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THE INTERRELATIONSHIPS BETWEEN SLEEP, PHYSICAL ACTIVITY, PSYCHOLOGICAL WELL-BEING, AND GESTATIONAL WEIGHT GAIN IN OVERWEIGHT AND OBESE PREGNANT WOMEN

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ABSTRACT

Background: Pregnant women often experience a combination of sleep disturbances, reduced levels of physical activity, and increased symptoms of stress and depression. Previous studies have suggested that disturbed sleep, low levels of physical activity, and poor psychological health all contribute to excessive gestational weight gain (GWG), which can lead to further complications. However, limited research has examined the combined associations of these factors in relation to GWG. The purpose of this study was twofold: (1) examine the interrelationships between sleep, physical activity, psychological health, and GWG to understand the extent to which these factors are related over a brief, 6-week pilot intervention to manage GWG; and (2) use the data collected in the first purpose to inform the development of specific sleep intervention content for a larger intervention trial to manage GWG. **Methods:** Participants included a cohort of overweight/obese pregnant women participating in a pilot test of the Healthy Mom Zone intervention to manage GWG. Data was collected at pre- and post-intervention and daily for sleep (i.e., sleep time, nap time, and number of times woke), physical activity (i.e., total active time via activity monitor), perceived stress (Perceived Stress Scale), and weight. Data were collected only pre- and post-intervention for depressive symptoms (Center for Epidemiological Studies Depression-Scale) and leisure-time exercise behavior (Leisure-Time Exercise Questionnaire). **Results:** Across the 6-week study, total sleep time was significantly and positively associated with physical activity (i.e., week [W]5) and stress (i.e., W1-6) and negatively associated with depressive symptoms (i.e., at pre- and post-intervention). Nap time was positively associated with stress (i.e., W1-6) and depressive symptoms (i.e., at pre- and post-intervention). Number of times woke was negatively associated with GWG (i.e., W3 and W4) and positively associated with stress (i.e., W1 and W4) and depression (i.e., pre- and post-intervention). **Discussion:** Given the associations between sleep and physical activity, psychological health, and GWG, sleep may be an important modifiable target for interventions in pregnancy. By targeting strategies to

improve sleep hygiene (e.g., creating a cool, quiet sleep environment, reducing sugary foods before bed), researchers may be able to indirectly promote increased physical activity, reduced stress and depressive symptoms, and better manage GWG. The study findings from this thesis may be useful to other researchers aiming to promote health in pregnant women. The findings will specifically be used to inform the development of sleep intervention content for a larger randomized trial of the Healthy Mom Zone study to manage GWG with overweight and obese pregnant women.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Chapter 1

Introduction

Introduction to Thesis

Pregnancy and childbirth represents a unique time in women's lives that is associated with numerous physical and psychological changes over a relatively short period of time. Women experience rapid changes in body shape, size, and weight as well as sharp fluctuations in emotional well-being; feelings of increased stress and depression are common as the physical changes of pregnancy unfold (United States Department of Health & Human Services [USDHHS], 2016). Excessive weight gain in pregnancy can exacerbate these symptoms and complicate pregnancies thus making proper management of weight essential for a healthy pregnancy. However, the majority of women gain more weight in pregnancy than is recommended, (see Table1; Institute of Medicine [IOM], 2009), and overweight and obese women are especially at risk for high gestational weight gain (GWG). Unfortunately, there are no gold standard interventions for effectively managing GWG, and little is known about the complex interrelationships between factors related to weight gain such as sleep, physical activity (PA), and psychological well-being. The purpose of this thesis is to examine these interrelationships among a cohort of overweight and obese pregnant women participating in a brief, 6-week pilot intervention study to manage GWG. Findings from this study will be used to inform modifiable targets for future studies aiming to intervene during pregnancy to manage GWG effectively.

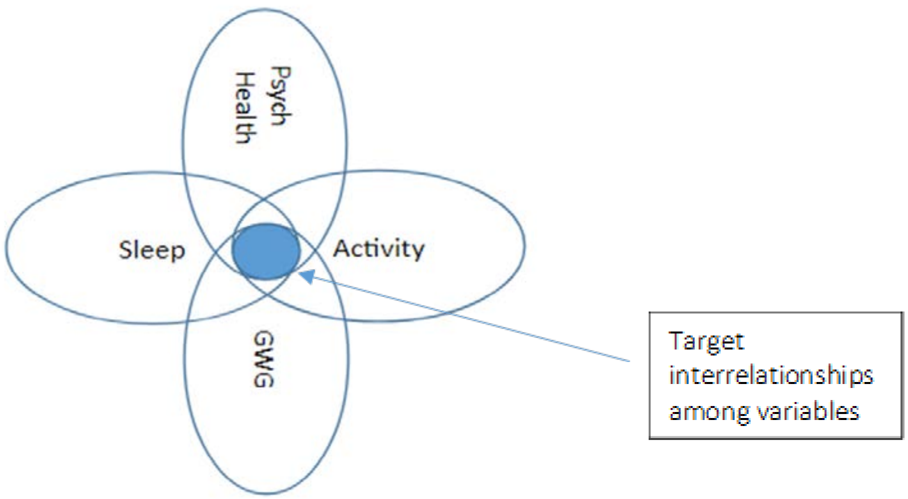
Table 1. Institute of Medicine Recommendations for Weight Gain During Pregnancy.

Category	BMI	Recommended Weight Gain
Underweight	$<18.5 kg\cdot m^{-2}$	28-40lbs
Normal Weight	$18.5\text{-}24.9 kg\cdot m^{-2}$	25-35lbs
Overweight	$25\text{-}29.9 kg\cdot m^{-2}$	15-25lbs
Obese	$>30 kg\cdot m^{-2}$	11-20lbs

Note. BMI = Body Mass Index; lbs. = pounds.

The conceptual framework for this thesis research is illustrated below in Figure 1. The following sections will explain the research evidence on the relationships between the targeted variables (sleep, PA, psychological well-being, and GWG).

Figure 1. Conceptual Diagram of Target Variables: Interrelationships between Sleep, Activity, Gestational Weight Gain (GWG), and Psychological (Psych) Health



Sleep During Pregnancy

Pregnant women are recommended to get between 7 and 9 hours of sleep each night, yet approximately 24% of women report getting less than 7 hours of sleep during pregnancy while 21% of women report getting more than 9 hours of sleep (Xu, Liu, Zhang, Sharma & Zhao, 2017). Furthermore, over 75% of women report experiencing sleep difficulties during pregnancy including multiple nocturnal awakenings, physical discomfort, and anxiety associated with fear of labor, having an unhealthy baby and forthcoming life changes (Izci-Balserak & Pien, 2014). Despite the fact that these sleep difficulties are all signs of poor sleep hygiene and are linked to adverse health outcomes (e.g., weight gain, depression), they are often overlooked since pregnancy is viewed as a period of time when sleep problems are normal and/or “to be expected” (Gay, Richoux, Beebe, & Lee, 2017; Hutchison, Stone, McCowan, Steward, Thompson, & Mitchell, 2012; National Sleep Foundation, 2018). However, researchers have shown that sleep deprivation and disturbances have been linked to preterm delivery, risk of cesarean delivery, postpartum depression, hyperglycemia, insulin resistance, type II diabetes, metabolic syndrome, coronary artery disease and stroke (Hutchison et al., 2012; Izci-Balserak & Pien, 2014). Thus, understanding the relationship between sleep, maternal behaviors, and health outcomes is essential and should a well-researched topic in the literature.

Practicing good sleep hygiene (i.e., regulating total sleep time, nap time, and number of times woke) is important not only because it is protective against adverse health outcomes but also, because it promotes physical and mental well-being (National Sleep Foundation, 2018). Good sleep hygiene includes limiting naps to 30 minutes, avoiding caffeine and high fat/sugar foods before bedtime, exercising regularly to improve sleep quality, getting adequate exposure to natural light during the day, and establishing a regular bedtime routine. Additionally, people should create a comfortable sleep environment by turning off lights and setting the thermostat to a cool temperature (e.g., between 60-67 degrees). Curtains, eyeshades, earplugs, and fans are other tools that could improve one's sleep experience (National Sleep Foundation, 2018; Woods, 2016). Overall, many modifiable factors exist which can contribute to good sleep hygiene. As such, sleep is an important variable to examine in pregnancy interventions because there are many methods, such as establishing bedtime routines, purchasing a supportive mattress, or creating a cool and quiet environment, which may improve sleep (Woods, 2016). Sleep would also appear to be an important factor to examine in relation to other pregnancy-related behaviors such as PA, psychological well-being, and GWG. Despite its potential potent influence on these behaviors, the literature in this area is sparse. The following sections provide an overview of the relationships between sleep and these maternal variables.

Sleep and Physical Activity

Pregnant women are advised to engage in at least 150 minutes of moderate-intensity PA each week (American Congress of Obstetrician Gynecologists [ACOG], 2015). Moderate-intensity PA includes exercises that raise one's heart and respiratory rates (Garland, 2016). However, studies have found that fewer than 15% of women achieve the recommended PA levels (Anjana, Sudha, Lakshmipriva, Anitha, Unnikrishnan, Bhavadharini et al., 2016; Garland, 2016; Guelfi, Wang, Dimmock, Jackson, Newnham, & Yang, 2015). Furthermore, recent evidence suggests that 51.6% of women decrease their PA levels during pregnancy, despite advisement to maintain PA levels as long as no medical or obstetric complications are present (Garland, 2016; Merkx, Ausems, Bude, de Vries, & Nieuwenhuijze, 2017). Researchers have examined the reasons for low PA levels, and have identified a variety of beliefs (e.g., lack of motivation, interest; fear of harming baby or self), with a common limitation of tiredness and exhaustion (Guelfi et al., 2015; Symons Downs & Hausenblas, 2004; 2005). However, the research examining sleep and PA during pregnancy is limited despite sleep deprivation being a common barrier to PA. Thus, understanding the relationship between sleep and PA is an important area of research.

