HHS Public Access

Author manuscript

Psychosom Med. Author manuscript; available in PMC 2019 February 01.

Published in final edited form as:

Psychosom Med. 2018 ; 80(2): 200–207. doi:10.1097/PSY.0000000000000542.

The relationship between childhood trauma and poor sleep health in adulthood

Ryan C. Brindle, Ph.D.[1], **Matthew R. Cribbet, Ph.D.**[2], **Laura B. Samuelsson, M.S.**[1], **Chenlu Gao, M.A.**[3], **Ellen Frank, Ph.D.**[1], **Robert T. Krafty, Ph.D.**[4], **Julian F. Thayer, Ph.D.**[5], **Daniel J. Buysse, M.D.**[1], and **Martica H. Hall, Ph.D.**[1]

[1]Department of Psychiatry, University of Pittsburgh

[2]Department of Psychological Sciences, Texas Tech University

[3]Department of Psychology and Neuroscience, Baylor University

[4]Department of Biostatistics, University of Pittsburgh

[5]Department of Psychology, The Ohio State University

Abstract

Objective—Childhood trauma has been related to adverse behavioral, mental, and health outcomes later in life. Sleep may be a potential mechanism through which childhood trauma is related to adverse health. The current retrospective study aimed to characterize the relationship between childhood trauma exposure and sleep health, a novel multidimensional measure of sleep.

Methods—Participants (N = 161; Mean(SD) age = 59.85(9.06); 67.7% female) retrospectively reported trauma exposure using the Trauma History Questionnaire. Childhood trauma was defined as the number of reported traumatic events prior to 18-years of age. Trauma exposure post-18 years of age and across the lifespan was also recorded. Sleep health was derived both from diary- and actigraphy-assessed measures of sleep regularity, timing, efficiency, and duration, subjective sleep satisfaction, and daytime sleepiness from the Epworth Sleepiness Scale. The relationships between childhood trauma exposure and sleep health was examined using hierarchical linear regression, controlling for relevant covariates.

Results—In unadjusted models, a greater number of childhood trauma exposures was associated with poorer diary- and actigraphy-measured sleep health in adulthood. After adjustment for current stress, depression history, and other sociodemographic covariates, greater childhood trauma remained significantly associated with poorer sleep health (diary: $\beta = -0.20$, $\Delta R^2 = .032$; actigraphy: $\beta = -0.19$, $\Delta R^2 = .027$). Trauma exposure post-18 years of age and across the lifespan did not relate to diary- or actigraphy-based sleep health.

Corresponding Author: Ryan C. Brindle, Ph.D. University of Pittsburgh School of Medicine, Department of Psychiatry, 3811 O'Hara Street, Pittsburgh, PA 15232 Phone: +1 (412) 246 6144, BrindleRC@upmc.edu.

Financial Disclosure Statement: The authors have no financial relationships relevant to this article to disclose.

Potential Conflicts of Interest: Drs. Hall, Brindle, Cribbet, Thayer, Krafty, Frank, Buysse, and Laura B. Samuelsson report grants from the National Institutes of Health. Additionally, Dr. Frank reports the following: American Psychological Association (Royalties); Guilford Press (Royalties); HealthRhythms, Inc. (Equity Interest); Psychiatric Assessments, Inc, (Equity Interest); Servier International (Advisory Board). Authors report no additional conflicts of interest.

Conclusion—Childhood trauma may affect sleep health in adulthood. These findings align with the growing body of evidence linking childhood trauma to adverse health outcomes later in life.

Keywords

Childhood Trauma; Sleep Health; Stress; Sleep Medicine; Sleep Diary; Actigraphy

Introduction

The prevalence of childhood trauma is alarmingly high (1,2) and is increasingly being considered a medically-relevant contributor to morbidity and mortality given the accumulating evidence showing relationships between childhood trauma and adverse behavioral (3,4), mental (5,6), and health outcomes (7,8). Because of this, it is important that we characterize the pathways through which childhood trauma affects health.

One such pathway may be sleep. Several retrospective cohort studies report a significant "dose-response" relationship between childhood trauma and sleep problems later in life (9–11). A systematic review of these studies noted significant effects of trauma on sleep apnea, nightmare-related distress, and insomnia symptoms (12). Sleep and sleep problems have also been related to a range of adverse behavioral, mental, and health outcomes similar to those associated with childhood trauma (13–16). Finally, normative sleep has been shown to be critical for physiological (17,18) and emotional (19) restitution and may represent an endogenous nocturnal coping mechanism necessary to stave off the physiological and emotion consequences of traumatic stress not adequately mitigated by psychological and behavioral coping mechanisms employed during wakefulness. For example, the quantity and quality of consolidated rapid-eye movement sleep following a traumatic experience has been associated with the presence and severity of post-traumatic stress disorder symptoms at follow-up (20,21). Consequently, chronically compromised sleep may contribute to long-term deterioration of physiological and emotional health. For these reasons, it is possible that sleep may be a pathway through which childhood trauma promotes poor health later in life and, if so, may also represent a potential behavioral target for intervention to reduce the negative, long term health effects of childhood trauma. To explore this possibility, a better understanding of the impact of childhood trauma on sleep is necessary. However, the heterogeneity of sleep outcome variables evaluated in previous studies, including the frequent use of single-item measures, significantly limits comparisons across studies and interpretation of results with regard to how sleep outcomes relate to health (12).

