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EXAMINATION OF PHYSICAL ACTIVITY MODE AND INTENSITY AMONG PREGNANT WOMEN OF DIFFERENT ACTIVITY LEVELS

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Abstract

Introduction. The overall objective of this honors thesis was to thoroughly examine the time spent in non-exercise and exercise-related physical activity (PA) modes and intensities and changes in activity patterns among pregnant women during their second and third pregnancy trimesters according to pedometer-determined parameters. **Methods.** Pregnant women (*N* = 36) wore a Yamax Digiwalker SW-701 Pedometer and completed the Previous Day Physical Activity Recall, a self-reported PA questionnaire that assessed the time spent in both non-exercise (e.g., work, transportation, sleeping, bathing) and exercise-related (e.g., jogging, walking, swimming) activities and the perceived intensity (mild, moderate, or vigorous) of these activities at both 20- and 32-weeks gestation. Women were categorized into the following three activity groups based on their average daily step count measured over a 3-day period at 20- and 32-weeks gestation: active (7,500+ steps/day), low-active (>7,499 steps/day), and transitioned to low-active (7,500+ steps/day at 20-weeks gestation, >7,499 steps/day at 32-weeks gestation). It was hypothesized that active women would show little to no changes in non-exercise and exercise-related physical activity behaviors from 20- to 32-weeks gestation, while low-active women would decrease mild intensity non-exercise physical activity behaviors, and transitioned to low-active women would decrease in moderate and vigorous intensity non-exercise and exercise-related physical activity behaviors. It was also hypothesized that the active group would spend more time in moderate and vigorous non-exercise and exercise-related physical activity than the low-active group. **Results.** Consistent with the hypothesis, women in the active group showed no significant changes in non-exercise and exercise-related physical activity behaviors from 20- to 32-weeks gestation, while women in the low-active group at both time points engaged in significantly less mild non-exercise physical activity at 32-weeks. Women who were categorized as active at 20-weeks but low-active at 32-weeks showed a decline in moderate intensity non-exercise physical activity behaviors across this period, further supporting the hypothesis. Low-active women spent significantly less time in moderate and vigorous exercise-related physical activity, and vigorous intensity non-exercise physical activity than active women, providing partial support for the hypotheses. **Conclusion.** These findings suggest that women of various activity levels may differentially alter their physical activity behaviors during pregnancy. For example, low-active women may prefer to decrease their mild intensity non-exercise physical activity, while those women in the transitioned to low-active group decrease their levels of moderate and vigorous non-exercise and exercise-related physical activity. Further understanding of these differences is necessary to optimize intervention strategies to increase physical activity during pregnancy.

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Chapter 1

Introduction

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles resulting in greater than resting energy expenditure (Centers for Disease Control and Prevention [CDCP], 2005). The recent United States Department of Health and Human Services (USDHHS, 2008) report documents the many health benefits that people can experience when they engage in at least 150 min per week of moderate-intensity PA. Moderate-intensity PA includes activities such as brisk walking, bicycling under 10 mph, water aerobics, and general gardening, while racewalking, jogging, running, swimming laps, jumping rope, and hiking uphill are categorized as vigorous-intensity activities (USDHHS, 2008). These PA guidelines recommend that adults also engage in moderate or high-intensity muscle strengthening activities that involve all major muscle groups (e.g., legs, hips, back, arms, shoulders, abdomen, and chest) on two or more days of the week (USDHHS, 2008).

The USDHHS (2008) report also recommends PA guidelines that are slightly different from the previous guidelines. For example, the American College of Sports Medicine (2000) recommended 30 min of moderate-intensity activity on 5 days per week, or 20 min of vigorous-intensity activity on at least 3 days per week. The USDHHS (2008) revised guidelines have incorporated an increase in PA time and volume, which may carry additional health benefits. For instance, they state that while the current PA recommendations are sufficient to achieve many health benefits, more extensive health benefits have been shown when adults increase their aerobic PA to 300 min of moderate-intensity PA or 150 min of vigorous-intensity spread across the week. Participation in regular PA serves to decrease the risk of several diseases including cancer, diabetes, obesity, hypertension, and cardiovascular disease (USDHHS, 1996, 2000, 2008). A physically active lifestyle is also associated with controlling weight and building and maintaining healthy bones, muscles, and joints (USDHHS, 1996, 2008). Regular PA may also preserve physical and mental functioning into old age, as well as extend longevity and active lifestyle expectancy (Blair & Morris, 2009; Chodzko-Zajko et. al., 2009). In addition to these numerous physical benefits, PA has also been shown to promote psychological well-being, improve self-esteem, and decrease both anxiety and depression (Martensen, 2008; Penendo & Dahn, 2005; USDHHS, 2000, 2008).

Despite the many benefits of regular PA, the U.S. continues to be afflicted with a physical inactivity epidemic. Currently, it is estimated that 80% of Americans are not participating in sufficient PA to achieve health benefits (USDHHS, 2000, 2008). Furthermore, an estimated 25% of all adults are classified as completely sedentary (Macera et. al., 2005; USDHHS, 2000, 2008). Given the numerous physical and psychological benefits that can be experienced from meeting these PA guidelines, the lack of the U.S. population meeting them has become an increasingly important public health concern. With the current obesity epidemic and the increasingly poor health status of Americans, PA is crucial now more than ever. While PA is important for people of all ages, there are certain populations that may experience additional benefits from PA. One such population is pregnant women, and it has only been in the last decade that significant research has been conducted on the benefits and recommendations for PA during and throughout pregnancy.

Guidelines for Exercising During Pregnancy

Despite the significant evidence supporting the benefits of PA in pregnancy, a proportion of the population still believes that retaining an active lifestyle during pregnancy may be dangerous. This is not wholly surprising, given that established guidelines for PA throughout pregnancy are a fairly recent entity. In 1985, the American College of Obstetricians and Gynecologists (ACOG) issued the first set of guidelines in response to mounting concerns about the effects of the physiological responses accompanying PA on the fetus during pregnancy (i.e. increase in maternal heart rate and body temperature, redistribution of blood flow, etc.). These initial guidelines were conservative by modern standards, recommending that the exercising mother maintain a heart rate of less than 140 beats per min, which would normally be achieved by mild PA such as walking (ACOG, 1985). The ACOG (1985) advised that strenuous PA should be kept to less than 15 min in duration, extremes of flexion or extension should be avoided, and maternal core temperature should remain below 38°C. These guidelines furthermore restricted certain movements and positions, including ballistic movements, valsalva maneuvers, and PA in the supine position after the fourth month of gestation (ACOG, 1985).

The release of these initial guidelines spurred an increase in research involving PA during pregnancy, and in response to new information, the ACOG released a revised set of guidelines in 1994. These modifications no longer restricted maternal heart rate or duration, but still included a restriction on supine activity after the first trimester, as well as emphasizing proper heat dissipation during pregnancy (ACOG, 1994). The ACOG guidelines (1994) also recommended that the intensity of PA be modified according to symptoms the provided a set of relative and absolute contraindications to PA (see Table

1). While these contraindications still remain in current ACOG guidelines for PA during pregnancy, our understanding of PA during pregnancy has been further developed since the release of these guidelines.

Table 1

Relative and Absolute Contraindications to PA (ACOG, 1994)

Relative Contraindications	Absolute Contraindications
Severe anemia	Hemodynamically significant heart disease
Unevaluated maternal cardiac arrhythmia	Ruptured membranes
Chronic bronchitis	Premature labor
Poorly controlled type 1 diabetes	Diagnosed multiple pregnancies
Extremely over or underweight	Intrauterine growth retardation
Extremely sedentary	Incompetent cervix
Poorly controlled hypertension	Placenta previa
Orthopedic limitations	Pregnancy-induced hypertension
Poorly controlled seizure disorder	Primary pulmonary hypertension
Heavy smoker	Multiple gestation at risk for premature labor
Intrauterine grown restriction	Persistent second- or third- trimester bleeding
Poorly controlled hyperthroidism	

Note. Relative contraindications are those which require doctor's clearance in order to engage in PA during pregnancy. Absolute contraindications include those conditions under which exercise is not recommended (ACOG, 1994).

The ACOG (2002) guidelines followed the recommendations of the ACSM (2000), encouraging 30 min of moderate-vigorous PA on most, if not all days of the week. However, the updated USDHHS (2008) guidelines indicate that healthy women who are not considered highly active or do not regularly engage in vigorous-intensity PA should engage in 150 min per week of moderate-intensity activity throughout their pregnancy and postpartum period, preferably spread out throughout the week. Women who were active and/or regularly performed vigorous-intensity PA prior to pregnancy should continue engaging in PA throughout their pregnancy and postpartum period, provided that they remain healthy and consult with their doctor (USDHHS, 2008). In the absence of contraindications (see Table 1 on p. 5), PA is encouraged throughout the pregnancy and postpartum period for healthy, normal pregnancies.

Health Benefits of PA During Pregnancy

Benefits of PA for Both Mother and Baby. Studies in the past few decades have confirmed the safety of PA as recommended in these guidelines (ACOG, 2002; USDHHS, 2008). Evidence has showed that a PA program of any variety of modes does not appear to be associated with any adverse affects to the mother or fetus in a healthy, normal pregnancy (Lokey, Tran, Wells, Myers, & Tran, 1991). While some have expressed concerns about the potential ill-effects of PA during pregnancy, including hyperthermia, shortened gestational age, and decreased birth-weight, such claims are not supported by the most recent scientific reviews (Barakat, Stirling, & Lucia, 2008; Brown, 2002; Martens, Hernandez, Strickland, & Boarwright, 2006). The physiological adaptations of the body to PA during pregnancy have not only been deemed safe, but furthermore, appear to protect the fetus from potential harm (Brown, 2002; Lokey et al., 1991).

An important function of PA throughout pregnancy is the potential control of gestational weight gain (GWG), and prevention of excessive GWG during pregnancy. The Institute of Medicine ([IOM], 2009) recently updated their guidelines for healthy levels of GWG. The recommended GWG for each category of prepregnancy BMI can be found below in Table 2. The prevention of high GWG may provide a long-term benefit for both mother and baby (Gavard & Artal, 2008). Clapp and Little (1995) found that women participating in regular PA at least three times per week had significantly less subcutaneous fat accretion and GWG in their third trimester than those who stopped exercising altogether during pregnancy. This is particularly important because women with GWG above the recommended level experience a myriad of negative consequences, including increased risk for pregnancy-induced hypertension, gestational diabetes mellitus, and labor and delivery complications (e.g., increased risk of cesarean delivery, failure of labor induction; IOM, 2009).

Table 2

IOM (2009) Guidelines for Gestational Weight Gain (GWG) During Pregnancy

Prepregnancy BMI	Total weight gain range
Underweight (< 18.4 kg/m^2)	28-40 pounds
Normal weight (18.5 – 24.9 kg/m^2)	25-35 pounds
Overweight (25.0 – 29.9 kg/m^2)	15-25 pounds
Obese (≥ 30.0 kg/m^2)	11-20 pounds

Note. BMI = body mass index.

