Published in final edited form as:

Paediatr Perinat Epidemiol. 2010 January ; 24(1): 45–52. doi:10.1111/j.1365-3016.2009.01081.x.

Physical activity and sleep among pregnant women

Katja Borodulin^{1,2}, Kelly R Evenson¹, Keri Monda¹, Fang Wen¹, Amy H Herring^{3,4}, and Nancy Dole⁴

¹ University of North Carolina at Chapel Hill, Gillings School of Global Public Health, Department of Epidemiology, Chapel Hill, North Carolina ² National Institute for Health and Welfare, Helsinki, Finland ³ University of North Carolina at Chapel Hill, Gillings School of Global Public Health, Department of Biostatistics, Chapel Hill, North Carolina ⁴ Carolina Population Center, Chapel Hill, North Carolina

Summary

Sleep disturbances are common among pregnant women and safe treatments to improve sleep are needed. Generally, physical activity improves sleep, but studies are lacking on the associations of physical activity with sleep among pregnant women. Our aim was to investigate the cross-sectional association of various modes of physical activity and activity clusters with sleep quality and duration among 1259 pregnant women. Participants were recruited into the Pregnancy, Infection, and Nutrition Study from prenatal clinics at the University of North Carolina Hospitals (Chapel Hill, NC). Women self-reported sleep quality and duration and physical activity in the past week. We used cluster analysis to create seven physical activity profiles and multivariate logistic regression analysis with adjustments for age, race/ethnicity, education, marital status, parity, self-rated general health, anxiety, and depressive symptoms. Women with higher levels of occupational physical activity were more likely to report either short or normal sleep duration as compared to longer duration. Women with higher levels of indoor household physical activity were less likely to report normal sleep duration as compared to shorter duration. Women in the recreational-indoor household activity cluster were less likely than women in the inactivity cluster to report normal sleep duration as compared to longer duration. Our data suggest weak associations of physical activity with sleep duration and quality in late pregnancy. Physical activity is recommended to pregnant women for health benefits, yet more research is needed to understand if physical activity should be recommended for improving sleep.

Keywords

cluster analysis; exercise; physical activity; pregnancy; reproduction; sleep; women

Introduction

Pregnant women report sleep disorders frequently and increasingly as their pregnancies progress.^{1–4} Pregnant women complain about poor sleep quality, shorter sleep duration, awakenings, trouble falling asleep, and a lower sleep efficiency (i.e., time spent awake in bed).^{1,2} Many sleep disorders are caused by physiological changes in pregnancy, such as discomfort, shortness of breath, restless legs syndrome, increased urination frequency, and nightmares.^{1,2} Previous studies suggest that pregnant women increase their total sleeping

time in early pregnancy and obtain less deep sleep, but the amount of total sleep starts to decrease after the first trimester.^{1, 3, 5} Multiparae have more awakenings during the night and a lower sleep efficiency than primiparae.^{1, 3}

Both poor quality of sleep and abnormal sleep duration (i.e., less or more than 7-8 hours of sleep per day) are associated with increased morbidity and mortality.⁶⁻¹⁰ Thus, modifiable behaviors that improve sleep are important. Physical activity and exercise are associated with better sleep and fewer sleep disturbances among healthy adults.¹¹⁻¹⁸ Exercise in bouts longer than 1 hour is associated with longer sleep duration and low intensity exercise has been shown to have positive effects on sleep.¹² In addition, physical activity carried out in early evening may be the optimal timing for improved sleep.¹³ One study reported regular walking was associated with fewer sleep disorders¹⁷ and in another study higher intensity exercise was associated with better sleep,¹⁵ but most of the previous studies have not examined different types of physical activity.

Considering the health benefits of good sleep, pregnant women are an important target group to improve sleep, yet the challenge lies in finding an adequate and safe treatment, because pharmacological treatment is not recommended for pregnant women.^{1, 12} The potential role of physical activity in improving sleep among pregnant women has not been studied in detail before. We found only three published pregnancy studies that had simultaneously measured sleep and physical activity,¹⁹⁻²¹ but none investigated whether sleep and physical activity were associated. Our aim was to investigate the cross-sectional association of various modes of physical activity with sleep quality and duration among pregnant women.