Sleep health (22) is an important construct designed to conceptualize and quantify sleep in a manner consistent with other health-related variables, e.g., cardiovascular-, metabolic-, psychiatric-health. As such, sleep health has been conceptualized as a multivariable construct including measures of sleep *regularity*, *satisfaction*, *timing*, *efficiency*, and *duration*, and *daytime sleepiness*. In support, structural equation modeling has shown these six dimensions successfully load onto a single underlying latent sleep health construct (model fit indices: CFI = .995, TLI = .964, SRMR = .026; 23). As such, this construct offers several advantages over traditionally evaluated, single-item measures of sleep. First, sleep health is a continuous measure that frames sleep in a positive light and can be implemented

and interpreted across a range of health-related contexts and populations (e.g., patients, healthcare providers, educators). Second, quantifying sleep health on a continuous scale makes available a wealth of research opportunities not previously available in experimental designs where sleep health was dichotomized on the basis of disease presence or absence (e.g., insomnia, sleep apnea). Sleep health is not simply the absence of a clinical sleep disorder, but can vary incrementally between individuals allowing for the exploration of correlates of individual differences in sleep health. Third, each of the six sleep health components has been shown to independently relate to health outcomes (please see Table 1 in reference (22)) including cardiovascular and metabolic diseases (24), psychiatric illness (13), cognitive performance (25), and mortality (26–29). Consequently, sleep health establishes a framework for future research to characterize sleep-related pathways to disease. To date, independent studies have significantly related sleep health to blood pressure and BMI (23), self-reported health (30), and clinically-significant depression symptoms (31). Finally, sleep health aligns with broader health agendas and public policy and represents a target for the improvement of sleep, regardless of whether a clinically significant sleep disorder is present. The current retrospective study aimed to examine the relationships between retrospectively-reported childhood trauma exposure and sleep health in adulthood. Based on evidence linking childhood trauma to suboptimal sleep and sleep disorders (12), it was hypothesized that individuals reporting increased trauma exposure during childhood would have poorer subjectively- (e.g., diary) and behaviorally-measured (e.g., actigraphy) sleep health.

Methods

Participants

The current study represents a secondary analysis of data collected to analyze the relationships between sleep, depression and cardiovascular disease risk. Participants were recruited from a larger cohort of four separate studies conducted at the University of Pittsburgh between 1982–1999. One study [MH024652 (32)] examined sleep in adults without personal or first-degree family history of psychiatric disorders; the remaining three studies assessed sleep in individuals with major depressive disorder (MDD) [MH029618, MH049115, MH041884 (33–36)]. Of the 339 participants re-contacted from 2010–2014 to participate in the current study, 177 consented. For the purpose of the present report, data were available for 161 participants. This study was approved by the University of Pittsburgh Institutional Review Board and all participants provided written informed consent. Financial compensation was provided to participants.

Procedure

Upon entry to the current study participants underwent mental and physical health assessments. During the mental health assessment, lifetime psychiatric history was assessed by trained clinicians using the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I; 37). During the physical health assessment, a detailed medical history was taken, along with objective anthropometric measurements [e.g., body mass index (BMI) in kg/m^2]. Participants were instructed to complete a daily diary and wear a wrist actigraph over a 2-week period to track health and sleep-wake behaviors. Finally, participants returned to the

laboratory and completed a battery of questionnaires, a cardiovascular assessment, and a 2-night polysomnography (PSG) laboratory sleep study (cardiovascular and PSG data presented elsewhere (38)).

Study Measures

Sleep Health—Our protocol afforded the opportunity to calculate both subjective sleep health, as assessed by daily diary self-reports, and behaviorally-assessed sleep health, as assessed by wrist actigraphy. For the subjective assessment of sleep health, the six components of sleep health (22) were derived from the Pittsburgh Sleep Diary (39), which participants completed for up to two weeks (mean = 9.75 days, range: 6–14 days), and the Epworth Sleepiness Scale (40), a validated measure of daytime sleepiness. Actigraphy-based sleep health was derived from actigraphy-assessed measures of sleep duration, regularity, timing, and efficiency; the sleep quality and daytime sleepiness components were measured by self-report, as appropriate to the protocol. Participants wore the Actiwatch-2® actigraph (Philips-Respironics, Bend, OR) 24-hours per day on the non-dominant wrist for a minimum of 7 consecutive days (mean = 9.29 days, range: 7–14 days). Nocturnal sleep intervals were identified by automated algorithms and confirmed by event markers and daily diaries. Actigraphy data were analyzed with Actiware 6.1 software, using the medium sensitivity setting and scored in 30-second epochs. Table 1 outlines the operationalization of the six components of sleep health and the rationale for chosen cut-off values. In general, cut-off values were chosen from larger, community-based samples of older adults and from published meta-, and psychometric-analyses (41–44). Each component of sleep health was dichotomized as 0 or 1, with a higher score indicting better sleep health. Thus, total sleep health scores range from 0–6, with a value of 6 indicating optimal sleep health and a value of 0 indicating poorest sleep health.

Trauma History—Trauma history was measured using the Trauma History Questionnaire (THQ; 45,46). The THQ is a retrospective self-reported inventory of “high-magnitude stressor events” applicable to the general population. The THQ is relatively stable over time. The stability coefficient for total number of trauma events is 0.76 over 2 weeks (47), while values for individual trauma categories range from 0.54–0.92 over a 2–3 month period (48). The inventory is comprised of 24 yes/no questions, grouped into three categories: crime-related trauma, general disasters, and unwanted physical/sexual trauma. When an event is endorsed, participants provide frequency of occurrence and age of exposure(s). To test the hypothesis of the current study, trauma exposure before 18 years of age (number of endorsed event types multiplied by reported frequency of each event type) was calculated from the THQ. Trauma exposures across the lifetime and after 18 years of age were also quantified.

Possible Covariates

Current stress at the time of study participation was measured using a self-reported inventory of chronic and ongoing stress. Participants rated the extent to which each of eleven stressor categories (e.g., financial, relationship, work-related stress) caused stress over the prior 12 months. The rating scale was 0 (no stress) to 3 (most upsetting stress); total scores ranged from 0–33. Diagnostic information from the original four studies and the mental health assessment of the current study were used to determine *lifetime depression status*.

Individuals with no history of MDD at either time point were categorized as having "no MDD history." Those who endorsed a single major depressive episode across the lifespan were grouped in a "single episode MDD" category. Finally, participants endorsing more than one lifetime major depressive episode were coded as "recurrent MDD." In follow-up supplementary analyses, *Hamilton Depression Rating Scale scores*, less sleep items (items 4–6), were used in lieu of *lifetime depression history* (49,50). The total score from a modified 12-item version of the Interpersonal Support Evaluation (51) was used to assess perceived availability of *interpersonal support*. Participants responded to counterbalanced (positive versus negative) items using a 4-point Likert-style scale anchored by "definitely false" and "definitely true," with higher scores indicating a greater availability of interpersonal support (range: 0–48). This scale has been shown to display high internal reliability (Cronbach's α range = 0.88–0.90) and acceptable test-retest reliability (*r*-range: 0.70–0.87). Socio-economic status was measured using *education* level and s*ubjective social standing*. Education was self-reported using an 8-level scale that ranged from middle school to post-graduate school. Subjective social standing was assessed using a 9-rung social standing ladder (52). Participants were asked to rate their perceived social standing, relative to their community ranging from 1 (highest) to 9 (lowest). *Daily alcohol use*, in drinks per day, was assessed via daily diary. *Sex*, *age*, and *BMI*, and *time 1 parent cohort* were also identified as potential covariates.

