Original Study

Patterns and Correlates of Self-Reported Physical Activity in a Cohort of Racially Diverse Pregnant Adolescents

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A B S T R A C T

Study Objective: Regular physical activity (PA) during pregnancy decreases the risk of gestational hypertension and preeclampsia. Currently, little is known about the PA of pregnant adolescents. Our intent was to characterize the PA behaviors of a group of racially diverse, low-income pregnant teens and to identify potential determinants of PA.
Design, Setting, Participants, and Interventions: A cohort of 157 racially diverse pregnant adolescents (13-18 years of age) completed up to 3 previous day PA recalls as part of a larger prospective longitudinal study on determinants of maternal and fetal bone health. Subjects self-reported activities from 7 AM to 11:30 PM, choosing from a list of 37 activities including a category for "other." Subjects recorded activities in 30-minute intervals.
Main Outcome Measures: Estimated metabolic equivalent task (MET) values were assigned to each activity and summed for a measure of total daily PA in MET min/d. Determinants of PA were evaluated using a stepwise linear mixed effect model.
Results: The average calculated MET min/d was 1478 ± 130. Significant determinants of MET min/d included race ($P = .007$), maternal age at conception ($P = .042$), gestational age ($P = .002$), and attending school ($P < .001$). Black teens were less physically active than white teens, and older teens were more active than younger teens; activity decreased throughout gestation, and teens currently attending school were more active.
Conclusion: PA is low across gestation and pregnant teens spent more than half of their monitored time in sedentary activities. Targeted interventions are needed to achieve current PA goals in this pediatric obstetric population.
Key Words: Physical activity, Inactivity, Adolescent pregnancy

Introduction

Physical activity (PA) recommendations for pregnant women have changed markedly over the past 50 years. Data from the late 19th and early 20th centuries highlighted the importance of rest during pregnancy to promote fetal health through higher birth weights.[1] Continued epidemiologic studies determined that the benefits of PA outweighed potential detriments, which resulted in the first American College of Obstetricians and Gynecologists guidelines for prenatal PA in 1985. In these guidelines, pregnant women were encouraged to engage in aerobic activity but with strict guidelines on duration, heart rate, and body temperature.[1] In 2002, the American College of Obstetricians and Gynecologists released revised guidelines that were in agreement with the 2008 US Department of Health and Human Services (USDHHS) Physical Activity Guidelines for Americans. These guidelines recommended that healthy adult pregnant women follow the same guidelines as healthy adults: at least 2.5 hours (150 minutes) per week of moderate aerobic activity, or approximately 21 minutes of brisk walking (or similar activity) each day.[2]

PA patterns of pregnant women age 16 and older in the United States have been characterized by Evenson and Wen using National Health and Nutrition Examination Survey (NHANES) data (n = 1280).[3] These data showed that most adult pregnant women in this survey failed to meet national PA guidelines.[3] This is unfortunate because of the observed positive association between light PA and decreased risk of gestational hypertension and preeclampsia.[4–6] Factors that have been positively associated with PA include earlier gestational age,[3,7,8] higher household income,[9] and identifying race/ethnicity as non-Hispanic white.[9] Studies of adult pregnant women have shown that PA tends to decrease across pregnancy, as would be expected given the increasing weight of the fetus and increased reports of maternal fatigue as pregnancy progresses.[3,7,8]

Challenges in meeting PA recommendations across pregnancy might be greater for certain pregnant populations. Although adolescent pregnancy rates have continued to decline in the United States, recent data indicate that teenage pregnancies comprise greater than 6% of live births in the United States.[10] This group is known to have unique medical, social, and economic concerns. At this time, there are no national PA guidelines specific to pregnant teens. The Physical Activity Guidelines for Americans

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recommend that healthy, nonpregnant teens participate in at least 1 hour of PA per day, although less than one-third of US high school students report meeting these guidelines.[11] Furthermore, inactivity (defined as participating in no activity beyond baseline activities of daily living)[12] is more common in female adolescents than in male adolescents and more common in black female adolescents than in white female adolescents.[11] Low socioeconomic status is also a significant determinant of physical inactivity among teens.[13] This might be of concern for pregnant adolescents because teen pregnancy disproportionately affects minorities and lower socioeconomic status teens.