Increased BMI and GWG have been associated with macrosomia (i.e., increased infant birth weight), higher fat mass in infants, and subsequently overweight during childhood (Hillier et al., 2007; Oken et al., 2007). Stuebe, Oken, and Gillman (2009) found that both vigorous exercise and midpregnancy walking were inversely associated with excessive gestational weight gain, demonstrating the value of PA in ameliorating excessive GWG. Furthermore, there is evidence to show that PA interventions either before or during pregnancy have the potential to lessen the adverse consequences of maternal body weight before pregnancy on the baby's birth size (Barakat, Lucia, & Ruiz, 2009).

PA has also been shown to have significant effects on the risk of developing preeclampsia (also known as pregnancy-induced hypertension) during pregnancy (Dempsey, Butler, & Williams, 2005). The ACOG (2004) defines preeclampsia as a condition of pregnancy consisting of high blood pressure, swelling, and protein in the urine, usually developing after 20-weeks gestation. Preeclampsia can be mild or severe, and it is potentially dangerous for both mother and baby. While the exact causes for the development of preeclampsia are not fully understood, there is evidence demonstrating that pregnant women who remain physically active have a reduced risk for developing preeclampsia, with Demsey et al. (2005) finding that these women may benefit from as much as a 40% reduction in the risk for preeclampsia.

One of the most prominent health conditions that may afflict pregnant women is gestational diabetes mellitus (GDM), defined as any degree of glucose intolerance with onset or first recognition during pregnancy, usually between 24- and 28-weeks gestation (American Diabetes Association [ADA], 2004). Several recent epidemiological studies have suggested the evidence of a relationship between PA and a reduced risk of GDM (Mottola, 2008; Zhang, Solomon, Manson, & Hu, 2006). Available data have shown that women who engage in regular PA throughout their pregnancy have nearly a 50% reduced risk of GDM compared with inactive women (Dempsey et al., 2005). Also, Horns et al. (1996) found that women who continue to engage in PA in the last trimester of pregnancy reported having fewer of the common discomforts associated with pregnancy, including swelling, fatigue, shortness of breath, and leg cramps. PA has also been shown to have a positive effect on energy levels for the expecting mother, with women engaging in regular PA reporting maintenance of high energy levels as the pregnancy progresses (Kramer, 2002).

In addition to the numerous physical health benefits associated with PA, there are a host of psychological benefits of PA for pregnant women. Researchers have demonstrated improvements in several aspects of self-reported body image among exercising pregnant women (Kramer, 2002). Mood stability throughout the progression of the pregnancy is also a topic of particular interest. While worsening moods are common during pregnancy, a study conducted by Poudevigne and O'Connor (2005) found a consistent and positive correlation between mood disturbance and physical inactivity among pregnant women, such that there was a significant increase in mood disturbances among pregnant women of greater degrees of inactivity. The findings of this study have also suggested that women who remain physically active in their third trimester exhibited significantly lower levels of anxiety than inactive women. This particular finding has also been supported by other researchers. For example, Symons Downs, DiNallo, and Kirner (2008) found that pre-pregnancy exercise behavior was associated with both depressive symptoms and body image satisfaction across the first, second, and third pregnancy trimesters and the postpartum period, such that increased exercise behavior was correlated with decreased depressive symptoms and increased body image satisfaction. This study also demonstrated that the moderating influence of pre-pregnancy exercise behavior on depressive symptoms was evident in early pregnancy (Symons Downs et al., 2008).

There is also a good body of evidence on the benefits of maternal PA throughout pregnancy for the developing baby. While the specific effects of a PA regimen on fetal growth and size at birth may be dependent on the type of PA program, the PA training-induced increase in maternal (and perhaps fetal) plasma volume, cardiac volume, and placental function may actually increase nutrient delivery to the placental site (Clapp, 2003). By simply engaging in PA, the mother induces cardiovascular, respiratory, and hormonal changes, each of which contribute to an optimal environment for growth of the fetus (Martens, Hernandez, Strickland, & Boatwright, 2006).

Researchers have identified a relationship between regular PA and the risk of low birth weight outcomes. A study conducted by Leiferman and Evenson (2003) showed that women who failed to engage in regular PA before and during their pregnancy were significantly more likely to give birth to a very low birth weight baby compared to those who remained physically active before and throughout their pregnancy. Furthermore, previously active women who stopped PA during their pregnancy were significantly more likely to give birth to a very low weight or low weight baby than women who maintained previous PA levels throughout their pregnancy. Giving birth to a low weight baby is concerning given the evidence that low birth weight babies may be at greater risk for late-onset septicemia (the presence of bacteria in the blood, often associated with severe infections; Fanaroff et al., 1998) as well as obesity (Nair, Nair, Chacko, Zulifar, George, & Sarma, 2009), Type 1 diabetes (Garcia Cuartero et al., 2009), chronic lung disease, and mild problems in cognition, attention, and neuromuscular functioning later in life (Hack, Klein, & Talor, 1995).

There is also evidence that maternal PA behavior may also impact certain behavioral characteristics of the baby after birth. For instance, the babies of mothers that continue regular PA throughout the duration of their pregnancy tend to be both more alert and readily self-quieted after birth (Clapp, 2001; Grisky, 2002). The findings of a study conducted by Griskey (2002) also suggest that mothers who exercised during pregnancy had less demanding babies. More specifically, their infants were able to keep themselves content and were more aware of their surroundings, seeming to demand less attention from their mothers (Griskey, 2002).

PA during pregnancy also serves to prepare both the mother and baby for the upcoming challenge of labor and delivery. A study conducted by Clapp (1990) showed that continuation of an endurance PA regimen also has a beneficial effect on both the course and outcome of labor. Specifically, participation in regular PA may be associated with reduced risk for cesarean delivery, with some studies showing sedentary women to be at up to a 4.5 times greater risk of cesarean delivery than active women (Bungum, Peaslee, Jackson, & Perez, 2000). Furthermore, the stress placed on the fetus during maternal PA may actually help to improve the baby's tolerance to stress before and during labor (Brown, 2002; Clapp, 2001), therefore better preparing the baby for the potentially stressful delivery. Clapp (2000; 2001) has also demonstrated that participation in PA during pregnancy may aid in faster and easier labor and delivery, and that those women who participated in regular PA throughout their pregnancy also showed a quicker recovery after giving birth. Lastly, maintaining an adequate aerobic fitness level as well as engaging in muscular resistance training have both been show to play a paramount role in preparing the mother for the physical demands of giving birth (Martens et. al., 2006).

Concerns About the Effects of PA During Pregnancy

While there is good empirical evidence on the safety of exercise during pregnancy (ACOG, 2002; IOM, 2009), there are nonetheless concerns. Much of these concerns relate to participation in vigorous-intensity PA during pregnancy. For example, a study conducted by Downey (2008) explored the experiences of highly active women who continued with vigorous PA during their pregnancy. All of the participants reported experiencing negative encounters and limitations being placed on them regarding their exercise behavior during pregnancy. Women reported that they were advised by friends and family to stay away from any vigorous activity, particularly as the pregnancy progressed. Furthermore, when these women chose to maintain their vigorous exercise routines in public throughout their pregnancy, they reported noticeable negative reactions from other exercisers and people nearby (e.g., strange looks, verbal comments). This type of discouraging behavior from others may contribute to the lack of women who continue PA during their pregnancy. The topic of vigorous intensity PA during pregnancy is still controversial, despite the evidence that it appears to pose no adverse maternal or neonatal outcomes (Penney, 2008).

An additional concern arises from the many known physiological, metabolic, and endocrine changes in the body that occur during pregnancy. Given these significant alterations, there are concerns that the temporary physiological adaptations accompanying PA may not be the same among the pregnant population as in the normal population (Gorski, 1985). One of the primary concerns is the response in fetal heart rate to maternal PA. Studies have documented a small rise in fetal heart rate during PA, ranging from 5-25 bpm (Riemann & Hansen, 2000; Sternfield, 1997). Several mechanisms for such an increase have been proposed, the most likely of which is a stimulation of maternal vasoactive hormones or training-induced uterine contraction (Riemann & Hansen, 2000). While such effects on fetal heart rate have not been correlated with an increase in fetal morbidity or mortality, such a fetal response may still pose certain concerns for the health of the fetus (Wolfe & Mottola, 1993).

One of the basic physiological adaptations to PA is a re-distribution of blood flow to accommodate the increased oxygen demands of the active muscles (Wilmore, Costill, & Kenney, 2008). This adaptation evokes certain concerns for PA among the pregnant population because such redistribution of blood flow may cause deleterious changes to uterine blood flow (Riemann & Hansen, 2000; Sternfield, 1997). Exercise training has been shown to cause increases in both blood and stroke volume to facilitate sufficient uterine blood flow during maternal PA (Pirarnik et al., 1993; Pivarnik et al., 1994; Webb, 1994). Although this mechanism has been proposed to prevent any fetal damage via compromised uterine blood flow, there is yet to be absolute proof that this poses absolutely no threat to the developing fetus.

A final concern about PA for the pregnant population is that PA induced temperature rise may theoretically induce teratogenic effects in the fetus (Riemann & Hansen, 2000; Sternfield, 1997). Although studies examining this effect are difficult at best to transfer to humans, the animal experimental literature has documented that a maternal increase in body temperature during the first trimester has resulted in marked fetal abnormalities (McMurray & Katz, 1990). However, human studies have shown that maternal heat dissipation shows a marked increase during pregnancy, which may counter any negative fetal outcomes resulting from a rise in maternal body temperature (Clapp, 1991; McMurray & Katz, 1990, McMurray, Katz, Meyer-Goodwine, & Cefalo, 1993). Studies have yet to show whether this remains the case during long-term, intense PA. The unethical nature of human studies involving a significant rise in maternal body temperature makes it difficult to study the fetal effects of such a phenomenon, and this explains why some concerns still remain about this issue.

Given these potential concerns, better surveillance and measurement of PA during pregnancy is crucial. One of the most fundamental limitations in current knowledge is that much of the early research surrounding PA in pregnancy was done in laboratory settings, with few studies examining women's PA behaviors in real life, free-living conditions. For example, much of the early work by Pivarnik et al. (1994) and Clapp (1990, 1991, 1995, & 2003) identified the physiological effects of PA on pregnancy outcomes and examined safety issues regarding PA during pregnancy. While this research has been important, these studies used mostly fit and active pregnant participants, making it difficult to extrapolate their findings to the general population. To combat this limitation, more recent studies have specifically investigated PA among pregnant women in free-living conditions (Borodulin, Evenson, Wen, Herring, & Benson, 2008; DiNallo, Le Masurier, Williams, & Symons Downs, 2008; Evenson, Savitz, & Huston, 2004; Hausenblas & Downs, 2005; Poudevigne & O'Connor, 2006; Symons Downs, Le Masurier, & DiNallo, 2009; Zhang & Savitz, 1996).

Examining women's pregnancy PA behaviors has proven to be challenging for many reasons, and consensus has yet to be reached on the most effective and accurate method of assessing PA in pregnancy. The use of accelerometry may offer us the closest estimate to a gold standard of PA in free-living. However, there is limited research using accelerometry with pregnant women. Given the importance of PA during pregnancy, it is crucial to obtain an accurate understanding of current patterns of pregnancy PA. The current methods of examining pregnancy PA are limited due to the methodological and conceptual issues associated with PA measurement and the physiological and lifestyle changes that accompany pregnancy. These issues will be discussed in the following section.