Statistical Analysis

A small group of participants (n = 13) indicated that their traumatic experiences before the age of 18 were too numerous to count. To preserve rank order of reported trauma exposures in statistical analyses, these participants were given a value equal to the 95th percentile (53). It should be noted that, in sensitivity analyses, removal of these participants did not change the reported results (results not shown). Hierarchical linear regression was used to examine the relationship between childhood trauma exposure and both diary- and actigraphy-based sleep health. An unadjusted model tested whether increased childhood trauma related to poorer sleep health. In a second model, adjustments were made for time 1 parent cohort and covariates found to be associated with sleep health in the present sample: lifetime depression status, current stress, subjective social standing, and interpersonal support, p values < .10. Finally, a fully adjusted model was tested that included all *a priori* potential covariates. This series of analyses was repeated using both lifetime trauma exposure and trauma exposure post-18 years of age as independent variables. Finally, a series of follow-up analyses using binary logistic regression were undertaken to determine which dimensions of sleep health were significantly associated with childhood trauma. An unadjusted model was tested followed by two adjusted models that were identical to those outlined above. Lifetime depression status was dummy-coded before inclusion in all regression analyses. All data are presented as mean (standard deviation), unless otherwise stated. Statistical analyses were carried out using SPSS version 23 (IBM; Chicago, IL). For all analyses, statistical significance was operationalized as $\alpha < .05$. For analyses with actigraphy-based sleep health, 138 participants were available for analysis; discrepancies in participant number (as reported in the tables) represent occasional missing data points.

Results

Sample Characteristics

Participants (N = 161; 67.7% females; 98.1% non-Hispanic White) were, on average, 59.85 (9.06) years old and had a BMI of 30.11 (7.05). Fifty-nine participants had no lifetime history of MDD, 17 participants met criteria for a single lifetime MDD episode, and 66 individuals were classified as recurrent MDD patients. On average, current self-reported stress score was 5.09 (4.17) and scores of interpersonal support and subjective social standing were 41.12 (6.44) and 3.71 (1.71), respectively. Average sleep health score was 3.11 (1.18) and 3.09 (1.34) for diary- and actigraphy-based measures, respectively. Average Hamilton Depression Rating Scale score was 4.47 (4.77) and average childhood trauma exposure was 1.03 (1.77) events.

Childhood Trauma and Sleep Health

The amounts of trauma exposure reported pre- and post-18 years of age were significantly related ($r = .191$, $p = .016$), although the relationship was not particularly strong. Sample sleep characteristics and results of the linear regression analysis of childhood trauma and sleep health can be found in Tables 2 and 3, respectively. In both unadjusted and adjusted models, childhood trauma was related to both diary- and actigraphy-based sleep health such that greater childhood trauma was associated with a lower sleep health scores (β-range = −.19 to −.27; all $p \leq .07$). After controlling for time 1 parent cohort, gender, age, lifetime depression history, subjective social standing, BMI, current stress, daily alcohol use, and interpersonal support, diary-based sleep health decreased by −.15 units (95% CI −0.28 to −0.01, $p = .031$) per traumatic event (adjusted model 2, Table 3). For actigraphy-based sleep health, sleep health decreased −.17 (95% CI −0.35 to 0.01, $p = .07$) units per childhood traumatic event in the same fully adjusted model (adjusted model 2, Table 3). Increased childhood trauma was significantly associated with increased risk of reporting poor diary-assessed sleep efficiency after controlling for time 1 parent cohort, depression history, current stress, interpersonal support, and subjective social standing (OR = 1.34, $p = .041$) in sleep health component analyses. No single component of actigraphy-based sleep health was significantly related to childhood trauma (all p's $\geq .07$).

Lifetime Trauma and Sleep Health

Regression analyses revealed that neither lifetime trauma exposure nor trauma exposure post-18 years of age was related to diary- or actigraphy-based sleep health (all p's $> .05$; Table 3).

Sensitivity Analyses

In sensitivity analyses, substituting Hamilton Depression Rating Scale scores for lifetime depression status did not change any of the reported results (Table S1, Supplemental Digital Content). Similarly, substituting subjective social standing with education did not alter the observed results (Table S2) Finally, analyses restricted to participants with complete data (e.g., all variables of interest and covariates), yielded identical results to those reported (Table S3).

Discussion

Our findings are consistent with the hypothesis that greater childhood trauma is associated with poorer sleep health in adulthood. Regression analysis revealed that increased retrospectively reported childhood trauma exposure was associated with poorer diary- and actigraphy-based sleep health, after multivariate adjustment for current stress, interpersonal support, depression history and other sociodemographic covariates. Notably, associations among trauma and sleep health were observed for childhood trauma only; neither lifetime trauma exposure nor trauma exposure after 18 years of age was significantly related to sleep health. Overall, these results align with evidence that childhood trauma may influence sleep and waking health later in life.

Several retrospective cohort studies report a significant association between childhood trauma and indices of suboptimal sleep later in life. In the Finnish Health and Social Support cohort, a significant graded association was found between family-related childhood trauma and self-reported sleep quality; endorsing multiple traumatic events significantly increased the odds of lower sleep quality later in life (9). A significant association between childhood abuse and subjective sleep quality was observed in the Midlife Development in the US cohort (10). In a California-based health maintenance organization cohort, endorsing any number of adverse childhood experiences (e.g., abuse, violence) significantly increased the odds of self-reported troubles falling asleep and daytime sleepiness (11). Reporting frequent insufficient sleep was significantly more likely in individuals reporting ≥1 adverse childhood experience in the Behavioral Risk Factor Surveillance Survey (2). Finally, a systematic review of retrospective cohort studies (12) and two prospective studies (54,55) support the hypothesis that childhood trauma is associated with indices of poor sleep later in life.

