Disparities in adolescent sleep health by sex and ethnoracial group

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ABSTRACT

Improving adolescent sleep health is a national priority for ameliorating health and wellbeing (Healthy People 2020), as the majority of adolescents do not get the minimum recommended amount of 8 h of sleep per night. Prior research has identified sex and ethnoracial disparities in adolescent sleep but has been limited by data availability. National studies have collected reported sleep data, while objective sleep data has been available in community samples only. Using new data from adolescents in the Fragile Families and Child Wellbeing Study, a population-based birth cohort study of children born 1998–2000, we are able to characterize sex and ethnoracial disparities in sleep health in the first national sample of actigraphy-assessed sleep health among adolescents. In cross-sectional analyses, we used linear and logistic regression models to assess sex and ethnoracial disparities in weekday sleep duration, timing, and quality measured using actigraphy collected from 738 adolescents at approximately age 15. We identified sex and ethnoracial group differences in weekday and weekend adolescent sleep duration, with larger disparities on weekends than weekdays. Male adolescents had 27-min shorter nightly sleep durations than females on weeknights. Non-Hispanic black adolescents had 32-min shorter nightly sleep durations than non-Hispanic whites on weekdays and 41-min shorter nightly sleep durations on weekends. While sex disparities persisted after accounting for naps, black-white differences were attenuated by napping such that there was no statistically significant black-white disparity in 24-h sleep on either weekdays or weekends. We did not identify disparities in sleep timing or quality. Future research should investigate the pathways through which these disparities arise, including behavioral and contextual mechanisms.

1. Introduction

Insufficient, irregular, and inferior quality sleep are common among American adolescents, with the majority of adolescents reporting that they do not get enough sleep (Eaton et al., 2016; Hawkins & Takeuchi, 2016; Healthy People 2020). These national trends obscure substantial disparities in adolescent sleep health, however. A series of nationally-representative cohort studies find that female adolescents have shorter sleep durations and more irregular sleep patterns than male adolescents (Adam, Snell, & Pendry, 2007; Eaton et al., 2010; Keyes, Maslowsky, Hamilton, & Schulenberg, 2015; Maslowsky & Ozer, 2014). Ethnoracial disparities are particularly pronounced, with a recent systematic review concluding that black adolescents have consistently shorter sleep durations and later sleep timing than white adolescents (Guglielmo, Gazmarian, Chung, Rogers, & Hale, 2018). Because sleep is fundamental to adolescent wellbeing – adolescents with shorter, later, lower quality, and/or more variable sleep have worse physical and mental health, perform more poorly in school, and engage in more unsafe activities and risky health behaviors than their better-slept peers (Shochat, Cohen-Zion, & Tzischinsky, 2014) – identifying sex and ethnoracial disparities in adolescent sleep health may provide insight into the role of sleep in population health disparities.

Due to data limitations, much of the research on disparities in adolescent sleep health comes from self- or parent-reports of adolescent sleep patterns, which may be subject to incorrect recall or other types of bias. Current knowledge is also limited by the range of sleep outcomes that can be measured in surveys; most studies assess sleep duration, with little attention to sleep quality and even less investigation of sleep timing. Sleep health is multifaceted, however, and requires adequate duration (sleeping for enough hours ), regularity (sleeping at the same
times), and quality (little difficulty falling and staying asleep) at a level that leaves the sleeper feeling refreshed (Buyssse, 2014). To move forward this literature, we use newly-collected actigraphy data from a national sample of adolescents who are part of the broader Fragile Families and Child Wellbeing Study (FFCWS), a cohort study of children born 1998–2000 in the United States. While prior studies at the national level have relied on self-reported measures of sleep health or have been limited to single-community studies using actigraphy, we examine these associations using a large, diverse cohort study with objectively-measured sleep data that captures sleep duration, timing, and quality. By investigating ethnoracial and sex disparities in multifaceted sleep health, we contribute to a growing literature showing that social factors are key determinants of sleep across the life course and suggest components of sleep that may be targets of intervention to ameliorate population health.