PA Measurement in Pregnancy

To assess PA in the general population and specifically among pregnant women, two main modes of PA measurement have been commonly used. PA data can easily be measured with subjective, self-report questionnaires. Alternatively, objective measures of PA, including pedometers and accelerometers, can also be used to obtain an assessment of PA that is not solely based on participant recall. Particularly among pregnant women, PA assessment can be problematic using both objective and subjective measures. There is no single criterion measure for PA behavior to compare self-reported and objective monitors to, making it difficult to assess the accuracy of PA measures during this time (King, Torres, Potter, Brooks, & Coleman, 2004). Objective measures are becoming more integrated into pregnancy studies to overcome the limitations of self-report measures, particularly over-reporting of PA (Anderson, Hagstromer, & Yngve, 2005). However, the current research still remains scant, and is based on a relatively small number of studies (Chasan-Taber, Schmidt, & Roberts, 2004; Lindseth & Vari, 2005; Schmidt, Pekow, Freedson, Markenson, & Chasen-Taber, 2006). A description of the measures that have been used with pregnant women as well as an evaluation of their strengths and weaknesses will be discussed in the following section.

Objective Assessments: Pedometers and Accelerometers

The use of objective measures such as pedometers and accelerometers in the assessment of PA has proven to be particularly useful. Objective measures were developed to assess PA in both controlled and free-living environments, and as a means of minimizing the error that can be found using self-report measures. They have also been used concurrently with self-report measures to obtain a more comprehensive and accurate view of PA, particularly during pregnancy (Chasen-Taber et al., 2004; Freedson, Melanson, & Sirard, 1998; Symons Downs et al., 2009).

Pedometers. Pedometers are small, low-cost step counters that simply provide an estimation of the number of steps taken in a given period of time. Specifically, pedometers provide a quantification for steps taken, however, they do not have the ability to measure the quality or intensity of an activity (Hendelman, Miller, Bagget, Debold, Freedson, 2000). There are many pedometers currently available to researchers, and the Yamax Digiwalker SW-701 is one that has been commonly used in PA research. This small, lightweight pedometer is worn on a belt around the waist, and uses a spring suspended lever arm that moves in response to the vertical accelerations during motion to count steps. This pedometer measures steps taken on a daily basis, resetting the step count at midnight. This pedometer has yielded both acceptable validity and accuracy, as well as adequate reliability, including high inter-instrument agreement (Bassett, Ainsworth, & Hartman, 1993; Crouter, Schneider, & Leggett, 2003; Schneider, Crouter, Lukajic, & Bassett 2003).

Despite the many applications of pedometers, a particular weakness of these devices comes from their design. Pedometers are not designed to have the capacity to measure PA intensity, an important element of PA measurement (Tudor-Locke & Bassett, 2004). Also concerning PA intensity, researchers have suggested that pedometers may be most sensitive to PA at more moderate to vigorous intensity levels (Rousham, Clarke, & Gross, 2006). These limitations of both pedometers with regard to intensity are particularly problematic in the pregnant population. Studies have shown that as pregnancy progresses, women are more likely to engage in lower intensity PA (Borodulin et al., 2008; Schmidt et al., 2006; Zhang & Savitz, 1996). Both the inability of pedometers to detect these changes in intensity and their insensitivity to mild intensity PA provide significant limitations for measuring PA during pregnancy with these devices.

Accelerometers. Accelerometers measure the magnitude of acceleration and they provide information on the amount and intensity of PA engaged in by the participants (Hendelman et al., 2000). The Actigraph (model 7164, Manufacturing Technology, Inc., Fort Walton Beach, FL) is used to assess PA at a pre-determined epoch, ranging from one second to one minute. The Actigraph then reports "activity counts" for each interval, which is then downloaded using software such as Microsoft Excel. Activity counts are an arbitrary number, and they are not comparable to more common measurements of PA (e.g., min spent in PA or metabolic equivalents [METs]), which has led researchers to develop regression equations to convert activity counts into more interpretable data (Freedson, Melanson, & Sirard, 1998; Hendelman et al., 2000).

Specific to pregnant populations, the Actigraph has been used to examine the concurrent validity of the following two pregnancy-specific PA questionnaires: (1) Pregnancy Physical Activity Questionnaire (PPAQ; Chasan-Taber et al., 2004); and (2) the Kaiser Physical Activity Survey in pregnant women (KPAS; Schmidt et al., 2006). The activity as reported in these questionnaires was compared with Actigraph data and activity count cut points developed by Hendelman et al. (2000) and Freedson et al. (1998), which correspond with different levels of energy expenditure. While the PPAQ was significantly correlated with the Hendelman et al. (2000; $r = 0.43$, $p < 0.001$) cutpoints, no significant correlations were observed with the Freedson et al. (1998; $r = 0.08$, $p = 0.77$) cut points.

Despite their abundant applications, the accuracy of accelerometers has not been without criticism. For example, accelerometers are limited in that by nature they do not include certain movements in their measurement of activity. A study conducted by Hendelman et al. (2000) demonstrated that the types of activities performed over the measurement period largely determine the accuracy of objective measures. Particularly for women, free-living movements including weight-bearing PA, limb movement, or gradient change may constitute a significant proportion of the daily activity (Ainsworth, 2000). Accelerometers are, however, unable to detect energy costs from movements such as these (Hendelman et al., 2000). In cutting out a potentially significant source of activity in their measurements, this method of PA measurement may yield a low estimate of daily PA (Ainsworth, 2000).

The Actigraph has been found to under-report PA by three kcal/min for both slow walking (54 and 80 $m*min^{-1}$) and fast running speeds (214 $m*min^{-1}$) when compared to indirect calorimetry (King, Torres, Potter, Brooks, & Coleman, 2004). Also, Bassett et al. (2000) compared several objective measures of PA in a free-living environment to indirect calorimetry. They found that the Actigraph under-reported PA by 5.6 kcal/min when using the Freedson et al. (1998) cut points. In another field study, the Actigraph was found to under-report PA by 53% when compared to indirect calorimetry (Welk, Blair, Wood, Jones, & Thompson, 2000). This tendency for accelerometry to under-report PA levels should be taken into account when using this device to assess PA levels, perhaps providing justification for the use of accelerometry and an additional activity measure when assessing PA behaviors.

A final limitation of both accelerometers and pedometers in general is that they fail to measure the mode or types of PA the participants are engaging in throughout the measurement period. While these data provide a quantification of PA levels, they do not provide the qualitative data necessary to place any study of PA measurement into a greater context. Especially for pregnant women, much of women's daily levels of PA come from a variety of sources, and it is important to understand not only how much PA these women are engaging in, but also the types and intensities of their activities. Given these limitations, it is clearly is important to include multiple PA instruments (i.e., self-report and objective measures) in study protocols to provide the most comprehensive evaluation of overall PA behaviors during pregnancy (Wood, 2000).

Subjective Assessments

Because objective measures cannot provide information on the type or mode of PA self-report measures (e.g. standardized questionnaires, daily activity logs) are needed to examine the descriptive content of PA levels and patterns. Self-report measures are easy to administer and are more cost-effective than using objective assessments of PA (Chasen-Taber et al., 2004); making them better suited to assess PA among larger samples. However, there are also some limitations. Self-report PA measures are especially susceptible to over/under-reporting biases. Anderson et al. (2005) showed that with increasing amounts of PA (greater than 60 min) and increasing intensity (greater than 6 METs), over-reporting increased by as much as 188 min/day. One of the most important factors impacting the validity of self-report measures to assess PA in pregnancy is the use of a pregnancy-specific questionnaire. Unfortunately, most of the currently available questionnaires have been developed and validated in populations of men. Furthermore, most of these are based on participation in moderate- and vigorous-intensity sports and exercise-related PA activities (i.e. running, weight-lifting, soccer; Chasen-Taber et al., 2004). This quality of these questionnaires makes them difficult for application to pregnant women, given that women are not recommended to partake in many of these types of PA during pregnancy (Ainsworth, 2000).

Another important element in measuring PA, particularly among pregnant women, is the inclusion of household activities and childcare into daily activity levels, given that these types of activities comprise a substantial proportion of the types of PA that pregnant women do (Schmidt et al., 2004; 2006). Therefore, a pregnancy-specific questionnaire should include multiple modes/or types of PA that include not only exercise-related PA behaviors (e.g., running, swimming, walking, weight-lifting, sports, etc.), but also other activities throughout the day that will contribute significantly to the overall daily levels of activity (i.e., work, taking care of children, household chores). Ainsworth (2000) has shown that the use of non-pregnancy specific PA questionnaires that fail to include household activities, childcare, and other common daily activities outside of explicit PA behaviors may yield inaccurate results when applied to the pregnant population.

Many different types of PA self-report questionnaires have been developed, some of which have been utilized specifically among pregnant women, to try to minimize some of the weaknesses of subjective PA measures. Some of the most commonly used self-report questionnaires for studies of PA during pregnancy include the Leisure-time Exercise Questionnaire (LTEQ; Godin & Shepard, 1985) the Pregnancy Physical Activity Questionnaire (PPAQ; Chasen-Taber et al., 2004), and the Previous Day Physical Activity Recall (PDPAR) Questionnaire. These different self-report PA measures will each be described further in the following section.

Previous Day Physical Activity Recall (PDPAR) Questionnaire. The PDPAR is a self-report instrument, developed to assess free-living activity by requiring individuals to recount the various activities and their respective PA intensity levels that they took part in during the previous day (Weston, Petosa, & Pate, 1997). The PDPAR was originally developed to assess PA among school-age children during the after school period, 3:00-11:30 pm. The original instrument consists of a grid of 30-min time blocks, and provides a list of 35 common activities (Pate et. al., 1997). Each student was instructed to record his or her primary activity during each 30-min time block for the previous day. Furthermore, each student elaborated on the intensity level of the recorded PA he or she participated in, rating the activity as light, moderate, or hard. Those activities requiring normal movement and breathing were to be classified as 'light', those requiring moderate movement and increased breathing were categorized as 'moderate', and those requiring fast movement and hard breathing were categorized as 'hard' (Pate et. al. 1997).

In the U.S., the PDPAR has been widely used in both observational and intervention trials, and has shown marked validity, reliability, and sensitivity to change

(Dishman et al., 2005; Pate et al., 2003, 2005). Previous researchers have found the PDPAR to have a test-retest reliability of $r = .98$ (Weston et al., 1997). Furthermore, the PDPAR has been validated against the Actigraph accelerometer ($r = 0.42$, $p < 0.001$) using the Freedson et al. (1998) cut points, confirming previous findings that the PDPAR is an accurate assessment of PA behavior (Anderson, Hagstromer, & Yngve, 2005). However, given the original development of the PDPAR as a self-report instrument for child and adolescent populations, there is little evidence of the validity, accuracy, and reliability of the PDPAR among adult, populations, and particularly pregnant women. Currently, no published studies have been located using the PDPAR in pregnant populations; however, research does support the use of similar previous day recall measures in pregnancy (Fahrenwald & Walker, 2003).