The present finding that retrospectively-reported childhood trauma is significantly related to poor sleep health, after multivariate adjustment including lifetime depression history, current stress, interpersonal support, and other covariates, replicates previous research and provides several novel additions to the literature. First, both diary- and actigraphy-based sleep health measures were associated with childhood trauma, but not adult or lifetime trauma. This finding not only speaks to the potentially heightened impact that childhood trauma has on sleep later in life, but also provides more robust evidence in support of previous findings linking childhood trauma and self-reported sleep disturbances using single-item measures. Previous research has often operationalized sleep using single-item or dichotomous sleep measures which limits the ability to interpret results vis-á-vis health, compare results across studies, and fails to capture the multidimensional nature of sleep (12,22). Sleep health, a composite measure of sleep duration, efficiency, satisfaction, timing, regularity, and daytime sleepiness, captures the multidimensional nature of sleep. The composite measure of sleep health related to childhood trauma after adjustment for a range of potential covariates including lifetime depression history and current stress. That childhood trauma was not systematically related to any one sleep health dimension after covariate adjustment, yet was associated with a multivariable composite measure of sleep speaks to the complex relationship between trauma and sleep and provides incentive for future research to probe the impact of trauma across many dimensions of sleep. It should be noted that the summation procedure used in the present study represents one method for computing sleep

health. While others have used a similar approach (31), latent factor analysis (23) and survey style assessments (30) have also been used to quantify sleep health. Although conceptually similar, each approach is statistically unique and underscores the need for a psychometrically valid method operationalizing sleep health. Second, as each of these dimensions has been independently associated with clinical health outcomes (22), these results provide a framework for future research aimed at understanding the role of sleep as a potential mediator of the adverse health impact of childhood trauma. For example, in three separate studies sleep health has been associated with clinically-relevant depression symptoms (31), self-reported health (30), and blood pressure and BMI (23). Finally, not unlike a cardiovascular disease risk profile (56), sleep health is relevant to everyone, irrespective of whether a clinical sleep disorder is present or not, and is easily understandable. Thus, interventions to promote sleep health might be developed to reach a larger number of at-risk individuals. More specific to the aims of the present paper, sleep health interventions might also be developed as part of public health campaigns to improve sleep health in target populations (e.g., individuals with childhood trauma exposure).

Equally important is understanding the possible physiological, behavioral, and psychosocial pathways whereby childhood trauma adversely affects sleep health later in life. For example, childhood trauma may negatively affect cortisol regulation (57), to the detriment of sleep (58). Studies in children have shown trauma exposure to be associated with an attenuated cortisol awakening response (59,60) and a failure of cortisol to decline in the evening (61). Although still debated, trauma has been related to both augmented (57,62) and diminished (63,64) cortisol stress responses. Similarly, individuals who experience trauma in childhood have upregulated indicators of sympathetic nervous system activity, such as urinary catecholamines (65,66). Behaviorally, environments where trauma is present promote the uptake of behaviors that may impair sleep such as smoking or alcohol use (3,4,67). Similarly, a traumatic childhood environment may interfere with the learning of habits related to coping with stress and possibly lead to more stress in the future (68). Although these explanations are plausible, our results showed that the significant association between childhood trauma and sleep health withstood adjustment for daily alcohol use, current stressors, and subjective social status. Finally, the development of a mental health disorder after trauma exposure may lead to poor sleep. For example, both depression and post-traumatic stress disorder (PTSD) are associated with poor sleep (69–71). Although the current study excluded individuals with PTSD, we found that the relationship between childhood trauma and sleep health was independent of clinically-assessed lifetime MDD history.

The present results must be considered in light of several limitations. First, it is possible that recall bias may have influenced retrospective reports of trauma. However, previous studies designed to assess retrospective recall bias of trauma have failed to produce compelling evidence of systematic recall bias (72–74). Second, the sample was composed of mostly non-Hispanic White participants. Thus, generalizability to other racial/ethnic cohorts may be limited. Third, the present results do not provide information regarding the lifetime development of sleep health as a function of trauma. It would be informative to understand if trauma affects sleep health immediately or if sleep health evolves as a function of trauma across the lifespan. Fourth, sample size limitations precluded analyses regarding type of

childhood trauma. Although some studies have reported a consistent negative impact of childhood trauma on future sleep, irrespective of type (e.g., physical, emotion, or sexual abuse; 9–11), other have not (75), leaving unanswered the question as to whether different types of trauma in childhood differentially affect sleep in adulthood. Given that types of childhood trauma have been shown to differentially affect biological stress responses (76–79), more fine-grained analyses of childhood trauma type are warranted in future studies.

In conclusion, in this retrospective study, greater trauma exposure prior to 18 years of age was associated with poorer sleep health in adulthood after controlling for a range of factors including lifetime MDD history and current stress. These results demonstrate that, although time may pass, childhood trauma may continue to be associated with sleep health in mid- and late-life. Given the alarming prevalence of childhood trauma experience, these data also underscore the need for research focused on understanding the negative impact childhood trauma has on sleep health and its downstream consequences to health and functioning later in life.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors would like to thank the study participants who took part in both phases of this study over a 12 to 30-year period of time. We are also grateful to our dedicated study staff for ensuring that the study envisioned by a group of investigators became a reality.

Funding Source: Supported by grants from the National Institutes of Health: Primary T2 study was R01 HL104607 (M. Hall). T1 studies were R01 MH024652 and R01 MH029618 (D. Kupfer), R01 MH049115 (E. Frank), and R01 MH041884 (M. Thase). Partial support for investigator effort was also provided by R01 GM113243 (R. Krafty, M. Hall), T32 HL07560 (R. Brindle, M. Cribbet), and F32 HL137227 (R. Brindle). Infrastructure support was provided by UL1 TR000005 and UL1 RR024153.

