To Sleep or Not to Sleep: A Repeated Daily Challenge for African American Children

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SUMMARY

Aims: Sleep is important for children, because of the impact on their development and well-being. Previous survey research suggested that poor sleep occurs more frequently in minorities. However, objective data characterizing their sleep patterns are lacking. **Methods:** Children enrolled in a 1-year cross-sectional sequence designed study centered on a 14-day objective sleep recording, which was repeated three times. Children lived on the South Side of Chicago and were self-defined as being African Americans. **Results:** Findings reflect data of 24 children with a mean age of 5.4 ± 1.7 years of which 54.2% were girls. They slept at night 6.51 h and during the day changeably 1.42 h, likely being noon naps during the week and afternoon naps on Saturday and Sunday. Variability in quality of sleep, and also nighttime sleep duration, especially on Friday and Saturday, was characteristic. The highest variability was noted in sleep onset and offset latency, and in the quality of napping. The interrelation of daytime and nighttime sleep changes was suggestive of “catch-up” daytime sleep. **Conclusion:** At nighttime children habitually obtained few hours of sleep with diurnal sleep fluctuations likely being “a need” and “a chance.” Interventions might emphasize on creating optimal opportunities to sleep.

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Introduction

In spite of the acknowledged vital role of sleep in brain maturation [1,2] and therefore overall development [3], childhood sleep is undoubtedly the most overlooked behavior of this century [4]. It is indeed undeniably apparent that society places emphasis on daytime functioning such as the first steps, the first words, the good grades, and so forth. Yet too often the critically important role of sleep in this developmental context is forgotten. Studies have associated poor sleep with health [5], learning [6], and behavioral problems [7] with a rapidly growing body of empirical data supporting such associations. Nevertheless, in our modern society, it remains challenging to catch enough and quality sleep.

The need for accurate delineation of ethnic differences in sleep patterns is felt within the field of pediatric sleep [8,9]. Furthermore, few sleep studies have a longitudinal design, and hence, a repeated in-home objective measurement of sleep beyond 7 days has not been pursued. Studies with longitudinal designs would allow investigation of sleep embedded in its sociocultural context. In particular, necessity rather than choice may lead to ecological and cultural disadvantages in minority families' sleep behavior. The 2010 Sleep in America Poll [10] focused for instance on sleep habits and attitudes with an equal sample distribution regarding

ethnicity. Although findings reflect only adults, they were suggestive of ethnic or cultural differences in sleep behaviors and hence support the importance of sleep in comprehensively understanding well-being of minority racial groups. For example, the most frequent activity every night by African Americans (75%) and Hispanics (72%) was watching TV. Based on the Poll, 43% of African Americans and 41% of Hispanics used a computer or the Internet in the evening. Both such TV and computer habits are considered as indicators of poor sleep hygiene. In addition, from the Sleep in America Poll sample, African American adults get the least amount of sleep (i.e., 6 h 14 min) and report to need less sleep for optimal performance (i.e., 7 h 5 min). The National Sleep Foundation [10] therefore concluded that ethnic or cultural differences in reporting, in treating, and in consequences of sleep problems in minority adults are an important problem which needs to be addressed.

Given that a child's sleep is dependent upon parental attitudes and habits [11,12], sleep of a minority child might be at significant risk. For instance, when controlling for sociocultural characteristics in a sample comprising 48% African American preschoolers, retrospective analyses suggested that disadvantaged children have inconsistent bedtime routines [13]. Such routines foster irregular sleep–wake patterns. It is well documented that the polyphasic

sleep–wake pattern presents at birth develops into a biphasic sleep–wake pattern, and the adult sleep architecture is reached around the age of 5 years [14]. As such, it is acknowledged that the need as well as the opportunity to sleep coincides with and is modulated by internal and external factors; for example, biomedical, environmental, and familial [15]. Objective childhood sleep data in predominantly African American samples, however, are lacking. Each of the African American sleep reports, to the best of our knowledge, stratified post hoc on ethnicity or alternatively studied a convenient subsample of African Americans using primarily surveys. Some examples of survey data are as follows: in a community sample with 26.5% of African American 2- to 8-year-olds parental report suggested that their child naps more and naps especially more frequently during the week [16]; in a sample from Illinois metropolitan pediatric clinics, 2- to 5-year-olds were reported to nap longer and sleeping less at night [17]. Also others [18,19] have highlighted poor nightly sleep in African American subsamples. Our recent survey [20] similarly suggested problematic sleep in African American youth. Their sleep was characterized by difficulties in initiating and maintaining sleep, which consequently probes the sleep–wake pattern of developing African Americans. Altogether, but based on mostly survey evidence in the extant literature, there is support for poor sleep in African American children. Our main goal was therefore to examine through repeated objective recordings the interrelation of nighttime and daytime sleep of African American children. In particular, it was hypothesized that sleep duration during daytime might be compensatory.