Pregnant adolescents have been noted to have increased risk of several adverse pregnancy outcomes such as preterm birth (PTB), low birth weight (LBW), cesarean delivery, hypertensive disorders, and maternal death compared with adult women.[14] The degree to which suboptimal PA patterns might contribute to adverse maternal and neonatal outcomes is unknown, and there are no data characterizing activity patterns in this group. Because adolescents are a generally high-risk obstetric population,[14] targeting PA guidelines for this population might enable pregnant adolescents to minimize the risk of adverse pregnancy outcomes.

Because of the lack of data available on PA levels in pregnant adolescents in the United States, the goal of this study was to characterize self-reported data on PA patterns in a group of racially diverse, predominantly low-income pregnant adolescents. Factors associated with PA were identified, and study findings were compared with published data from pregnant adult cohorts to identify whether unique associations exist for pregnant adolescents.

Materials and Methods

This study was a secondary analysis of data collected from a prospective longitudinal study undertaken between 2006 and 2010 that was designed to identify determinants of maternal and fetal bone health and anemia across pregnancy. Pregnant adolescents aged 13-18 years were eligible to participate in the parent study if they were healthy and between 12 and 30 weeks of gestation at entry into the study. Adolescents were recruited from the Rochester Adolescent Maternity Program in Rochester, New York and the Maternity Center East Clinic in Baltimore, Maryland, but only adolescents from Rochester provided self-reported PA data. A total of 171 adolescents participated in the parent study, which collected self-reported PA data up to 3 times across pregnancy using the Previous Day Physical Activity Recall questionnaire (PDPAR).[15,16]

Of the 171 adolescents in the original study, 157 had data from at least 1 PDPAR available. Teens who completed PDPARs did not differ significantly from the larger study population. Maternal and neonatal serum biomarkers and fetal biometry measures from this study population have been previously described.[17–21] Adolescents with HIV infection, diabetes, clinically diagnosed eating disorders, those carrying multiple fetuses, or those with malabsorptive disorders were excluded from participating. Written informed consent was obtained from all participants, and parental consent and adolescent assent were obtained in adolescents aged 14 years and younger. Study protocols were approved by the institutional review boards of the University of Rochester and Cornell University.

Adolescents completed up to 3 study visits during early, mid, and late gestation, which were timed to coincide with scheduled prenatal care appointments. Nurses recorded maternal anthropometric data in the medical chart, and health project coordinators administered the PDPAR at each study visit. The PDPAR has been validated for students in grades 7-12.[16] This written questionnaire asked adolescents to self-report information on their previous day's activities between 7 AM and 11:30 PM. The PDPAR includes a numbered list of 37 activities typical for youth, grouped into the following categories to improve recall: eating, sleeping/bathing, transportation, work/school, spare time, play/recreation, and exercise/workout.[16] A category was included for “other” activities that were not included on the list. Adolescents recorded the numerical code for the primary activity that corresponded with each 30-minute interval of the previous day's reporting period. When adolescents described an activity as “other” or “hobby” because it was not included on the 37-item activity list, they were asked to describe the activity. Each activity was assigned an intensity level of very low, low, moderate, or hard by the study coordinator as previously described.[16] An adolescent was considered to have attended school on a given day if she reported school as an activity on the PDPAR.

Estimated metabolic equivalent task (MET) values were assigned to each activity on the basis of the level of intensity assigned for each activity.[16] A MET value of 1 indicates the activity requires no more energy than resting, whereas higher values indicate greater expenditure than resting. The Compendium of Physical Activity was used to assign MET values to activities classified as “other” or “hobby.”[22–24] MET values were summed for the entire day to obtain a measure of total daily PA (MET min/d). Additionally, the total number of 30-minute time blocks with energy expenditure ≥3 METs (moderate to vigorous activity [MVPA]) and ≥6 METs (vigorous PA [VPA]) were totaled for each day as previously described.[15] The Centers for Disease Control and Prevention defines moderate-intensity PA as “3.0 to 5.9 times the intensity of rest” and vigorous-intensity PA as “6.0 or more times the intensity of rest.”[25] Thus, because 1 MET approximates resting energy expenditure, our MVPA and VPA variables align with Centers for Disease Control and Prevention terminology and definitions.