Abbreviations

MDD	Major Depressive Disorder
BMI	Body Mass Index
PSG	Polysomnography
SD	Standard Deviation
THQ	Trauma History Questionnaire
OR	Odds Ratio
PTSD	Post-Traumatic Stress Disorder

References

1. Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, Koss MP, Marks JS. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. Am J Prev Med. 1998; 14:245–58. [PubMed: 9635069]

2. Chapman DP, Liu YL, Presley-Cantrell LR, Edwards VJ, Wheaton AG, Perry GS, Croft JB. Adverse childhood experience and frequent insufficient sleep in 5 U.S. states, 2009: A retrospective cohort study. BMC Public Health. 2013; 13:1–9. [PubMed: 23280303]
3. Dube SR, Miller JW, Brown DW, Giles WH, Felitti VJ, Dong M, Anda RF. Adverse childhood experiences and the association with ever using alcohol and initiating alcohol use during adolescence. J Adolescent Health. 2006; 38:444e1–e10.
4. Dube SR, Felitte VJ, Dong M, Chapman DP, Giles WH, Anda RF. Child abuse, neglect, and household dysfunction and the risk of illicit drug use: The adverse childhood experiences study. Pediatrics. 2003; 111:564–72. [PubMed: 12612237]
5. Chapman DP, Whitfield CL, Felitti VJ, Cube SR, Edwards VJ, Anda RF. Adverse childhood experiences and risk of depressive disorders in adulthood. J Affective Disorders. 2004; 82:217–25.
6. Heim C, Nemeroff CB. The role of childhood trauma in the neurobiology of mood and anxiety disorders: Preclinical and clinical studies. Biol Psychiat. 2001; 49:1023–39. [PubMed: 11430844]
7. Dong M, Giles WH, Felitti VJ, Dube SR, Williams JE, Chapman DP, Anda RF. Insights into causal pathways for ischemic heart disease: Adverse childhood experiences study. Circulation. 2004; 110:761–66.
8. Brown DW, Anda RF, Tiemeier H, Felitti VJ, Croft JB, Giles WH. Adverse childhood experiences and the risk of premature mortality. Am J Prev Med. 2009; 37:389–96. [PubMed: 19840693]
9. Koskenvuo K, Hublin C, Partinen M, Paunio T, Koskenvuo M. Childhood adversities and quality of sleep in adulthood: A population-based study of 26,000 Fins. Sleep Med. 2010; 11:17–22. [PubMed: 19962937]
10. Greenfield EA, Lee C, Friedman EL, Springer KW. Childhood abuse as a risk factor for sleep problems in adulthood: Evidence from a U.S. national survey. Ann Behav Med. 2011; 42:245–56. [PubMed: 21656087]
11. Chapman DP, Wheaton AG, Anda RF, Croft JB, Edwards VJ, Liu Y, Sturgis SL, Perry GS. Adverse childhood experiences and sleep disturbances in adults. Sleep Med. 2011; 12:773–9. [PubMed: 21704556]
12. Kajeepeta S, Gelaye B, Jackson CL, Williams MA. Adverse childhood experiences are associated with adults sleep disorders: A systematic review. Sleep Med. 2015; 16:320–30. [PubMed: 25777485]
13. Baglioni C, Nanovska S, Regen W, Spiegelhalder K, Feige B, Nissen C, Reynolds CF, Riemann D. Sleep and mental disorders: A meta-analysis of polysomnographic studies. Psychol Bull. 2016; 142:969–90. [PubMed: 27416139]
14. Hasler BP, Smith LJ, Cousins JC, Bootzin RR. Circadian rhythms, sleep, and substance abuse. Sleep Med Rev. 2012; 16:67–81. [PubMed: 21620743]
15. Malhotra A, Loscalzo J. Sleep and cardiovascular disease: An overview. Prog Cardiovasc Dis. 2009; 51:279–84. [PubMed: 19110129]
16. Cai H, Shu X, Xiang YB, Yang G, Li H, Ji BT, Gao J, Gao YT, Zheng W. Sleep duration and mortality: A prospective study of 113,138 middle-aged and elderly Chinese men and women. Sleep. 2016; 38:529–36.
17. Vyazovskiy VV, Harris KD. Sleep and the single neuron: The role of global slow oscillations in individual cell rest. Nat Rev Neurosci. 2013; 14:443–51. [PubMed: 23635871]
18. Xie L, Kang H, Xu Q, Chen MJ, Liao Y, Thiyagarajan M, O'Donnell J, Christensen DJ, Nicholson C, Iliff JJ, Takano T, Deane R, Nedergaard M. Sleep drive metabolite clearance from the adult brain. Science. 2013; 342:373–77. [PubMed: 24136970]
19. van der Helm E, Walker MP. Overnight therapy? The role of sleep in emotional brain processing. Psychol Bull. 2009; 135:731–48. [PubMed: 19702380]
20. Mellman TA, Bustamante V, Fins AI, Pigeon WR, Nolan B. REM sleep and the early development of posttraumatic stress disorder. Am J Psychiatry. 2002; 159:1696–701. [PubMed: 12359675]
21. Mellman TA, Pigeon WR, Nowell PD, Nolan B. Relationships between REM sleep findings and PTSD symptoms during the early aftermath of trauma. J Trauma Stress. 2007:20893–901.
22. Buysse DJ. Sleep health: Can we define it? Does it matter? Sleep. 2014; 37:9–17. [PubMed: 24470692]