Materials and Methods

Subjects

This study was approved by the Institutional Review Board of The University of Chicago (IRB 10-677-B) and participating community centers on the South Side of Chicago. We obtained informed consent from parents and when applicable assent from children.

Subjects were 3–9 years old, lived in the South Side of Chicago area, and were self-defined as being African Americans.

Measures

Sleep: The Actiwatch-2, a nondominant wrist accelerometer (Philips-Respironics, Inc., version 5; Bend, OR, USA), is $43.5 \times 23.3 \times 10.4$ mm and weighs 16.1 g with band. This device objectively records sleep and wake states over 24 h. It was worn on the non-dominant wrist via hospital wristbands. The Actiware software recording was set at 1 min epoch. Epoch registration of activity counts is determined by comparison; that is, counts for the epoch in question and those immediately surrounding that epoch are weighted with a threshold sensitivity value (TSV) that was set at 40 (default, being medium sensitivity) [score = $E_{-2} \cdot (1/25) + E_{-1} \cdot (1/5) + E_0 + E_{+1} \cdot (1/5) + E_{+2} \cdot (1/25)$, with E_n being activity counts for the epoch, with E_0 the scored epoch]. Subsequently, if the number of activity counts is equal or below the TSV, that epoch is scored as “sleep,” whereas if exceeding TSV, it is scored as “wake.” (for more details see <http://learnactiware.com/tutorials/>).

Sleep intervals over a 24-h period were manually marked based on parental log report and clinical experience [21–23]. Sleep parameters of interest were as follows: *Sleep Period Time (SPT)* being the difference in time between the end and the start times of the given interval; start time is determined automatically as the first 10-min period in which no more than one epoch is scored as mobile and end time is identical to the previous but represents the last 10-min period, and as a result, this is regarded similar to the time in bed per parental report. *Total Sleep Time (TST)* is representing the amount of time between start and end times scored as “sleep.” Another parameter is the *Sleep Efficiency (SEI)* index which is $(TST/SPT) \cdot 100$. *Sleep Onset Latency (SONL)* which is the period between start time of the given interval and sleep start expressed in minutes. *Wake After Sleep Onset (WASO)* is calculated as the amount of time between start and end times of the given interval scored as “wake” expressed in minutes. *Sleep Offset Latency (SOFL)*, which is the period between end time of the given interval and sleep end, expressed in minutes. *Sleep Bouts (SLBOUITS)* the total number of continuous blocks with each epoch block scored as sleep between the start and end interval. *Fragmentation Index (FRAGIN)* being the sum of percent mobile and percent immobile bouts <1-min duration to the number of immobile bouts, for the given interval, or also considered as an index of restlessness. All sleep parameters (except the SONL, SOFL, FRAGIN, and SLBOUITS) were calculated through an enhanced software algorithm applying polysomnography-derived correction factors and using statistics from surrounding major rest periods to improve the sleep statistics for a particular sleep interval (<http://actigraphy.respironics.com/resources.aspx>).

Sunday–Thursday was considered as a week and Friday–Saturday as a weekend, unless specified otherwise with “overall” sleep being day- and nighttime sleep combined.

Sleep data are expressed in terms of mean and variability [22] for nighttime sleep, daytime sleep (or napping), and overall sleep, and this for weekdays, weekend days and 14 days (or each recording period).

Procedure

Subjects enrolled in a 1-year cross-sectional sequence designed study centered on a 14-day objective sleep recording. Namely, the child wore an Actiwatch for 24 h per day during three separate 2-week periods (I, II, III) spread over 3 months. Inclusion criteria were African American child between the ages of 3–9 years with a primary caregiver fluent in English language and having telephone access. The Kish grid procedure [24] for subject selection was used when several children within the family were eligible for the study. The Kish grid is a pre-assigned table of random numbers for the selection of one child per family. Subjects were excluded when parents reported that children had sleep problems (e.g., sleep apnea), medical illness (e.g., diabetes), developmental disabilities, psychiatric disorders, or were taking medications on a regular basis. Furthermore, the Behavioral Risk Factor Surveillance System Questionnaire [25] was partially implemented to screen the primary caregiver in terms of medical illness, psychological disorders, health problems, and drug use. Per recording period subjects received a \$25 gift card.

Statistical Analysis

Statistical descriptions were made by the use of the mean (M) and standard deviation (SD) for continuous variables and percentage for categorical variables. Variability (V) of sleep parameters was expressed as a percentage relative to the mean of the sleep parameter for each child. ANCOVA (with age as covariate), Kruskal–Wallis, or chi-square analyses were performed for group differences. Repeated ANCOVA or the nonparametric Friedman ANOVA chi-square analyses where appropriate were conducted to assess differences across 3 months. Sleep parameter trends were calculated as the “moving average,” with the geometric mean for the recording period being the baseline from which daily average fluctuations were derived.

