate correlations among the six behavioral domains. Among these physical activity and diet quality were significantly associated with each other ($p<.001$), as were sleep hygiene and cognitive stimulation ($p<.05$), sleep hygiene and stress management ($p<.001$), sleep hygiene and social engagement ($p<.05$), cognitive stimulation and stress management ($p<.001$), cognitive stimulation and social engagement ($p<.000$), and stress management and social engagement ($p<.001$). These results agree with the previous findings of the factor analysis results previously discussed.

Discussion

The goal of this study was to determine whether changing the social/emotional aspects of one's life (specifically sleep hygiene behaviors) would prove beneficial in improving one's

perceived sleep quality. Secondarily, we investigated to determine whether or not health related behaviors related to the physical body would play a greater, lesser, or equivalent role than the social/emotional behaviors in improving the quality of sleep.

To accomplish this, extant data was used from an RCT where a measure of sleep hygiene behavior was obtained in conjunction with five other health-related behaviors using daily reports from a smartphone app. This app specifically measured six different behavioral factors namely; physical exercise, diet quality, sleep quality, stress reduction, social engagement, and cognitive stimulation. The subjective sleep quality score was measured with the PSQI survey.

Two latent factors were identified through factor analysis, namely social/emotional behaviors and physical body behaviors. These results agree with previous findings that both physical exercise and diet quality can be considered within the same factor groupings (Donovan et al., 1993). However, it is believed that this is the first study to analyze all six different behaviors and categorize them into separate factor groupings.

The key finding of this study include that the physical body behavioral factor significantly predicted an improvement in global sleep quality (reduction in sleep problems), whereas the social/emotional behavioral factor did not. The significance of the physical body behavioral factor was robust to all covariate adjustments.

This finding supports a number of previous studies showing that both physical exercise (Gerber et al., 2014) (Oksanen et al., 2013) (Hudgel, 2013) (Pa et al., 2014), and diet quality (Irish et al., 2014) (Chaput, 2014) (Tan et al., 2015) (Grandner et al., 2014) (Sasahara et al., 2015) (Kurotani et al., 2015) are both associated with affecting sleep patterns. While this study did not identify a significant effect of improvement on sleep quality from social/emotional behaviors, there were a number of other studies that did find significant correlations between

sleep quality and stress (Hall et al, 2015) (Pereria et al., 2015) (Pow et al., 2016), social engagement (Hall et al, 2015) (Pereria et al., 2015) (Pow et al., 2016), and cognitive stimulation (Pa et al., 2014).

The present study had a couple limitations that should be mentioned. Extant data from a population in Cache County, Utah was utilized, comprised of 99% Caucasian individuals. Therefore, there are likely limits to the generalizability of this study's findings to other ethnic groups. In addition, there may have been a selection bias among the study's population due to the original nature of the study from which the data were utilized. Additional limitations are a relatively small sample size. Though a longer follow up time than many studies with six months of follow up, this study did not observe individual behavior patterns and sleep quality changes across a full twelve months where seasonal variations could be observed.

This study also had a number of strengths. It is believed that this is the first study that used the six domain holistic approach to understanding how to improve sleep quality. An innovative feature of this study was the use of a smartphone data collection tool that was helpful in obtaining frequent and accurate data with relative ease. This study allowed the participants to make their own decisions on which behavioral changes to make. This feature is extremely valuable in that is makes the study similar to real life situations in which patients have the autonomy to run their life as they see fit.

Future directions to further advance this area of research might be to study the weekly or daily changes in behavior and its effect on the rate of change in sleep quality using more than two data points to assess the change in overall sleep quality. Such an investigation might explain what duration of time (magnitude of time lag) for behavior change would be necessary and sufficient to improve the quality of one's sleep and to what magnitude. Further, this approach

could be used to examine the effect that these two different behavioral factors might have on a number of different outcomes such as cognitive test scores, depression, and perceived stress, among others.

In conclusion, the current study has provided information that may be helpful in a medical setting with patients who are struggling with sleep problems. Study findings could be used to help those who are trying to improve their sleep quality by drawing attention to physical activity and diet quality rather than other behavioral improvements. This research revealed that there tend to be two separate behavioral patterns that are likely to be observed in a clinical environment. This information may help physicians to better assist the patient in achieving their desired health outcomes.

Reflective Writing

As I started working towards earning my Honors designation, I began to learn the many different things I would need to complete. The one that was most intimidating however was the capstone project. In my mind, I could never imagine writing such a long document, but with the assurance of the honors advisor, I started working toward this goal.