23. Cribbet MR, Hall M, Matthews K, Troxel W, Franzen P, Goldstein T, Reynolds C, Nofzinger E, Monk T, Kupfer D, Buysse D. A multidimensional construct of sleep health is associated with body mass index and blood pressure. Sleep. 2016; 39:A347–8.
24. Jennings JR, Muldoon MF, Hall M, Buysse DJ, Manuck SB. Self-reported sleep quality is associated with the metabolic syndrome. Sleep. 2007; 30:219–23. [PubMed: 17326548]
25. Belenky G, Wesensten NJ, Thorne DR, Thomas ML, Sing HC, Redmond DP, Russo MB, Balkin TJ. Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study. J Sleep Res. 2003; 12:1–12. [PubMed: 12603781]
26. Hublin C, Partinen M, Koskenvuo M, Kaprio J. Heritability and mortality risk of insomnia-related symptoms: A genetic epidemiologic study in a population-based twin cohort. Sleep. 2011; 34:957–64. [PubMed: 21731146]
27. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: A systematic review and meta-analysis of prospective studies. Sleep. 2010; 33:585–92. [PubMed: 20469800]
28. Åkerstedt T, kecklund G, Johansson S. Shift work and mortality. Chronobiol Int. 2004; 21:1055–61. [PubMed: 15646250]
29. Newman AB, Spiekerman CF, Enright P, Lefkowitz D, Manolio T, Reynolds CF, Robbins J. Daytime sleepiness predicts mortality and cardiovascular disease in older adults. J Am Geriatr Soc. 2000; 48:115–23. [PubMed: 10682939]
30. De Batlle J, Benitez ID, Dalmases M, Mas A, Garcia-Codina O, Medina-Bustos A, Escarrabill J, Salto E, Sanchez-de-la-Torre M, Barbe F. Usefulness of a 5-item scale to assess sleep health status: Results of the Catalan Health Survey 2015 [abstract number C80-D]. Am J Respir Crit Care Med. 2017; 195:A6535.
31. Furihata R, Hall MH, Stone KL, Ancoli-Israel S, Smagula SF, Cauley JA, Kaneita Y, Uchiyama M, Buysse DJ. SOF Research Group. An aggregate measure of sleep health is associated with prevalent and incident clinically-significant depression symptoms among community-dwelling older women. Sleep. 2017; 40:esw075.
32. Ehlers CL, Kupfer DJ, Buysse DJ, Cluss PA, Miewald JM, Bisson EF, Grochocinski VJ. The Pittsburgh study of normal sleep in young adults: Focus on the relationship between waking and sleeping EEG spectral patterns. Electroencephalogr Clin Neurophysiol. 1998; 106:199–205. [PubMed: 9743277]
33. Carrier J, Land S, Buysse DJ, Kupfer DJ, Monk TH. The effects of age and gender on sleep EEG power spectral density in the middle years of life (ages 20–60 years old). Psychophysiology. 2001; 38:232–42. [PubMed: 11347869]
34. Buysse DJ, Hall M, Tu XM, Land S, Houck PR, Cherry CR, Kupfer DJ, Frank E. Latent structure of EEG sleep variables in depressed and control subjects: Descriptions and clinical correlates. Psychiatry Res. 1999; 79:105–22.
35. Frank E, Kupfer DJ, Swartz HA, Pilkonis PA, Houck PR, Rucci P, Novick DM, Grochocinski VJ, Staph DM. Randomized trial of weekly, twice-monthly, and monthly interpersonal psychotherapy as maintenance treatment for women with recurrent depression. Am J Psychiatry. 2007; 164:761–7. [PubMed: 17475735]
36. Thase ME, Kupfer DJ, Fasickka AJ, Buysse DJ, Simmons AD, Frank E. Identifying an abnormal electroencephalographic sleep profile to characterize major depressive disorder. Biol Psychiatry. 1997; 41:964–73. [PubMed: 9110102]
37. First, MB., Spitzer, RL., Gibbon, M., Williams, JBW. Structured Clinical Interview for DSM-IV-TR Axis I Disorders, research version, patient edition (SCID-I/P). New York: Biometrics Research, New York State Psychiatric Institute; Nov. 2002
38. Hall MH, Mulukutla S, Kline CE, Samuelsson LB, Taylor BJ, Thayer JF, Krafty RT, Frank E, Kupfer DJ. Objective sleep duration is prospectively associated with endothelial health. Sleep. 2017; 40:zsw003.
39. Monk TH, Reynolds CF, Kupfer DJ, Buysse DJ, Coble PA, Hayes AJ, Machen MA, Petrie SR, Ritenour AM. The Pittsburgh Sleep Diary. J Sleep Res. 1994; 3:111–20.
40. Johns MW. A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. Sleep. 1991; 14:540–45. [PubMed: 1798888]

41. Patel SR, Hayes AL, Blckwell T, Evans DS, Ancoli-Israel S, Wing YK, Stone KL. MrOS and SOF Research Groups. The association between sleep patterns and obesity in older adults. Int J Obesity. 2014; 38:1159–64.
42. Spielman AJ, Caruso LS, Glovinsky PB. A behavioral perspective on insomnia treatment. Psychiat Clin N Am. 1987; 10:541–53.
43. Perlis ML, Swinkels CM, Gerhman PR, Pigeon WR, Matteson-Rusby SE, Jungguist CR. The Incidence and temporal patterning of insomnia: A pilot study. J Sleep Res. 2010; 19:31–5. [PubMed: 19912510]
44. Silva AA, Mello RGB, Schaan CW, Fuchs FD, Redline S, Fuchs SC. Sleep duration and mortality in the elderly: A systematic review with meta-analysis. BMJ Open. 2016; 6:e008199.
45. Green, BL. Trauma History Questionnaire. In: Stamn, BH., editor. Measurement of stress, trauma, and adaptation. Lutherville, MD: Sidran Press; 1996. p. 366-369.
46. Hooper LM, Stockton P, Krupnick JL, Green BL. Development, use, and psychometric properties of the trauma history questionnaire. Journal of Loss and Trauma. 2011; 16:258–83.
47. Mueser KT, Rosenberg SD, Fox L, Salyers MP, Ford JD, Carty P. Psychometric evaluation of trauma and posttraumatic stress disorder assessments in persons with severe mental illness. Psychol Assessment. 2001; 13:1101–17.
48. Norris, FH., Riad, JK. Standardized self-report measures of civilian trauma and posttraumatic stress disorder. In: Wilson, JP., Keane, TM., editors. Assessing Psychological Trauma and PTSD. New York: Guilford Press; 1997. p. 7-42.
49. Hamilton M. A rating scale for depression. J Neurol, Neurosurg, Psychiat. 1960; 23:56–62. [PubMed: 14399272]
50. Williams JBW. A structured interview guide for the Hamilton Depression Rating Scale. Arch Gen Psychiat. 1988; 45:742–47. [PubMed: 3395203]
51. Cohen, S., Mermelstein, R., Kamarck, T., Hoberman, H. Measuring the functional components of social support. In: Sarason, IG., Sarason, BR., editors. Social support: Theory, research and application. The Hague, The Netherlands: Martinus Nijhoff; 1985. p. 73-94.
52. Operario D, Adler NE, Williams DR. Subjective social status: Reliability and predictive utility for global health. Psychology and Health. 2004; 19:237–46.
53. Ghosh, D., Vogt, A. Outliers: An evaluation of methodologies. Proceedings of the 2012 Joint Statistical Meeting; July 28–August 2, 2012; San Diego, USA. Abstract 476
54. Gregory AM, Caspi A, Eley TC, Moffitt TE, O'Connor TG, Poulton R. Prospective longitudinal associations between persistent sleep problems in childhood and anxiety and depression disorders in adulthood. J Abnorm Child Psych. 2005; 33:157–63.
55. Noll JG, Trickett PK, Susman EJ, Putnam FW. Sleep disturbances and childhood sexual abuse. J Pediatr Psychol. 2006; 31:469–80. [PubMed: 15958722]
56. Goff DC Jr, Lloyd-Jones DM, Bennett G, Coady S, D'Agostino RB Sr, Gibbons R, Greenland P, Lackland DT, Levy D, O'Donnell CJ, Robinson J, Schwartz JS, Smith SC Jr, Sorlie P, Shero ST, Stone NJ, Wilson PW. ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014; 129:S49–73. [PubMed: 24222018]
57. Heim C, Newport DJ, Heit S, Graham YP, Wilcox M, Bonsall R, Miller AH, Nemeroff CB. Pituitary-adrenal and autonomic responses to stress in women after sexual and physical abuse in childhood. JAMA. 2000; 284:592–597. [PubMed: 10918705]
58. Carlson M, Earls F. Psychological and neuroendocrinological sequelae of early social deprivation in institutionalized children in Romania. Ann NY Acad Sci. 1997; 15:419–28.
59. Saridjan NS, Kocevska D, Luijk MPCM, Jaddoe VWV, Verhulst FC, Tiemeier H. The prospective association of the diurnal cortisol rhythm with sleep duration and perceived sleeping problems in preschoolers: The Generation R Study. Psychosom Med. 2017; 79:557–64. [PubMed: 28570434]
60. Goenjian AK, Yehuda R, Pynoos RS, Steinberg AM, Tashjian M, Yang RK, Najarian JM, Fairbanks LA. Basal cortisol, dexamethasone suppression of cortisol, and MHPG in adolescents after the 1988 earthquake in Armenia. Am J Psychiat. 1996; 153:929–34. [PubMed: 8659616]