In examining the relationship between sleep and PA in non-pregnant populations, one study found that, in women aged 20-39, longer sleep duration led to a greater amount of moderate-vigorous PA (McClain, Lewin, Laposky, Kahle, & Berrigan, 2014). Conversely, adults who experienced daytime sleepiness were less likely to participate in PA (McClain et al., 2014). Researchers from the *Study of Women's Health Across the Nation*- examined sleep quality and duration along with PA, as defined by three categories: active living, household/caregiving, and sports/exercise (Kline, Irish, Krafty, Sternfeld, Kravitz, Buysse et al., 2013). The researchers found that sports/exercise activity is associated with better sleep quality whereas active living and household/caregiving were not strongly associated with sleep quality (Kline et al., 2013). This study suggests that women duration of sleep and PA may influence one another.

Only a handful of studies have examined the relationship between sleep and PA among pregnant women. One study found that women who participated in moderate-intensity exercise experienced better sleep quality (Soltani, Haytabakhsh, Williams, O'Callaghan, Bor, Ding et al., 2012). Additionally, another study looked at pregnant women who participated in occupation, household, and outdoor PA.

Recreational PA was associated with good sleep quality. Occupational PA was associated with short or healthy (e.g., between 7-9 hours) sleep duration, whereas household and recreational PA was associated with longer sleep duration (e.g., more than 9 hours of sleep; Borodulin, Evenson, Monda, Wen, Herring, & Dole, 2011). It is possible that increased PA leads to improved sleep quality but sleep duration is dependent upon the type of PA performed. However, because this is a new area of research, more evidence is necessary to understand the relationship between sleep and PA.

Sleep and Psychological Well-Being

Pregnant women experience numerous physical changes, including changes in various hormone levels. Estrogen, a hormone responsible for decreasing rapid eye movement (REM) sleep, increases during pregnancy (Hutchison et al., 2012). Progesterone, a hormone responsible for increasing non-REM sleep; ventilation, which can lead to a respiratory alkalosis; and ultimately sleepiness due to its sedative and inhibitory effect on muscles; also increases during pregnancy (Hutchison et al., 2012; Izci-Balserak & Pien, 2014). Progesterone may also be responsible for sleep disturbances, such as frequent urination and snoring in late pregnancy (Izci-Balserak & Pien, 2014). Additionally, pregnant women see an increase in the stress hormone, cortisol, which is associated with sleep disturbances and depression (Luiza, Gallaher & Powers, 2015; Mellor, Chua, & Boyce 2014). These significant hormonal changes can negatively influence both sleep and psychological health.

In addition to hormonal changes, the prenatal period consists of many life changes, which may lead to stressors such as financial burdens, increased family and household responsibility, and strain in intimate relationships, and pregnancy complications only exacerbate these (Dunkel Schetter & Tanner, 2012). According to one study, 78% of women experience low-to-moderate stress and 6% of women experience high stress during this time (Dunkel Schetter & Tanner, 2012). This high prevalence is concerning since stress has been linked to many adverse health outcomes for both mothers and offspring, including preterm birth, mortality, morbidity, respiratory distress syndrome, chronic lung disease, neurodevelopmental disabilities, cognitive difficulties, and low birth weight (Dunkel Schetter & Tanner, 2012; Grote, Bridge, Gavin, Melville, Iyengar & Katon, 2010). Antenatal depression has also been linked to adverse health outcomes including preterm birth, low birth weight, and childhood developmental delays (Mellor, Chua, & Boyce 2014). Studies have examined the prevalence of antenatal depression and found that up to 16% of women have at least some symptoms of depression, while 5% present with clinical criteria for major depressive disorder (Dunkel Schetter & Tanner, 2012). Overall, both stress and depression negatively affect pregnancy outcomes.

Despite the physical changes that occur in pregnancy, as well as the unique life changes likely to increase symptoms of stress and depression, there are a limited number of studies examining the relationship between sleep and psychological well-being in pregnancy. One study recruited 50 participants to keep a sleep/wake diary, which included questions on sleep and stress, for 42 days in order to study the relationship between sleep and stress (Akerstedt, Orsini, Petersen, Axelsson, Lekander & Kecklund, 2012). The researchers found that stress in pregnancy is a significant predictor of poor subjective sleep quality. From this data, researchers suggested that stress is a primary cause of insomnia, which would in turn, lead to poor sleep quality. Another study examined the relationship between sleep-disordered breathing and depression in 189 pregnant women (Mellor, Chua, & Boyce 2014). Participants were asked to complete measures of personal demographics, sleep (Pittsburgh Sleep Quality Index and the Berlin Questionnaire), and depression (Edinburgh Postnatal Depression Scale). Findings from this study indicated that poor sleep quality preceded higher depressive symptoms, thus also suggesting that improved sleep could potentially lead to fewer depressive symptoms (Mellor, Chua, & Boyce 2014).

The limited number of studies on the associations between sleep and PA, psychological well-being and GWG suggest that improving sleep hygiene (e.g., getting between 7-9 hours of sleep, reducing nap time and sleep disturbances), can impact other important behaviors (e.g., PA, psychological well-being, GWG) which are subsequently important targets for intervention (Akerstedt et al., 2012; Gay et al., 2017; Mellor, Chua, & Boyce 2014; Soltani, et al., 2012). In fact, sleep may be an especially important variable for pregnancy intervention programs because it may be more easily manipulated compared to other behavioral targets. That is, by adjusting elements such as sleep environment, bedtime nutrition, and bedtime routine, intervention researchers have the ability to not only influence sleep, but also the potential to have indirect impacts on other variables such as PA, psychological well-being, and GWG.

Sleep and GWG

Among non-pregnant populations, insufficient sleep has been identified as a risk factor for weight gain and obesity (Knutson & Van Cauter, 2008; Markwald, Melanson, Smith, Higgins, Perreault, Eckel et al., 2013). For women in particular, insufficient sleep appears to reduce dietary restraint, which leads to greater weight gain (Knutson & Van Cauter, 2008; Markwald et al., 2013). Additionally, it appears to reduce leptin (which affects feelings of satiety) and increases ghrelin (which promotes hunger; Knutson & Van Cauter, 2008). Adequate sleep appears to be an important factor that increases dietary restraint and prevents weight gain.

Among pregnant women, excessive GWG can lead to a wide variety of adverse health outcomes, including increased risk for long-term obesity, cardiovascular disease, and type II diabetes (Choi, Fukuoka, & Lee, 2013). To prevent these adverse outcomes, the IOM (2009) developed guidelines for appropriate GWG (shown in Table 1); which are based on a woman's pre-pregnancy BMI. According to one study, women who are overweight or obese are at an increased risk of exceeding IOM (2009) GWG guidelines when compared to women who are underweight or healthy prior to pregnancy (Gay et al., 2017). Given the risks associated with gaining an excessive amount of weight during pregnancy (e.g., higher chance of gestational diabetes, pre-eclampsia, cesarean section, birth trauma; IOM, 2009), particularly for overweight and obese women, it is imperative that researchers study the underlying factors associated with excessive GWG, such as sleep, in order to better encourage appropriate GWG and protect both mothers and their infants.

Unfortunately, few studies have examined the relationship between sleep and GWG during pregnancy. One recent study recruited 128 women from prenatal clinics and childbirth classes to assess their sleep disruptions, durations, and quality during their last month of pregnancy (Gay et al., 2017). The study implemented wrist Actigraphy monitoring to track sleep disruptions and duration for 72 hours, and used the Pittsburgh Sleep Quality Index to track sleep quality. They also looked at self-reports of height and weight to determine excessive GWG and BMI. The researchers found that women who gained more weight than IOM recommendations reported poorer sleep quality than women who gained less weight than IOM recommendations. Additionally, for women who were overweight or obese prior to pregnancy, excess GWG was associated with reduced sleep duration and increased sleep disruptions. Women who gained more than the IOM (2009) GWG guidelines also slept more during the day, which is a sign of poor sleep hygiene (Gay et al., 2017; National Sleep Foundation, 2018). Another study, which examined weight gain in relation to pre-pregnancy BMI, diet, and PA among healthy pregnant women, found that women with self-reported perceived sleep deprivation had an increased chance of gaining less than recommended by the IOM (2009) guidelines (Merkx, Ausems, Bude & Nieuwenhuijze, 2015). Therefore, adequate sleep duration, reduced sleep disturbances, and high sleep quality all play a role in promoting healthy GWG (Gay et al., 2017; Merkx et al., 2015).

While PA is a modifiable behavior and often a target for behavioral interventions, it has been difficult to increase in previous prenatal intervention programs (Merkz et al., 2015). There are several reasons for the challenges. First, physical changes during pregnancy often make it difficult for women to engage in regular PA, particularly during the third trimester when weight gain, soreness, and fatigue are at their highest (Aparicio et al., 2016; Garland, 2016). Furthermore, obese women often report avoiding PA due to joint pain and increased difficulty in moving which they attribute to their large size (Garland, 2016). Second, social misconceptions, such as the myth that resting during pregnancy is safest for the baby since PA may cause miscarriages or preterm birth, restrict fetal growth, or lead to injury, results in lower levels of PA during pregnancy (Aparicio et al., 2016; Garland, 2016). However, there is limited evidence that PA causes adverse pregnancy outcomes (ACOG, 2015). It is possible that by improving sleep through one of the other avenues discussed, such as creating a bedtime routine, there could be indirect positive effects for promoting PA.