The Leisure-Time Exercise Questionnaire (LTEQ). The Leisure-time Exercise Questionnaire (LTEQ; Godin & Shephard, 1985) is a self-report measure asking participants to recall the number of 15-min bouts of mild, moderate and strenuous leisure-time PA (i.e., exercise-related PA) in a typical week, outside of school or work. The LTEQ scores are converted to metabolic equivalents (METs) and a total score is generated using the following formula: (vigorous exercise x 9) + (moderate exercise x 5) + (mild exercise x 3). The LTEQ has been validated against VO_2 measurements ($r = 0.24$, $p < 0.001$), and it was found to be an accurate assessment of PA behavior (Godin & Shephard, 1985). Correlations between VO_2 and the LTEQ were greater for strenuous activity ($r = 0.38$, $p < 0.001$) than for moderate ($r = 0.03$, $p > 0.05$) or mild ($r = 0.04$, $p > 0.05$) activity (Godin & Shephard, 1985). This may reduce the accuracy of the LTEQ when used in pregnant populations, who are more likely to engage in mild to moderate activity (Evenson et al., 2004). The LTEQ has been used previously to assess women's PA behaviors during pregnancy (Hausenblas & Symons Downs, 2005).

The Pregnancy Physical Activity Questionnaire (PPAQ). The Pregnancy Physical Activity Questionnaire (PPAQ; Chasan-Taber et al., 2004) is a self-report PA measure asking pregnant participants to recall their PA behaviors over an entire trimester. The PPAQ includes items that are not found in exercise-related and non-pregnancy specific questionnaires (e.g., carrying children, preparing meals, cleaning, and shopping). In addition, the PPAQ has been used to validate the KPAS (Schmidt et al., 2006). The PPAQ is more highly correlated with the Actigraph (the criterion measure for PPAQ validation) for moderate-vigorous PA [Hendelman et al. (2000) cut points; $r = .49$, $p < 0.001$] than for light PA [Hendelman et al., (2000) cut points; $r = .20$, $p < 0.001$; Chasan-Taber et al., 2004]. This may result in inaccuracies when measuring the PA behavior of women who engage in more light PA than moderate to vigorous PA.

Current Knowledge of PA During Pregnancy

The findings from recent epidemiological studies indicate that a small proportion of women are achieving the recommended level of PA during pregnancy (Borodulin et al., 2008). More specifically, a large-scale study conducted by Evenson, Savitz, and Huston (2004) indicated that only 16% of pregnant women self-reported they were meeting the PA guidelines. Also, a recent study by DiNallo et al. (2008) using accelerometry found that less than 12% of pregnant women were meeting objectively-determined PA guidelines during free-living conditions. Furthermore, studies to date have also consistently shown that in free-living conditions women tend to reduce their levels of PA across the pregnancy trimesters, with the least amount of PA occurring in the third trimester (Clissold, Hopkins, & Seddon, 1991; Dale, Mullinax, & Bryan, 1982; Hausenblas & Symons Downs, 2004; Symons Downs & Hausenblas, 2003, 2007).

Studies of Interest for the Current Research

While the literature examining PA patterns during pregnancy has expanded greatly in recent years, there are two particular studies that are of interest for the current research, and therefore warrant further discussion. A recent study published by Symons Downs et al. (2009) examined women's PA behaviors with both subjective (self-report) and objective (pedometer) assessments. The participants were a total of $N = 80$ pregnant women recruited from a local medical clinic in Central PA (Study 1: $N = 50$, M age = 29.92, $SD = 4.05$ years; Study 2: $N = 30$, M age = 31.0, $SD = 4.1$ years). PA was assessed for three consecutive days at 20- and 32-weeks gestation with a Yamax pedometer and the Leisure-time Exercise Questionnaire (LTEQ; Goden et al., 1986). The LTEQ assesses mild, moderate, vigorous, and overall PA in Metabolic Equivalents (METs).

Symons Downs et al. (2009) used both the step counts obtained from the Yamax pedometer and the total LTEQ scores from self-report data to assess pregnant women's activity levels. Using total LTEQ scores, women were described as either sufficiently active or insufficiently active at both 20- and 32-weeks gestation, according to current PA guidelines (ACOG, 2004; ACSM, 2000). Furthermore, using the women's average daily step count over the three day period at 20- and 32- weeks gestation, women were categorized into one of four activity categories, based on modified pedometer indices of those proposed by Tudor-Locke and Bassett (2004). The five activities categories were specified as follows: sedentary (<5,000 steps/day), low active (5,000-7,499 steps/day), somewhat active (7,500-9,999 steps/day), and active (10,000+ steps/day). The specific

LTEQ scores for each intensity level were also used to assess activity intensity and compare levels of PA at each intensity from 20- to 32-weeks gestation.

Symons Downs et al. (2009) found that the LTEQ and pedometer indices classified between 67% and 86% of the women as insufficiently active at 20-weeks gestation. In addition, a greater proportion of women were classified as sedentary and low active at 32-weeks gestation (73%) compared with 20-weeks gestation (50%). It was also found that from 20- to 32-weeks gestation, both mean steps/d and LTEQ strenuous min significantly declined across this time period. Lastly, as the authors had predicted, there was a positive association between mean steps/day, LTEQ total, strenuous, and mild min of PA at 20- and 32-weeks gestation. This study provides an effective example of integrating both objective and subjective PA measures during free-living conditions in pregnancy, and it has generated a better understanding of PA patterns throughout pregnancy. Furthermore, this study highlights the need for further research in this area, given the startling proportion of pregnant women that are not meeting current PA guidelines.

The second study directly related to the proposed research was conducted by Borodulin and colleagues (2008) and the purpose of this study was to examine the mode, frequency, duration, and intensity of PA among pregnant women to determine the extent to which women achieved the recommended levels of PA. They also explored how women's PA behaviors changed across the pregnancy trimesters. The participants of this study were 1,428 pregnant women (median age = 30) who completed telephone interviews during their pregnancy at 17-22 weeks and 27-30 weeks gestation. PA was assessed through the administration of a past week recall questionnaire, assessing frequency, duration, and perceived intensity of PA in each of the following categories: recreational, occupational, transportation, child and adult care, and indoor and outdoor household activity. Women were also assigned to one of three activity categories (active, inactive, or became inactive) based on their reported PA at both time points. The ACOG (2002), CDC (2005), and ACSM (2004) guidelines were also used to categorize women by whether they reached the recommended levels of PA during pregnancy or not.

Borodulin et al. (2008) found women's PA level decreased from the second to third trimester, both in the total activity category and activity in the mild (fairly light) and vigorous (hard/very hard) intensity categories. The proportion of women meeting PA guidelines during the first trimester was between 13% (using the ACOG, 2002 guidelines), and 38% using the (CDC, 2005 and ACSM, 2004 guidelines). This proportion decreased to only 3% (using ACOG guidelines) and 11% (using CDC/ACSM guidelines) in the third trimester. When examining the activity groupings, the women who remained in the active group at both the second and third trimester reported higher levels of PA in all activity modes compared to those who became active or inactive during pregnancy. Very few women (3.5% during the second trimester, 6.1% during the third trimester) reported being entirely inactive during pregnancy when taking into account work activity, as most women continued working during their second and third trimester.

Areas for Future Research

Building from the findings of these two important studies, there are several implications for further research. The research conducted by Symons Downs et al. (2009) illustrates the importance of examining the component of exercise intensity with both self-report and objective measures. However, it is necessary to take the findings of the Symons Downs et al. (2009) study one step further by also taking a broader look at both the mode/type of PA and the intensity of PA to obtain a more comprehensive assessment of women's PA behaviors from 20- to 32-weeks gestation, similar to the PA dimensions measured in the Borodulin et al. (2008) study. Previous work by Ainsworth (2000) and Borodulin et al. (2008) also emphasize the importance of incorporating not only exercise-related PA as was done in the Symons Downs et al. (2009) study, but also PA from other sources (e.g., , work, childcare, household chores). Furthermore, it is important to replicate the pedometer-determined findings from the Symons Downs et al. (2009) study because these findings and those of Borodulin et al. (2008) indicate that women of different activity levels (i.e., low-active, active) may exhibit different patterns of PA mode and intensity during pregnancy, and may also differentially alter their PA behaviors as their pregnancy progresses.

Purposes of the Current Study

The overall objective of this honors thesis was to thoroughly examine the time spent in non-exercise and exercise-related PA modes and intensities and changes in activity patterns among pregnant women during their second and third pregnancy trimesters according to pedometer-determined parameters. Specifically, the first purpose was to examine the changes in PA mode (i.e., non-exercise and exercise-related PA) and intensity (i.e., mild, moderate, and vigorous) from 20- to 32-weeks gestation within the following three activity groups: (1) active (7,500+ mean steps/day), (b) low-active (<7,499 mean steps/day, and (c) transitioned to low-active (7,500+ mean steps/day at 20-weeks gestation, <7,499 mean steps/day at 32-weeks gestation). For clarity of presentation, the PDPAR categories are presented below as either non-exercise PA, defined as the PDPAR categories of sleeping, eating, bathing, work, transportation, and hobbies, and exercise-related PA, defined as the PDPAR category of exercise (i.e., jogging, swimming, and lifting weights). Also, previous researchers (Borodulin et al., 2008; Symons Downs et al., 2009) have found that women may not remain in the same activity group from 20- to 32-weeks gestation, therefore in addition to the active (i.e., 7,500 or more steps) and low-active (i.e., 7,499 or less steps) categories, women who transition from active at 20-weeks to low-active at 32-weeks were categorized in the 'transitioned to low-active group'. It was hypothesized that no significant decrease in mean steps/day would be observed for the active group, while significant decreases will be observed from 20- to 32-weeks for the low-active and transitioned to low-active groups.

It was also hypothesized that within the active group there would be little change in time spent in non-exercise PA (i.e., PDPAR categories of sleeping, eating, bathing, work, transportation, work, and hobbies) as well as exercise-related PA (i.e., PDPAR categories of exercises such as jogging, swimming, lifting weights) from 20- to 32-weeks gestation. However, based on previous findings (Borodulin et al. 2008) it was predicted that low levels of PDPAR moderate and vigorous non-exercise PA and exercise-related PA would be observed for the low-active group at both 20- and 32-weeks gestation. It was also was expected that the low-active group would also have a decrease in mild intensity non-exercise PA from 20- to 32-weeks. Lastly, for the group that transitioned from active at 20-weeks to low-active at 32-weeks, it was hypothesized that a decline would be observed in time spent in PDPAR moderate and vigorous non-exercise and exercise-related PA.

In addition to examining the time spent in the PDPAR non-exercise and exercise-related PA categories from 20- to 32-weeks within the pedometer-determined groups (i.e., purpose 1), a second study purpose was to compare the time spent in these PDPAR categories specifically between the low-active and active groups at 20-weeks and 32-weeks gestation. Consistent with previous research (Borodulin et al., 2008; Symons Downs et al.,2009), it was hypothesized that the active group would have more time spent in both moderate and vigorous non-exercise and exercise-related PA than the low-active group at both 20- and 32-weeks gestation. It was also predicted that the low-active group would spend more time in the PDPAR mild intensity non-exercise and exercise-related PA compared to the active group at both 20- and 32-weeks gestation.