Maternal prepregnancy weight, ethnicity (Hispanic or non-Hispanic), race (black, white, or other), smoking history, and illicit drug use were self-reported. Prepregnancy body mass index (BMI) was on the basis of self-reported data, and at prenatal care visits maternal height and weight were recorded and BMI calculated in the medical record. Two adolescents self-identified as Native American and were included with black adolescents for analysis purposes. Including these 2 adolescents with the black group vs the white group did not change any of the significant study findings. Gestational weight gain was categorized according to the Institute of Medicine guidelines.[26] PTB was defined as less than 37 weeks gestational age at the time of delivery. If the gestational age calculated from

the sonogram data differed from the self-reported gestational age by greater than 10 days, the sonogram measure was used. LBW was defined as a birth weight less than 2500 g. Anemia was defined when maternal hemoglobin concentrations were below 11.0 g/dL during the first and third trimester and less than 10.5 g/dL during the second trimester. Data on anemia and Fe status in these adolescents have been published.[27]

Statistical analyses were performed using JMP Pro 11.2.0 (SAS Institute Inc, Cary, NC). Because each adolescent had between 1 and 3 sets of PA data, each set of data was analyzed as a separate event in a backwards stepwise mixed model. In this mixed model, the given measure of PA (such as MET min/d) was the y variable. Unique subject identifier was the only random effect; the remaining variables (gestational age, race, age at conception, school attendance) were fixed effects. Categorical variables were dummy-coded. Non-normally distributed variables (eg, MET min/d) were transformed to achieve normality if appropriate. Results are reported as the mean ± SD or median (interquartile range) unless otherwise noted. Data were considered significant when P was less than .05.

Results

Characteristics of the adolescent cohort are presented in Table 1. The prevalence of PTB was 9.2% (14 of 153 adolescents with data available) and the prevalence of LBW was 6.0% (9 of 149 adolescents with data available). Seven adolescents had only 1 PDPAR, 37 had 2 PDPARs, and 113 had 3 PDPARs, for a total of 420 PDPARs across the 157 adolescents. Four of these PDPARs occurred in the first trimester, 214 in the second trimester, and 202 in the third. None of the birth outcomes analyzed (gestational age at delivery, PTB, neonatal birthweight, LBW, small for gestational age, vaginal vs cesarean delivery) were significantly related to PA, nor were parity, duration of labor, maternal anemia, gestational weight gain, or prepregnancy BMI.

The PDPAR captured an average of 1478 ± 130 MET min/d. The distribution of MVPA was heavily right-skewed, with a median of 20 minutes of MVPA per visit. Of all the variables examined, only gestational age, race, age at conception, and school attendance were significant determinants of MET min/d (Table 2). As weeks of gestation increased, MET min/d decreased significantly (P = .002) such that every trimester of gestation was associated with a 3% decrease in MET min/d. Black teens had significantly lower PA compared with white teens by an average of 47 MET min/d (P = .002; Table 3). There was a weak positive relationship between maternal age at conception and PA (P = .04). Finally, school attendance was positively associated with PA.

Figure 1 shows the breakdown of activities occupying the average adolescent's day in this cohort. The 30-minute blocks of every activity were summed for each PDPAR (i.e. 5 30-minute blocks of sleep throughout the day = 150 minutes) and the amount of time spent in every activity was averaged across all PDPARs. The activities that adolescents reported in the category of "other" mostly consisted of attending church, going to court, reading, or prenatal care visits. Additionally, Figure 1 shows how activities differed on days that adolescents reported attending school and days that they did not. PA was significantly higher on days that adolescents reported attending school (1560 ± 143 MET min/d; n = 126 days) compared with days for which adolescents did not report attending school (1440 ± 189 MET min/d; n = 294 days; P < .0001). If school was reported on the PDPAR, it was the primary daytime activity. If school was not reported on the PDPAR, sleeping was the primary daytime activity, occupying nearly 5 hours on average on nonschool days (297 ± 156 minutes; n = 294 days).