Physical Activity and Psychological Well-Being

In addition to its many physical health benefits, studies have found that women who engage in PA during pregnancy show improvements in psychological health during pregnancy. In studying stress, one study found that women report less stress, as well as improved mood and pain tolerance when they exercise (Garland, 2016). In looking at depression, a systematic review analyzed 10 observational and 7 intervention studies that looked at the relationship between PA, sedentary behavior and postnatal depressive symptoms. A common trend among studies was that as leisure-time PA increases, depressive symptoms decrease (Teychenne & York, 2013). Evidently, by participating in PA, women can reduce postnatal depression symptoms.

Another study looked at depression and PA in obese pregnant women in (de Wit, Jelsma, van Poppel, Bogaerts, Simmons, Desoye et al., 2015). Depression was measured using the WHO well-being index and moderate-to-vigorous PA was tracked with accelerometers. The results of the study found that women who had good mental health spent 85% more time in moderate-to-vigorous PA compared to women with depressive symptoms (de Wit et al., 2015). The finding that depressive symptoms cause women to be less willing to participate in PA during pregnancy was further corroborated by other pregnancy studies (Loprinzi, Fitzgerald, & Cardinal et al., 2012). Additionally, according to a review of studies on PA and depression during pregnancy, PA may work to reduce depression through several physiological pathways (Lewis & Kennedy, 2011). For example, it may correct imbalances of the hypothalamic-pituitary-adrenal axis or in the central monoamine system. Imbalances in both of these pathways have been linked to depression, so correcting these imbalances effectively minimizes depressive symptoms (Lewis & Kennedy, 2011). Other techniques, such as therapy and antidepressants, have been used to correct these imbalances, but neither technique is as affordable or safe, especially for pregnant women, as PA. (Lewis & Kennedy, 2011). Overall, PA has the potential to reduce stress and depressive symptoms, which can lead to further health benefits (de Wit et al., 2015; Garland, 2016; Lewis & Kennedy, 2011; Loprinzi, Fitzgerald, & Cardinal et al., 2012). Additionally, since some studies have shown that PA is positively associated with GWG, it is likely that associations also exist between GWG and psychological well-being.

Physical Activity and GWG

Similar to the relationship between sleep and weight, lower levels of PA are associated with higher weight both in non-pregnant and pregnant women (Hill & Melanson, 1999; IOM, 2009). Increasing PA during pregnancy may help prevent adverse health outcomes associated with excessive GWG as well as assist women during labor and delivery by building endurance (Choi, Fukuoka, & Lee, 2013; Gay et al., 2017). Women are advised to participate in exercises such as walking, cycling, and weight training to achieve at least 150 minutes of moderate-intensity PA each week (ACOG, 2015; Coll, Domingues, Hallal, da Silva, Bassani, Matijasevich et al., 2015).

Despite these recommendations, most previously active women are discontinuing or decreasing leisure-time PA during pregnancy (Coll et al., 2015). In fact, one study found that almost 60% of pregnant women in the U.S. were sedentary (Symons Downs & Hausenblas, 2004). Less active and/or sedentary women are predisposed to obesity, hypertension, gestational diabetes, long-term chronic disease risks, preeclampsia, complications during labor and birth, postpartum weight retention, postpartum mood disorder, and excess GWG (Aparicio et al., 2015; Coll et al., 2015; Garland, 2016). In fact, one study on Hispanic women found that 52% of women gained excess GWG (Chasan-Taber, Silveira, Lynch, Pekow, Solomon, & Markenson, 2014; Merkx et al., 2015). Moreover, women who are overweight or obese prior to pregnancy are at an increased risk for excess GWG (Schlaff, Holzman, Maier, Pfeiffer, & Pivarnik, 2014). Evidently, PA, or lack thereof, plays a role in preventing or exacerbating excessive GWG, respectively, particularly in overweight or obese women.

In examining the effect of PA on GWG, numerous studies have been conducted with mixed findings between studies. In fact, a meta-analysis of intervention trials focused on PA and GWG found that 5 out of 12 trials showed lower GWG in control groups whereas 7 trials showed lower GWG in exercise groups. In comparing mean GWG between exercise and control groups, there was no overwhelming difference between GWG in exercise and control groups for any of the studies analyzed (Streuling, Beyerlein, Rosenfeld, Hofmann, Shulz, & von Kries, 2011). Several studies have replicated the finding that PA does not significantly influence excessive GWG (Chasan-Taber et al., 2014; Jing, Huang, Liu, Luo, Yang, Liao, 2015). One such study, conducted on pregnant women in China, found that an intervention involving the introduction of PA did not significantly decrease total GWG throughout the pregnancy. In fact, both intervention and control groups saw a weekly and total weight gain that was above IOM (2009) recommendations (Jing et al., 2015).

Despite the ambiguity of the effects of PA on GWG in the literature, many studies in pregnant populations have demonstrated an association between PA and GWG. In fact, numerous studies show that increased levels of PA lead to a decrease in total excess GWG (Aparicio, Ocon, Padilla-Veinuesa, Soriano-Maldonado, Romero-Gallardo et al., 2016; Harrison, Brown, Hayman, Moran, & Redman, 2016; Melzer, Shutz, Boulvain, Kayser, 2010). Furthermore, a decrease in PA or a sedentary lifestyle has been associated with excess GWG (Aparicio et al., 2015; Garland, 2016; Merkz et al., 2015). Based on these significant findings, it is possible that the discrepancy between studies is representative of the varying effectiveness of physical activity programs (e.g., location of program, type of exercise, and intensity of exercise), a lack of participant compliance in certain studies, or the role of confounding variables in GWG (e.g., sleep, nutrition, psychological well-being; Harrison et al., 2016; Streuling et al., 2011)

Psychological Well-Being and GWG

There is scant literature on the relationship between psychological well-being and GWG. One study examined the relationship between stress reduction interventions and GWG (Thomas, Vieten, Adler, Ammondson, Coleman-Phox, Epel et al., 2014). Researchers recruited 59 healthy weight (i.e., BMI < 25.0) pregnant women to participate in focus groups that consisted of semi-structured interviews, with questions concerning weight gain and stress. Responses were recorded and analyzed. A noteworthy finding from the study was that 80% of women reported experiencing stress during pregnancy. Furthermore, the majority of these women recognized a connection between stress and eating in their lives (Thomas et al., 2014). In other words, it seems that stress may lead to a stress eating response, which could potentially lead to excessive GWG.

Another study on depression looked at the relationship between high prepregnancy BMI, antenatal depression, and GWG (Molyneaux, Poston, Khondoker, & Howard, 2016) among a cohort from the *Avon Longitudinal Study of Parents and Children* (ALSPAC). Measures were obtained on pre-pregnancy BMI, depression (assessed with the Edinburgh Postnatal Depression Scale), and GWG (extracted from women's obstetric records). The researchers found that while obese women were at greater risk of suffering from antenatal depression, there was no evidence for an association between depression and GWG (Molyneaux, et al., 2016). Overall, more research is necessary on the relationship between GWG and psychological well-being.

Current Thesis Research

Sleep, PA, psychological well-being, and GWG are key factors that influence a woman's health during pregnancy. However, PA, psychological health, and GWG are also factors that are difficult to manipulate in intervention programs. As noted above, PA behavior is difficult to change due physical changes that limit engaging in regular PA as well as beliefs and societal misconceptions that PA can be "harmful" during pregnancy (despite the lack of evidence to support these misperceptions; Aparicio et al., 2016; Garland, 2016). Although there is evidence that shows how physiological changes during pregnancy can increase the likelihood of stress and depressive symptoms, there is little information in the literature about effective strategies to impact psychological health during pregnancy. Finally, preventing high GWG is also difficult to control since it requires attention to energy balance (e.g., increase PA and decrease energy intake), and reducing energy intake is not generally recommended by healthcare providers during pregnancy (Knutson & Van Cauter, 2008).

Furthermore, there are no located intervention studies in literature that have effectively targeted sleep, PA, psychological health, and GWG to promote healthy maternal-infant outcomes. However, there is a need for research that examines how to promote these behaviors in pregnancy. Given the challenges to promoting PA and healthy weight gain in pregnancy, sleep may be a useful behavioral target for intervention that can have indirect effects on PA and GWG. Particularly during pregnancy, women may be willing to modify their sleep hygiene if they believe the changes will not only improve their sleep, but also lead to a healthier pregnancy (Garland, 2016; Woods, 2016). Some changes that could be implemented include a regular bedtime routine, a reduction in high fat/sugar foods before bedtime, and creating a dark, cool and quiet sleeping environment (National Sleep Foundation, 2018; Woods, 2016). Women may be more amenable to making these behavioral changes, which could then positively influence them to consider making other changes such as increasing their PA or making dietary changes to help them sleep better. Overall, the limited research examining the interrelationships among sleep, PA, psychological well-being, and GWG in pregnancy make it difficult to design effective intervention studies to promote all of these behaviors. However, while PA, psychological well-being, and GWG present challenges to intervention researchers, recent advancements in technology may enable researchers to better study, measure, and thus, manipulate, sleep.