1.1. Prior studies

There has been relatively little research on the demographic predictors of adolescent sleep health in the United States, with the bulk of extant studies using large national samples of adolescents with self- or parent-reported measures of adolescents’ nightly sleep duration, adequacy, or quality. Sex differences are apparent: males report sleeping longer than females in adolescence (Adam et al., 2007; Keyes et al., 2015; Maslowsky & Ozer, 2014). Ethnoracial background is associated with disparities in adolescent sleep health, with white adolescents reporting longer nightly sleep durations than black or Hispanic adolescents (Guglielmo et al., 2018).

Although more limited in generalizability, two community studies examine demographic disparities in smaller samples of adolescents for whom objective (i.e., not self-reported) measures of sleep are available. Using a sample of 250 western Pennsylvania adolescents, Matthews, Hall, and Dahl (2014) examined sex and racial differences in actigraphic sleep duration and quality. Male adolescents in this sample slept for fewer minutes on weekdays and during the full week than did females, although there was no difference in weekend sleep. Males also had more fragmented sleep than did females. Black adolescents had shorter weekday, weekend, and full-week sleep durations and greater sleep fragmentation than white adolescents. Similarly, Moore et al. (2011) examined sex and ethnoracial differences in actigraphic sleep duration and timing using a sample of 247 adolescents living in Cleveland, Ohio. In this sample, males and nonwhite adolescents slept less on an average night than did females and majority ethnoracial group adolescents. Additionally, nonwhite adolescents had more variable sleep timing than white adolescents.

Between these two bodies of research, the direction of sleep disparities among demographic groups is at times inconsistent, complicating our understanding of the social determinants of adolescent sleep. Notably, sex differences go in opposite directions depending on the sleep measurement used. Although males report longer sleep durations than females, actigraphy shows that males sleep less and more poorly than females. There is consistent evidence that nonwhite adolescents have shorter nightly sleep durations than white adolescents, regardless of sleep measurement.

In sum, research on disparities in adolescent sleep health is limited by either the quality of their sleep measures or their generalizability. Prior studies have either (1) used national studies that rely on self- or parent-reported measures of nightly adolescent sleep times, sleep adequacy, or sleep quality or (2) used high-quality sleep measures in community samples. However, given increasingly low-cost methods of collecting objective sleep measurements in natural sleep settings and interest in gathering this type of data at the population level and/or appending it to extant cohort studies, it is now feasible to bring a population-based approach to studies of objective sleep data.

1.2. Study contributions

We add to the literature on ethnoracial and sex disparities in adolescent wellbeing by analyzing disparities in multifaceted sleep health, including duration, timing, and quality. By using multiple days of actigraphic sleep data, we are also able to conduct analyses of within-person variability in sleep, including how sleep timing changes from one day to the next. We also capture sleep that occurs outside of the nighttime sleep period (i.e., napping), an important component of sleep health that has not been examined in prior studies.

We predict that the associations between demographic factors and adolescent sleep health in this national sample will be most similar to those previously identified using objective measures of sleep duration. Therefore, we anticipate that males will have shorter sleep durations and lower quality sleep than females. Similarly, we hypothesize that black and Hispanic adolescents will sleep less and more poorly than non-Hispanic whites.

2. Methods

2.1. Data

Data come from the Fragile Families and Child Wellbeing Study (FFCWS), a population-based cohort study of 4898 children born between 1998 and 2000 in large American cities. The city-based design included a stratified random sample of 16 cities with populations ≥200,000 and an additional 4 cities based on funder interest.

We use survey weights to produce estimates of disparities in adolescent sleep health that can be generalized to births in these 20 cities between 1998 and 2000. These weights correct for sample design, including an over sample of non-marital births due to original study aims (see Reichman, Teitler, Garfinkel, and McLanahan (2001)). The weights also account for attrition on observable characteristics across study waves; FFCWS conducted interviews with parents at the time of the child’s birth as well as five follow-up waves when the child was approximately ages 1, 3, 5, 9, and 15. Finally, the weights adjust for baseline nonresponse.

2.2. Sample

We analyzed data from the adolescent wave of the FFCWS, collected from 2014 to 2017 when participants were approximately age 15. Families were eligible for inclusion in the broader age 15 follow-up if the child was alive and not legally adopted (95% of baseline sample). Among those 4663 families, 1535 families were randomly selected for the in-home component of the study and 1090 home visits were completed. Using survey weights, these 1090 cases can be weighted to be representative of births in the 20 original sampling cities.