Chapter 2

Methods

Participants

The participants of this study were women in their second pregnancy trimester (*N* = 36, *M* age = 30.33, *SD* = 3.64 years; *M* height = 65.59, *SD* = 3.01; *M* weight = 148.82 lb, *SD* = 27.4) recruited from a larger study conducted in the Exercise Psychology Lab, under Dr. Danielle Symons Downs at The Pennsylvania State University. A vast majority of the participants were Caucasian (97.2%), and employed full-time (58%). A majority of the participants (97%) were college graduates, 47% of which had graduate/professional school degrees. The most commonly reported level of family income was between $40,000-100,000 (56%). Lastly, the average body mass index (BMI) at 20-weeks gestation was 25.21 kg*m^{-2} (*SD* = 5.24), and at 32-weeks gestation was reported at 26.38 kg*m^{-2} (*SD* = 5.47). The full demographics of the participants can be found below in Table 3.

Measures

Previous Day Physical Activity Recall Questionnaire (PDPAR). The PDPAR-3 as modified for this study, was used to assess time spent in various modes and intensities of PA for pregnant women. This self-report instrument incorporated three days of PA, and pregnant women completed the questionnaire at both 20- and 32-weeks gestation. The PDPAR-3 was modified in several ways from the original PDPAR to serve the purpose of this study. First, the assessment was extended to cover all 24 hours of the previous day, and activity periods were broken down into 15 rather than 30 min intervals so that women could more accurately track their PA done in smaller bouts of time. Second, the

Table 3

The Number (N) and Percent (%) of Demographic Characteristics for Participants

Characteristic	*N*	%[a]
Race/Ethnicity		
Caucasian	35	97
Marital Status		
Married	34	94
Divorced	1	3
Single	1	3
Education		
College	18	50
Graduate/Professional Degree	17	47
Other	1	3
Family Income		
Less than $10,000	1	3
$10,000-20,000	2	5
$20,000-40,000	5	14
$40,000-100,000	20	56
More than $100,000	8	22
Current Occupational Status		
Full-time	21	59
Part-time	12	33
Homemaker	2	5
Self-Employed	1	3

Note. May not add up to 100% due to missing data.

activity list was extended to 41 activities, divided into 7 categories, with the intention of covering the majority of daily activities for pregnant women. These categories consist of non-exercise PA (i.e., sleeping, eating, bathing/dress, work, transportation, hobbies) and exercise-related PA (e.g., jogging, walking, swimming, weight lifting, etc). Third, the list also includes six blank spaces at the bottom in which the participant was able to write down any activities they performed that were not included in the list. The intensity level for each activity was recorded as outlined on p. 18, rating activities as mild, moderate, or vigorous. Appropriate metabolic equivalent scores (METs) for each activity and intensity level were assigned according to the values from the Compendium of Physical Activities (Ainsworth et al., 2000). The PDPAR is a valid and reliable self-report measure of PA (Anderson et al., 2005; Dishman et al., 2005; Pate et al., 2003, 2005).

Yamax Digiwalker SW-701 Pedometer. The Yamax Digiwalker SW-701 Pedometer (Yamax Corporation, Tokyo, Japan) was used to obtain an objective measure of PA levels. This pedometer was worn in the current study for three consecutive days at 20-weeks gestation to assess the number of steps/day women accumulated under free-living conditions. Previous studies have demonstrated the accuracy of Yamax pedometers among adult population under free-living conditions (Le Masurier, Lee, & Tudor-Locke, 2004; Schneider et al., 2003). Relevant to the study at hand, Yamax pedometers have also shown documented accuracy among women over time (Felton, Tudor-Locke, & Burkett, 2006), and have been used in prior research with pregnant women under free-living conditions (Symons Downs et al., 2009).

Design and Procedure

After approval was granted for the current study from the University's Institutional Review Board (PSU IRB #23915), participants were recruited through both local and university newspaper advertisements. Those women who were interested were instructed to call a number provided in the advertisement and speak with a member of the research team. Participants were also recruited through flyers and informational letters about the study at local obstetrics and gynecology (OBGYN) offices. Interested women provided their contact information and returned it to a nurse at the OBGYN clinic. Women were informed about the general procedures and details of the study on the phone, and if eligible scheduled an appointment with a member of the research team for a preliminary meeting at the General Clinical Research Center (GCRC). To be eligible, women were to be within the ages of 18-45, English-speaking, and obtained written approval from their OBGYN to rule out any possible contraindications to PA during pregnancy as outlined in the AGOC guidelines (2002).

At the GCRC meeting, the member of the research team first went over informed consent form procedures with the participant. The participant was given their PDPAR survey, and asked to complete it nightly for the next three days, outlining their PA during the previous day in 15 min intervals from 12:00 a.m. to 12:00 p.m. They were also given their Yamax Digiwalker SW-701 pedometer and were instructed about proper usage of the pedometer, which was to be placed on their belt directly above their right knee. Participants were instructed to put the pedometer on upon waking up in the morning, and asked to wear it during all daily activities for the next three days, excluding water activities (swimming, bathing, etc.). Previous research suggests that three days of pedometer data is sufficient to accurately categorize an individual's PA behaviors (Tudor-Locke et al., 2004, 2005). At the end of each day, the participant was instructed to self-report their step count for the day. After receiving all instructions, participants were given time to ask any further questions they may have, and were given a contact number for a member of the research team as well as written instructions of the study procedures.

Data Reduction

The PDPAR produces a vast amount of data for each participant over the three-day period, thus the data were reduced to simplify data analysis procedures. For each participant, time spent (as recorded in 15-min blocks) in each of the seven activity categories for each day was calculated. Total daily time spent in the different activity categories was also separated by the reported intensity. Sedentary/low-active categories (i.e. less than 3 METs) such as sleeping, bathing/resting and eating, were categorized as mild intensity. The remaining categories (i.e., working, transportation, hobbies and exercise-related PA) varied in reported intensities, and were categorized as non-exercise PA (i.e., eating/cooking, bathing, work, transportation, and hobbies) and exercise PA (e.g., specific exercise behaviors, such as walking, jogging, swimming, and weight-lifting).

Chapter 3

Data Analysis

Preliminary Analyses

All data screening and statistical analyses were carried out using Statistical Package for the Social Sciences (SPSS) version 17.0. Total time spent (in hours) in each activity category and intensity level for each day of the 3-day period was entered into the SPSS file for each participant, as well as their daily step counts. Descriptive statistics were obtained to describe the participants (see Table 3). A syntax was created to calculate average steps/day, average min/day spent in each PA category, and average min/day spent in each reported PA intensity level, separated by their respective non-exercise PA (i.e., sleeping, eating, bathing/dressing, working, transportation, hobbies) and exercise-related PA categories.

The same syntax was also used to separate the participants into PA-level categories, based on their average steps/day over the three-day period. Pedometer indices for different activity levels were determined based on the previous work of Tudor-Locke & Bassett (2004) and modified by Symons Downs et al. (2009) for the pregnant population and applied to free-living conditions. These modified cut-points differentiated women into categories of: sedentary (<5,000 steps/day), low-active (5,000-7,499 steps/day), somewhat active (7,500-9,999 steps/day), and active (10,000+ steps/day). For the current study, these categories were combined to create an adequate spread, given the relatively small sample size ($N = 36$). Women with <7,499 steps/day were categorized as low-active, and 7,500+ steps/day as active. However, because several women did not remain in the same activity category from 20- to 32-weeks gestation, the 'transitioned to low-active' group was created for those participants with 7,500+ steps/day at 20-weeks and <7,499 steps/day at 32-weeks gestation. No participants were found to transition from the low-active group to the active group. One-way ANOVA and chi-square analyses were used to examine differences in demographic characteristics between the women in the two activity groups. No significant differences were observed for age, marital status, race, family income, occupational status, and first trimester weight (p's $> .05$).

Main Study Analyses

To examine the changes in PA behaviors within the active, low-active, and transitioned to low-active groups 20- to 32-weeks gestation, cases were selected based on activity category groupings at both time points. Paired samples *t*-tests were used to examine the changes in average steps/day taken by the active, low-active, and transitioned to low-active group from 20- to 32-weeks gestation. Paired samples *t*-tests were then used to determine significant differences in time spent in the various PA activity categories from 20- to 32-weeks gestation within each group. Differences in time spent in each non-exercise and exercise-related PA intensity from 20- to 32-weeks gestation were also calculated for each of the activity groups. To make comparisons between the low-active and active groups at both 20- and 32-weeks gestation, the data file was split. Descriptive statistics were used to obtain time spent in all PDPAR categories, non-exercise PA intensity levels, and exercise-related PA intensity levels in both groups at 20- and 32-weeks gestation. To test for significant differences between the low-active group and active group, one-way ANOVA tests were used comparing time spent in all PA mode (i.e., non-exercise and exercise-related PA) and intensity (i.e., mild, moderate, vigorous) categories at both 20-and 32-weeks gestation.

Chapter 4

Results

Analysis of Time Spent in PDPAR Non-Exercise PA and Exercise PA Categories and Intensities within Each Activity Group from 20- to 32-Weeks Gestation

Table 4 displays the general comparison in average steps/day at 20- and 32-weeks gestation within the three activity groups: (1) active at both 20- and 32-weeks gestation, (2) low active at 20- and 32-weeks gestation, and (3) active at 20-weeks gestation but transitioned to low-active at 32-weeks gestation. For the women classified as active at both time points there was no significantly significant decline in average steps from 20- weeks (*M* = 9,484.39, *SD* = 1,029.31) to 32-weeks gestation (*M* = 9,108.44, *SD* = 1,452.15), *p* = .545. In the low-active group, a statistically significant decrease in average steps was observed from 20-weeks (*M* = 5,413.89, *SD* = 1690.03) to 32-weeks

Table 4

The Mean (M), Standard Deviation (SD), and Paired Samples t-Test of Average Steps/Day Among the Active Group (>7,500 steps/day), Low-Active Group (<7,499 steps/day), and Activity Change Group (>7,500 steps/day at 20-weeks gestation, <7,499 steps/day at 32-weeks gestation) at 20- and 32-Weeks Gestation

	20-weeks		32-weeks			
Step Category	*M*	*SD*	*M*	*SD*	*df*	*p-value*
Active at both 20- and 32-weeks (*n* = 6)	9,484.39	1,029.31	9,108.44	1,452.15	5	.545
Low-active at both 20- and 32-weeks (*n* = 13)	**5,413.89**	1,690.03	**3,978.33**	1,861.16	12	**.027**
Active at 20-weeks, low-active at 32-weeks (transitioned to low-active; *n* = 9)	**8,893.78**	995.99	**4,339.67**	1,610.99	8	**.000**

Note. df = degrees of freedom.

gestation (*M* = 3,978.33, *SD* = 1,861.16), *p* = .03. Also, for the group of women who were classified as active at 20-weeks but transitioned to low-active at 32-weeks (activity change group), a statistically significant decrease in average steps was observed from 20-weeks (*M* = 8,893.78, SD = 995.99) to 32-weeks gestation (*M* = 4,339.67, *SD* = 1,610.99), $p < .001$.

Active Group. Table 5 displays the changes in PA behaviors among the active group of pregnant women from 20- to 32-weeks gestation. Self-reported time spent doing work and hobbies remained relatively constant from 20- to 32-weeks gestation among women in the active group at both time points. Although not significant, time spent sleeping and in transportation both decreased (Sleeping- 20-weeks: *M* = 549.12, *SD* = 63.69; 32-weeks: *M* = 530.83, *SD* = 86.89; Transportation- 20-weeks: *M* = 131.53, *SD* = 97.30; 32-weeks: *M* = 103.00, *SD* = 59.85), $p > .05$. Self-reported time spent bathing/dressing showed a significant decline from 20-weeks (*M* = 86.45, *SD* = 33.24) to 32-weeks gestation (*M* = 49.04, *SD* = 31.97), *p* = .02. While not statistically significant, time spent in the exercise PA category slightly increased from 63.58 min/day at 20-weeks to 75.84 min/day at 32-weeks gestation among the active group ($p > .05$).