Subsequently, individual standardized regression-based change (SRBC) scores were calculated. The SRBC score is a statistical technique for measuring change that includes the examination of the level of initial performance and addresses the statistical phenomenon of regression to the mean and therefore a preferred method for assessing change over time within an individual. In addition, SRBC scores are clinically meaningful and allow direct comparisons; that is, scores beyond ± 1.96 [or 95% confidence interval (CI)] indicate a significant change within the individual. In other words, notwithstanding the age range, we will model changes in individual sleep.

Spearman (r_s) correlation analyses were performed to express the associations between sleep change (or SRBCs) parameters. Distance-weighted least squares smoothing procedure method fitting a curve revealing nonsalient overall patterns of data, often consisting of segments that cannot be described by one function, was applied. This curve analyses allow generation of nonlinear estimation hypotheses to be quantitatively verified. Namely, patterns in individual changes in sleep across the recording periods are visualized. Statistical analyses were performed with Statistica version 10 (StatSoft, Inc., STATISTICA, Tulsa, OK, USA). In the presentation of the results, the statistical *P*-values will be printed (two-tailed).

Results

Findings reflect three times 14-day objective sleep recording data of children ($n = 24$) with a mean age of 5.4 ± 1.7 years [95% CI: 4.64–6.11] of which 13 were girls (54.2%). Children wore the Actiwatch on 12.4 ± 2 days on average. Twice a logistic issue resulted in <7 days of recording, that is, for a child in the second and for another child at the third recording period, and hence, data were replaced by regression missing data imputation per child.

For descriptive purposes, stratified on median Chicago Household Income (HI: \$46,877) and poverty level (PL: 20.9%) (United States Census Bureau, 2010), our sample consisted of 58.3% lower-class (i.e., $HI \leq \$46,877$ and $PL \leq 20.9\%$), 37.5% middle-class (i.e., $HI \leq \$46,877$ and $PL > 20.9\%$), and 4.2% upper-class families (i.e., $HI > \$46,877$ and $PL > 20.9\%$). Socioeconomic distribution by age and gender was equal [$\chi^2(32) = 27.6$, $P = 0.69$]. Being a single mom and social class were unrelated [$\chi^2(8) = 9.2$, $P = 0.33$] with 50% of the sample being a single

mom (i.e., never married and living alone with child). This sample is furthermore socio-demographically similar to our large-scale sleep survey of youth ($n = 221$) living on the South Side of Chicago [20].

Sleep Patterns

Given that our sleep depends on previous sleep, we visualized the sleep parameters per 24 h via a moving average (see Figure 1) [22]. Table 1 shows that sleep of minority children for each recording period (I–III) was insufficient.

Overall Sleep across Three Separate 14-day Recording Periods

SPT: Although overall SPT, that is day- and nighttime combined, was unaltered over 3 months [$F(2,46) = 1.5$, $P = 0.24$], children spent on average 32.5 min more in bed during weekends [vs. weekdays across I–III; $F(1,23) = 20.8$, $P = 0.0001$; that is for I: 45.6 min, II: 20.5 min, III: 31.4 min and thus on average 32.5 min], and SPT was especially variable during weekend [vs. week across I–III; $F(1, 23) = 5.4$, $P = 0.03$] (Table 1A). SONL: SONL changed across each of the recording periods [Figure 1B or Table 1A I–III; $F(2,46) = 8.9$, $P = 0.0006$, and correspondingly was variable: $F(2,46) = 3.6$, $P = 0.04$ or Table 1 see $V \pm SD$], and it was on average 7.4 min longer on weekends [vs. weekdays across I–III; $F(1,23) = 11.4$, $P = 0.003$]. SOFL: Also, SOFL fluctuated over 3 months [$F(2,46) = 7.1$, $P = 0.002$], while it appeared least variable during weekend [VSOF: $F(1,23) = 9.1$, $P = 0.006$]. SEI and WASO: SEI was 4.1% lower during weekend [SEI: $F(1,23) = 13.0$, $P = 0.002$], with children's sleep having 28.9 min more WASO on weekends [vs. weekdays across I–III; WASO: $F(1,23) = 15.3$, $P = 0.0007$]. TST: Children's TST, day- and nighttime combined, was unaltered [$F(2,46) = 0.01$, $P = 0.99$] yet variable [VTST: $F(2,46) = 3.7$, $P = 0.034$]. SLBOUTS and FRAGIN: Furthermore, more SLBOUTS during weekend [vs. weekdays across I–III; $F(1,23) = 9.6$, $P = 0.005$] was found yet sleep during weekend was also more restless [FRAGIN: $F(1,23) = 4.6$, $P = 0.04$].

In summary, although spending more time in bed during weekend days, the quality was questionable and this pattern was chronic (i.e., across I–III).