Of the 1090 families randomly selected for in-home visits, 1058 consented to participate in actigraphy data collection and 923 adolescents ultimately provided at least one valid day of actigraphy data. Because we analyzed sleep on both weekdays and weekends, we further limited our analytic sample to the 785 adolescents with valid actigraphy for both at least one weekday and at least one weekend day. Of these 785 adolescents, 47 were missing data on covariates (29 were no longer living with either biological parent and their non-parental caregiver was not asked all demographic questions necessary for our analyses; the remaining 18 had missing values for other reasons). Thus, our final analytic sample includes 738 adolescents.

Appendix A compares the sociodemographic characteristics of the analytic sample with those of the home visit participants, which was the group eligible for actigraphy data collection and for whom survey weights were available. We found both weighted samples to be similar in the distribution of adolescent, household, and primary caregiver demographics. T- and chi-squared tests comparing the distribution of these characteristics across samples did not identify any statistically
significant differences.

2.3. Measures

2.3.1. Sleep

Data on adolescent sleep was collected using one week of actigraphy data collection (Actiwatch Spectrum, Philips Respironics, Murrysville, PA). Each record was independently scored by two individuals, and discrepancies between scorers (N = 16) were adjudicated by a third scorer. Sleep intervals were defined as those periods that began with a 30-s epoch of high activity (>10 activity counts) prior to at least five 30-s epochs of little to no activity (<10 activity counts). To differentiate sleep intervals and low-activity wake periods, scorers used a combination of (1) visual inspection, (2) changes in light levels detected by the device, and (3) within-person similarity in activity levels across potential sleep intervals. Within each sleep interval, the duration of sleep was calculated in SAS (version 9.4, SAS Institute, 2008) using an algorithm that was validated against polysomnography in a young adult sample (Marino et al., 2013). All sleep intervals with at least 30 min of sleep were included in analyses. The main sleep interval is the sleep interval with the most nighttime sleep (overlapping the period of 10pm-8am); other sleep intervals at least 60 min away from the main interval and on the same day are treated as naps.

The analytic sample for weekday sleep included adolescents who had both at least one valid day of weekday actigraphy data at least one valid day of weekend actigraphy data. Valid actigraphy days included days on which there was no device malfunction (i.e., data were able to be retrieved and downloaded), no device failure (i.e., no false activity patterns indicating battery failure), and the adolescent complied with actigraphy procedures (i.e., did not remove the device for more than 4 h per day and did not have an off-wrist period of more than 1 h within 10 min of the beginning or end of the main sleep interval).

Variables measuring average sleep duration included the adolescent’s sleep minutes, whether the adolescent’s nighttime sleep duration was between 8 and 10 h (the range recommended by two panels on adolescent sleep duration (Hirshkowitz et al., 2015; Paruthi et al., 2016)), whether the adolescent ever napped, and 24-h sleep minutes. Of note, only 14 adolescents, or 2% of the adolescent weekday sample, slept for an average of 10 h or more on weeknights, and 58 adolescents, or 11% of the adolescent weekend sample, slept for an average of 10 h or more on weekend nights.

Additionally, we considered the adolescent’s sleep timing and caregiver type indicated whether the primary caregiver was the adolescent’s biological mother (reference; 96%) or father (4%). Primary caregiver’s age was measured in years (average age 42). The primary caregiver’s educational attainment included categories for college graduate (reference; 31%), some college (33%), a high school diploma or GED (20%), and less than a high school degree (16%). Household income was measured relative to the poverty line, with adolescents living in households whose income exceeded 299% of the poverty line.
Table 2
Selected coefficients and standard errors from linear regression models of demographic factors and adolescent weekday sleep duration, N = 738.