The self-reported time spent in mild, moderate, and vigorous non-exercise PA among the active group is presented in Table 5. The greatest observed decrease was in time spent in moderate intensity non-exercise PA from 20-weeks (*M* = 69.00, *SD* = 39.59) to 32-weeks gestation (*M* = 48.00, SD = 57.07), however, this decrease was not statistically significant ($p > .05$). Non-significant changes were observed for mild and vigorous intensity non-exercise PA from 20-weeks (*M* = 783.00, *SD* = 44.28; *M* = 3.00, *SD* = 6.71, respectively) to 32-weeks gestation (*M* = 781.04, *SD* = 169.08; *M* = 4.00, *SD* = 8.94, respectively), (*p's* > .05).

Table 5

The Mean (M), Standard Deviation (SD), and Paired t-Test of Average Min Spent/Day in the PDPAR Non-Exercise PA and Exercise PA Categories and Intensities for the Active Group (>7,500 steps/day) at 20- and 32-weeks Gestation

N = 5	20-weeks		32-weeks				
Variable	*M*	SD	*M*	SD	*t*	*df*	*p-value*
Activity Category							
Non-Exercise Categories							
Sleeping	549.12	63.69	520.83	86.89	.621	4	.568
Bathing/dressing	**86.45**	33.24	**49.04**	31.97	3.383	4	**.028**
Work	379.47	156.90	379.90	122.75	-.424	4	.693
Cooking/Eating	78.87	53.45	90.01	28.06	-.389	4	.717
Transportation	131.53	97.30	103.00	59.85	.605	4	.578
Hobbies	155.23	91.17	153.67	99.09	.050	4	.962
Exercise	63.58	28.63	75.84	53.05	-.820	4	.458
Non-Exercise PA Intensity							
Mild	783.00	44.28	781.04	169.08	.025	4	.981
Moderate	69.00	39.59	48.00	57.07	.749	4	.495
Vigorous	3.00	6.71	4.00	8.94	-.180	4	.866
Exercise PA Intensity							
Mild	13.00	29.08	22.00	27.06	-1.50	4	.208
Moderate	47.00	30.53	49.00	68.95	-.095	4	.929
Vigorous	3.00	6.71	4.00	8.96	-.180	4	.866

Note. df = degrees of freedom; Time spent in various non-exercise PA intensities excludes time spent sleeping

Specifically examining mild, moderate, and vigorous intensity exercise-related PA for the active group, there was an increase in mild exercise PA from 20-weeks (*M* =13.00, *SD* = 29.08) to 32-weeks gestation (*M* = 22.00, *SD* = 22.76), however, this difference was not significant ($p > .05$). Small changes were also see is moderate and vigorous intensity exercise PA from 20-weeks (*M* = 47.00, *SD* = 30.53; *M* = 3.00, *SD* = 6.71, respectively) to 32-weeks gestation (*M* = 49.00, *SD* = 68.95; *M* = 4.00, *SD* = 8.96, respectively), however, these differences were also not significant ($p > .05$).

Low-Active Group. Table 6 shows the changes in PA behavior from 20- to 32-weeks gestation for women in the low-active group at both time points. No statistically significant changes were observed in time spent in the various PDPAR categories, however two notable patterns of behavior were observed. First, time spent sleeping showed an increase of on average 40 min/day from 20-weeks to 32-weeks gestation among the low-active group, while time spent in most other PDPAR activity categories decreased during this period. Second, a slight, non-significant increase in time spent in the exercise PA category was observed from 20-weeks (*M* = 31, *SD* = 44.64) to 32-weeks gestation (*M* = 36.50, *SD* = 30.46), $p = .72$.

Table 6 also displays the differences in average time spent in each non-exercise PA intensity category for the low-active group. A decrease in mild intensity non-exercise PA was observed from 20-weeks (*M* = 833.00, *SD* = 68.64) to 32-weeks gestation (*M* = 755.40, *SD* = 116.13), although this difference was not statistically significant ($p = .06$). Further examination of these findings indicated that these women engaged in 0 min of vigorous intensity non-exercise PA at both 20- and 32-weeks gestation. In addition, although the difference was not significant ($p = .28$), these women also decreased their moderate intensity non-exercise PA from 20-weeks (*M* = 46.54, *SD* = 51.50) to 32-weeks gestation (*M* = 29.50, *SD* = 20.34).

Table 6

The Mean (M), Standard Deviation (SD), and Paired t-Test of Average Min Spent/Day in the PDPAR Non-Exercise PA and Exercise PA Categories and Intensities for the Low-Active Group (>7,499 steps/day) at 20- and 32-weeks Gestation

N = 10	20-weeks		32-weeks				
Variable	*M*	SD	*M*	SD	*t*	*df*	*p-value*
Activity Category							
Non-Exercise Activities							
Sleeping	542.50	49.00	582.59	117.64	-1.66	9	.130
Bathing/dressing	79.00	53.37	73.00	44.10	5.80	9	.576
Work	318.04	136.22	328.50	139.30	-.157	9	.879
Cooking/Eating	119.55	47.81	102.21	29.07	1.410	9	.192
Transportation	134.57	85.40	92.23	31.37	1.886	9	.092
Hobbies	198.00	110.35	165.40	88.54	1.081	9	.308
Exercise	31.00	44.64	36.50	30.46	-.364	9	.724
Non-Exercise PA Intensity							
Mild	**833.00**	68.64	**755.40**	116.13	2.121	9	**.063**
Moderate	46.54	51.50	29.50	20.34	1.133	9	.287
Vigorous	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exercise PA Intensity							
Mild	16.50	45.50	22.00	24.40	-.349	9	.735
Moderate	14.50	8.31	14.50	22.01	.000	9	1.00
Vigorous	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note. df = degrees of freedom; Time spent in various non-exercise PA intensities excludes time spent sleeping.

When examining the group changes in time spent in mild, moderate and vigorous exercise PA, no statistically significant changes were found from 20- to 32-weeks gestation. These women also participated in 0 min/day of vigorous intensity exercise-related PA at both time points. However, the low-active women also maintained the same average time spent in moderate intensity exercise-related PA (M =14.50) across the two pregnancy time points, with a slight (but not statistically significant) increase in time spent in mild exercise-related PA from 20-weeks (M = 16.50, SD = 22.00) to 32-weeks gestation (M = 22.00, SD = 24.40), p = .73.

Transitioned to Low-Active Group. Table 7 displays the changes in self-reported PA of those participants categorized as active at 20-weeks, but low-active at 32-weeks gestation. These women showed no statistically significant changes in time spent in the various PDPAR categories. However, the transitioned to low-active group was the only group to show a decrease in time spent in exercise-related PA from 20-weeks (M = 40.56, SD = 37.28) to 32-weeks gestation (M = 26.11, SD = 21.32), although this decline was not significant (p > .05). Among this group, slight changes were found in the time spent in non-exercise PA for mild and vigorous intensity from 20-weeks (M = 860.55, SD = 59.50; M = 5.00, SD = 7.5, respectively) to 32-weeks gestation (M = 869.89, SD = 81.42; M = 1.67, SD = 5.01, respectively); however, these changes were not statistically significant (p's > .05). The only statistically significant change was found in time spent in moderate intensity non-exercise PA (p = 0.04) which decreased from M = 47.78 min/d (SD = 8.46) at 20-weeks to M = 25.56 min/d (SD = 40.58) at 32-weeks gestation.

Finally, Table 7 also illustrates the changes in time spent specifically in mild, moderate, and vigorous exercise PA among the transitioned to low-active group. No

Table 7

The Mean (M), Standard Deviation (SD), and Paired T-Test of Average Minutes Spent/Day in the PDPAR Non-Exercise PA and Exercise PA Categories and Intensities for the Transitioned to Low-Active Group (7,500+ steps/day at 20-weeks gestation, <7,499 steps/day at 32-weeks gestation) at 20- and 32-weeks Gestation

N = 9	20-weeks		32-weeks				
Variable	*M*	SD	*M*	SD	*t*	*df*	*p-value*
Activity Category							
Non-Exercise Activities							
Sleeping	498.33	35.62	507.21	51.11	-.456	8	.660
Bathing/dressing	112.22	65.96	108.33	105.77	.214	8	.836
Work	400.56	142.71	430.35	141.14	-.616	8	.555
Cooking/Eating	110.67	33.86	90.55	23.77	1.302	8	.229
Transportation	93.89	57.59	85.00	35.00	.474	8	.648
Hobbies	155.73	80.83	166.00	82.92	-.324	8	.754
Exercise	40.56	37.28	26.11	21.32	1.747	8	.119
Non-Exercise PA Intensity							
Mild	860.55	59.50	869.89	81.42	-.376	8	.717
Moderate	**47.78**	8.46	**25.56**	40.58	2.541	8	**.035**
Vigorous	5.00	7.50	1.67	5.01	1.109	8	.299
Exercise PA Intensity							
Mild	8.33	17.85	10.00	12.50	-.426	8	.681
Moderate	27.22	31.63	14.45	14.88	1.247	8	.248
Vigorous	5.00	7.50	1.67	5.01	1.109	8	.299

Note. df = degrees of freedom. Time spent in various Non-Exercise PA intensities excludes time spent sleeping.

statistically significant changes were found in any intensity of exercise-related PA from

20- to 32-weeks gestation ($p < .05$). Examination of the mean scores did reveal a notable decrease in the time spent in moderate intensity exercise-related PA from 20-weeks (M = 27.22, SD = 14.45) to 32-weeks gestation (M = 14.45, SD = 14.88) as well as a small decrease in vigorous intensity exercise-related PA from 20-weeks (M = 5.00, SD = 7.50) to 32-weeks gestation (M = 1.67, SD = 5.01).

PA Behaviors Among the Low-Active and Active Groups at 20- and 32-Weeks Gestation

Differences in Time Spent in the Seven PDPAR Categories. The analyses of the PDPAR activity categories and the corresponding differences in time spent in each category between the low-active and active group are presented in Table 8. These findings indicated no statistically significant differences between the low-active and active group in time spent in any of the seven PDPAR activity categories at 20-weeks gestation. However, at 32-weeks gestation, a statistically significant difference was found between the low-active (M = 30.65, SD = 26.43) and active group (M = 67.50, SD = 50.86) for the average time spent in the exercise-related PA category, F (1,27) = 6.16, p = .02.