Nighttime Sleep across Three Separate 14-day Recording Periods

SPT: During weekend, children had longer nighttime SPT [$F(1,23) = 16.1$, $P = 0.0006$] and more variable SPT [$F(1,23) = 11.8$, $P = 0.003$] (Table 1B). SONL: An interaction effect was found for nighttime SONL [$F(2,46) = 3.6$, $P = 0.03$]; namely, mean nighttime SONL was different across three recording periods in combination with longer SONL during the weekend compared with weekdays (see also Figure 1). Across 3 months also nighttime SONL showed variation [$F(2,46) = 5$, $P = 0.02$]. SOFL: Likewise, nighttime SOFL fluctuated over 3 months [Figure 1; $F(2,46) = 12.6$, $P = 0.00004$, and was least variable on weekends $F(1,23) = 14.8$, $P = 0.0008$, Table 1B]. SEI and WASO: On weekend days, SEI was 4.8% less [$F(1,23) = 13.5$, $P = 0.001$] while

Figure 1 Moving average of 24-h sleep parameters over a 14-day recording period (overall sleep). **(A)** Sleep Period Time (darkest), Total Sleep Time (light grey), and Wake After Sleep Onset (dashed). **(B)** Sleep Onset Latency (dark) and Sleep Offset Latency. **(C)** Sleep Efficiency Index and Fragmentation Index (dark). GM, geometric mean (baseline); THU through WED were the days of recording period I; □, recording period I; ○, recording period II; Δ, recording period III.

Table 1 Descriptives of (A) overall sleep, (B) nighttime sleep and (C) daytime sleep

Recording period	(A) Overall sleep					
	14 days		Week		Weekend	
I	M ± SD	V ± SD	M ± SD	V ± SD	M ± SD	V ± SD
SPT (min)	555 ± 36	15 ± 4	541 ± 40	14 ± 5	587 ± 52	13 ± 6
TST (min)	426 ± 41	20 ± 4	423 ± 42	18 ± 5	429 ± 68	19 ± 8
SONL (min)	35 ± 16	90 ± 35	34 ± 18	88 ± 31	35 ± 19	77 ± 36
WASO (min)	129 ± 45	62 ± 13	118 ± 44	59 ± 14	158 ± 68	56 ± 23
SOFL (min)	15 ± 9	92 ± 24	15 ± 11	90 ± 32	15 ± 10	85 ± 25
SLBOUTS (number)	22 ± 6	38 ± 8	22 ± 6	35 ± 10	25 ± 7	37 ± 17
FRAGIN (%)	42 ± 14	39 ± 12	41 ± 15	38 ± 14	44 ± 15	34 ± 14
SEI (%)	69 ± 6	16 ± 4	70 ± 6	15 ± 4	67 ± 10	15 ± 7
II						
SPT (min)	556 ± 29	14 ± 4	550 ± 33	12 ± 4	571 ± 50	13 ± 8
TST (min)	428 ± 55	20 ± 5	431 ± 56	18 ± 6	421 ± 73	23 ± 7
SONL (min)	19 ± 11	105 ± 30	17 ± 11	94 ± 31	23 ± 17	96 ± 28
WASO (min)	129 ± 56	56 ± 16	120 ± 53	54 ± 23	149 ± 71	49 ± 25
SOFL (min)	16 ± 8	106 ± 36	15 ± 9	100 ± 39	18 ± 16	82 ± 29
SLBOUTS (number)	24 ± 6	36 ± 9	23 ± 5	35 ± 11	25 ± 8	37 ± 17
FRAGIN (%)	42 ± 13	39 ± 13	41 ± 14	39 ± 16	43 ± 15	33 ± 15
SEI (%)	72 ± 9	17 ± 5	74 ± 9	15 ± 6	68 ± 12	29 ± 9
III						
SPT (min)	543 ± 31	15 ± 4	533 ± 36	12 ± 4	564 ± 47	18 ± 9
TST (min)	422 ± 50	18 ± 4	418 ± 48	16 ± 5	432 ± 77	19 ± 7
SONL (min)	24 ± 10	120 ± 40	20 ± 10	107 ± 46	35 ± 22	96 ± 27
WASO (min)	122 ± 49	61 ± 18	115 ± 46	55 ± 19	132 ± 77	61 ± 26
SOFL (min)	21 ± 10	97 ± 32	20 ± 12	100 ± 35	23 ± 14	77 ± 30
SLBOUTS (number)	22 ± 5	36 ± 11	21 ± 5	34 ± 13	24 ± 8	33 ± 16
FRAGIN (%)	40 ± 15	36 ± 14	39 ± 15	36 ± 14	42 ± 17	32 ± 21
SEI (%)	71 ± 7	15 ± 6	72 ± 7	14 ± 7	68 ± 11	12 ± 7
(B) Nighttime sleep						
Recording period	14 days		Week		Weekend	
	M ± SD	V ± SD	M ± SD	V ± SD	M ± SD	V ± SD
I						
SPT (min)	515 ± 31	14 ± 5	504 ± 39	13 ± 7	540 ± 42	14 ± 7
TST (min)	389 ± 37	19 ± 4	390 ± 39	18 ± 6	386 ± 58	19 ± 7
SONL (min)	43 ± 21	90 ± 32	43 ± 23	89 ± 30	43 ± 22	84 ± 40
WASO (min)	126 ± 43	65 ± 16	115 ± 42	61 ± 18	154 ± 67	58 ± 22
SOFL (min)	17 ± 11	102 ± 22	17 ± 14	100 ± 26	17 ± 12	92 ± 36
SLBOUTS (number)	28 ± 6	28 ± 7	27 ± 6	25 ± 8	30 ± 8	27 ± 13
FRAGIN (%)	33 ± 9	30 ± 10	32 ± 9	29 ± 11	35 ± 9	28 ± 12
SEI (%)	68 ± 7	17 ± 4	70 ± 7	16 ± 4	65 ± 10	16 ± 8
II						
SPT (min)	520 ± 33	13 ± 4	515 ± 33	11 ± 5	534 ± 53	15 ± 9
TST (min)	394 ± 52	19 ± 6	397 ± 57	18 ± 7	388 ± 60	21 ± 8
SONL (min)	23 ± 15	117 ± 25	20 ± 16	103 ± 34	29 ± 22	105 ± 28
WASO (min)	126 ± 56	59 ± 17	118 ± 53	56 ± 23	146 ± 72	53 ± 29
SOFL (min)	18 ± 9	117 ± 43	17 ± 11	110 ± 39	20 ± 18	86 ± 30
SLBOUTS (number)	29 ± 7	25 ± 5	28 ± 7	23 ± 6	29 ± 8	27 ± 11
FRAGIN (%)	34 ± 9	30 ± 9	32 ± 9	28 ± 9	36 ± 12	26 ± 14
SEI (%)	71 ± 10	17 ± 6	72 ± 11	16 ± 7	67 ± 12	18 ± 9
III						
SPT (min)	508 ± 35	16 ± 5	498 ± 37	12 ± 5	526 ± 56	19 ± 11
TST (min)	389 ± 51	18 ± 4	385 ± 52	16 ± 5	397 ± 67	19 ± 7
SONL (min)	30 ± 15	128 ± 38	25 ± 13	118 ± 46	45 ± 36	101 ± 27