Methods

Study population

Women were recruited into the Pregnancy, Infection, and Nutrition 3 (PIN3) Study, a prospective study that examined associations between physical activity, stress, and preterm birth. Patients seeking services from prenatal clinics at the University of North Carolina Hospitals (Chapel Hill, NC) were identified by study staff through a review of prenatal medical charts and women were recruited if they were less than or equal to 20 weeks' gestation. More detailed information on the PIN Study is provided at <http://www.cpc.unc.edu/projects/pin>.

Exclusions for recruitment included women under the age of 16 years, non-English speakers, those not planning to continue care or deliver at the study site, women carrying multiple gestations, or women who did not have a telephone from which they could complete phone interviews. Recruitment started in January 2001 and ended in December 2005. During this time 3203 women were eligible for the study and 2006 volunteered to participate. Women participated in two research center visits, two telephone interviews at 17-22 and 27-30 weeks' gestation, and completed several self-administered questionnaires. Women were excluded from these analyses if they participated in the PIN3 Study for a second or third time (n=131) or had missing information on physical activity (n=306), sleep duration or quality (n=295), or other covariates (n=15), leaving 1259 women in the current analyses. The University of North Carolina Institutional Review Board approved the study protocol, and the participants gave written informed consent.

Measurement of physical activity

Interviewers administered a past week recall on physical activity during the two telephone interviews and information obtained at 27-30 weeks' gestation was used in these analyses. Using recreational activity as an example, the question asking about participation in

particular modes of physical activity was: “In the past week, did you participate in any non-work, recreational activity or exercise, such as walking for exercise, swimming, or dancing, that caused at least some increase in breathing and heart rate?” If the participant responded ‘Yes’, then the interviewer asked her to list all types of activities, one by one, with the following question: “What type of recreational activities did you do during the past week?” For each activity, the participant reported the number of sessions per week, duration of each session, and the perceived intensity level using the following options: ‘fairly light,’ ‘somewhat hard,’ and ‘hard or very hard’. The activities were assigned an absolute intensity level using published metabolic equivalent (MET) tables.^{22, 23} These questions were repeated for occupational, transportation, care giving, indoor household, and outdoor household activity. The outcome variables were log-transformed MET hours in the past week (MET h/wk) for each mode of activity. More detailed description is provided elsewhere.²⁴

Measurement of sleep duration and quality

Sleep quality and duration was collected in a self-administered questionnaire given to women at their 24-29 weeks' gestation clinic visit. Sleep quality was assessed with the following question: “How would you describe the quality of your sleep most nights?” The response options were poor, fair, good, and excellent. Poor and fair categories were combined into ‘poor sleep quality’ and good and excellent into ‘good sleep quality’ in the analyses. The question on sleep duration was: “How many hours of sleep do you usually get each 24 hours?”, with response options 3 or fewer hours, 4 hours, 5 hours, 6 hours, 7-8 hours, and 9 or more hours. Sleep duration was categorized with 7-8 hours being ‘normal sleep’, 6 hours or less being ‘short sleep’, and 9 hours or more being ‘long sleep’ for the analysis. The sleep instrument is described in detail elsewhere.²⁵

Measurement of other variables

Age, race and ethnicity, marital status, parity, general health, and education were assessed from medical records or during the first telephone interview. At their second clinic visit, women were given a self-administered questionnaire in which depressive symptoms were measured by the Center for Epidemiologic Studies Depression scale (CES-D)²⁶ and anxiety by the State Anxiety Inventory (STAI).²⁷

Statistical methods

Cluster analysis was used to identify physical activity profiles that would describe individual physical activity behavior, independent of the actual modes of activity. Cluster analysis methods attempt to find natural groupings in data by clustering individuals into meaningful groups based on the values of assessed variables (here, physical activity variables).²⁸⁻³¹ Multiple non-hierarchical cluster analyses were conducted to partition data into different numbers of user-specified non-overlapping groups. Computationally the goal is to maximize the inter- to intra-variability ratio, indicating that individuals differ more from those in different clusters than those in the same cluster. To achieve this, 1000 iterations of cluster procedures were conducted to identify optimal specifications for initial cluster centers (SAS FASTCLUS); the iteration that maximized the ratio suggested the best fit and was used in further analyses. Clustering variables included the log-transformed MET h/wk physical activity measures for recreational, care giving, indoor household, outdoor household, transportation, and occupational activity. Inspection of resulting clusters revealed the 7-cluster solution to provide the most robust and intuitively meaningful collection of groups. Names for the seven resulting groups were based on the predominant distribution: “inactive”, “recreational”, “mixed”, “care giving”, “recreational-indoor”, “transportation”, and “recreational-care giving”. See Figure 1 for a graphical description of the 7-cluster model and the mean level of activity that women in each cluster reported.