Activity data in the full cohort of adolescents were compared with the USDHHS Physical Activity Guidelines for pregnant women. The USDHHS recommends 150 min/wk (an average of 21 min/d) of moderate intensity aerobic

Table 1
Characteristics of the Pregnant Adolescents

Characteristic	Value
Age at delivery, years (n = 154)	17.5 ± 1.1 (14.0-19.0)
Gynecological age at conception, years (n = 151)	4.8 ± 1.8 (1.2-10.7)
Entry into prenatal care: weeks of gestation (n = 136)	10.5 ± 4.7 (2-24)
Gestational age at delivery, weeks (n = 153)	39.2 ± 3.0 (21.0-42.1)
Race (n = 157)	
White	35.0
Black	63.7
American Indian	1.3
Ethnicity (n = 92)	
Hispanic	24.8
Non-Hispanic	75.2
Parity, 1 or more (n = 92)	8.9
Prepregnancy BMI (n = 155)	24.8 ± 5.4 (15.1-43.6)
Category	
Underweight	7.1
Normal weight	55.5
Overweight	20.6
Obese	16.8
Smoked during pregnancy (n = 157)	10.8
Maternal anemia at midgestation (n = 116)	8.6
Maternal anemia at delivery (n = 138)	15.9
Birth weight, g (n = 149)	3211 ± 578 (1054-4705)
Birth length, cm (n = 148)	50.6 ± 3.5 (35.5-57)

BMI, body mass index
All data are reported as mean ± SD (range) or as a percentage. The number of subjects "n" varies because of some participants not reporting all sociodemographic data, missed study visits, or loss to follow-up.

Table 2
Mixed Model Results: Predictors of Natural Log of MET min/d

Effect	Estimate	SE	*df*	*t*	*P*
Fixed					
Intercept	7.1633	0.0987	180.3	72.59	<.0001
Race = black*	−0.0340	0.0124	141.8	−2.74	.0069
Age at conception†	0.0113	0.0055	154.1	2.05	.0420
Gestational age‡	−0.0025	0.0008	377.6	−3.16	.0017
School = yes§	0.0906	0.0121	398.8	7.50	<.0001
Random					
Subject identifier	–	–	–	–	–

MET, metabolic equivalent task; PDPAR, Previous Day Physical Activity Recall questionnaire; SE, standard error
The variable, MET (min/d), was log-transformed before analyses. Categorical variables were dummy-coded.
* Maternal race was reported as black.
† Maternal age (years) at time of conception.
‡ Gestational age on the date for which physical activity was reported.
§ Subject reported attending school (for any amount of time) on the PDPAR.

Table 3
MET min/d According to Race

Measure	White (n = 55)	Black (n = 102)
MET min/d	1508 ± 131[a] (1283-1852)	1461 ± 127[b] (1215-1935)
MVPA min/d	30 (0-80)	10 (0-40)

MET, metabolic equivalent task; MVPA, moderate to vigorous physical activity
Values within a row with different superscript letters statistically differ from each other ($P < .05$). Two American Indian adolescents were included with the black teens. Their inclusion in either the white vs black group made no difference in the reported significance. The natural log of MET min/d was tested in the mixed model shown in Table 2. Untransformed data, averaged for each subject, are presented for interpretation. MET min/d is presented as mean ± SD (range), and MVPA min/d is presented as median (interquartile range).

activity during pregnancy. Seventy-one of 157 pregnant adolescents (45%) met this guideline and reported 21 minutes or more of MVPA per day, as reported in their 1-3 study visits. Although the USDHHS report does not recommend VPA for pregnant women who did not exercise vigorously before pregnancy, it is interesting to note that only 2 adolescents reported any VPA at any stage of pregnancy. These 2 adolescents each reported 1 hour of VPA at 20 and 21 weeks' gestational age, respectively.

Discussion

The purpose of this study was to characterize the PA patterns in a cohort of predominantly minority, urban pregnant adolescents and to identify factors associated with PA level. We found that self-reported PA was independently associated with gestational age, maternal age at conception, attending school, and race. Additionally, we compared our data with national guidelines and found that just less than half of adolescents achieved the recommended amount of PA advocated for pregnant women.