|                   | Model 1                  | Model 2                  | Model 3                  | Model 4                  |
|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                   | Night sleep minutes      | Night sleep duration in   | Any naps                 | 24-h sleep minutes       |
| Linear            | β (95%CI)                | recommended range         | Logistic                 | Logistic                 |
| Male              | -27.14***                | 0.40*                    | 0.63                     | -27.58***                |
|                   | (-37.29, -16.99)         | (0.18, 0.89)             | (0.24, 1.63)             | (-39.13, -16.03)         |
| Ethnoracial group |                          |                          |                          |                          |
| Black, non-Hispanic | -32.61*                 | 0.34                     | 1.95                     | -10.26                   |
|                   | (-61.37, -3.84)          | (0.08, 1.46)             | (0.50, 7.68)             | (-36.46, 15.94)          |
| Hispanic          | 0.47                     | 1.47                     | 0.54                     | 4.658                    |
|                   | (-43.62, 44.57)          | (0.21, 10.12)            | (0.06, 4.66)             | (-40.64, 49.95)          |
| Other, non-Hispanic | -28.73                  | 0.40                     | 1.22                     | -10.90                   |
|                   | (-111.39, 53.93)         | (0.07, 2.12)             | (0.04, 36.59)            | (-81.90, 60.10)          |
| Covariates        | ✓                        | ✓                        | ✓                        | ✓                        |
| Weekday night sleep minutes | ✓                    | ✓                        | ✓                        | ✓                        |

Note: *p<0.05, **p<0.01, ***p<0.001; ✓ included in the model; covariates include grade level, family structure, and the primary caregiver’s relationship to the adolescent, age, educational attainment, and household income relative to the poverty line; estimates are weighted.

Table 3
Selected coefficients and standard errors from linear regression models of demographic factors and adolescent weekday sleep timing and quality, N = 738.

|                   | Model 1                  | Model 2                  | Model 3                  |
|-------------------|--------------------------|--------------------------|--------------------------|
|                   | Midpoint of night sleep  | Sleep maintenance        | WASO                     |
| Linear            | β (95%CI)                | efficiency               | minutes                  |
| Male              | -0.04                    | -0.55                    | 18.57                    |
|                   | (-0.55, 0.47)            | (-1.54, 0.45)            | (0.25, 1.381.96)         |
| Ethnoracial group |                          |                          |                          |
| Black, non-Hispanic | -0.29                 | -0.69                    | 14.48                    |
|                   | (-0.68, 0.11)           | (-2.11, 0.73)           | (0.02, 10.418.68)        |
| Hispanic          | 0.38                     | -0.12                    | 0.63                     |
|                   | (-0.39, 1.16)           | (-1.51, 1.27)           | (0.00, 185.21)           |
| Other, non-Hispanic | -0.52                 | -0.29                    | 2.80                     |
|                   | (-1.26, 0.22)           | (-2.01, 1.43)           | (0.00, 13.793.97)        |
| Covariates        | ✓                        | ✓                        | ✓                        |
| Weekday night sleep minutes | ✓                    | ✓                        | ✓                        |

Note: *p<0.05, **p<0.01, ***p<0.001; ✓ included in the model; covariates include grade level, family structure, and the primary caregiver’s relationship to the adolescent, age, educational attainment, and household income relative to the poverty line; estimates are weighted.

(34%) serving as the reference group and additional categories for households whose income to poverty ratio was 200–299% (15%), 100–199% (26%), or less than 100% (25%).

2.4. Analytic strategy

We modeled the adolescent’s nightly sleep minutes, 24-h sleep minutes, midpoint of night sleep, sleep maintenance efficiency, and WASO using linear regression. For binary outcomes – if the adolescent’s nightly sleep duration was within the recommended range and if the adolescent napped – we used logit models. Selected coefficients from these models are presented in Tables 2–5; all coefficients are available in the corresponding Appendices B, C, D, and E. All models included as covariates the adolescent’s grade level; family structure; and primary caregiver’s relationship to the adolescent, age, educational attainment, and household income relative to the poverty line. Models of sleep maintenance efficiency, WASO, and napping also controlled for nightly sleep minutes.

3. Results

Results are presented in five tables. Table 1 includes unadjusted descriptive statistics for weekday and weekend night sleep. Tables 2–5 show results from adjusted analyses of disparities in adolescent sleep health. All analyses were adjusted for adolescent sex, ethnoracial group, and grade level; family structure; and the primary caregiver’s relationship to the adolescent, age, educational attainment, and household income relative to the poverty line. Tables 2 and 4 present results from analyses of sex and ethnoracial disparities in adolescent sleep duration on weekday and weekend nights, respectively. These outcomes include night sleep minutes, whether the adolescent’s nightly sleep duration fell within the recommended range, whether the adolescent napped, and the adolescent’s 24-h sleep minutes. Tables 3 and 5 present results from analyses of the sex and ethnoracial disparities in adolescent sleep timing and quality on weekday and weekend nights, respectively. Sleep timing included the midpoint of sleep, while sleep quality was indicated by sleep maintenance efficiency and WASO.