To study the associations between physical activity and sleep quality and duration, unconditional logistic regression analysis was used. Results were reported as odds ratios (OR) with 95% confidence intervals (95% CI). We analyzed the odds for good sleep quality as compared to poor quality, for normal sleep duration as compared to short duration, and for normal sleep duration as compared to long duration. Unadjusted models included the physical activity variables and adjusted models also included age, race/ethnicity, education, marital status, parity, self-rated general health, anxiety, and depressive symptoms. These variables were selected as covariates in the analyses because they correlated (using Pearson or Spearman correlation coefficients) with both physical activity and sleep in the bivariate analyses. All analyses were examined separately for physical activity clusters (reference category being the 'inactive cluster') and the original physical activity modes themselves (continuous, log-transformed total MET h/wk). The total amount of physical activity (i.e., all modes summed together) was not associated with sleep quality or duration and therefore was not used in the further analyses. Hosmer-Lemeshow goodness of fit tests were carried out for the adjusted models.

Results

Participants' mean age was 29.4 years (standard deviation 5.4 years) and most were non-Hispanic white (73.5%), had no children (51.6%), and were married (79.2%) (Table 1). Women reported mostly excellent or very good general health (77.2%) and most were working (66.6%). Highest levels of physical activity were reported for recreational activity (mean 7.3 MET h/wk and median 3.7 MET h/wk) and lowest for transportation physical activity (mean 1.1 and median 0.0 MET h/wk). The mean overall level of physical activity was 22.2 MET h/wk and median 14.9 MET h/wk. The majority, 61.3%, reported normal sleep duration (7-8 hours of sleep per day), 25.4% short sleep, and 13.3% long sleep, while 44.0% of the women reported excellent or good sleep quality, whereas 43.9% reported fair and 12.1% poor quality.

A good sleep quality was reported among women in the recreational physical activity cluster and who were aged 26 to 34 years, married, nulliparous, more highly educated, currently working, and in excellent or very good general health (Table 1). Normal sleep duration was observed more often among women who were aged 26 to 34 years, non-Hispanic whites, nulliparous, married, more highly educated and currently working, and in excellent or very good general health.

Women in the care giving physical activity cluster were less likely (OR 0.59, 95% CI 0.38-0.89) to report good sleep quality as compared to those in the inactive cluster, but this association was attenuated after adjusting for age, race/ethnicity, education, marital status, parity, general health, anxiety, and depressive symptoms (Table 2). In the models using physical activity modes, rather than clusters, recreational activity was associated with good sleep quality (OR 1.05, 95% CI 1.01-1.09) and care giving activity with poorer sleep quality (OR 0.96, 95% CI 0.93-0.99), but these associations attenuated to the null after adjusting for covariates.

Women in the recreational physical activity cluster were more likely than those in the inactive cluster to report normal sleep duration as compared to short duration (OR 2.02, 95% CI 1.20-3.40), but this association was attenuated after further adjustments (OR 1.37, 95% CI 0.78-2.39) (Table 3). In the unadjusted models using activity modes, higher recreational activity (OR 1.04, 95% CI 1.00-1.08) and transportation activity (OR 1.06, 95% CI 1.01-1.13) were associated with higher odds and higher indoor household activity with lower odds (OR 0.95, 95% CI 0.90-0.99) for normal sleep duration when compared to short sleep duration. After adjusting for other covariates, these associations attenuated, except for

indoor household activity (OR 0.95, 95% CI 0.90-1.00). In the adjusted model, occupational physical activity was associated with normal sleep duration as compared with short sleep (adjusted OR 0.96, 95% CI 0.91-1.00).

In the models predicting normal sleep duration as compared with long sleep, women in the recreational-indoor cluster had a lower odds than women in the inactive cluster to report normal sleep (unadjusted OR 0.69, 95% CI 0.41-1.16, adjusted OR 0.55, 95% CI 0.32-0.94). For the physical activity modes, higher levels of occupational activity (OR 1.11, 95% CI 1.04-1.20) and transportation activity (OR 1.08, 95% CI 1.00-1.16) were associated with normal sleep duration, yet only occupational physical activity was associated in the adjusted models (OR 1.11, 95% CI 1.03-1.19).