As gestation progressed, MET min/d decreased significantly on average by 1% per month, which corresponded to an average decrease of 3% per trimester. This finding is consistent with data obtained in previous studies of adult gravida, which also reported decreases in PA throughout pregnancy.[7] The methods of measuring and reporting PA in the literature differ greatly, which unfortunately precludes us from making direct comparisons with our adolescent population. Evenson and Wen reported that women in the first trimester were nearly twice as likely to meet PA recommendations for MVPA than women in the third trimester.[3] Borodulin et al. reported that, among women reporting any weekly exercise, the duration and MET h/wk of all activities declined significantly from the second to third trimester.[8] This is likely because of increasing levels of fatigue and weight gain. The decreases and overall low level of PA across pregnancy raise concerns for prenatal health, because of the known role of PA in minimizing maternal and fetal complications.[4–6]

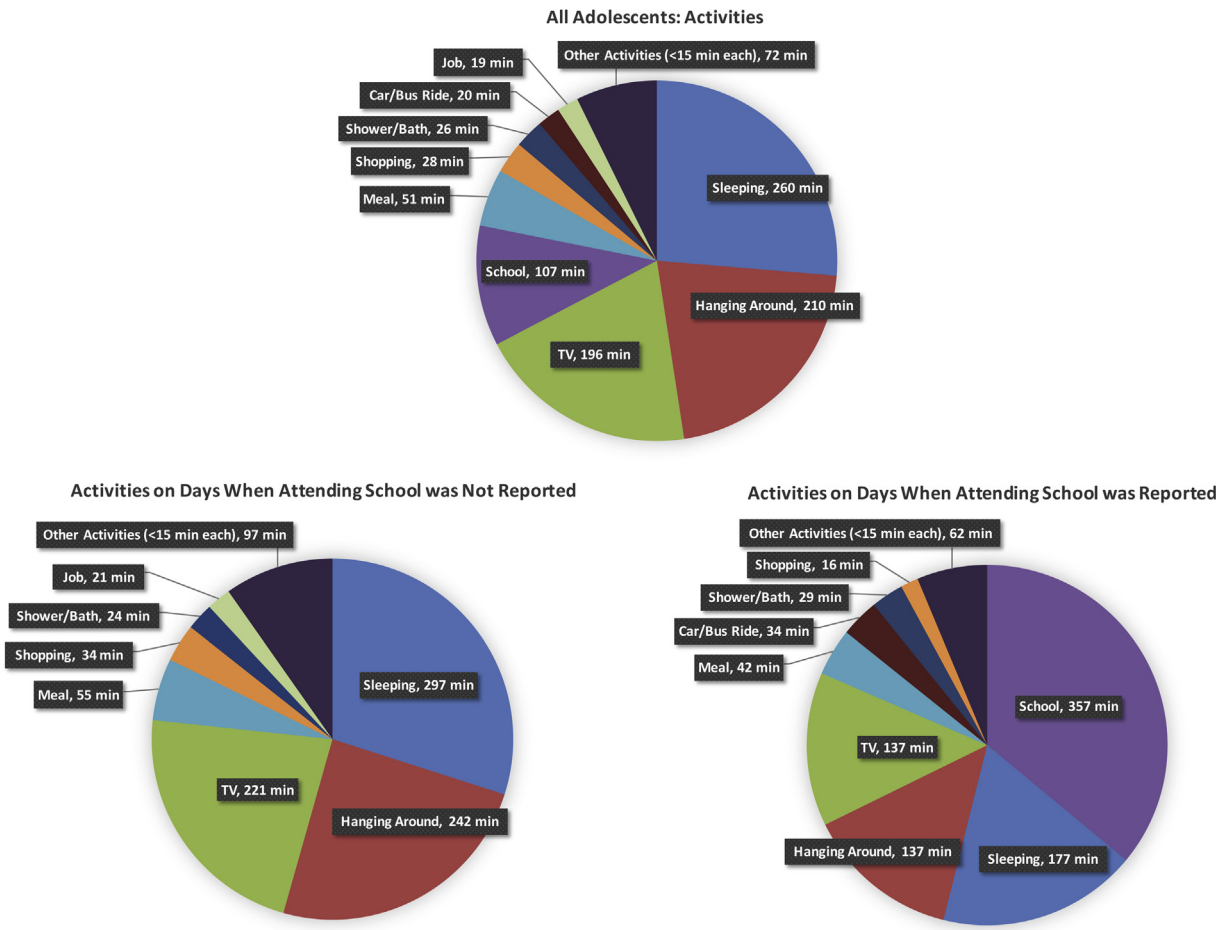

Fig. 1. Breakdown of reported activities during a day in this cohort. The activities that adolescents reported in the category of "other" mostly consisted of attending church, going to court, reading, or prenatal care visits.