The proposed thesis research capitalizes on the infrastructure of a pilot intervention study (Healthy Mom Zone) to manage GWG in overweight and obese pregnant women. The goal of this pilot study was to develop the intervention content, components, dosages, and measurement protocol in preparation for a larger randomized controlled trial to manage GWG in overweight/obese pregnant women. Given this opportunity, the purpose of this study was to: (1) examine the interrelationships between sleep, PA, psychological health, and GWG (as illustrated previously in Figure 1) to understand the extent to which these factors were related over the 6-week brief intervention and, (2) use the data collected from this thesis project to inform the development of specific sleep content for a future behavioral interventions as well as specifically a larger randomized trial of the Healthy Mom Zone study. Based on the limited research in this area (Gay et al., 2017; Hutchison et al., 2012; Izci-Balserak & Pien, 2014; Soltani et al., 2012), a prior hypotheses were established between sleep and the other factors but no hypotheses were established for the interrelationships between PA, psychological well-being, and GWG. It was hypothesized that total sleep time (TST) between 7-9 hours would be positively associated with PA, and negatively associated with psychological health and GWG. It was also hypothesized that nap time (greater than 30 minutes) and number of times woke would both be negatively associated with PA, and positively associated with psychological health, and GWG.

Chapter 2

Methods

Study Overview

This study is part of a larger intervention trial, Healthy Mom Zone (HMZ). HMZ is a longitudinal study to manage GWG in overweight and obese pregnant women and included two phases. Phase 1 was a brief, 6-week pilot test of the intervention to establish the intervention dosages, measurement protocol, and individually tailored adaptive intervention design. The study proposed here is an extension of this pilot study. Phase 2 is to test the fully adaptive intervention over the course of the pregnancy. It is a randomized controlled trial of 30 overweight or obese pregnant women. In HMZ, the adaptive intervention dosages include 7 different healthy eating/PA/goal-setting/self-monitoring programs, shown in detail in Table 2. For additional detail on the HMZ study protocol, see Symons Downs et al. (in review). In short, an adaptive intervention aims to vary the intervention dosage based on the participant's need similar to clinical practice. It includes critical decision points (e.g., which dosage to start with), intervention components (e.g., set of intervention options at each critical decision point), tailoring variables (e.g., variables expected to influence the effect of the component), and decision rules (e.g., links tailoring variables to the intervention components). One part of developing this adaptive intervention is pilot testing different aspects of these elements to formulate the full intervention plan. The study's focus is on the interrelationships between sleep, PA, GWG, and psychological well-being to understand the extent to which these factors are related and may be used to develop specific sleep promotion content for Phase 2 intervention. For more information on adaptive intervention and its purpose in this study, see Symons Downs et al. (in review). Overall, this thesis research is based on the Phase 1 pilot test of the HMZ intervention, which included a baseline appointment, a 6-week intervention period, and a follow-up appointment. Detailed procedures are discussed below in the procedures section.

Table 2: Healthy Mom Zone Pilot Study 1 Dosages

Dosage	Intervention
1 (Baseline)	30-min session/week on: Education, Goal-Setting, Self-Monitoring, HE/PA Plans
2 (Step-Up 1)	30-min session/week on: Education, Goal-Setting, Self-Monitoring, HE/PA Plans + 30-min HE Active Learning
3 (Step-Up 2)	30-min session/week on: Education, Goal-Setting, Self-Monitoring, HE/PA Plans +30-min HE Active Learning + (separate day/week): 30-min PA/Active Learning
4 (Step-Up 3)	30-min session/week on: Education, Goal-Setting, Self-Monitoring, HE/PA Plans +30-min HE Active Learning + (separate day/week): 30-min PA/Active Learning + Instructor Feedback (3 days/week of electronic feedback and encouragement)
5 (Step-Up 4)	30-min session/week on: Education, Goal-Setting, Self-Monitoring, HE/PA Plans +30-min HE Active Learning + (separate day/week): 30-min PA/Active Learning + Instructor Feedback (1 phone call/week of feedback and encouragement) + Single Meal Replacement (on education day)
6 (Step-Up 5)	30-min session/week on: Education, Goal-Setting, Self-Monitoring, HE/PA Plans +30-min HE Active Learning + (separate day/week): 30-min PA/Active Learning + Instructor Feedback (1 phone call/week of feedback and encouragement) + Single Meal Replacement (on education day) + 2nd 30 min PA session (added to Education & HE Learning day)
7 (Step-Up 6)	30-min session/week on: Education, Goal-Setting, Self-Monitoring, HE/PA Plans +30-min HE Active Learning + (separate day/week): 30-min PA/Active Learning + Instructor Feedback (3 days/week of electronic feedback and encouragement) + Single Meal Replacement (on education day) + 2nd 30 min PA session (added to Education & HE Learning day) +3rd PA session (at home)

Note. HE = Healthy Eating; PA = Physical Activity

Participants

For this thesis research, the study participants included complete data collected from 20 of the initial 28 Phase 1 pregnant women (*M* age = 28.8, *M* BMI = 29.1) representing 71% of the cohort. Women were enrolled into the study between 14 and 28 weeks gestation and residing in communities around Central Pennsylvania. Inclusion criteria were: 18-35 years old, BMI between 25-40 (over 40 with physician consent), gestation age at entry of study between 14-28 weeks, singleton pregnancy, and available for the full 6-week intervention. Exclusion criteria were: older or younger than 18-35 years old, BMI outside of 25-40 (or without physician consent), multiple pregnancies, current pregnancy complications and/or PA restrictions, health restrictions that limited diet, and unavailability over the course of the intervention program.

Procedures

Overweight/obese pregnant women from the HMZ Study completed a 6-week intervention program. Data were collected at pre/post intervention for depressive symptoms and leisure-time exercise. Data were collected at pre/post intervention and daily for sleep variables (i.e., total sleep time [TST], nap time, and number of times woke), PA, perceived stress, and weight. Participants were provided with a Jawbone activity tracker for the entire duration of the study to collect data on PA. Data were calculated for GWG based on weekly averages of the daily weight data.

The study began with an initial phone screening to ensure participants were eligible for the study. Next, participants attended an in-person, baseline appointment that involved completing consent forms, assessments of medical history, pregnancy history, and demographics, completing a brief physical exam to ensure health and safety to participate in the study, and online self-reported measures (e.g., leisure-time exercise, depression symptoms, perceived stress) using the online data capture system, RedCAP. They also received additional study information and instructions on how to use the mHealth tools (e.g., activity trackers; see below for more detail). Participants also received a Jawbone UP wrist-worn activity monitor (worn duration of study). Participants were provided with a Wi-Fi Fitbit Aria scale to measure their weight on a daily basis during weeks 2 through 5. Participants were asked to fill out a daily sleep log to collect TST, nap time, and number of times woke.

Next, participants had a 7-day, pre-intervention period so that participants could practice using the mHealth tools (e.g., activity trackers), and set up the participant's online accounts. The research team also collected data on weight, PA, sleep, and self-reported measures (including leisure-time exercise behavior, depressive symptoms, and perceived stress). Next, participants were randomized into 1 of 7 intervention dosages (see Table 2) for 6-weeks. Women concluded the intervention period with a 7-day intervention assessment. Similar to the pre-intervention period, researchers collected data on activity (e.g., Jawbone), weight, PA/sleep logs, and self-reported measures. The study concluded with a follow-up session where women completed self-reported measure and a semi-structured interview to assess their evaluation of their intervention experience and preferences for any future modifications to the interventions (this information with be used to modify the intervention for future application).

Study Measures

Sleep Log Variables

A PA/Sleep log was created for this study in order to analyze certain aspects of participant's self-reported PA and sleeping behavior. The log created was a collaboration of PA/Sleep logs utilized in other studies, namely Stanford University's Sleep Disorder Clinic Insomnia Program Daily Sleep Log (Stanford Health Care, 2018). For this study, researchers were interested in TST, nap time, and number of times woken up at night. TST was defined as the total number of minutes a participant slept at night. Nap time was defined as the total number of minutes a participant slept during the day. Number of times woken up was defined as the number of times a participant's sleep was disrupted during the night, such as to use the bathroom or due to physical discomfort. Participants were asked to fill out PA/sleep logs, preferably in the morning, on a daily basis. Date and time of completion was recorded on each log.

Jawbone Active Time

The Jawbone UP band is a reliable method for assessing activity and sleep patterns throughout the day (Lee, Kim & Welk, 2014). Women wore the Jawbone UP activity tracker daily on their dominant wrist for the duration of the intervention program. Data collected through the wristband was synced to an app on the user's phone. Researchers accessed the data through Jawbone's online system, which provides detailed results of the user's activity patterns. The main variable of interest for this current study was active time, defined as the total number of minutes a user has been participating in moderate-vigorous PA throughout the day. For jawbone, compliance, defined as greater than 4 days/week of data, was excellent at 90%.

Perceived Stress Scale (PSS)

The Perceived Stress Scale (PSS) examines the degree to which situations in one's life are appraised as stressful (Cohen, Kamarck, & Mermelstein, 1983). The PSS uses 14-items to assess a person's thoughts and feelings on various situations using a 5 option scale, ranging from 'never' to 'very often' feeling or thinking a particular way. The PSS is a reliable and valid measure of stress often used among pregnant women (Solivan, Harville, & Buekens, 2015). Women are considered 'stressed' if they score above the 66th percentile or a score greater than 55 (Cohen, Kamarck, & Mermelstein, 1983). In this study, women completed the PSS on a weekly basis so that stress could be tracked for the duration of the intervention program. Internal consistencies were good at all time points, ranging from alpha = 0.75 to 0.84.

Center for Epidemiological Depression (CES-D)

The Center for Epidemiological Studies Depression (CES-D) is a 20-item scale to measure the level of depressive symptoms in the general population. (Radloff, 1977). The 20-item scales looks at symptom groups (e.g., sadness, loss of interest, appetite, sleep, thinking/concentration, guilt, tired, movement, suicidal ideation) and measures how often participants experience certain symptoms within a two week period (Center for Epidemiologic Studies Scale Revised, 2004). A score greater than 16 indicates that a person has depressive symptoms. The CES-D is a reliable and valid measure of stress often used among pregnant women (Natamba, Achan, Arbach, Oyok, Ghosh, Mehta et al., 2014). In this study, participants completed a CES-D survey at baseline and post intervention. Internal consistency at pre- and post-intervention were good, alpha = 0.87 and 0.97, respectively.