Discussion

Our cross-sectional data on 1259 pregnant women suggest that physical activity was not strongly associated with sleep quality or duration. Higher occupational physical activity was associated with sleep duration in the adjusted model, suggesting that women who have physically demanding jobs are more likely to sleep normal or short hours (7-8 h or less). Furthermore, women reporting higher indoor household physical activity were less likely to report normal sleep duration as compared to short duration and women belonging to the recreational-indoor activity cluster were less likely to report normal duration as compared to long duration. More research should be carried out among pregnant women to understand if the amount or intensity of work-related or indoor household activity is a key behavior affecting sleep duration.

We found only a few associations with sleep duration that remained after adjustment for potential confounding factors. This could be explained by women's physical activity behavior, as participation in physical activity decreases towards the third trimester³² and the amount of activity may not be long or intensive enough to yield a beneficial effect on sleep. Another explanation is that most women reported normal sleep duration and the cohort did not include enough poor sleepers to show the beneficial effect of physical activity on sleep, as has also been suggested in previous studies among the general population.¹² Furthermore, pregnant women report awakenings due to discomfort, restless legs, and increased urination frequency², which are pregnancy-related and perhaps would disturb sleep regardless of physical activity.

We used cluster analysis to define physical activity behavior profiles. This method has been used in physical activity studies,^{28,29} but not to describe pregnant women's activity. Traditionally, research on pregnant women's physical activity has only included recreational physical activity,³³ whereas we were able to combine six modes. As part of our findings, we identified seven clusters, one of them being the inactive cluster. Previous studies in the general population have revealed that the amount of physical activity may have a dose-response type of association with sleep.¹² In line with this finding, the most active cluster (combined recreational and indoor household activity cluster), with 17.8 MET h/wk, was associated with sleep quantity. On the other hand, the second highest total MET h/wk was reported for the mixed cluster (recreational-indoor household-outdoor household, 13.4 MET h/wk) and no associations were found. Thus, it could be speculated whether different modes of activity counterbalance each other since their effect on sleep may be of an opposite direction (as shown in tables 2 and 3). Our findings on sleep duration, particularly, showed that various modes of physical activity had opposite directions in terms of the associations.

Methodological issues

This study used self-reported measurements of physical activity and sleep, which are subject to recall and misclassification bias. The sleep measurements have been used before and have good validity.²⁵ The physical activity recall was designed for pregnant women and has shown from moderate to good validity and reliability.³⁴ Due to the cross-sectional nature of these data, when interpreting these results, one should consider the temporal sequence and that the association between physical activity and sleep may be reciprocal and subject to reverse causality.^{12, 13, 18, 35} Also, some of the confounders could be mediators and that control for these variables may be an over adjustment, such as depressive symptoms and anxiety.

Many clinic-based pregnancy studies have limitations in terms of generalizability.^{36, 37} In the preceding PIN Study cohorts it is reported that underrepresented women were more often younger, African American, less educated, had higher parity and higher pregnancy risk profile.^{36, 37} This cohort was limited to one prenatal clinic associated with a tertiary care hospital and may not be representative of a general pregnant population.

Conclusion

Among this cohort of 1259 pregnant women, occupational and indoor household physical activity modes and the recreational-indoor household activity cluster were related with sleep duration. Physical activity was not associated with sleep quality. More research is needed to understand if physical activity should be recommended for improving sleep, especially studies using prospective designs. Physical activity could be a safe, non-pharmacological treatment for sleep disorders during pregnancy. Further research should investigate whether type, mode, duration, intensity, or time of the day of physical activity is associated with sleep and whether it is sleep duration or quality where associations are found.