Differences in Time Spent in Mild, Moderate, and Vigorous Non-Exercise PA. The group comparisons for time spent in mild, moderate, and vigorous intensity non-exercise PA at 20- and 32-weeks gestation are shown in Table 9. A statistically significant difference was observed between the groups for time spent in vigorous intensity non-exercise PA at 20-weeks gestation with the low-active group participating in significantly less vigorous intensity non-exercise PA (M = 0.00, SD = 0.00) than the active group (M = 4.69, SD = 7.18); F (1,27) = 5.50, p = .03. While not statistically significant, the low-active group participated in more mild intensity non-exercise PA at

Table 8

The Mean (M), Standard Deviation (SD), and One-Way ANOVA of Average Min Spent/Day in the PDPAR Activity Categories by Low Active (<7,499 steps/day) and Active (>7,500 steps/day) Groups at 20- and 32-weeks Gestation

	Low-Active		Active				
Variable	*M*	SD	*M*	SD	*df*	*F*	*p-value*
20-weeks gestation					1, 27		
Non-Exercise Activities							
Sleeping	538.84	44.54	512.50	50.96		2.142	.155
Bathing/dressing	78.84	46.77	102.81	52.75		1.636	.212
Work	327.72	131.38	362.81	151.92		.431	.517
Cooking/eating	127.69	53.25	99.38	40.54		2.647	.115
Transportation	115.77	82.30	103.75	69.25		.183	.673
Hobbies	196.15	103.60	160.94	79.17		1.078	.308
Exercise	33.85	49.63	51.56	34.29		1.288	.266
32-weeks gestation					1, 27		
Non-Exercise Activities							
Sleeping	553.04	90.66	546.67	101.52		.022	.882
Bathing/dressing	81.09	74.39	63.37	45.27		.306	.585
Work	386.43	138.64	354.16	125.5		.267	.610
Cooking/eating	94.13	26.66	88.33	25.43		.229	.636
Transportation	89.32	31.03	94.17	57.74		.078	.782
Hobbies	154.26	85.59	158.33	89.59		.011	.919
Exercise	30.65	26.43	67.50	50.86		6.16	**.020**

Note. df = Degrees of freedom.

both 20-weeks (*M* = 842.69, *SD* = 63.43) and 32-weeks gestation (*M* = 801.18, *SD* = 764.20) than the active group at both time points (*M* = 815.63, *SD* = 95.98; *M* = 764.20, *SD* = 156.75).

Table 9

The Mean (M), Standard Deviation (SD), and One-Way ANOVA of Average Min Spent/Day in Mild, Moderate, and Vigorous Intensity Non-Exercise PA Across all PDPAR activity categories by Low Active (<7,499 steps/day) and Active (>7,500 steps/day) Groups at 20- and 32-Weeks Gestation

	Low-Active		Active				
Variable	*M*	SD	*M*	SD	*df*	*F*	*p-value*
20-weeks gestation					1, 27		
Mild	842.69	63.43	815.63	95.98		.761	.391
Moderate	37.33	48.14	60.94	37.74		2.193	.150
Vigorous	**0.00**	**0.00**	4.69	7.18		5.502	**.027**
32-weeks gestation					1, 27		
Mild	801.18	118.43	764.20	156.75		.402	.532
Moderate	30.65	37.09	42.50	52.79		.408	.528
Vigorous	.65	3.13	3.33	8.16		1.684	.205

Note. Low-active =<7,499 steps/day, Active = 7,500+ steps/day. df = Degrees of freedom.

Differences in Time Spent in Mild, Moderate, and Vigorous Exercise-Related PA. Table 10 displays the group comparisons for mild, moderate, and vigorous exercise-related PA at 20- and 32-weeks gestation. At 20-weeks gestation, the active group participated in significantly more moderate intensity (*M* = 37.19, *SD* = 31.57); *F* (1,27) = 7.27, *p* = .01, and vigorous intensity exercise PA (*M* = 4.69, *SD* = 7.18); *F* (1,27) = 5.50, *p* = .03, than the low-active group (*M* = 12.69, *SD* = 9.27; *M* = 0.00, *SD* = 0.00, respectively). While not statistically significant, the low-active group also participated in a greater amount of mild intensity exercise (*M* = 21.15, *SD* = 47.92) than the active group at 20-weeks gestation (*M* = 9.69, *SD* = 20.04), *p* = .39. Lastly, the active group also participated in significantly more moderate intensity exercise at 32-weeks gestation (*M* = 45.83, *SD* = 62.16) than the low-active group (*M* = 14.56, *SD* = 18.46); *F* (1,27) = 4.69, *p* = .04. No significant group differences were observed for mild or vigorous intensity exercise-related PA at 32-weeks gestation, *p*'s > .05.

Table 10

The Mean (M), Standard Deviation (SD), and One-Way ANOVA of Average Min Spent/Day in Mild, Moderate, and Vigorous Intensity Exercise PA by Low Active (<7,499 steps/day) and Active (>7,500 steps/day) Groups at 20- and 32-weeks Gestation

	Low-active		Active				
Variable	*M*	SD	*M*	SD	*df*	*F*	*p-value*
20-weeks gestation					1, 27		
Mild	21.15	47.92	9.69	20.04		.758	.392
Moderate	**12.69**	9.27	**37.19**	31.57		7.272	**.012**
Vigorous	**0.00**	0.00	**4.69**	7.18		5.502	**.027**
32-weeks gestation					1, 27		
Mild	15.43	18.94	18.33	25.82		.096	.759
Moderate	**14.56**	18.46	**45.83**	62.16		4.684	**.039**
Vigorous	.65	3.13	3.33	8.16		1.684	.205

Note. Low-active = <7,499 steps/day, Active = 7,500+ steps/day; Df= Degrees of freedom.

Chapter 5

Discussion

The overall objective of this honor's thesis was to thoroughly examine PA mode, intensity, and change in activity patterns during the second and third pregnancy trimesters among women who were categorized as either active (7,500+ steps), low-active (< 7,499), and women who transitioned from active at 20-weeks gestation to low active at 32-weeks gestation according to pedometer-determined parameters. From 20- to 32-weeks gestation, the active group showed virtually no significant decreases in steps/day or time spent in the various exercise and non-exercise PA categories (i.e. sleeping, eating, bathing/dressing, work, transportation, hobbies, and exercise) or PA intensities, while the low-active group showed a decrease in steps/day and time spent in mild intensity non-exercise PA (i.e., all mild intensity cooking/eating, bathing/dressing, work, hobbies, and transportation). Also, the women who transitioned from the active group at 20-weeks to the low-active group at 32-weeks showed significant decreases in both steps/day and in moderate intensity non-exercise PA (i.e., all moderate intensity work, hobbies, and transportation). In general, differences were observed between the active and low-active groups in the amount of time spent in moderate intensity non-exercise PA and moderate and vigorous intensity exercise-related PA (i.e., moderate and vigorous intensity jogging, swimming, sports, weight-lifting). Several findings warrant further discussion.

The first study purpose was to evaluate the changes in: a) time spent in the PDPAR non-exercise (i.e., sleeping, eating, working, dressing, transportation, hobbies) and exercise categories; b) intensity of non-exercise PA; and c) intensity of exercise-related PA within each activity group from 20- to 32-weeks gestation. Consistent with the hypothesis, not all women remained in the same activity group from 20- to 32-weeks gestation. More specifically, 6 women were classified as active at both 20- and 32-weeks gestation, 13 women were classified as low-active, and 9 women were classified as active at 20-weeks but transitioned to the low-active group at 32-weeks gestation (i.e., transitioned to low-active group). Consistent with the hypothesis, women in both the low-active group and transitioned to low-active group demonstrated a significant decline in steps/day from 20- to 32-weeks, while the active group did not significantly decline in steps/day. This finding suggests that women in the low-active and transitioned to low-active group significantly alter their levels of PA during pregnancy to a greater degree than those in the active group. Therefore, these women may be more important targets for PA promotion during pregnancy, as they may need the encouragement and motivation over those women in the active group.

Consistent with the hypothesis that there would be few changes in time spent in the PDPAR non-exercise and exercise categories and PA intensities among the active group from 20- to 32-weeks gestation, the only statistically significant decline was time spent in the bathing/dressing category. While not statistically significant, it is interesting to note that on average there was an increase in time spent in the exercise-related PA category from 20- to 32-weeks gestation. This trend is contrary to what current research suggests, which is that women generally decrease their exercise behaviors as their pregnancy progresses, with the least amount of exercise occurring in the third trimester (Clissold, Hopkins, & Seddon, 1991; Dale, Mullinax, & Bryan, 1982; Hausenblas & Symons Downs, 2004; Symons Downs & Hausenblas, 2003, 2007). Therefore, this may illustrate an important pattern of PA behavior specifically among active pregnant women, which may not be obvious when active and low-active pregnant women are examined together rather than separately, as was done in most of the previous research. There were also no significant decreases in time spent in mild, moderate, or vigorous non-exercise and exercise-related PA among the active group from 20- to 32-weeks gestation, providing further support for this hypothesis.

It is interesting that these women showed a notable (though not statistically significant) increase in mild intensity exercise-related PA behaviors, accompanying a non-significant decline by an average of 20 min/day of moderate intensity non-exercise PA. This finding provides insight into the PA patterns of the relatively few women who remain relatively active throughout their pregnancy. That is, even for active pregnant women, it may be desirable to decrease time spent in moderate intensity non-exercise PA as their pregnancy progresses. However, this finding also demonstrates that it is possible decrease moderate intensity PA without seriously impacting overall activity level, perhaps by participating in more mild intensity activities (e.g., non-exercise PA such as household cleaning, playing with children, or grocery shopping, or exercise PA such as leisure walking and swimming).

Interventions to maintain levels of PA during pregnancy should therefore focus on making changes in daily routines and activities to better accommodate pregnant women, but doing so in a way that does not create a vast decline in their activity level. For example, if pregnant women feel too uncomfortable to run at a moderate intensity for 30-min, instead of just stopping or omitting exercise altogether, they could instead choose other activities (non-exercise or exercise related) that still allow them to experience the benefits from exercise. Similarly, if women no longer feel capable of completing their normal moderate intensity household tasks (e.g., mowing the grass, vacuuming), then instead they should complete more mild intensity household activities that they feel comfortable doing (e.g., dusting, folding laundry). Intervention efforts should perhaps focus on teaching women to shift their activities rather than declining or stopping them altogether. Evidence to support this strategy is supported by Chambliss (2005) who investigated the association of PA duration and intensity in a weight-loss program. The findings indicated that duration of exercise (at least 150 min/week of walking) was more important than vigorous versus moderate intensity PA in achieving health, fitness, and weight loss goals. These findings support the idea of flexibility in PA interventions, and the molding of these interventions to meet the preferences of the participants, particularly during pregnancy.

As hypothesized, the low-active group significantly decreased mild intensity non-exercise PA behaviors from 20- to 32-weeks gestation. It is interesting to note that this group also showed a non-significant increase in mild intensity exercise-related PA, similar to the active group. Although this was merely an observed pattern, not a statistically significant trend, it does suggest that perhaps even low-active women try to participate in more exercise-related PA, but at a lower intensity, as their pregnancy progresses. Because these trends were not significant, it is important for future research to examine this assumption. Also as predicted, no differences were observed in moderate and vigorous non-exercise PA or exercise-related PA among the low-active group from 20- to 32-weeks gestation, as these women engaged in little to none of these behaviors at both time points. Notably, the low-active women participated in 0 min/day of both vigorous intensity non-exercise and exercise-related PA at both 20- and 32-weeks gestation; a finding that supports the previous findings of Borodulin et al. (2008).