(continued)

Table 1 (Continued)

(B) Nighttime sleep						
	14 days		Week		Weekend	
WASO (min)	119 ± 47	64 ± 19	113 ± 44	57 ± 21	129 ± 77	64 ± 31
SOFL (min)	24 ± 13	104 ± 29	23 ± 14	108 ± 32	26 ± 16	80 ± 27
SLBOUITS (number)	27 ± 6	27 ± 9	27 ± 7	23 ± 10	28 ± 8	28 ± 14
FRAGIN (%)	33 ± 10	31 ± 13	32 ± 10	30 ± 13	34 ± 12	26 ± 15
SEI (%)	70 ± 9	16 ± 6	71 ± 9	15 ± 6	67 ± 11	13 ± 8
(C) Daytime sleep						
	14 days		Week		Weekend	
I	M ± SD	V ± SD	M ± SD	V ± SD	M ± SD	V ± SD
SPT (min)	89 ± 31	49 ± 22	79 ± 33	40 ± 13	113 ± 73	25 ± 16
TST (min)	81 ± 27	44 ± 21	73 ± 30	35 ± 10	103 ± 67	22 ± 18
SONL (min)	13 ± 10	80 ± 42	9 ± 9	73 ± 20	22 ± 41	68 ± 46
WASO (min)	9 ± 8	118 ± 39	6 ± 4	157 ± 42	9 ± 8	85 ± 54
SOFL (min)	9 ± 6	105 ± 47	10 ± 8	111 ± 28	9 ± 9	55 ± 45
SLBOUITS (number)	4 ± 2	62 ± 24	3 ± 1	65 ± 15	4 ± 3	34 ± 27
FRAGIN (%)	20 ± 10	84 ± 29	15 ± 11	68 ± 28	20 ± 12	63 ± 37
SEI (%)	72 ± 9	18 ± 9	75 ± 10	17 ± 6	73 ± 11	10 ± 11
II						
SPT (min)	102 ± 34	49 ± 24	100 ± 30	44 ± 29	109 ± 61	40 ± 24
TST (min)	93 ± 31	46 ± 24	97 ± 26	41 ± 27	98 ± 55	38 ± 24
SONL (min)	9 ± 5	100 ± 43	8 ± 6	86 ± 43	9 ± 9	76 ± 45
WASO (min)	9 ± 5	112 ± 60	9 ± 6	96 ± 61	10 ± 9	85 ± 45
SOFL (min)	11 ± 9	107 ± 29	12 ± 12	100 ± 35	8 ± 6	83 ± 40
SLBOUITS (number)	4 ± 2	60 ± 26	4 ± 2	58 ± 32	4 ± 3	45 ± 33
FRAGIN (%)	22 ± 9	62 ± 24	23 ± 10	59 ± 31	19 ± 11	73 ± 25
SEI (%)	75 ± 8	14 ± 10	76 ± 8	13 ± 11	75 ± 14	11 ± 9
III						
SPT (min)	89 ± 27	38 ± 23	86 ± 29	34 ± 24	111 ± 33	47 ± 31
TST (min)	82 ± 23	36 ± 21	79 ± 24	34 ± 23	99 ± 27	44 ± 30
SONL (min)	9 ± 5	84 ± 39	9 ± 6	74 ± 33	11 ± 7	75 ± 43
WASO (min)	8 ± 7	117 ± 57	7 ± 7	114 ± 57	12 ± 11	106 ± 51
SOFL (min)	11 ± 7	110 ± 31	10 ± 9	101 ± 43	10 ± 9	85 ± 27
SLBOUITS (number)	4 ± 2	50 ± 14	3 ± 2	48 ± 17	4 ± 2	51 ± 21
FRAGIN (%)	16 ± 8	81 ± 32	15 ± 8	73 ± 37	21 ± 12	70 ± 29
SEI (%)	73 ± 7	18 ± 12	75 ± 8	17 ± 14	74 ± 9	22 ± 27