61. Cicchetti D, Rogosch FA, Gunnar MR, Toth SL. The differential impacts of early physical and sexual abuse and internalizing problems on daytime cortisol rhythm in school-aged children. Child Dev. 2010; 81:252–69. [PubMed: 20331666]
62. Heim C, Newport DJ, Wagner D, Wilcox MM, Miller AH, Nemeroff CB. The role of early adverse experience and adulthood stress in the prediction of neuroendocrine stress reactivity in women: A multiple regression analysis. Depress Anxiety. 2002; 15:117–25. [PubMed: 12001180]
63. Elzinga BM, Roelofs K, Tollenaar MS, Bakvis P, van Pelt J, Spinhoven P. Diminished cortisol responses to psychosocial stress associated with lifetime adverse events: A study among healthy young adults. Psychoneuroendocrinology. 2008; 33:227–37. [PubMed: 18096322]
64. Lovallo WR, Farag NH, Sorocco KH, Cohoon AJ, Vincent AS. Lifetime adversity leads to blunted stress axis reactivity: Studies from the Oklahoma Family Health Patterns project. Biol Psychiat. 2012; 71:344–49. [PubMed: 22112928]
65. De Bellis MD, Baum AS, Birmaher B, Keshavan MS, Eccard CH, Boring AM, Jenkins FJ, Ryan ND. Developmental traumatology Part I: Biological stress systems. Biol Psychiat. 1999; 45:1259–70. [PubMed: 10349032]
66. Otte C, Neylan TC, Pole N, Metzler T, Best S, Henn-Haase C, Yehuda R, Marmar CR. Association between childhood trauma and catecholamine response to psychological stress in police academy recruits. Biol Psychiat. 2005; 57:27–32. [PubMed: 15607297]
67. Roberts ME, Fuemmeler BF, McClernon FJ, Beckham JC. Association between trauma exposure and smoking in a population-based sample of young adults. J Adolescent Health. 2008; 42:266–74.
68. Liu RT, Alloy LB. Stress generation in depression: A systematic review of the empirical literature and recommendations for future studies. Clin Psychol Rev. 2010; 30:582–93. [PubMed: 20478648]
69. Adrien J. Neurobiological bases for the relation between sleep and depression. Sleep Med Rev. 2002; 6:341–51. [PubMed: 12531125]
70. White KH, Rumble ME, Benca RM. Sex differences in the relationship between depressive symptoms and actigraphic assessments of sleep and rest-activity rhythms in a population-based sample. Psychosom Med. 2017; 79:479–84. [PubMed: 27922568]
71. Kobayashi H, Boarts JM, Delahanty DL. Polysomnographically measured sleep abnormalities in PTSD: A meta-analytic review. Psychophysiology. 2007; 44:660–69. [PubMed: 17521374]
72. Williams LM. Recovered memories of abuse in women with document child sexual victimization histories. J Trauma Stress. 1995; 8:649–73. [PubMed: 8564277]
73. Delle Femina D, Yeager CA, Lewis DO. Child abuse: Adolescent records vs adult recall. Child Abuse Neglect. 1990; 14:227–31. [PubMed: 2340430]
74. Edwards VJ, Anda RF, Nordenberg DF, Felitti VJ, Williamson DF, Wright JA. Bias assessment of child abuse survey: Factors affecting probability of response to a survey about childhood abuse. Child Abuse Neglect. 2001; 25:307–12. [PubMed: 11330927]
75. Poon CYM, Knight BG. Impact of childhood parental abuse and neglect on sleep problems in old age. J Gerontol B Psychol Sci Soc Sci. 2011; 66:307–10. [PubMed: 21339302]
76. Ginty AT, Masters NA, Nelson EB, Kaye KT, Conklin SM. Cardiovascular reactions to psychological stress and abuse history: The role of occurrence, frequency, and type of abuse. Anxiety Stress Coping. 2017; 30:155–62. [PubMed: 27425575]
77. Kuhlman KR, Geiss EG, Vargas I, Lopez-Duran NL. Differential associations between childhood trauma subtypes and adolescent HPA-axis functioning. Psychoneuroendocrinology. 2015; 54:103–14. [PubMed: 25704913]
78. Lovallo WR, Farag NH, Sorocco KH, Cohoon AJ, Vincent AS. Lifetime adversity leads to blunted stress axis reactivity: Studies from the Oklahoma Family Health Patterns Project. Biol Psychiatry. 2012; 15:344–49.
79. Carpenter LL, Shattuck TT, Tyrka AR, Geracioti TD, Price LH. Effect of childhood physical abuse on cortisol stress response. Psychopharmcology (Berl). 2011; 214:367–75.