Gestational Weight Gain (GWG)

Participants were provided with a Wi-Fi FitBit Aria scale, which has been used in previous weight management programs with reasonable success (Laranjo, Lau, Martin, Tong, & Coiera, 2017). The scale was used to measure participant body weight on a daily basis through the intervention. Women were asked to weigh themselves first thing in the morning prior to using the bathroom and eating, and with minimal clothing. Weight was wirelessly synced to participants' online FitBit accounts where researchers could access it (Laranjo et al., 2017). Researchers added up weekly weight data and calculated the average daily weight for each participant. Approximate GWG between weeks, for the entire duration of the intervention program, was calculated by subtracting the preceding week's average weight from the current week's average weight.

Leisure-Time Exercise Questionnaire (LTEQ)

According to an early study by Godin and Shephard (1985), the leisure-time exercise questionnaire (LTEQ) can provide information on activity patterns, which is both valid and reliable for researchers studying exercise behaviors. Participants indicate the amount of time they spent participating in mild, moderate, and strenuous leisure-time activity during a typical week. Strenuous activity is defined as exercise that significantly increases the heart rate such as running, swimming or playing basketball. Moderate activity is defined as non-exhausting exercise that results in light sweating such as fast walking, tennis, or easy cycling. Mild activity is defined as minimal effort exercise with little to no sweating such as yoga, golf, or easy walking (Godin & Shephard, 1997). In this study, the LTEQ was used to examine the extent to which the participants were meeting the 150 minutes of moderate-vigorous PA per week guidelines at baseline and follow-up (U.S. Department of Health and Human Services, 2008).

Data Analysis

The data were analyzed using IBM SPSS software. After all relevant data points were entered; researchers ran descriptives (i.e., means and standard deviations), frequencies, and Pearsons correlations to determine the interrelationships between sleep (i.e., TST, nap time, times woke), PA (i.e., active time), psychological well-being (i.e., depression and sleep), and GWG. Correlations for data that were collected on a weekly basis (i.e., TST, nap time, number of times woke, active time, and stress), were analyzed within week, across week, and immediately preceding or following a week for patterns. Within a week was defined as a correlation between two variables that occurred within the same week (e.g., W1 PA and W1 GWG). Across week was defined a as a correlation between one variable (e.g., W1 PA) and any other week of another variables (e.g., W2, W3, and W5 GWG). Immediately preceding was defined as a correlation between one variable (e.g., W2 PA) and a second variable occurring in the week immediately before the first variable (e.g., W1 GWG). Conversely, immediately following was defined as a correlation between one variable (e.g., W2 PA) and a second variable occurring in the week immediately after the first variable (e.g., W3 GWG).

When analyzing correlations for variables that were collected pre- and post- intervention (i.e., depression, leisure-time exercise), researchers looked at correlations across weeks. In this case, across weeks was defined as a correlation between depression at either pre- or post- intervention and any week of another variable (e.g., W2, W3 and W6 GWG). Finally, when analyzing correlations for variables that were calculated between weeks, researchers looked at correlations between weeks and across weeks. In this case, between weeks was defined as a correlation between GWG (e.g., W1-W2) and another variable during either one of the weeks (e.g., W1 or W2 PA). Across weeks was defined similarly as correlations between GWG (e.g., W1-W2) and any week of another variable (e.g., W1, W4, and W5 PA).

Chapter 3

Results

Participant demographics (Table 3) and means (*M*) and standard deviations (*SD*) for sleep, PA, psychological well-being, and GWG variables (Table 4) are shown below. At baseline, 69% of women were getting the recommended amount of sleep, between 7 and 9 hours, each night (Xu et al., 2017). At baseline, 11% of women were meeting the recommended PA guidelines (American Congress of Obstetrician Gynecologists, 2015; USDHHS, 2008) based on their responses to the LTEQ. Also at baseline, 10% of women were classified as highly stressed based on their responses to the Perceived Stress Scale (PSS) at baseline, and 20% were classified as depressed according to the Center for Epidemiological Depression Scale. According to the IOM (2009) GWG guidelines, 43.8% of the participants gained weight in excess of the guidelines whereas 18.8% gained less than the guidelines.

Sleep and Physical Activity

Correlations are presented by week between sleep variables and active time in Table 5. There were no significant correlations within or across weeks between sleep and active time. However, there were significant correlations between sleep and active time in weeks immediately preceding and following. For example, in one out of the six weeks of intervention (i.e., W6), TST was positively and significantly correlated with the preceding weeks active time (W5). There were no other significant correlations between sleep variables and active time.

Some correlations trended toward significance (*p*-values between 0.05 and 0.1). For example, within weeks, active time (W6) was positively correlated with TST (W6). Active time (W2) was negatively correlated with nap time (W2). Examining relationships across all weeks showed other trending correlations. Active time (W2) was associated with TST (W4) and nap time (W1, W2, and W4). Active time (W5) was also associated with TST (W5) and active time (Week 6) was associated with

Table 3. Demographic Characteristics of the Sample (n = 20)

	Number	Mean (Range)
Age (years)		28.8 (18-38)
Pre Pregnancy Weight (pounds)		172.9 (131-230)
Pre Pregnancy Body Mass Index		29.1 (24.7-39)
Baseline Weight (pounds)		182.8 (147.7-245.6)
Gestational Age at Study Entry (weeks)		16.4 (12-25)
Relationship Status		
Single	2	
Married	12	
Divorced	0	
Widow	0	
Not married, living with partner	2	
Other	1	
Not Specified	3	
Employed		
Full Time	17	
Part Time	2	
Self-Employed	1	
Ethnicity		
Hispanic or Latino	1	
Non-Hispanic or Latino	17	
Not Specified	2	
Race		
African American/Black	0	
American Indian or Alaska Native	0	
Asian	0	
Caucasian/White	20	
Native Hawaiian or other Pacific Islander	0	
Other	0	
Family Income		
<$10,000	2	
$10-20,000	2	
$20-40,000	2	
$40-100,000	9	
>$100,000	5	
Body Mass Index Category		
Overweight	11	
Obese	9	

Table 4. Mean (M), and Standard Deviation (SD) for Sleep, Physical Activity, Gestational Weight Gain, and Psychological Well-Being Variables.

Variable	n	M	SD
Total Sleep Time (minutes)			
W1	16	3041	408.6
W2	17	3140	302.4
W3	16	3204	370.8
W4	17	3121	323
W5	15	3266	313.6
W6	15	3220	354.8
Nap Time (minutes)			
W1	11	272.5	315.8
W2	10	184.2	311.3
W3	7	113.9	109.1
W4	10	205.8	311.6
W5	10	255.3	430.2
W6	10	204.4	260.3
Number of Times Woke			
W1	16	14.1	6.9
W2	17	12.7	6.8
W3	15	16.5	8.3
W4	16	13.3	5.2
W5	14	15.4	7.5
W6	15	13.3	7.5
Active Time (minutes)			
W1	18	496.3	153.3
W2	14	481	195.9
W3	17	623.2	235.2
W4	15	499.3	208.7
W5	15	451.9	197.6
W6	13	502.1	203.3
Gestational Weight Gain (pounds)			
W1-W2	13	1.5	1.1
W2-W3	16	0.9	1.5
W3-W4	17	1.1	1.1
W4-W5	17	1.1	1
W5-W6	16	1.6	0.9
Stress			
W1	20	42.8	8.3
W2	19	42.5	9.4
W3	18	38.7	7.8
W4	18	41.1	7.7
W5	17	39.8	9
W6	18	38.9	8.5
Depression			
Pre	18	8.9	8.7
Post	16	7.9	7.4

TST (W6) and number of times woke (W2 and 6). There were several trending correlations between active time and sleep in weeks immediately preceding and following. For example, in one out of the six weeks of intervention (i.e., W2), active time was negatively correlated with nap time immediately preceding (W1). In addition, active time (W5) was positively correlated with TST (W6).

Table 5. Correlations Between Sleep and Physical Activity Variables.

	Active Time					
Total Sleep Time	W1	W2	W3	W4	W5	W6
W1	0.104	0.118	0.028	0.033	0.001	0.158
W2	0.079	0.199	0.118	0.07	0.207	0.262
W3	-0.061	0.302	-0.216	0.103	0.014	0.279
W4	-0.103	***0.464***	0.098	0.162	-0.036	0.273
W5	0.325	0.398	0.416	0.342	0.227	0.487
W6	0.442	0.491	0.421	0.39	**.556***	***0.525***
Nap Time						
W1	-0.122	***-0.566***	-0.275	-0.41	-0.472	-0.518
W2	0.01	***-0.612***	-0.313	-0.392	-0.282	-0.599
W3	0.404	0.447	0.325	0.561	0.738	0.749
W4	0.04	***-0.646***	-0.198	-0.39	-0.293	-0.542
W5	-0.348	-0.575	-0.418	-0.462	-0.536	-0.507
W6	-0.181	-0.227	-0.057	0.039	-0.095	-0.173
Number of Times Woke						
W1	0.407	-0.136	0.372	0.154	0.121	-0.073
W2	-0.235	-0.292	-0.422	-0.236	-0.296	***-.617****
W3	-0.047	-0.075	-0.114	0.032	-0.029	-0.266
W4	0.299	0.159	0.356	0.288	0.183	0.071
W5	-0.324	0.056	-0.304	-0.115	-0.416	-0.164
W6	-0.131	-0.349	-0.228	-0.187	-0.106	***-0.569***

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

Sleep and Stress

Correlations are presented by week between sleep variables and stress in Table 6. There were significant correlations within weeks. For example, stress (W1 and W2) was positively and significantly correlated with TST (W1 and W2) and nap time (W1 and W2). Also, there were significant correlations across weeks. For example, stress (W1) was associated with TST (W1, W2, W4, W5, and W6) and nap time (W1, W2, W4, W5, and W6), and number of times woke (W2 and W6); stress (W2) was associated with TST (W2) and nap time (W1 and W2); stress (W3) was associated with TST (W5) and nap time (W5); stress (W4) was associated with TST (W2 and W6) and nap time (W2 and W6) and number of times woke (W2); stress (W5) was associated with TST (W2), nap time (W2) and number of times woke (W2); stress (W6) was associated with TST (W2), nap time (W2), and number of times woke (W2). There were also significant correlations between stress and sleep in weeks immediately preceding and following. For example, in one (i.e., W2) out of the six-week intervention, stress was positively and significantly correlated with TST and nap time (W1) in the week preceding. In one (i.e., W1) out of the six-week intervention, stress was positively and significantly correlated with TST, nap time and number of times woke (W2) in the week following.