Acknowledgments

Funding for this study was provided by the National Institutes of Health (NIH)/NCI #CA109804-01, NIH/NICHD #HD37584, and NIH/GCRC #RR00046. The PIN Study was supported by NIH / National Institute of Child Health and Human Development (#HD37584). In addition, the Finnish Cultural Foundation and the Academy of Finland are acknowledged for their financial support. The PIN Study is a joint effort of many investigators and staff members whose work is gratefully acknowledged. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

References

1. Moline M, Broch L, Zak R. Sleep problems across the life cycle in women. *Current Treatment Options in Neurology*. 2004; 6:319–330. [PubMed: 15157409]
2. Lee KA. Alterations in sleep during pregnancy and postpartum: a review of 30 years of research. *Sleep Medicine Reviews*. 1998; 2:231–242. [PubMed: 15310494]
3. Lee KA, Zaffke ME, McEnany G. Parity and sleep patterns during and after pregnancy. *Obstetrics and Gynecology*. 2000; 95:14–18. [PubMed: 10636494]
4. Santiago JR, Nolleto MS, Kinzler W, Santiago TV. Sleep and sleep disorders in pregnancy. *Annals of Internal Medicine*. 2001; 134:396–408. [PubMed: 11242500]
5. Hedman C, Pohjasvaara T, Tolonen U, Suhonen-Malm AS, Myllyla VV. Effects of pregnancy on mothers' sleep. *Sleep Medicine*. 2002; 3:37–42. [PubMed: 14592252]
6. Gale C, Martyn C. Larks and owls and health, wealth, and wisdom. *BMJ*. 1998; 317:1675–1677. [PubMed: 9857121]
7. Kripke DF, Garfinkel L, Wingard DL, Klauber MR, Marler MR. Mortality associated with sleep duration and insomnia. *Archives of General Psychiatry*. 2002; 59:131–136. [PubMed: 11825133]

8. Tamakoshi A, Ohno Y. Self-reported sleep duration as a predictor of all-cause mortality: results from the JACC study, Japan. *Sleep*. 2004; 27:51–54. [PubMed: 14998237]
9. Ayas NT, White DP, Manson JE, Stampfer MJ, Speizer FE, Malhotra A, et al. A prospective study of sleep duration and coronary heart disease in women. *Archives of Internal Medicine*. 2003; 163:205–209. [PubMed: 12546611]
10. Gottlieb DJ, Punjabi NM, Newman AB, Resnick HE, Redline S, Baldwin CM, et al. Association of sleep time with diabetes mellitus and impaired glucose tolerance. *Archives of Internal Medicine*. 2005; 165:863–867. [PubMed: 15851636]
11. Kronholm E, Harma M, Hublin C, Aro AR, Partonen T. Self-reported sleep duration in Finnish general population. *Journal of Sleep Research*. 2006; 15:276–290. [PubMed: 16911030]
12. Youngstedt SD. Effects of exercise on sleep. *Clinics in Sports Medicine*. 2005; 24:355–365. xi. [PubMed: 15892929]
13. Atkinson G, Davenne D. Relationships between sleep, physical activity and human health. *Physiology and Behavior*. 2007; 90:229–235. [PubMed: 17067643]
14. Urponen H, Vuori I, Hasan J, Partinen M. Self-evaluations of factors promoting and disturbing sleep: an epidemiological survey in Finland. *Social Science and Medicine*. 1988; 26:443–450. [PubMed: 3363395]
15. Quan SF, O'Connor GT, Quan JS, Redline S, Resnick HE, Shahar E, et al. Association of physical activity with sleep-disordered breathing. *Sleep Breath*. 2007; 11:149–157. [PubMed: 17221274]
16. King AC, Oman RF, Brassington GS, Bliwise DL, Haskell WL. Moderate-intensity exercise and self-rated quality of sleep in older adults. A randomized controlled trial. *JAMA*. 1997; 277:32–37. [PubMed: 8980207]
17. Sherrill DL, Kotchou K, Quan SF. Association of physical activity and human sleep disorders. *Archives of Internal Medicine*. 1998; 158:1894–1898. [PubMed: 9759685]
18. Fogelholm M, Kronholm E, Kukkonen-Harjula K, Partonen T, Partinen M, Harma M. Sleep-related disturbances and physical inactivity are independently associated with obesity in adults. *International Journal of Obesity*. 2007
19. Clarke P, Gross H. Women's behavior, beliefs, and information sources about physical exercise in pregnancy. *Midwifery*. 2004; 20:133–141. [PubMed: 15177856]
20. Clarke PE, Rousham EK, Gross H, Halligan AW, Bosio P. Activity patterns and time allocation during pregnancy: a longitudinal study of British women. *Annals of Human Biology*. 2005; 32:247–258. [PubMed: 16099772]
21. Watson PE, McDonald BW. Activity levels in pregnant New Zealand women: relationship with socioeconomic factors, well-being, anthropometric measures, and birth outcome. *Applied Physiology, Nutrition, and Metabolism*. 2007; 32:733–742.
22. Ainsworth BE, Haskell WL, Leon AS, Jacobs DR Jr, Montoye HJ, Sallis JF, et al. Compendium of physical activities: classification of energy costs of human physical activities. *Medicine and Science in Sports and Exercise*. 1993; 25:71–80. [PubMed: 8292105]
23. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise*. 2000; 32:S498–504. [PubMed: 10993420]
24. Borodulin KM, Evenson KR, Wen F, Herring AH, Benson AM. Physical activity patterns during pregnancy. *Medicine and Science in Sports and Exercise*. 2008; 40:1901–1908. [PubMed: 18845974]
25. Jenkins C, Stanton B, Niemcryn S, Rose R. A scale for the estimation of sleep problems in clinical research. *Journal of Clinical Epidemiology*. 1988; 41:313–321. [PubMed: 3351539]
26. Radloff L. The CES-D scale: a self-report depression scale for research in the general population. *Applied Psychological Measurement*. 1977; 1:385–401.
27. Spielberger, C. *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press; 1983.
28. Nelson MC, Gordon-Larsen P, Adair LS, Popkin BM. Adolescent physical activity and sedentary behavior: patterning and long-term maintenance. *American Journal of Preventive Medicine*. 2005; 28:259–266. [PubMed: 15766613]