3.1. Sleep health in a national sample of adolescents (unadjusted)

Table 1 presents weighted but unadjusted estimates of sleep health in this national sample of adolescents. Broadly, we find that adolescent sleep duration is shorter and more likely to be supplemented by naps on weekdays than on weekends.

On weekday nights (Sunday – Thursday nights), adolescents sleep for 7 h and 42 min on average; consequently, 37% of adolescents do not sleep within the recommended range for their age group. Just over one third of adolescents nap on weekdays, however, and after accounting for naps the total sleep duration across the 24-h weekday averages 7 h and 59 min.

On weekend nights (Friday and Saturday nights), adolescents sleep for an average of 8 h and 17 min. Just under one quarter of adolescents nap on weekends, meaning that on average adolescents obtain 8 h and 38 min of sleep per 24 h on weekends.

Sleep timing is later on weekend nights than weekday nights. On average, adolescents fall asleep at 12:12am on weeknights and wake at
and thus have 60% lower odds sleeping within the recommended guidelines than females (Table 2, Model 2). This gap is not compensated by napping (Table 2, Model 3). Considering sleep across the entire 24-h weekday, males sleep for 28 min less than females (Table 2, Model 4). On weekend nights, point estimates suggest that sex disparities in nightly and 24-h sleep duration are even more pronounced, though these disparities do not reach statistical significance (Table 4). We do not identify any sex differences in sleep timing or quality on weekday or weekend nights (Tables 3 and 5).

### 3.2. Disparities in adolescent sleep health (adjusted)

#### 3.2.1. Sex

Male adolescents sleep less than female adolescents on weekdays. Males sleep on average 27 min less each weekday (Table 2, Model 1) and Thus, they have smaller waist circumference (WASO) on both weekdays and weekends (N = 738). We also considered models limiting analyses to adolescents with at least two valid actigraphy days on both weekdays and weekends (N = 535). In this more restrictive sample, patterns of disparities remain similar, with males having shorter sleep durations than females and non-Hispanic black adolescents having shorter sleep durations than whites. The magnitude of disparities is generally larger but less precisely estimated due to reduced sample size.

#### 3.2.2. Ethnoracial background

On both weekdays and weekends, non-Hispanic black adolescents have shorter nightly sleep durations than non-Hispanic white adolescents but no difference in sleep duration across the 24-h period, suggesting that naps play a role in attenuating these differences. On weekday nights, non-Hispanic black adolescents sleep for about 33 min less than non-Hispanic white adolescents (Table 2, Model 1), yet there is no statistically significant difference in total 24-h sleep duration between these groups (Table 2, Model 4). On weekend nights, the disparity is nighttime sleep is larger, at 41 min (Table 4, Model 1). However, non-Hispanic black adolescents have almost 4 times the odds of napping on weekends (Table 4, Model 3) as non-Hispanic white adolescents, such that in a 24-h period there is no statistically significant difference in sleep duration between these groups (Table 4, Model 4). We do not identify any ethnoracial disparities in adolescent sleep timing and quality on weekday or weekend nights (Tables 3 and 5).

#### 3.3. Supplemental analyses

##### 3.3.1. Different numbers of valid actigraphy days

We conducted sensitivity analyses using different cutoffs for sufficient number of days of actigraphy observation for adequate precision in measuring adolescent sleep health. In our primary analyses, we limit the analytic sample to adolescents with at least one valid day of actigraphy on both weekdays and weekends (N = 738). We also considered models limiting analyses to adolescents with at least two valid actigraphy days on both weekdays and weekends (N = 535). In this more restrictive sample, patterns of disparities remain similar, with males having shorter sleep durations than females and non-Hispanic black adolescents having shorter sleep durations than whites. The magnitude of disparities is generally larger but less precisely estimated due to reduced sample size.