To begin, I wanted to find something that I could relate to my professional goals. Because I wanted to become a doctor, I chose to do a number of my contracts in a way that would help me to learn about both research and health related topics. My first contract helped me to enter into the world of research. A professor contacted me one semester and asked me if I wanted to become an aid for one of her classes. After discussing the options, we both decided that my time would be better spent helping her with the research project she was currently working on. This project was the Gray Matters study, and its goal was to find ways to help delay the onset of Alzheimer's Disease. For my first contract, she let me write a portion of her grant that would eventually be sent to the National Institute of Health. Specifically, my portion would be to discover the impacts of similar interventions among African-American communities. During this time I learned a lot about how to find different articles for a research paper, and why they are needed. Additionally, I learned to a small degree how to write research grants and proposals.

For my second contract, I decided that I would like to continue working on the Gray Matters study and I was made a supervisor over ten interns. As part of this, I was responsible for reading through different articles that the students had found for the project. They would use these approved articles by finding different facts that could be inserted into a smartphone app for the intervention. This contract helped me to further my knowledge of research and better

adjusted me to the language of research. Initially, it was difficult to understand what the majority of the articles referred to, but as I read more and more of them, I became more competent in knowing what was being discussed.

Both of these contracts prepared me well for writing my thesis. Before I began, we were required to take a thesis proposal course that was helpful in my deciding on my thesis topic. In this class, we were required to look at some past theses and to create a thesis proposal based on something that we would like to research or present. At the beginning of this class the idea of writing a 5000-word paper seemed like an impossible task, but as we broke down the steps, it made it more manageable.

At this point, I began discussing with my mentor the possible topics that we could study for my thesis. While I initially wanted to study Alzheimer's we decided that it would be more manageable to study specific aspects of the intervention and what they predicted. We then decided on the sleep quality measure, and proposed the hypothesis that the act of trying to change one's sleep quality, would have an impact on the sleep itself. We then compared this to some different measures as well. In the end, we found out that physical activity was a better predictor than trying to change one's sleep.

While there were some good things that I learned by working on my thesis, there were also a number of difficulties that I had to overcome. One of these was that I had no experience in writing a scientific piece of literature. I found myself often unable to word things in the way that I knew that they needed to be worded. Another difficulty that I faced was my inexperience with statistics. While I had taken an introductory statistics class before beginning my thesis, I didn't know the different calculations that were required for my data analysis.

As I worked on writing the paper and encountered these difficulties, I realized that without the help of my mentor I never would have been able to complete the project. Despite having beneficial experiences such as my contracts and the thesis class, I was still unsure of how to begin. My mentor worked with me and taught me the different parts that each paper is composed of. She then sent me off in the right direction to begin writing up each of those sections. Once one was completed, we would sit down together and discuss what could be improved and how specific changed in wording were better than others. I am grateful for this relationship that we developed as I later asked this mentor to write me a letter of recommendation for medical schools.

The honors program, as well as the project itself, has also helped me to become more prepared for entering the medical field. Each medical school has specific requirements on the amount of research they want to see applicants participate in. This program helped me to be able to fulfill these requirements in a way that prepared me for things that I may be required to do later on. In addition to that, it has helped me to expand my horizons and study things that I may not have wanted to originally.

Another aspect that this project has helped with is deepening my understanding of my major and how I can work with others as an interdisciplinary team. While my thesis involved only the help of one specific professor, I do know that the Gray Matters project as a whole worked with many different fields of expertise. Some examples of this include that they had people from the math department run some of the most complicated statistics and some professors in the Psychology department were also consulted for evaluating the participants. This has led me to believe that working with others in the scientific community is more beneficial than working alone.

In the end, I believe that this project will be something that I can look back on with pride. I will be able to know that I did something that I originally thought might be impossible. In addition to that, it helped me to become more knowledgeable about what I might expect as I enter the professional world.

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Appendix A

PSQI Questions

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions. During the past month:

	During the past month:
When have you usually gone to bed? (example: if at 7:30pm enter 7:30pm, if at 1am, enter 1:00am) (1)	
How long (in minutes) has it taken you to fall asleep each night? (2)	
When have you usually gotten up in the morning? (3)	
How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) (4)	

During the past month, how often have you had trouble sleeping because you:

	During the past month:			
	Not during the past month (1)	Less than once a week (2)	Once or twice a week (3)	Three or more times a week (4)
a. Cannot get to sleep within 30 minutes (1)				
b. Wake up in the middle of the night or early morning (2)				
c. Have to get up to use the bathroom (3)				

d. Cannot breathe comfortably (4)				
e. Cough or snore loudly (5)				
f. Feel too cold (6)				
g. Feel too hot (7)				
h. Have bad dreams (8)				
i. Have pain (9)				
j. Spend a lot of time with electronic distractions that keep you awake (TV, iPad, smartphone, etc) (10)				

During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?