M, mean; V (%variability), percentage variability relative to the mean of each child; SPT (min), Sleep Period Time; TST (min), Total Sleep Time; SONL (min), Sleep Onset Latency; WASO (min), Wake After Sleep Onset; SOFL (min), Sleep Offset Latency; SLBOUITS (number), Sleep Bouts; FRAGIN (%), Fragmentation Index; SEI (%), Sleep Efficiency Index; Week, Sunday, Monday, Tuesday, Wednesday, Thursday; Weekend, Friday and Saturday.

WASO was higher [$F(1,23) = 13$, $P = 0.002$]. TST: Nighttime TST was more variable on weekend across I–III [$F(1,23) = 5.3$, $P = 0.03$]. SLBOUITS and FRAGIN: More nighttime SLBOUITS were recorded during weekend [$F(1,23) = 5.4$, $P = 0.03$] but also a higher FRAGIN [$F(1, 23) = 10.7$, $P = 0.004$].

In summary, “shifts” in nighttime sleep during weekends in a realm of habitual (i.e., across I–III) poor sleep was found.

Daytime Sleep across Three Separate 14-day Recording Periods

WASO: Only more daytime WASO during weekend was recorded [$\chi^2(5) = 11.9$, $P = 0.04$] (Table 1C).

Daytime sleep duration inversely correlated with age across the recording periods; that is, $r = -0.46$ to -0.50 , $P < 0.05$. One 5-year-old child did not nap at all across the three recording periods, one 7-, 8- and 9-year-old children napped during only one of the recording periods, and one 4-year-old child napped only during two recording periods. All other children napped during each of the recording periods.

Separate analyses showed that during the first recording period, children napped on average 4.2 ± 3.3 days of the week and 1.3 ± 1.4 days of the weekend. This was similar during the second and third recording period; 3.5 ± 2.5 days of the week, and 1.3 ± 1.1 days of the weekend and 4.0 ± 3.2 days of the week, and 1.3 ± 1.1 days of the weekend, respectively. However, across

days, different napping patterns were found (Table 2); I: more morning naps (<11:00 am) on Thursdays, more noon naps (11:00 am–2:00 pm) on Friday, Monday–Wednesday, and fewer noon naps on Saturday and Sunday yet more afternoon naps (2:00 pm–4:00 pm) [$\chi^2(18) = 42.7, P < 0.0001$]; II: fewer afternoon naps on Fridays, and fewer noon napping on Saturday and Sunday but more afternoon naps on Saturday and late afternoon (>4:00 pm) on Sundays, while on Tuesdays and Wednesday more noon napping [$\chi^2(18) = 33.1, P = 0.02$]; III: more noon naps on Monday–Thursday, and more afternoon naps on Friday–Sunday, yet again fewer noon naps on Saturday and Sunday but also more late afternoon naps on these 2 days [$\chi^2(18) = 42.9, P < 0.0001$]. Table 2 shows that the distribution of naps over 3 months changed [$\chi^2(6) = 14.6, P = 0.02$], but no difference in their duration was found.

As a result, children slept about 390.7 ± 46.9 min per night and napped about 85 ± 26.7 min throughout a 14-day recording period over 3 months. Furthermore, with a variability of about 1.4 h, they slept consistently fewer hours than developmentally expected. In addition, they exhibited about 2.1 h wake time during their nighttime sleep period. Falling asleep took about 31.9 min at night and 10.5 min when napping. The highest variability was noted in SONL and SOFL, and the quality of napping (i.e., lots of WASO). In addition, weekly noon napping is shifted toward the afternoon on Saturday and Sunday.