There were also relationships that trended towards significance between stress and sleep. There were no trending correlations within weeks, however, in looking at correlations across weeks, stress (W2) was associated with TST (W6), nap time (W6), and number of times woke (W3); stress (W3) was associated with TST (W1, W2, and W4) and nap time (W1, W2, and W4); stress (W5) was associated with TST (W6) and nap time (W6). There were also trending correlations between stress and sleep in weeks immediately preceding and following. For example, in one (i.e., W3) out of the six-week intervention, stress was positively correlated with TST and nap time (W2) in the week preceding. In two (i.e., W3 and W5) out of the six-week intervention, stress was positively correlated with TST and nap time (W4 and W6).

Sleep and Depression

Correlations between weekly sleep variables and by baseline and post for depression are presented in Table 7. There were significant correlations between depression and sleep across weeks. For example, depression (pre-intervention) was negatively and significantly correlated with TST (W2 and W6). In addition, depression (pre-intervention) was positively and significantly correlated with nap time (W1, W2, W4, W5, and W6) and number of times woke up (W2 and W6). TST (W6) was negatively and significantly correlated with depression (post-intervention). Nap time (W1, W2, W4, W5, and W6) and

Table 6. Correlations Between Sleep and Stress Variables.

	Stress					
Total Sleep Time	W1	W2	W3	W4	W5	W6
W1	**.711***	**.665***	***0.55***	0.475	***0.57***	0.424
W2	**.875****	**.772****	***0.602***	**.671***	**.700***	**.690***
W3	-0.221	0.548	-0.13	0.061	-0.153	0.452
W4	**.815****	0.482	***0.634***	0.287	0.352	0.276
W5	**.829****	0.485	**.781***	0.42	0.496	0.298
W6	**.718***	***0.624***	0.452	**.686***	***0.556***	0.5
Nap Time						
W1	**.711***	**.665***	***0.55***	0.475	***0.57***	0.424
W2	**.875****	**.772****	***0.602***	**.671***	**.700***	**.690***
W3	-0.221	0.548	-0.13	0.061	-0.153	0.452
W4	**.815****	0.482	***0.634***	0.287	0.352	0.276
W5	**.829****	0.485	**.781***	0.42	0.496	0.298
W6	**.718***	***0.624***	0.452	**.686***	***0.556***	0.5
Number of Times Woke						
W1	0.347	0.196	-0.013	0.219	0.271	0.113
W2	**.522***	0.386	0.343	**.576***	**.518***	**.499***
W3	0.2	***0.464***	0.013	0.291	0.173	0.38
W4	0.174	0.185	-0.205	-0.041	-0.121	-0.133
W5	0.213	0.268	0.232	0.384	0.21	0.353
W6	**.522***	0.251	0.115	0.374	0.386	0.181

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

number of times woke (W2) were positively and significantly correlated with depression (post-intervention). There were also relationships that trended towards significance between depression and sleep, across weeks. For example, depression (post-intervention) was negatively correlated with TST (W5), and positively correlated with number of times woke (W5 and W6).

Sleep and GWG

Correlations are presented by week between sleep variables and GWG in Table 8. In looking at relationships across weeks, GWG (W3-4) was associated with nap time (W3); GWG (W4-W5) was associated with nap time (W3 and W4); and GWG (W5-W6) was associated with TST (W4). There were

Table 7. Correlations Between Sleep and Depression Variables.

	Depression	
Total Sleep Time	Baseline	Post
W1	-0.342	-0.285
W2	**-.566***	-0.345
W3	-0.17	0.066
W4	-0.33	-0.202
W5	-0.388	***-0.481***
W6	**-.607***	**-.631***
Nap Time		
W1	**.850****	**.792***
W2	**.900****	**.860****
W3	-0.443	0.04
W4	**.930****	**.971****
W5	**.972****	**.953****
W6	**.824****	**.827****
Number of Times Woke		
W1	0.429	0.269
W2	**.596***	**.546***
W3	0.119	0.109
W4	0.327	0.21
W5	0.324	***0.565***
W6	**.560***	***0.542***

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

also significant correlations between weeks. For example, in one (i.e., W3-W4), out of the six-week intervention, GWG was positively and significantly correlated with nap time (W3). Additionally, in one (i.e., W4-W5) out of the six-week intervention, GWG was negatively and significantly correlated with number of times woke (W4).

Additionally, there were relationships that trended towards significance across weeks. For example, GWG (W1-W2) was associated with TST (W1); GWG (W2-W3) was associated with nap time (W3); and GWG (W3-W4) was associated with TST (W6). There were also trending correlations between weeks. For example, in one (i.e., W1-W2) out of the 6-week intervention, GWG was negatively correlated with TST (W1). Additionally, in one (i.e., W2-W3) out of the 6-week intervention, GWG was negatively correlated with nap time (W3).

Table 8. Correlations Between Sleep and Gestational Weight Gain Variables.

			GWG		
Total Sleep Time	W1-W2	W2-W3	W3-W4	W4-W5	W5-W6
W1	***-0.527***	0.371	0.335	-0.132	-0.081
W2	-0.405	0.191	0.247	-0.144	-0.396
W3	-0.186	0.061	0.216	0.375	-0.379
W4	-0.144	-0.004	0.308	0.086	**-.541***
W5	-0.115	0.243	0.362	0.1	-0.166
W6	-0.17	0.13	***0.461***	-0.144	-0.148
Nap Time					
W1	-0.204	0.101	-0.26	0.18	0.28
W2	0.065	0.102	-0.242	0.195	0.53
W3	0.219	***-0.747***	**.807***	-0.334	-0.153
W4	0.337	-0.077	0.068	0.352	0.141
W5	-0.301	-0.029	-0.034	0.519	-0.126
W6	0.084	-0.244	-0.146	0.043	0.075
Number of Times Woke					
W1	0.007	0.069	-0.313	-0.431	0.393
W2	0.048	-0.053	-0.167	-0.034	0.401
W3	-0.021	-0.188	0.286	**-.522***	0.356
W4	0.148	-0.194	0.087	**-.547***	0.039
W5	0.082	-0.118	0.424	-0.084	-0.074
W6	0.073	0.303	-0.346	-0.118	0.442

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

Physical Activity and Stress

Correlations are presented by week between stress and active time in Table 9. There were significant correlations within weeks. For example, stress (W2 and W3) was negatively and significantly correlated with active time (W2 and W3). Additionally, there were significant correlations across weeks. For example, stress (W2) was associated with active time (W2, W4, and W6); stress (W3) was associated with active time (W1, W2, W3, W4, and W6); stress (W4) was associated with active time (W3); stress was associated with stress (W5) and active time (W2 and W3); and stress (W6) was associated with active time (W2 and W3). There were also significant correlations between stress and active time in weeks immediately preceding and following. For example, in two (i.e., W3 and W4) out of the 6-week intervention, stress was negatively and significantly correlated with active time (W2 and W3) in weeks preceding. In one (i.e., W3) out of the 6-week intervention, stress was negatively and significantly correlated with active time (W4) in weeks following.

There were also relationships that trended towards significance between stress and active time. There were no trending correlations within weeks however; there were trending correlations across weeks. For example, stress (W1) was associated with active time (W2); stress (W2) was associated with active time (W1); and stress (W5) was associated with active time (W1 and W4). There were also trending correlations immediately preceding and following. For example, in two (i.e., W2 and W5) out of the 6-week intervention, stress was negatively with active time (W1 and W4) in weeks preceding. In one (i.e., W1) out of the 6-week intervention, stress was negatively correlated with active time (W2) in weeks following.

Table 9. Correlations Between Physical Activity and Stress Variables.

	Stress					
Active Time	W1	W2	W3	W4	W5	W6
W1	-0.179	***-0.466***	**-.485***	-0.288	***-0.429***	-0.27
W2	***-0.509***	**-.667****	**-.680****	-0.352	**-.555***	**-.538***
W3	-0.398	***-0.472***	**-.596***	**-.527***	**-.586***	**-.515***
W4	-0.356	**-.583***	**-.622***	-0.316	***-0.447***	-0.412
W5	-0.18	-0.354	-0.411	-0.229	-0.345	-0.228
W6	-0.465	**-.557***	**-.564***	-0.338	-0.452	-0.407

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

Physical Activity and Depression

Correlations are presented by week between depression and active time in Table 10. There were significant correlations between depression and active across weeks. For example, depression (pre-intervention) was negatively and significantly correlated with active time (W2). Additionally, active time (W2, W4, and W6) was negatively and significantly correlated with depression (post-intervention).