29. Monda KL, Popkin BM. Cluster analysis methods help to clarify the activity-BMI relationship of Chinese youth. *Obesity Research*. 2005; 13:1042–1051. [PubMed: 15976147]
30. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Current Opinion in Lipidology*. 2002; 13:3–9. [PubMed: 11790957]
31. Everitt, B.; Landau, S.; Leese, M. *Cluster Analysis*. London: Arnold; 2001.
32. Borodulin K, Evenson KR, Wen F, Herring A, Benson A. Physical activity patterns during pregnancy. *Medicine and Science in Sports and Exercise*. 2008 In press.
33. Poudevigne MS, O'Connor PJ. A review of physical activity patterns in pregnant women and their relationship to psychological health. *Sports Medicine*. 2006; 36:19–38. [PubMed: 16445309]
34. Evenson, KR. UNC Carolina Population Center. Chapel Hill, NC: UNC Carolina Population Center; 2008. The Pregnancy, Infection, and Nutrition Study. [updated 2008; cited 2008 February 29, 2008]; Available from: http://www.cpc.unc.edu/projects/pin/docs_3/PIN_PAQ_080907.pdf
35. Resnick HE, Carter EA, Aloia M, Phillips B. Cross-sectional relationship of reported fatigue to obesity, diet, and physical activity: results from the third national health and nutrition examination survey. *Journal of Clinical Sleep Medicine*. 2006; 2:163–169. [PubMed: 17557490]
36. Savitz D, Dole N, Williams J, Thorp J, McDonald T, Carter A, et al. Determinants of participation in an epidemiologic study of preterm delivery. *Paediatric and Perinatal Epidemiology*. 1999; 13:114–125. [PubMed: 9987790]
37. Savitz DA, Dole N, Kaczor D, Herring AH, Siega-Riz AM, Kaufman J, et al. Probability samples of area births versus clinic populations for reproductive epidemiology studies. *Paediatric and Perinatal Epidemiology*. 2005; 19:315–322. [PubMed: 15958154]

Figure 1.

The physical activity clusters. The y-axis shows geometric mean values of the past week of physical activity in MET h/wk, the x-axis shows the clusters by physical activity mode, and the total amount of physical activity in each cluster is stated above the bars.