Interrelation of Changes in Nighttime and Daytime Sleep across Three Separate 14-day Recording Periods

Regardless of the days of the week, several sleep changes (i.e., SRBC) over 3 months were associated. Namely, more SPT at nighttime was associated with less WASO at napping ($r_s = -0.67, P = 0.001$), while more variable TST at nighttime associated with shorter SOFL at napping ($r_s = -0.81, P < 0.0001$). Also inversely associated were variable FRAGIN at nighttime and WASO at napping ($r_s = -0.74, P < 0.0001$). Highly variable SLBOUTS at nighttime was associated with more FRAGIN at napping ($r_s = 0.69, P = 0.002$). When focusing on weekdays separately, more variable SPT at nighttime was associated positively with nap SPT ($r_s = 0.93, P = 0.002$). During weekends, more variable nighttime SONL was associated negatively with variable FRAGIN at daytime ($r_s = -0.91, P = 0.002$).

Alternatively, more FRAGIN at nighttime during the week was associated with an increased weekend daytime SEI change ($r_s = 0.65, P = 0.006$), while more variable SLBOUTS at nighttime

during the week correlated with increased weekend daytime SONL change ($r_s = 0.70, P = 0.003$).

Also when examining daytime and nighttime sleep interrelations (Figure 2), they were suggestive of “catch-up” daytime sleep. Namely, SRBC above or below two indicates an individual clinical significant change. In general, when sleeping fewer hours at night, napping increased and this especially when given the opportunity (e.g., weekend).

Discussion

The findings of our study of young African American children from disadvantaged background indicated that children habitually sleep a suboptimal amount and that napping might be “a need” and “a chance.” Children slept at night 6.5 h and at daytime changeably 1.4 h, likely being noon naps during the week and afternoon naps on Saturday and Sunday. Variability in quality of sleep, and also nighttime sleep duration, especially on Friday and Saturday, was characteristic. Interventions might emphasize on creating optimum opportunities to sleep.

There were methodological limitations in the present study that merit discussion. In-home sleep recording was performed by actigraphy or a nondominant wrist accelerometer, which does not allow sleep staging and generates interdependent sleep parameters, both being a limitation. Yet this device showed sufficient reliability and validity to approximate sleep [26]. This study further focused on objective sleep duration and thus to a lesser extent on potential sleep schedules. Similarly, sleep behaviors and problems, sleep ecology, and circadian rhythmicity will be discussed elsewhere. This also applies to lifestyle and neighborhood stressors, and child’s daytime behavior data collected in this study. Sleep was recorded in a small sample of African American children. External generalizability of findings remains limited to an African American sample of 3- to 9-year-olds, which was in socio-demographic terms comparable to an underserved minority sample yet without overt problems and representative when compared to our large-scale survey [20]. As strength, the within-subject design has the benefit that every subject acted as their own “control.” Given that the Actiwatch is “observing” the subjects and it is a commonly applied tool within pediatric sleep research, there are no between-subject criteria. The repeated measure and applied tool combined with an extended (i.e., 14 days) objective recording period spread over 3 months (i.e., multiple data points collected), increased validity of findings.

Our findings concurred with previous parental reports indicating poor sleep in minority subsamples [10,13,16,17,27,28]. For

Table 2 Distribution and duration of daytime sleep

Nap	I (n = 21)		II (n = 19)		III (n = 19)		Test statistic P-value
	%	M $\pm$ SD (min)	%	M $\pm$ SD (min)	%	M $\pm$ SD (min)	
Morning	2	162 $\pm$ 187	5	140 $\pm$ 9	1.6	64 $\pm$ 1	H(2,10) = 3.3, $P = 0.20$
Noon	70	95 $\pm$ 35	68	95 $\pm$ 44	73	101 $\pm$ 37	H(2,35) = 4.1, $P = 0.13$
Afternoon	24	100 $\pm$ 76	13	99 $\pm$ 53	12.7	77 $\pm$ 47	H(2,61) = 1.4, $P = 0.49$
Late Afternoon	5	54 $\pm$ 31	14	118 $\pm$ 114	12.7	65 $\pm$ 50	H(2,37) = 1.7, $P = 0.43$

I, first recording period; II, second recording period; III, third recording period; M, mean; SD, standard deviation.

Figure 2 Interrelation between daytime and nighttime sleep. *Left panel:* 14-day total sleep time: When sleeping more after 4 weeks (x-axis) but subsequently sleeping less (i.e., after 6 weeks; y-axis), daytime napping increased (i.e., over 12 weeks; z-axis). Alternatively, when sleeping fewer hours (x-axis) yet when subsequently sleep time was increased (y-axis), napping was decreased (z-axis). *Middle panel:* Week total sleep time: When sleeping fewer hours at nighttime during the weekend (x-axis) and subsequently continue to sleep few hours at night during the week (i.e., after 6 weeks; y-axis), week napping increased (z-axis), and reverse. *Right panel:* Weekend total sleep time: When sleeping fewer hours at nighttime during the weekend (x-axis), irrespective of the subsequent amount of sleep time on weekend days (i.e., after 6 weeks; y-axis), weekend napping increased (i.e., over 12 weeks; z-axis). However, when sleeping more (x-axis) and continue to sleep more at nighttime during the weekends (y-axis), weekend napping also increased (z-axis). SRBC above or below two indicates a clinical significant change.