### Table 4

Selected coefficients and standard errors from linear regression models and odds ratios and 95% confidence intervals from logistic regression models of demographic factors and adolescent weekend sleep duration, N = 738.

| Model | Night sleep minutes | Night sleep duration in recommended range | Any naps | 24-h sleep minutes |
|-------|---------------------|------------------------------------------|----------|--------------------|
|       | Linear β (95% CI)   | Logistic OR (95% CI)                     | Logistic OR (95% CI) | Linear β (95% CI) |
| Male  | -39.55 (96.89, 17.78) | 0.49 (0.17, 1.40) | 0.68 (0.23, 2.01) | -45.59 (-106.1, 14.96) |
| Ethenoracial group (ref: white, non-Hispanic) | | | | |
| Black, non-Hispanic | -41.31** (-68.54, -14.09) | 0.78 (0.20, 3.01) | 3.90* (1.23, 12.35) | -24.17 (-57.72, 9.390) |
| Hispanic | -18.00 (-62.27, 26.27) | 0.72 (0.12, 4.24) | 2.19 (0.31, 15.54) | -2.854 (-49.83, 14.12) |
| Other, non-Hispanic | -88.34 (-201.78, 25.11) | 0.19 (0.03, 1.34) | 0.78 (0.03, 20.99) | -80.29 (-208.6, 48.07) |
| Covariates | ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ |

Note: *p<0.05, **p<0.01, ***p<0.001; ✓ included in the model; covariates include grade level, family structure, and the primary caregiver’s relationship to the adolescent, age, educational attainment, and household income relative to the poverty line; estimates are weighted.

### Table 5

Selected coefficients and standard errors from linear regression models of demographic factors and adolescent weekend sleep timing and quality, N = 738.

| Model | Midpoint of night sleep | Sleep maintenance efficiency | WASO minutes | 24-h sleep minutes |
|-------|-------------------------|------------------------------|--------------|--------------------|
|       | Linear β (95% CI)       | Linear β (95% CI)           | Linear β (95% CI) | Linear β (95% CI) |
| Male  | -0.05 (-0.96, 0.87)     | −0.54 (-1.35, 0.28)         | 33.93 (0.10, 11,003.20) | 80.29 0.19 2.854 |
| Ethenoracial group (ref: white, non-Hispanic) | | | | |
| Black, non-Hispanic | -0.01 (-0.78, 0.77) | -0.17 (-1.68, 1.35) | 3.05 (0.01, 1782.60) | 2.19 (0.31, 15.54) |
| Hispanic | 0.54 (0.33, 1.41) | 0.03 (-2.14, 2.19) | 0.79 (0.09, 1,782.60) | 2.19 (0.31, 15.54) |
| Other, non-Hispanic | -1.45 (-3.80, 0.90) | 0.46 (-1.84, 2.76) | 0.30 (0.00, 704.50) | 0.78 (0.03, 1.34) |
| Covariates | ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ |

Note: *p<0.05, **p<0.01, ***p<0.001; ✓ included in the model; covariates include grade level, family structure, and the primary caregiver’s relationship to the adolescent, age, educational attainment, and household income relative to the poverty line; estimates are weighted.
4. Discussion

Using data from a population-based sample of American adolescents born in large cities between 1998 and 2000, we identify sex and ethnoracial disparities in objectively-measured adolescent sleep health. We find that sex differences in adolescent sleep are pronounced, with males sleeping less than females. Ethnoracial disparities in adolescent sleep are similarly notable. Although non-Hispanic black adolescents sleep for more than 30 min less each night than non-Hispanic white adolescents on both weekday and weekend nights, they offset this difference by napping more. We did not identify any sex or ethnoracial disparities in sleep timing or quality.

With regard to sex disparities, these findings both replicate and extend prior research on adolescent sleep health. We find that males sleep for 27 min less than females on weekdays but that there is no statistically significant sex difference in weekend night sleep duration. These sex differences are consistent with disparities in adolescents' nightly sleep duration from earlier actigraphic studies. In a Pennsylvania community sample, Matthews et al. (2014) also find that males have shorter weekend sleep durations than females (12 min shorter for black males than black females; 24 min shorter for white males than white females) but that there is no sex difference in weekend night sleep duration. Moore et al. (2011) analyzed average nightly sleep duration across the week (pooling weekday and weekend observations) and identified that females sleep for 22 min longer than males in an Ohio community sample. Notably, these findings are the opposite of those observed in self-reported studies, in which adolescent males report sleeping longer than adolescent females (Keyes et al., 2015; Maslowsky & Maslowsky, 2014). There are many potential reasons for these opposite sex differences between self- and objectively-measured sleep, encompassing both biological (sex) and behavioral (gender) components.