Table 1

Distributions of background characteristics for sleep quality and duration

	Sleep quality			Sleep duration		
	All N = 1259 n (%)	Poor N = 705 n (%)	Good N = 554 n (%)	Short N = 320 n (%)	Normal N = 772 n (%)	Long N = 167 n (%)
Physical activity clusters						
Inactive cluster	275 (21.8)	154 (21.8)	121 (21.8)	75 (23.4)	164 (21.2)	36 (21.6)
Recreational cluster	150 (11.9)	77 (10.9)	73 (13.2)	24 (7.5)	106 (13.7)	20 (12.0)
Mixed cluster	123 (9.8)	69 (9.8)	54 (9.8)	31 (9.7)	78 (10.1)	14 (8.4)
Care giving cluster	146 (11.6)	100 (14.2)	46 (8.3)	47 (14.7)	83 (10.8)	16 (9.6)
Recreational/indoor cluster	219 (17.4)	114 (16.2)	105 (19.0)	61 (19.1)	120 (15.5)	38 (22.8)
Transportation cluster	149 (11.8)	79 (11.2)	70 (12.6)	32 (10.0)	100 (13.0)	17 (10.2)
Recreational/care giving cluster	197 (15.7)	112 (15.9)	85 (15.3)	50 (15.6)	121 (15.7)	26 (15.6)
Age (years)						
16–25	286 (22.7)	171 (24.3)	115 (20.8)	95 (29.7)	139 (18.0)	52 (31.1)
26–34	771 (61.2)	417 (59.2)	354 (63.9)	170 (53.1)	509 (65.9)	92 (55.1)
35 and over	202 (16.0)	117 (16.6)	85 (15.3)	55 (17.2)	124 (16.1)	23 (13.8)
Race/ethnicity						
Non-Hispanic white	925 (73.5)	506 (71.81)	419 (75.6)	197 (61.6)	612 (79.3)	116 (69.5)
Non-Hispanic black	200 (15.9)	122 (17.3)	78 (14.1)	78 (24.4)	87 (11.3)	35 (21.0)
Other	134 (10.6)	77 (10.9)	57 (10.3)	45 (14.1)	73 (9.54)	16 (9.6)
Parity						
No children	650 (51.6)	327 (46.4)	323 (58.3)	142 (44.4)	423 (54.8)	85 (50.9)
One child	414 (32.9)	250 (35.5)	164 (29.6)	107 (33.4)	246 (31.9)	61 (36.5)
Two or more children	195 (15.5)	128 (18.2)	67 (12.1)	71 (22.2)	103 (13.3)	21 (12.6)
Marital status						
Married	997 (79.2)	542 (76.9)	455 (82.1)	217 (67.8)	655 (84.8)	125 (74.9)
Not married	262 (20.8)	163 (23.1)	99 (17.9)	103 (32.2)	117 (15.2)	42 (25.2)
Education (years)						
Under 13	215 (17.1)	150 (21.3)	65 (11.7)	87 (27.2)	86 (11.1)	42 (25.2)
13–15	234 (18.6)	147 (20.9)	87 (15.7)	83 (25.9)	121 (15.7)	30 (18.0)

	Sleep quality			Sleep duration		
	All	Poor	Good	Short	Normal	Long
	N = 1259 n (%)	N = 705 n (%)	N = 554 n (%)	N = 320 n (%)	N = 772 n (%)	N = 167 n (%)
Over 15	810 (64.3)	408 (57.9)	402 (72.6)	150 (46.9)	565 (73.2)	95 (56.9)
Self-rated general health						
Excellent or very good	972 (77.2)	505 (71.61)	467 (84.3)	208 (65.0)	641 (83.0)	123 (73.7)
Good	232 (18.4)	155 (22.0)	77 (13.9)	86 (26.8)	112 (14.5)	34 (20.4)
Fair or poor	55 (4.4)	45 (6.4)	10 (1.8)	26 (8.1)	19 (2.5)	10 (6.0)
Working status						
Not working	420 (33.4)	262 (37.2)	158 (28.5)	113 (35.3)	217 (28.1)	90 (53.9)
Working	839 (66.6)	443 (62.8)	396 (71.5)	207 (64.7)	555 (71.9)	77 (46.1)
Physical activity modes (median MET h/week) ^a						
Recreational	3.7	3.0	3.7	2.8	3.7	3.7
Occupational	0.0	0.0	0.0	0.0	0.0	0.0
Care giving	0.0	0.0	0.0	0.0	0.0	0.0
Indoor household	1.7	1.8	1.4	1.9	1.5	1.3
Outdoor household	0.0	0.0	0.0	0.0	0.0	0.0
Transportation	0.0	0.0	0.0	0.0	0.0	0.0
Depressive symptoms ^b	11.9	14.7	8.4	15.8	10.3	12.0
Anxiety ^b	33.0	36.1	28.9	37.2	31.3	32.5

^aValues are medians.

^bValues are means.