example, in 2- to 8-year-olds, weekday nighttime sleep duration ranged from 598 to 618 min per parental report, which was about 20 min less in comparison with White non-Hispanics [16]. In the National Sleep Foundation study, reflecting the past 2 weeks, preschoolers and school-aged children slept about 9.4–9.6 h [29]. Our actigraphic recording findings indicated an average of 390.7 min of nighttime sleep and an overall sleep period of 9.2 h long with 7.6 h of total (i.e., actual) sleep. Our finding further allies with the reported family habit of 6.2 h of sleep in African American adults [10]. Similarly, our recorded sleep data are fitting the 95% CI of 9.46–9.84 h for sleep period time in our large-scale survey in the South Side of Chicago [20]. This is in line with the potential overestimation per subjective report and underestimation per polysomnographic recording of actigraphic recording findings [23]. More importantly, in light of habitually poor nighttime sleep found in this study not all children napped and this neither on all days nor on regular times. The interrelations with nighttime sleep were furthermore suggestive of “catch-up” daytime sleep or sleeping when the opportunity was given. Particularly, nighttime variability in sleep period time, sleep duration, and fragmentation interrelated with daytime sleep quality. That is, qualitative better daytime sleep (i.e., few WASOs) to likely uphold overall needed sleep. More recently, such diurnal fluctuations and potential sleep architecture rebounds are gaining interest [30]. For instance, higher levels of daytime sleepiness and lower slow wave sleep (or deep sleep) in adult nappers have been speculated. [31] More importantly, napping is being related to performance [32,33]. However, whether such findings regarding napping can be extrapolated to childhood needs to be explored.

Despite being discrepant to subjective [23] or polysomnographic [23] nighttime sleep onset and offset assessments, both sleep parameters were found to be highly variable. Specifically, sleep onset latency or the time it takes to fall asleep was varied.

Additionally, sleep onset latency was longer on weekends, whereas sleep offset latency was least variable on weekends. With respect to our sleep onset and offset findings, the link with sleep quality and schedule cannot be ignored [34]. Although being a single mom was found not to impact preschoolers’ bedtime routines [13], marital conflict, emotional insecurity [35] may affect sleep in its quality, duration, and timing. Investigation with regard to the impact of sleep ecology or environmental factors is similarly needed. Indeed, shared sleep ecology has been reported in minority samples [8]. Likewise, neighborhood violence has been suggested to impact sleep adversely [36]. Alternatively, from a cultural or socioeconomic perspective, “opportunity sleeping” may have gradually cultivated in underprivileged children or mimic their 21st century social regulation of sleep [37]. Hypothetically, children might not have outgrown the polyphasic sleep habit due to societal constraints. In our ephemeral lifestyles, for instance, the importance of regularity of sleep may have dissipated. Namely, only 14% of the surveyed South Side of Chicago children awaken spontaneously [20], which is suggestive of a fulfilled need for sleep. Altogether “opportunity sleeping” might affect sleep onset and offset. Sleep onset latency and offset latency are additionally not to be discarded in the realm of sleep problems or disturbed sleep [34]. Speculatively, our African American children might be balancing between fear or anxiety and excessive sleepiness, and as a result, a vigilant state was sought, maintained, or preferred. They therefore may experience a daily challenge whether to sleep or not.

Two lay misperceptions should be disputed: namely, on the one hand, more or better sleep on weekends and, on the other hand, quality napping (i.e., few WASOs). Although we found more sleep bouts on weekends, we concomitantly found more wake after sleep onset and more fragmentation. As a result, this flexible “extra” amount of time spent in bed was not always gainful

toward “true” sleep. Such misperceptions probably confound results of subjective reports, further aiding the unrecognized seriousness of habitual sleep deprivation in developing children. Considering that developmentally a child engages in sleeping activities more than in any other activity during the 24-h cycle, and normal patterns of activities such as eating or playing have been meticulously delineated, observed, and quantified, sleep and its impact especially in the underprivileged child has been disregarded. Given that the duration of napping remained unaltered across 3 months its distribution changed, which is suggestive of a need coinciding with an opportunity. This interrelation has been supported in terms of our correlations and our plots. Such preponderance of napping in the sleep patterns of minorities was found in previous surveys yet unrelated to the amount or the quality of nighttime sleep. Albeit society emphasizes daytime functioning reinforcing accomplishments, the importance of sleep in cognitive–emotional/motivational behavioral functions is progressively more shown. Still, more sleep studies are needed to increase understanding of the dynamics in sleep–wake patterns, and subsequently its consequences, especially in the underprivileged.

In summary, habitually poor sleep in underprivileged children is a serious health risk that should no longer be ignored.

In the spirit of “No Child Left Behind” and “Achievement Gap” in the United States, the role of a vital function as sleep for a developing child has been amply addressed. Yet our findings not only repeat but also quantify the persistent disparity and health risk.

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Conflict of Interest

The authors declare no conflict of interest.

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