Maternal age across the range of 13 to 18 years in this population was weakly positively correlated with PA. This finding in our pregnant adolescents differs from national data in nonpregnant adolescents showing that female adolescents actually tend to decrease PA as they get older.[11] We posit that older teens might have taken a stronger interest in their own health to improve the health of their babies. Perhaps, because they were more mature, they were more likely to apply the information on nutrition and PA that was routinely provided during visits to the midwifery clinic for teens.

The strongest determinant of PA in this age group was school attendance, which was reported on 126 of the 420 PDPARs collected. Because we were unable to account for school breaks such as summer vacation, we cannot accurately determine the proportion of teens who were still regularly attending school throughout pregnancy. Although school might seem like a relatively sedentary activity, attending school was strongly positively associated with MET min/d. For those who were still attending school, being at school was the most time-intensive activity of the day. On days on which teens did not attend school, sleeping was the primary activity. It is well established that puberty brings on a delay in timing of sleep and that adolescent daytime sleepiness is widespread because of a variety of factors, most likely including busy schedules, social factors, and technology use.[28] These age-related factors, compounded with the fact that many women experience sleep disturbances during pregnancy,[29] might help explain the prevalence of daytime sleep and decreased PA in our pregnant adolescent cohort.

Race was associated with PA in this cohort. Black adolescents reported a significantly lower amount of PA compared with their white counterparts even after controlling for other significant factors associated with PA in this group. This finding aligns with national trends observed in nonpregnant high school girls; in 2015, the prevalence of not having participated in at least 60 minutes of PA on at least 1 day per week was 25.2% in black compared with 14.3% in white girls.[11] Although no studies have characterized the PA of pregnant teens specifically, Evenson and Wen observed the same racial differences in the national NHANES data (pregnant women aged ≥16 years of age).[9] Groth and Morrison-Beedy organized focus groups of low-income, pregnant black women in Rochester, the area where our cohort was recruited, to explore potential causes for this trend.[30] The major causes of inactivity they identified were: (1) lack of energy; and (2) lack of motivation to exercise.[30]

Forty-five percent of our pregnant adolescents appeared to achieve recommended MVPA (150 min/wk or 21 min/d) for adult pregnant women. This is basically double the percentage (23%) of adult women reported to achieve this recommendation in a study of NHANES data.[3] Our teens reported a median value of 20 minutes of MVPA per day, and Evenson and Wen report an average of 12.3 min/d of MVPA in adult pregnant women on the basis of NHANES accelerometer data (n = 359).[9] Similar to our cohort of pregnant adolescents, most pregnant adults (2/3) spent no time at all participating in VPA. Furthermore, these pregnant adults spent an average of 57% of their monitored day in sedentary behaviors, and Figure 1 shows that our pregnant teens also spent at least half of their day on average in sedentary behaviors, mainly sleeping, hanging around, and watching TV.

Although there are no other data on PA of pregnant teens with which to compare these findings, Saxena et al. have characterized VPA (defined as "activities that caused sweating and hard breathing") in nonpregnant urban female adolescents.[31] Unfortunately, we cannot directly compare our data because of the different measures. Still, Saxena et al. observed that 30.5% of teens reported regular VPA, whereas only 2 of our 157 pregnant adolescents reported any VPA at all. This low level of activity is concerning because this group is at increased risk of excessive gestational weight gain.[32] Regular PA could help these adolescents achieve recommended gains according to prepregnancy BMI.