One set of explanations relates to the limitations of various sleep measurements. Several studies indicate that the correlation between actigraphy and other sleep measures is less strong among adolescent males than females (Guedes et al., 2016; Johnson et al., 2007; Short, Gradisar, Lack, Wright, & Carskadon, 2012), possibly because higher levels of movement among males during sleep are incorrectly rendered as WASO when using actigraphy (Short et al., 2012). This would result in an underestimate of total sleep time for males. However, although we find large sex differences in night- and 24-h sleep time, we do not identify any statistically significant sex differences in WASO.

The second set of explanations suggests that there are gendered patterns of survey reporting and/or sleep hygiene behaviors. For example, it is possible that males erroneously self-report longer sleep durations because their sleep schedules are more variable than those of females. Or, males may take more short naps (<30 min) than females; analyses do not include naps lasting less than 30 min due to the difficulty of differentiating short naps from brief periods of inactivity (e.g., watching television) in actigraphy data. Males may also have worse sleep hygiene than females (e.g., consuming more caffeine, spending more time using screens). These findings suggest that gendered reasons for differences in nighttime sleep and constraints in napping deserve additional investigation.

Similarly, the large disparities in nightly sleep duration by ethnoracial group that we identify are similar to those found in previous studies of actigraphic adolescent sleep (Matthews et al., 2014; Moore et al., 2011) and self-reported adolescent sleep duration (Guglielmo et al., 2011). However, the role of napping in offsetting ethnoracial differences in sleep duration on a is a new and notable finding among adolescents. One prior study of children ages 2–8 also found that differences in napping behavior compensated for large ethnoracial differences in nightly sleep duration such that there was no difference in 24-h sleep duration among ethnoracial groups (Crosby, Lebourgeois, & Harsh, 2005). Our findings suggest that this pattern persists into adolescence and raise questions about whether such behavior may extend into adulthood.

These analyses have several limitations. First, while actigraphy provides an objective and valid assessment of nighttime sleep, its ability to distinguish periods of low activity from nap periods is weaker (particularly for very short naps), it does not capture perceived sleep quality (e.g., restorativeness), and there is a lack of consensus on preferred methods of actigraphy validation in large samples of adolescents. Second, although this study uses data from a large national sample of adolescents with objectively-measured sleep, the sample consists of adolescents who were born in urban areas. For this reason, findings cannot be generalized to all adolescents in the United States. We also caution against generalizing these results to all adolescents currently living in urban settings. Among FFCCWS participants, 50% of adolescents live within the city in which they were born, an additional 30% live in the surrounding metropolitan area, and the final 20% have moved to other locations.

Nonetheless, these results underscore the magnitude and heterogeneity of sex and ethnoracial disparities in adolescent sleep across a variety of dimensions of sleep health. Future research should investigate the underlying mechanisms through which such differences come about. Behavioral mechanisms, such as screen time, physical activity, and diet, can be identified using repeated within-person measures. Contextual mechanisms (i.e., the differential distribution of exposure to sleep-inhibiting or sleep-promoting family, household, neighborhood, school, and peer environments) can be explored in studies linking sleep data to rich population-level data. Understanding these pathways will elucidate opportunities for intervention to ameliorate disparities in adolescent sleep health.

Conflict of interest and financial disclosure statement

The authors have indicated no conflicts of interest relevant to the current study. Outside of the current work, Orfeu M. Buxton discloses that he received two subcontract grants to Penn State from Mobile Sleep Technologies / Proactive Life / Sonic Sleep (NSF/STR #1622766, NIH/ NIA SBIR #R43AG056250), and received honoraria/travel support for lectures from Boston University, Boston College, Tufts School of Dental Medicine, and All state, and receives an honorarium for his role as the Editor-in-Chief (designate) of Sleep Health sleephealthjournal.org. Lauren Hale receives an honorarium for her role as the Editor-in-Chief of Sleep Health sleephealthjournal.org.

CRediT authorship contribution statement

Sarah James: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. Anne-Marie Chang: Conceptualization, Methodology, Writing - review & editing. Orfeu M. Buxton: Conceptualization, Methodology, Writing - review & editing, Project administration. Lauren Hale: Conceptualization, Methodology, Writing - review & editing, Funding acquisition, Supervision.

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Appendix A. Supplemental tables

Supplementary tables to this article can be found online at https://
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