Not during the past month (1)

Less than once a week (2)

Once or twice a week (3)

Three or more times a week (4)

During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month (1)

Less than once a week (2)

Once or twice a week (3)

Three or more times a week (4)

During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?

Not during the past month (1)

Less than once a week (2)

Once or twice a week (3)

Three or more times a week (4)

During the past month, how would you rate your sleep quality overall?

Very Good (1)

Fairly Good (2)

Fairly Bad (3)

Very Bad (4)

Appendix B:

Smartphone Application Questions

For each of the questions listed below, the app pushed the question to the user's device. Optionally if the user wanted clarification on a question they would tap on the question and the explanation text appears.

1. How many minutes did you spend today doing "novel mental exercises"? Examples of novel mental exercises are memorizing a recipe or grocery list, learning new words or a foreign language, doing arithmetic problems, helping kids/grandkids with homework.
2. How many minutes did you spend today doing "cognitively stimulating activities"? Examples of cognitively stimulating activities are volunteering, joining a book club, playing a musical instrument, attending a lecture or concert, or debating friends on a hot topic of the day. Keep it fun so you'll stick with it!
3. How many minutes of "moderate" physical activity did you do today? The CDC recommends 2 hours 30 minutes of "moderate activity" per week. Examples of moderate activity: Walking, skiing, raking leaves, washing the car.
4. How many minutes of "vigorous" physical activity did you do today? The CDC recommends 1 hour 15 minutes of "vigorous activity" per week. Examples of vigorous activity: Jogging, bicycling, aerobics, carrying heavy items.
5. How would you rate your social engagement in the last 24 hours? Please use this rating system: 1=Extremely Bad, 2=Fairly Bad, 3=Not Good, 4=OK, 5=Good, 6=Very Good, 7=Excellent
6. How much effort have you put into decreasing your stress over the past 24 hours? Taking a walk, talking to a friend, or contacting a loved one can provide the opportunity to be both aware and a time-out to reset your stress. Each day, rate your stress reduction efforts as 0=No effort, 3=Some effort, 5=Moderate effort, 7=A lot of effort, 10=Working at it constantly.
7. How many cups of fruits and vegetables did you eat today? Each day aim to eat at least 5 cups of a variety of fruits and vegetables.

8. How many ounces of whole grains did you eat today? Each day aim to eat at least 3 ounces of whole grains. (1 slice of whole grain bread, 1/2 cup of brown rice or whole grain pasta counts as a serving)
9. How many servings of nuts, seeds, or legumes did you eat today? Each day aim to eat at least 1 serving of nuts, seeds, or legumes every day. (24 nuts or 1/2 cup of legumes such as black beans, split peas or lentils counts as a serving)
10. How would you rate your sleep promotion efforts over the past 24 hours? Good sleep is linked to better mental performance during the day, and lower risk for Alzheimer's disease. Promote better sleep by: 1) avoiding caffeine within 4 hours of bedtime, 2) finishing exercise 3 hours or more before bedtime, 3) creating a quiet, dark environment, 4) keeping computers, TVs, iPads, etc out of the bedroom, and 5) maintaining a regular bedtime and wake-up time each day, to help set your internal "clock" for better sleep. Rate your sleep promotion efforts by indicating how many of these 5 suggestions you followed.

Author Biography

Austin Dopp has completed his Bachelors of Arts degree with an Honors designation in Family, Consumer, Human Development, with an emphasis in Human Development, and a minor in Chemistry. He is from Idaho Falls, Idaho and is married with two daughters.

Austin began his research during his first semester when he joined the Connecting the Generations Project where he helped study how to strengthen relationships between grandparents and their grandchildren. He presented the initial findings at the FCHD Fall Research Fair in 2014. Eventually he also joined the USU Spider Silk Lab and learned how to do bench research as he helped to purify proteins necessary for future testing.

After joining the USU Honors Program he began assisting Dr. Maria Norton with the Gray Matters study in 2015 where he contributed to a small literature review portion of a multi-million dollar NIH R01 grant proposal. He then served as an unofficial undergraduate teaching fellow for a research methods class and supervised interns that also assisted with the Gray Matters Project. Finally he has recently completed his honors thesis on how to improve sleep exercise which he presented at the Undergraduate Research on Capitol Hill event April 2017.

Some of Austin's awards and accomplishments include being named on the Dean's list four semesters, received an A-pin, being awarded the Stella Griffiths Scholarship as well as the Lillywhite Scholar Award, and scoring in the 98th percentile in the MCAT.

His future goals include attending medical school this upcoming fall at _____, becoming a doctor, and being the best husband and father he can be throughout his future career.