In our pregnant adolescent cohort, we did not observe significant relationships between PA and neonatal outcomes, delivery outcomes, parity, maternal anemia, iron deficiency (serum ferritin < 12 μg/L), gestational weight gain, or prepregnancy BMI. Previous studies and meta-analyses in larger cohorts of adult women (ranging from 124 to 11,444 study participants) have observed significant negative relationships between PA and PTB,[4,33] preeclampsia and hypertensive disorders,[5,6,34] gestational weight gain,[35] and prepregnancy BMI.[35] Unfortunately, the sample size of our study population was not adequately powered to detect possible relationships between PA and PTB because just 14 adolescents in this cohort delivered preterm. Similarly, only 2 adolescents were diagnosed with preeclampsia and 2 with pregnancy-induced hypertension. Moreover, few of these adolescents could be classified as exercising regularly. Further studies with larger sample sizes are needed to examine the relationship between PA and birth outcomes during adolescent pregnancy. Anemia is known to lead to a decrease in PA, and we have previously reported that 25% of this cohort of adolescents were anemic during pregnancy.[27] It might be that we had too few iron-replete adolescents to fully evaluate the effect of iron status on PA because of the degree of iron deficiency and anemia among this cohort.

Our study was not without limitations. The USDHHS specifies that pregnant women can meet their PA recommendations with short bouts of exercise, as short as 10-minute efforts. Our study design was only able to account for 30-minute blocks of activity, so it is possible that some subjects did take short walks, for example, but not long enough that they wrote the activity down as the primary activity for that 30-minute block of time. Additionally, the design of the PDPAR relies on the assumption that 7:00 AM to 11:30 PM encompasses all PA, and our adolescents might have been active to varying degrees beyond these hours, especially beyond 11:30 PM. The PDPAR also unfortunately does not measure wake time, bed time, or total hours slept in a night, and it does not account for the possibility that a teen attending school might have had some PA class during that time, because this was not specifically asked.

Conclusions

This is the first study, to our knowledge, to characterize PA among a racially diverse group of pregnant adolescents

and to highlight factors associated with time spent being physically active. Our findings suggest that more than half of pregnant adolescents do not meet the current PA guidelines for pregnant women. The low levels of PA observed in this cohort of adolescents are concerning because the benefits of PA on health are well documented, and inadequate PA behaviors established during adolescence might continue throughout life. This group is known to be at increased risk of excessive gestational weight gains that might predispose these teens to increased risk of lifelong overweight and obesity. The effect of school attendance on PA was most notable from this study, and encouraging teens to stay in school might improve their well-being economically and physically in the future. We emphasize the need for specific activity guidelines for pregnant adolescents so that providers will be empowered to encourage healthy exercise habits in this higher-risk obstetric population.