There was also a lack of support for the hypothesis that the transitioned to low-active group would show a decline in exercise-related PA behaviors from 20- to 32-weeks gestation. Despite that the activity change group was the only activity group to decrease time spent in the exercise-related PA category from 20- to 32-weeks gestation, the decline was not significant. As hypothesized, those in the transitioned to low-active group showed a significant decrease in moderate intensity non-exercise PA behaviors, accompanied by a small, nonsignificant decrease in vigorous intensity non-exercise PA. Contrary to this hypothesis, the transitioned to low-active group also did not significantly decrease moderate and vigorous exercise-related PA, although this group did notably decrease time spent in both of these behaviors at 32-weeks gestation. Although these patterns did not reach significance, they still may draw attention to some potentially informative patterns of behavior. Women in the transitioned to low-active group exhibited the greatest variations in PA mode and intensity from 20- to 32-weeks gestation, highlighting the degree to which women of various activity levels differentially alter their PA behaviors through their pregnancy.

The second purpose was to examine differences in time spent in the PDPAR categories, non-exercise PA intensity, and exercise PA intensity between the low-active and active groups at 20- and 32-weeks gestation. As hypothesized and consistent with previous research (Symons Downs et al., 2009), the active group spent more time in exercise-related PA behaviors (e.g., walking, playing sports, yoga), although this difference was only observed at 32-weeks gestation. It is important to note that this was the only difference in time spent in the various PDPAR non-exercise (i.e., time spent sleeping, eating, working, bathing/dressing, transportation, hobbies) or exercise categories. This finding suggests that the difference in activity between low-active and active women can perhaps be attributed to participation in exercise behaviors, rather than more time spent non-exercise PA (i.e., childcare, cleaning, working) or less time spent in sedentary activities (i.e., hobbies, sleeping) by active women. While Evenson et al. (2004) found that pregnant women engage in less exercise than non-pregnant women of the same age, little research has investigated how participation in exercise behaviors during pregnancy may differentially alter their overall activity levels. However, a study conducted by Haakstad et al. (2007) did observe a positive association between exercise and reduced gestational weight gain in the third trimester, while non-exercise PA from household and childcare chores did not reduce the rate of maternal weight gain. This finding warrants further research and understanding, as it carries many important implications for PA promotion in pregnancy. For instance, Haakstad et al. (2009) found that one of the self-reported reasons that pregnant women stop exercising in the third trimester is because they feel that they have attained sufficient exercise at home or at work. Perhaps if more women were aware that household PA is typically not correlated with higher overall activity levels or reduced rate of maternal weight gain, they would be more likely to engage in more exercise PA behaviors throughout their pregnancy. More research is needed to better understand women's perceptions of PA mode and intensity to effectively promote the current PA guidelines of 150 min/week of moderate-intensity PA (USDHHS, 2008).

Partial support was found for the hypothesis that the active group would spend significantly more time in moderate and vigorous intensity non-exercise PA at 20- and 32-weeks gestation. Specifically, while the active group participated in significantly more vigorous intensity non-exercise PA, this effect was only observed at 20-weeks gestation. This finding is in contrast to the conclusions of Borodulin et al. (2008), who observed that active women engaged in more moderate and vigorous intensity PA (as assessed from a variety of sources, including childcare, transportation, household chores) across pregnancy. Concerning specifically exercise-related PA behaviors, the hypothesis was supported such that the active group participated in significantly more moderate and vigorous intensity exercise-related PA at 20-weeks, and more moderate intensity exercise-related PA at 32-weeks compared to the low-active group.

It is worth noting, however, that although the active group participated in significantly more vigorous intensity exercise-related PA than the low-active group at 20-weeks gestation, the actual differences in average min/day are very small. That is, the active group spent less than 5 additional min/day in vigorous intensity exercise at 20-weeks gestation compared to the low-active group. Although this is a small difference, there is research evidence for a dose-response to PA such that even minimal amounts of exercise may have a modest impact on such factors as blood pressure, insulin sensitivity, and even mental health (Hamer, Stamatakis, & Steptoe, 2008; Kesaniemi, Danforth, Jensen, Kopeman, Lefebvre, & Reeder, 2001). Little is known specifically about the impact of minimal amounts of vigorous exercise during pregnancy and the associated health outcomes. However, Clapp (2008) has investigated the long-term outcome of continued vigorous intensity exercise throughout pregnancy. In this study, Clapp found that women who continue vigorous intensity, weight-bearing exercise during pregnancy maintained their long-term fitness and had a lower cardiovascular risk profile in the perimenopausal period compared to women who did not perform vigorous exercise in pregnancy. Although this research does not specifically address the impact of modest amounts of vigorous intensity exercise, it does suggest that the continuation of vigorous intensity exercise may have significant long-term health outcomes for women. These findings by Clapp (2008) may also be important in recognizing the long-term importance of behavioral differences between the active and low-active group, including the participation in minimal amounts of vigorous intensity exercise. More research is still needed to better understand how small amounts of vigorous exercise during pregnancy is associated with maternal and infant health outcomes.

In addition, support was not found for the hypothesis that the low-active group would spend significantly more time in mild intensity non-exercise PA and mild intensity exercise-related PA at 20- and 32-weeks gestation. Although not significant, it is still nonetheless interesting to note that the low-active group did spend on average 30 more min per day in mild intensity non-exercise PA and 12 more min per day of mild intensity exercise-related PA compared to the active group at 20-weeks gestation. This preference for PA of different intensities may highlight an important difference between active and low-active pregnant women. This finding may be important to inform future PA interventions targeting pregnant women of different activity levels. Specifically, these findings suggest that more active women may prefer to do lower durations of moderate intensity non-exercise PA or moderate intensity exercise, whereas low-active women may prefer longer durations of mild intensity non-exercise PA or mild intensity exercise. For example, a study conducted by DiNallo et al. (2008) suggests that it may be beneficial to encourage pregnant women who do not feel they can achieve moderate intensity exercise to walk at a self-selected pace but for a longer duration. This may be beneficial for two reasons: a) walking seems to be the exercise activity of choice during pregnancy (Evenson et al., 2007); and b) this strategy may increase the likelihood that women continue to remain active throughout their pregnancy, as they can adjust their exercise to a level they are comfortable with.

There is also evidence suggesting that women's beliefs about the safety of exercise during pregnancy may impact their behaviors. For instance, Duncombe et al. (2009) found that women who rated gentle and low to medium exercise as unsafe reported engaging in less intense and fewer min of exercise. Similarly, Evenson and Bradley (2010) found that 73% of pregnant women agreed that there were benefits associated with moderate intensity exercise, while only 13% agreed that there were benefits associated with vigorous intensity exercise. Lastly, Mudd, Nechuta, Pivarnik, and Paneth (2009) found that 88% of pregnant women felt that moderate intensity exercise is safe, while only 36% felt vigorous exercise was safe. They also found that not participating in moderate/vigorous exercose was associated with feeling unsafe about vigorous exercise. This suggests that women feel more comfortable engaging in moderate intensity exercise during pregnancy, and would thus be more likely to respond positively to interventions aimed at increasing participation in moderate intensity exercise, rather than vigorous intensity. Physicians suggest that pregnant women should exercise within limits that do not cause severe discomfort and should, as pregnancy progresses, be prepared to modify the intensity and duration of their exercise programs to avoid risks and injury (Lumbers, 2002). However, research suggests that women's beliefs about the safety of exercise during pregnancy may also affect their PA behaviors and preferences for different intensities. The issue of exercise beliefs and pregnant women's perceived safety of exercise intensity warrants further investigation, as it may indicate a key issue in promoting PA among pregnant women.

The use of objective data to divide women into subgroups based on their levels of PA seems to have divided the participants into interesting and potentially informative categories. These activity groups each exhibit their own trends of PA throughout pregnancy, and thus may serve to improve the general understanding of PA trends among pregnant women of different activity levels. Better understanding of these PA trends may inform PA measurement, analysis, and prescription during pregnancy in the future. Therefore, the findings of the current study would suggest the need for further research of the trends observed among the PA activity groups in this study. The findings of the current study also suggest that not all pregnant women follow similar trends in PA during pregnancy, and therefore, one particular type of exercise intervention will not be effective for all pregnant women. Before designing effective interventions to help women remain active during their pregnancy (and therefore help these women to potentially receive the health benefits that accompany PA during this crucial period) researchers and medical professional must better understand how these groups of women are different.

While this study has contributed to the current knowledge on PA during pregnancy by using both objective and self-reported measures and by examining both the mode and intensity of non-exercise and exercise-related PA behaviors, there are some limitations. First, the sample of women used in this study was for the most part all from Central Pennsylvania, and were mostly Caucasian. Therefore, generalizing study findings to other, more diverse populations may be difficult. Second, while the sample size was adequate to perform the analyses for the study hypotheses, the small sample precluded further examination of the PA categories across other important demographic factors such as parity on age. Further research examining PA mode and intensity across both exercise-related and non-exercise related PA is needed to understand the impact of important demographic factors on these parameters in pregnancy.

Despite that a large part of the study was based on objective measures, much of the important data were derived from self-report measures. As previously mentioned, self-report measures are particularly susceptible to over-report bias (Anderson et al., 2005). Further research in this area should continue to use objective measures in addition to self-report measures, with greater utilization of objective monitors in the data collection process. By doing so, the concurrent validity of objective and self-report data could be assessed, and thus the overall accuracy of the study findings may be more appropriately evaluated.

In summary, the benefits of PA throughout pregnancy are abundant; therefore the proportion of women not participating in PA during pregnancy is a growing public health concern. To combat this trend towards inactivity and a sedentary lifestyle through pregnancy, it is important to obtain a detailed understanding of the lifestyle trends, popular opinions, and PA changes that accompany pregnancy. Using this knowledge, researchers, doctors and other health care professionals will be more adequately able to prescribe PA during pregnancy, and furthermore encourage more women to remain active during this crucial period.

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-Worked in a professional office setting, responsible for mail and housing needs of dormitory students
-Developed basic office and administrative skills

-Took over the duties and responsibilities of full-time desk staff after business hours

Volunteer Experience:

January 2009-December 2009
University Health Services Physical Therapy Department, Linda Eck, ATC, MS, PT, Supervisor
University Park, PA
<u>Intern</u>
- Observed Physical Therapists in assessment, interaction with, and treatment of patients
- Taught extensive knowledge of the operation of equipment and treatment tools used
- Responsible for setting up icing, whirlpool, and ultrasound procedures and cleaning all equipment and treatment areas
- Assisted patients with exercises

June 2008-August 2008
Allen Physiotherapy, Rehabilitation and Sports Medicine, Scott Barclay, PT, Supervisor
Cobham, Surrey, England
<u>Student Volunteer</u>
- Observed Physiotherapists in assessment, interaction with, and treatment of patients
- Took part in and observed HydroTherapy treatment in addition to traditional treatment programs

Community Service Involvement:

Fall 2007-Spring 2009
THON Rules and Regulation Committee
Pennsylvania State University, University Park, PA
<u>Security Captain</u>
- In charge of organizing committee throughout THON weekend
- Worked closely with our committee captain to keep the team organized and on task
- Worked with fellow committee members to ensure security throughout the 48-hour dance marathon (THON weekend)

Fall 2008-Spring 2009
THON Special Events Committee
Pennsylvania State University, University Park, PA
<u>Social Chair</u>
- Organized several events for our committee throughout the year and up until THON
- Collaborated with the other four committees to organize joint events
- Worked with fellow committee members to organize all fundraising events, design decorations for those events, prior to THON weekend