There were also relationships that trended towards significance between depression and active time across weeks. For example, active time (W1) was negatively correlated with depression (post-intervention).

Table 10. Correlations Between Active Time and Depression Variables.

	Depression	
Active Time	Baseline	Post
W1	-0.206	***-0.454***
W2	**-.571***	**-.705***
W3	-0.336	-0.447
W4	-0.342	**-.604***
W5	-0.328	-0.47
W6	-0.434	**-.683***

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

Physical Activity and GWG

Correlations are presented by week between Jawbone active time and GWG in Table 11. There were no significant correlations between active time and GWG across weeks or between immediately preceding or following weeks. There were relationships that trended towards significance across weeks. For example, GWG (W2-W3) was associated with active time (W6), and GWG (W5-W6) was associated with active time (W2 and W6). There were also trending correlations between weeks. For example, in one (i.e., W5-W6) out of the six-week intervention, GWG was negatively correlated with TST (W6).

Table 11. Correlations Between Physical Activity and Gestational Weight Gain Variables.

	Gestational Weight Gain				
Active Time	W1-W2	W2-W3	W3-W4	W4-W5	W5-W6
W1	0.428	-0.157	0.017	-0.326	0.102
W2	0.427	-0.396	-0.041	-0.241	***-0.476***
W3	0.265	-0.338	-0.114	-0.377	-0.415
W4	0.285	-0.448	-0.139	-0.36	-0.349
W5	0.333	-0.277	-0.037	-0.278	-0.003
W6	0.158	***-0.51***	-0.09	-0.227	***-0.508***

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

Stress and GWG

Correlations are presented by week for GWG and stress in Table 12. There were significant correlations across weeks. For example, GWG (W4-W5) was positively and significantly correlated with stress (W1, W3, and W4). There was also a significant correlation between stress and gestational weight gain between weeks. For example, in one (i.e., W4-W5) out of the 6-week intervention, GWG was positively and significantly associated with stress (W5).

There were relationships that trended towards significance across weeks. For example, GWG (W4-W5) was associated with stress (W5), whereas GWG (W5-W6) was associated with stress (W6).

Table 12. Correlations Between Gestational Weight Gain and Stress Variables.

	Stress					
Gestational Weight Gain	W1	W2	W3	W4	W5	W6
W1-W2	-0.264	-0.355	-0.487	-0.08	-0.399	-0.141
W2-W3	0.245	-0.155	0.063	-0.021	0.136	-0.064
W3-W4	-0.241	0.075	-0.093	-0.206	-0.409	0.052
W4-W5	**.498***	0.279	**.621***	**.514***	***0.466***	0.361
W5-W6	0.374	0.186	0.241	0.301	0.345	***0.434***

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

Depression and GWG

Correlations are presented by week for GWG and by pre- and post-intervention depression in Table 13. There was a significant correlation between depression and GWG. For example, depression (post-intervention) was positively and significantly correlated with GWG (W4-W5).

Table 13. Correlations Between Gestational Weight Gain and Depression Variables.

	Depression	
Gestational Weight Gain	Baseline	Post
W1-W2	0.03	-0.051
W2-W3	-0.085	-0.05
W3-W4	-0.202	-0.054
W4-W5	0.41	**.572***
W5-W6	0.271	0.106

*Indicates a significant correlation with p value <0.05
**Indicates a significant correlation with p value <0.01
Italics indicate a trending correlation with a p value between 0.05 and 0.1
All bolded text indicates significant or trending correlations.

Chapter 4

Discussion

The purpose of this study was twofold: (1) examine the interrelationship between sleep, PA, psychological health, and GWG to understand the extent to which these factors are related over the 6-week brief intervention to manage GWG; and (2) use the data collected from the first aim to inform the development of specific sleep content for future behavioral interventions as well as specifically for the larger randomized trial of the Healthy Mom Zone (HMZ) study to manage GWG in overweight and obese pregnant women. It was hypothesized that TST (between 7-9 hours) would be positively associated with PA, and negatively associated with psychological health and GWG. It was also hypothesized that nap time (greater than 30 minutes) and number of times woke would both be negatively associated with PA, and positively associated with psychological health, and GWG. The primary findings confirmed the hypothesis that TST was positively associated with PA and negatively associated with stress. Findings also confirmed that nap time and number of times woke was positively associated with psychological health. In contrast to the hypothesis, TST was negatively associated with depressive symptoms and number of times woke was negatively associated with GWG. Also in contrast to the hypothesis, there were no associations between TST and GWG; nap time and PA or GWG; or number of times woke and PA. Several of these findings warrant further discussion.

In partial support of the hypothesis and consistent with previous research on TST and PA (Borodulin et al., 2011; McClain et al., 2014), TST in W6 increased following a week of high PA in W5. This finding is consistent with the National Sleep Foundation (2018) recommendation that exercise can improve sleep hygiene, including TST. There were no significant relationships to indicate that sleep influenced the following week's active time. In addition, there was not a significant pattern between sleep and PA over all six weeks of the study, which could be due to poor sleep hygiene associated with physical discomfort during pregnancy, including heartburn, feeling hot and trouble breathing (Hutchison et al., 2012). It is possible that if sleep hygiene improved during pregnancy, PA would increase as well (McClain et al., 2014; Soltani et al., 2012).

Consistent with the hypothesis and previous studies suggesting that short sleep time leads to greater depressive symptoms (Mellor, Chua, & Boyce 2014), TST (W2 and W6) was negatively correlated with depression (pre- and post-intervention). That is, as total sleep decreased, depression scores increased. This finding is also consistent with the Anxiety and Depression Association of America's (ADAA, 2018) list of key depressive symptoms, which includes insomnia and early-morning awakening, since both symptoms can lead to a decrease in TST. The findings also confirmed the hypothesis, that nap time (W1, W2, W4, W5, and W6) and number of times (W2 and W6) woke were positively correlated with depression scores (pre- and post-intervention). It is possible that women who are depressed lack motivation to partake in normal daily activities and therefore chose instead, to nap. Additionally, depressive symptoms, including fatigue, decreased energy, and oversleeping, may cause clinically depressed women to nap more during the day, as a manifestation of their psychiatric disease (ADAA, 2018). Similarly, restlessness and irritability are common signs of depression, which may explain why an increased number of times awoken is positively associated with depression (AADA, 2018). Consistent with previous research suggesting over 75% of women experience sleep disturbances (Izci-Balserak & Pien, 2014), and with the proposed hypothesis, number of times woke was also positively correlated with preceding week's stress score. Overall, these findings suggest significant relationships between sleep and psychological health. Due to the limited research in this area (Akerstedt et al., 2012; Mellor, Chua, & Boyce 2014), further studies are needed to better understand these relationships and their possible direction of causality (e.g., depression causing less total sleep and more times awake or poor sleep leading to increased depression) before definitive conclusions can be made.

Consistent with the hypothesis and findings from past researchers' conclusions (Markwald et al., 2013), a significant and positive correlation between nap time (W3) and GWG (W3-W4) was observed. Taking a longer nap during the day may be an indicator of one's daytime sleepiness. This pattern may be related to one's inability to control appetite and thus weight gain occurs (Markwald et al., 2013). However, given the correlational nature of these study findings, this assumption is speculative and needs future research to examine the temporal relationships between these factors. In contrast to the hypothesis, as the number of times women woke up at night decreased, their GWG increased. It is difficult to interpret this finding in isolation given that women's GWG is expected to increase over pregnancy and thus, further research is necessary to examine these patterns of waking in the night with GWG.

Also consistent with prior research (Garland, 2016), PA was negatively correlated with stress in preceding, concurrent, and following weeks. According to the ADAA (2018), exercise is highly recommended as a coping-mechanism for stress. In fact, some forms of PA (e.g., walking, running, and yoga) has been shown to reduce fatigue, improve alertness, and enhance cognitive function, all of which are combative against some of the negative effects of stress (ADAA, 2018; Coll et al., 2015). For pregnant women, it may be especially important to increase PA in order to reduce stress, which could also lead to reduced risks for negative pregnancy outcomes (i.e., preterm birth, mortality, morbidity, respiratory distress syndrome, chronic lung disease, neurodevelopmental disabilities, cognitive difficulties, and low birth weight; Dunkel Schetter & Tanner, 2012; Grote et al., 2010).

In contrast to the hypothesis and previous research (Palagini, Gemignani, Banti, Manconi, Mauri, Riemann et al., 2014), TST was positively correlated with stress in preceding, concurrent, and subsequent weeks. However, consistent with the hypothesis, nap time, was positively correlated with stress in preceding, concurrent, and subsequent weeks. These findings suggest that as stress increases, TST and nap time increase as well. It is possible that since pregnancy introduces women to additional stressors, mental exhaustion increases, leading to increased sleep at night and during the day (Dunkel Schetter & Tanner, 2012). In other words, increased sleep at night and during the day may be a coping mechanism for the high level of stress that a woman is experiencing. Researchers may want to consider promoting TST between 7 and 9 hours a night, and limiting nap time to under 30 minutes during pregnancy. Oversleeping and long nap times are associated with reduced sleep hygiene, which may lead to greater stress. Hence, figuring out how to control sleep and nap time, may be an effective method for limiting stress (National Sleep Foundation, 2018; Xu, Liu, Zhang, Sharma & Zhao, 2017).