Table 2
Odds ratios (OR) and 95% confidence intervals [95% CI] for sleep quality, separately for physical activity clusters and modes (log-transformed total MET h/week)

Good sleep quality vs. poor sleep quality (<i>n</i> = 1259)		
	Unadjusted OR [95% CI]	Adjusted OR [95% CI] ^a
Physical activity clusters		
Inactive cluster	1.00 Reference	1.00 Reference
Recreational cluster	1.21 [0.81, 1.80]	0.96 [0.62, 1.50]
Mixed cluster	1.00 [0.65, 1.53]	0.86 [0.53, 1.37]
Care giving cluster	0.59 [0.38, 0.89]	0.74 [0.45, 1.20]
Recreational/indoor cluster	1.17 [0.82, 1.67]	1.03 [0.69, 1.52]
Transportation cluster	1.13 [0.76, 1.68]	0.91 [0.58, 1.42]
Recreational/care giving cluster	0.97 [0.67, 1.40]	0.97 [0.64, 1.49]
Physical activity modes		
Recreational	1.05 [1.01, 1.09]	1.01 [0.97, 1.05]
Occupational	0.98 [0.94, 1.02]	0.97 [0.93, 1.01]
Care giving	0.96 [0.93, 0.99]	0.99 [0.94, 1.04]
Indoor household	0.97 [0.94, 1.01]	0.98 [0.94, 1.03]
Outdoor household	1.00 [0.95, 1.05]	0.98 [0.93, 1.03]
Transportation	1.02 [0.97, 1.07]	1.00 [0.96, 1.06]

^a Adjusted for age, race/ethnicity, education, marital status, parity, self-rated health, anxiety and depressive symptoms.

Table 3

Odds ratios (OR) and 95% confidence intervals [95% CI] for normal sleep duration, separately for physical activity clusters and modes (log-transformed total MET h/week). Reference categories were short sleep and long sleep for the two separate models

	Normal vs. short sleep (<i>n</i> = 1092)		Normal vs. long sleep (<i>n</i> = 939)	
	Unadjusted OR [95% CI]	Adjusted OR [95% CI]	Unadjusted OR [95% CI]	Adjusted OR [95% CI] ^a
Physical activity clusters				
Inactive cluster	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference
Recreational cluster	2.02 [1.20, 3.40]	1.37 [0.78, 2.39]	1.16 [0.64, 2.12]	0.93 [0.50, 1.73]
Mixed cluster	1.15 [0.70, 1.89]	0.82 [0.48, 1.41]	1.22 [0.62, 2.40]	0.99 [0.49, 1.98]
Care giving cluster	0.81 [0.51, 1.27]	0.91 [0.55, 1.52]	1.14 [0.60, 2.17]	1.22 [0.61, 2.44]
Recreational/indoor cluster	0.90 [0.60, 1.36]	0.70 [0.45, 1.09]	0.69 [0.41, 1.16]	0.55 [0.32, 0.94]
Transportation cluster	1.43 [0.88, 2.32]	0.97 [0.57, 1.64]	1.29 [0.69, 2.42]	0.94 [0.49, 1.81]
Recreational/care giving cluster	1.11 [0.72, 1.70]	0.90 [0.56, 1.45]	1.02 [0.59, 1.78]	0.89 [0.49, 1.61]
Physical activity modes				
Recreational	1.04 [1.00, 1.08]	0.98 [0.94, 1.02]	1.00 [0.95, 1.05]	0.96 [0.91, 1.02]
Occupational	0.97 [0.93, 1.02]	0.96 [0.91, 1.00]	1.11 [1.04, 1.20]	1.11 [1.03, 1.19]
Care giving	0.99 [0.95, 1.03]	1.01 [0.96, 1.06]	1.02 [0.96, 1.07]	1.03 [0.96, 1.10]
Indoor household	0.95 [0.90, 0.99]	0.95 [0.90, 1.00]	0.99 [0.94, 1.05]	0.99 [0.94, 1.05]
Outdoor household	1.04 [0.98, 1.11]	1.01 [0.95, 1.07]	1.01 [0.94, 1.09]	0.99 [0.92, 1.07]
Transportation	1.06 [1.01, 1.13]	1.05 [0.99, 1.12]	1.08 [1.00, 1.16]	1.06 [0.98, 1.15]

^a Adjusted for age, race/ethnicity, education, marital status, parity, self-rated health, anxiety and depressive symptoms.