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References

1. Downs DS, Chasan-Taber L, Evenson KR, et al: Physical activity and pregnancy: past and present evidence and future recommendations. Res Q Exerc Sport 2012; 83:485
2. Xie Y, Madkour AS, Harville EW: Preconception nutrition, physical activity, and birth outcomes in adolescent girls. J Pediatr Adolesc Gynecol 2015; 28:471
3. Evenson KR, Wen F: National trends in self-reported physical activity and sedentary behaviors among pregnant women: NHANES 1999-2006. Prev Med 2010; 50:123
4. Evenson KR, Siega-Riz AM, Savitz DA, et al: Vigorous leisure activity and pregnancy outcome. Epidemiology 2002; 13:653
5. Spracklen CN, Ryckman KK, Triche EW, et al: Physical activity during pregnancy and subsequent risk of preeclampsia and gestational hypertension: a case control study. Matern Child Health J 2016; 20:1193
6. Yeo S: Adherence to walking or stretching, and risk of preeclampsia in sedentary pregnant women. Res Nurs Health 2009; 32:379
7. Forczek W, Curylo M, Forczek B: Physical activity assessment during gestation and its outcomes: a review. Obstet Gynecol Surv 2017; 72:425
8. Borodulin K, Evenson KR, Wen F, et al: Physical activity patterns during pregnancy. Med Sci Sports Exerc 2008; 40:1901
9. Evenson KR, Wen F: Prevalence and correlates of objectively measured physical activity and sedentary behavior among US pregnant women. Prev Med 2011; 53:39
10. Martin JA, Hamilton BE, Osternman MJ, et al: Births: final data for 2015. Natl Vital Stat Rep 2017; 66:1
11. Kann L, McManus T, Harris WA, et al: Youth Risk Behavior Surveillance - United States, 2015. MMWR Surveill Summ 2016; 65:1
12. Watson KB, Carlson SA, Gunn JP, et al: Physical inactivity among adults aged 50 years and older - United States, 2014. MMWR Morb Mortal Wkly Rep 2016; 65:954
13. Raudsepp L: The relationship between socio-economic status, parental support and adolescent physical activity. Acta Paediatr 2006; 95:93
14. Chen XK, Wen SW, Fleming N, et al: Teenage pregnancy and adverse birth outcomes: a large population based retrospective cohort study. Int J Epidemiol 2007; 36:368
15. Pate RR, Ross R, Dowda M, et al: Validation of a 3-day physical activity recall instrument in female youth. Pediatr Exerc Sci 2003; 15:257
16. Weston AT, Petosa R, Pate RR: Validation of an instrument for measurement of physical activity in youth. Med Sci Sports Exerc 1997; 29:138
17. Finkelstein JL, Pressman EK, Cooper EM, et al: Vitamin D status affects serum metabolomic profiles in pregnant adolescents. Reprod Sci 2015; 22:686
18. Whisner CM, Young BE, Witter FR, et al: Reductions in heel bone quality across gestation are attenuated in pregnant adolescents with higher prepregnancy weight and greater increases in PTH across gestation. J Bone Miner Res 2014; 29:2109
19. Young BE, Cooper EM, McIntyre AW, et al: Placental vitamin D receptor (VDR) expression is related to neonatal vitamin D status, placental calcium transfer, and fetal bone length in pregnant adolescents. FASEB J 2014; 28:2029
20. Young BE, McNanley TJ, Cooper EM, et al: Vitamin D insufficiency is prevalent and vitamin D is inversely associated with parathyroid hormone and calcitriol in pregnant adolescents. J Bone Miner Res 2012; 27:177
21. Young BE, McNanley TJ, Cooper EM, et al: Maternal vitamin D status and calcium intake interact to affect fetal skeletal growth in utero in pregnant adolescents. Am J Clin Nutr 2012; 95:1103
22. Ainsworth BE, Haskell WL, Leon AS, et al: Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc 1993; 25:71
23. Ainsworth BE, Haskell WL, Hermann SD, et al: Compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc 2011; 43:1575
24. Ainsworth BE, Haskell WL, Whitt MC, et al: Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 2000; 32: S498
25. Centers for Disease Control and Prevention. Physical Activity Basics: Glossary of Terms 2015. https://www.cdc.gov/physicalactivity/basics/glossary/index.htm. Accessed April 6, 2018
26. Institute of Medicine (US): Weight gain during pregnancy: reexamining the guidelines. Washington, DC, National Academies Press, 2009
27. Lee S, Guillet R, Cooper EM, et al: Maternal inflammation at delivery affects assessment of maternal iron status. J Nutr 2014; 144:1524
28. Hagenauer MH, Lee TM: Adolescent sleep patterns in humans and laboratory animals. Horm Behav 2013; 64:270
29. Oyiengo D, Louis M, Hott B, et al: Sleep disorders in pregnancy. Clin Chest Med 2014; 35:571
30. Groth SW, Morrison-Beedy D: Low-income, pregnant, African American women's views on physical activity and diet. J Midwifery Womens Health 2013; 58:195
31. Saxena R, Borzekowski DL, Rickert VI: Physical activity levels among urban adolescent females. J Pediatr Adolesc Gynecol 2002; 15:279
32. Whisner CM, Young BE, Pressman EK, et al: Maternal diet but not gestational weight gain predicts central adiposity accretion in utero among pregnant adolescents. Int J Obes 2015; 39:565
33. Berkowitz GS, Kelsey JL, Holford TR, et al: Physical activity and the risk of spontaneous preterm delivery. J Reprod Med 1983; 28:581
34. Di Mascio D, Magro-Malosso ER, Saccone G, et al: Exercise during pregnancy in normal-weight women and risk of preterm birth: a systematic review and meta-analysis of randomized controlled trials. Am J Obstet Gynecol 2016; 215:561
35. Muktabhant B, Lawrie TA, Lumbiganon P, et al: Diet or exercise, or both, for preventing excessive weight gain in pregnancy. Cochrane Database Syst Rev 2015; 15:CD007145