Consistent with the hypothesis and prior research, PA was negatively correlated with depression indicating that PA may be a useful mode for reducing depression (Lewis & Kennedy, 2011; Teychenne & York, 2013). Since PA is an affordable and safe method, which has been shown to reduce depression, it may an important target for interventions (Lewis & Kennedy, 2011). Also consistent with previous research suggesting that PA affects energy expenditure and thus, weight gain, there were trending, but no significant, negative correlations between PA and GWG (Aparicio et al., 2015, 2016; Chasan-Taber et al., 2014; Harrison et al., 2016; Schlaff et al., 2014; Melzer et al., 2010; Merkz et al., 2015). These findings are consistent with other researchers' conclusions that PA did not significantly influence GWG (Chasan-Taber et al., 2014; Jing et al., 2015; Streuling et al., 2011). Given the lack of relationship between PA and GWG and the challenges in promoting PA in pregnancy, researchers may want to consider controlling GWG by promoting good sleep hygiene since it appears to be related to GWG in this study.

Also consistent with previous research, higher GWG (W4-W5) was associated with higher stress (W4) and higher depression scores (post-intervention; Thomas et al., 2014). It is possible that high stress and depressive symptoms set the stage for people to consume more calories (e.g., overeat) as a possible coping mechanism, which in turn, leads to greater GWG (ADAA, 2018; Thomas et al., 2014). As reported by previous researchers, increased energy intake, in combination with decreased PA, as seen in association with both stress and depression, can lead to excessive GWG (ADAA, 2018; Aparicio et al., 2015; Garland, 2016; Merkz et al., 2015; Thomas et al., 2014). Overall, since stress and depression are both positively associated with GWG, it will be important for researchers to know how to manage psychological health in pregnancy in order to keep GWG within health limits (IOM, 2009), in addition to the importance of treating stress and depression for mental health on its own.

Overall, researchers may want to consider strategies to promote sleep hygiene, as it is related to PA, psychological well-being, and GWG. More specifically, researchers may want to promote TST (between 7-9 hours/night) as it is positively associated with PA and stress, and negatively associated with depression and GWG. To promote TST, researchers can suggest women limit sugary food and caffeine intake late in the day, preferably at least six hours before bedtime (Drake, Roehrs, Shambroom, & Roth, 2013). Additionally, researchers can encourage women to create a bedtime routine, which will help women fall asleep more quickly (National Sleep Foundation, 2018). For example, women could get into a habit of turning off their phone one hour before bed, participating in a quiet leisure activity 30 minutes before bed (i.e., reading a book, knitting, or talking with significant other), and implementing a simple, five minute breathing exercise program prior to lying down. Researchers may also want to reduce number of times woke, as it is positively associated with stress and depression and negatively associated with GWG. To reduce the number of times woke; researchers can suggest that women create a cool, dark, quiet sleep environment. This kind of environment is ideal for sleeping which may enable women to sleep comfortably through the night. Additionally, if financially feasible, women can purchase a firm, supportive mattress, which will promote comfort throughout the night and reduce number of times woke (Woods, 2016). If there are financial limitations, simpler methods, such as purchasing eyeshades, fans, or earplugs are available to help women sleep through the night (National Sleep Foundation, 2018; Woods, 2016). Finally, nap time is negatively associated with PA and positively associated with stress, depression and GWG. It is possible that by promoting TST and reducing number of times woke through the previously mentioned means; women will experience less daytime sleepiness, and thus, be able to limit nap time to between 0 and 30 minutes a day, which is ideal (National Sleep Foundation, 2018).

Strengths and Limitations

This thesis study has several strengths. First, this study has been useful in elucidating the interrelationships between sleep, PA, psychological well-being, and GWG. One key finding that emerged from this research was that TST is positively associated with PA and negatively associated with depression and GWG while number of times woke is positively associated with depression and stress and negatively associated with GWG. Second, although these data are correlational, they were collected within a prospective and randomized intervention design. Third, these study findings can be used to inform future interventions. For example, the knowledge learned from this study may help researchers to identify specific targets for intervention (e.g., sleep time, number of naps) that could be used to better promote PA and manage GWG. Other recommendations include promoting sleep hygiene, by creating ideal sleeping environments (i.e., cool, dark, and quiet), establishing a bedtime routine, and cutting out sugary foods before bed, since it is related to PA, psychological well-being and GWG.

Although this study is the first to document the interrelationships between sleep, PA, psychological health, and GWG, there are study limitations. One limitation was the small sample size used in this extension of Pilot Study 1. Although the sample size was sufficient to conduct the correlational analyses in this study, the small sample was limited in the ability to conduct other analyses such as repeated measures and group comparisons. In addition, despite using validated measures, some of the instruments were based on self-reported data (i.e., PSS, CES-D, and Sleep Log) which have inherent recall bias. Third, due to the short 6-week period of the intervention, it is also possible that some associations between variables were not observed (e.g., PA and GWG) because the intervention was not long enough to affect these factors. The future longitudinal trial of HMZ will occur over a longer period of pregnancy (e.g., 8-36 weeks gestation) and therefore there will be better ability to examine change over time in these variables.

Practical Implications of the Thesis

In summary, the main findings from this thesis study suggest that sleep hygiene is associated with PA, psychological health, and GWG. Specifically, TST (between 7-9 hours/night) is positively associated with PA and stress, and negatively associated with depression and GWG; nap time is negatively associated with PA and positively associated with stress, depression and GWG; and number of times woke is positively associated with stress and depression and negatively associated with GWG. One key suggestion for future research and interventions among pregnant women is that researchers should design intervention content that promotes good sleep hygiene. Suggestions for intervention content include:

- establish a bedtime routine
- achieve the recommended 7-9 hours of sleep per night
- decrease nap time to no more than 30 minutes per day
- reduce sleep disturbances and instead promote a positive sleep environment (e.g., set-up a dark, cool, and quiet sleep environment)

Future studies aiming to promote healthy weight gain in pregnancy may want to target sleep and promote these recommendations. These findings will be integrated into the future HMZ intervention trial.

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Academic Vita

Tara C Rogers

Education

The Pennsylvania State University | University Park, PA

- Bachelor of Science in Kinesiology, Movement Science Option **May 2018**
- College of Health and Human Development
- Schreyer Honors College
- American Red Cross Adult and Pediatric First Aid/CPR/AED Certified

Awards & Honors

Noll Endowment for Undergraduate Research **Summer 2017**

- Received funding from Penn State's College of Health and Human Development to conduct focused work on the Healthy Mom Zone project

Outstanding Scholar-Athlete **Spring 2017**

- Distinction awarded by the Women's Collegiate Water Polo Association to club scholar-athletes who achieved a grade point average between a 3.71 and 4.0

Academic All-Big Ten **Fall 2015- Spring 2016**

- Recognized by the Big Ten Conference for outstanding academic accomplishments while competing in intercollegiate athletics

Health Care Experience

Research Assistant | Exercise Psychology Lab | University Park, PA **Spring 2017- Spring 2018**

- Assist with lab work for Dr. Danielle Down's Healthy Mom Zone, a study focused on managing gestational weight gain in overweight and obese women by implementing a program focused on healthy eating, physical activity, goal-setting, and self-monitoring
- Enter data into a clinical database, complete data analysis and perform literature searches

Volunteer | Total Performance Physical Therapy | North Wales, PA **Summer 2017 (98 hours)**

- Shadow a physical therapist, who is a part of the United States Olympic Sports Medicine Team, at her suburban, outpatient physical and aquatic therapy clinic

Volunteer | Drayer Physical Therapy | Bellefonte, PA **Spring 2017 (75.5 hours)**

- Observed multiple physical therapists in a rural, outpatient care clinic
- Assisted staff with day-to-day tasks including laundry, retrieving and applying hot and cold packs, and cleaning

Volunteer | ProCare Physical Therapy | Centre Hall, PA **Fall 2016 (60 hours)**

- Observed a physical therapist as he treated patients in a rural, outpatient care facility
- Assisted staff with day-to-day tasks including laundry, retrieving hot and cold packs, removing stimulation pads, and cleaning

Volunteer | Physical Therapy and Wellness Institute | Lansdale, PA **Spring 2016 (13 hours)**

- Observed a physical therapist as he evaluated and treated patients in a suburban, outpatient care facility

Volunteer | NovaCare Rehabilitation | Lansdale, PA **Summer 2014 (34 hours)**

- Observed a physical therapist as he treated mainly adolescent athletes in a suburban, outpatient care facility

Leadership and Communication Experience

Committee of Student Engagement | Kinesiology Club | University Park, PA **Spring 2017-Spring 2018**

- Work with members of the committee to plan and organize social events
- Encourage involvement in the club by reaching out to individual members and promoting kinesiology club events

Member | Women's Leadership Initiative | University Park, PA **Fall 2016-Spring 2017**

- One of 34 students selected from the College of Health and Human Development on the basis of academic performance
- Strengthened leadership skills by attending professional development workshops and networking events

Member | Athletic Director's Leadership Institute | University Park, PA **Fall 2015-Spring 2016**

- Selected among Penn State varsity student-athletes on the basis of academic performance and leadership potential
- Actively participated in workshops which developed leadership skills, such as communication and problem solving

Participant | Public Speaking Civic Engagement | University Park, PA **Fall 2015**

- Selected by my peers to compete in a public speaking competition

Service Experience

Member | Kinesiology Club's Dance Marathon | University Park, PA **Fall 2016-Spring 2017**

- Assist in efforts to raise money and support for children with pediatric cancer through fundraising events with Penn State Kinesiology Club

Counselor | Outdoor School | State College, PA **Spring 2016 and Spring 2018**

- Responsible for the safety of a group of eight, fifth-grade students while they stayed overnight at Camp Blue Diamond
- Assisted in teaching students about the natural world through various lessons and games

Volunteer | Summer Special Olympics | University Park, PA **Summer 2015**

- Encouraged athletes and presented them with awards during the swimming portion of the summer games