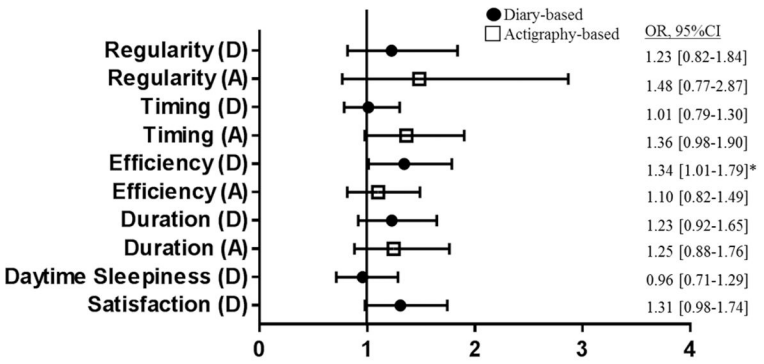

Figure 1.

Odds of reporting a problem (score = 0) with each of the sleep health dimensions as a function of childhood trauma exposure (N = 138 for diary-based sleep health components and N=118 for actigraphy-based sleep health components).

Note: Odds ratios and confidence intervals are adjusted for Time 1 parent cohort, depression history, current stress, interpersonal support, and subjective social standing. D=Diary-based, A=Actigraphy-based *denotes significantly increased risk, $p<.05$

Table 1

Sleep Health Score Derivation

Sleep Health Component	Operationalization	Scoring	Score 0[a] (N)	Score 1[a] (N)	Cut-off Reason
Regularity	Standard deviation of calculated sleep midpoint from daily sleep diary	Male ≤ 29min = 1 >29min = 0 Female ≤ 26min = 1 >26min = 0	129 108	32 30	Median values from MrOS and SOF studies; larger community-based samples of elderly participants (41)
Satisfaction[b]	Average self-reported sleep quality from daily sleep diary, 0 (very bad) - 100 (very good) scale	Median Split > 66.66 = 1 < 66.66 = 0	81	80	Median split in current sample
Sleepiness[b] (daytime)	Total score on Epworth Sleepiness Scale	≤ 10 = 1 > 10 =0	30	131	A cut-off of 10 has been previously found to indicate excessive daytime sleepiness (40)
Timing	Average of calculated sleep midpoint from daily sleep diary, midnight = 0min	Male ≥147 OR ≤ 218min = 1 <147 OR > 218min = 0 Female ≥161 OR ≤ 234min = 1 <161 OR > 234min = 0	91 80	70 58	Median values from MrOS and SOF studies; larger community-based samples of elderly participants (41)
Efficiency	Average calculated sleep efficiency from daily sleep diary	> 85% = 1 < 85% = 0	31 33	130 105	Sleep restriction therapy aims to achieve sleep efficiency of 85% (42,43)
Duration	Average self-reported sleep duration from daily sleep diary	7hr – 8hr = 1 < 7hr = 0 > 8hr = 0	104 87	57 51	Meta-analysis of 27 elderly cohort studies (N > 70,000) reported increased all-cause mortality in sleep durations ≤ 7hrs and ≥ 8hrs (44)
					Total Sleep Health Score Range: 0 (poor) – 6 (optimal)

Notes:

[a]Top number represents diary-based values, bottom number represents actigraphy-based values,

[b]No actigraphy based-values are provided because these subjective measures were used in both diary- and actigraphy-based sleep health derivations

Table 2

Sleep Characteristics of Sample

Sleep Measure	N	Diary Mean(SD)	N	Actigraphy Mean(SD)
Duration, min *	158	406.86 (61.44)	136	414.00 (52.73)
Efficiency, % *	158	89.57 (7.45)	136	87.42 (5.21)
Timing, min from midnight *	158	203.10 (64.78)	136	200.83 (62.47)
Regularity, SDmin *	158	46.59 (25.95)	136	50.17 (43.87)
WASO, min	158	28.06 (25.43)	136	42.39 (22.59)
Latency, min	158	19.41 (15.90)	136	8.70 (7.05)
Fragmentation Index	--	--	136	20.32 (9.47)
Satisfaction, 0–100 *	158	65.04 (14.63)	--	--
ESS Scale Score, 0–24 *	158	6.94 (3.92)	--	--

Notes: SD = standard deviation, WASO = wake time after sleep onset, ESS = Epworth Sleepiness Scale

* included in sleep health variable,

Table 3

Linear Regression Analysis of Trauma and Sleep Health

	N	β	*t*	*p*	ΔR^2
Childhood Trauma					
Diary-based Measure					
Unadjusted	158	−.24	−3.11	.002	.058
Adjusted Model 1	138	−.20	−2.39	.018	.036
Adjusted Model 2	133	−.20	−2.19	.031	.032
Actigraphy-based Measure					
Unadjusted	135	−.27	−3.18	.002	.070
Adjusted Model 1	118	−.21	−2.21	.029	.036
Adjusted Model 2	114	−.19	−1.84	.069	.027
Adult Trauma					
Diary-based Measure					
Unadjusted	159	−.08	−0.98	.33	.006
Adjusted Model 1	139	.08	0.95	.35	.006
Adjusted Model 2	134	.09	1.06	.29	.008
Actigraphy-based Measure					
Unadjusted	136	.15	−1.71	.09	.021
Adjusted Model 1	119	−.04	−0.45	.66	.002
Adjusted Model 2	115	−.03	−0.36	.72	.001
Lifetime Trauma					
Diary-based Measure					
Unadjusted	159	−.13	−1.59	.11	.016
Adjusted Model 1	139	.04	0.41	.68	.001
Adjusted Model 2	134	.05	0.57	.57	.002
Actigraphy-based Measure					
Unadjusted	136	−.20	−2.35	.020	.039
Adjusted Model 1	119	−.09	−0.94	.35	.007
Adjusted Model 2	115	−.07	−0.76	.45	.005

Model 1 adjusted for current stress, depression history, subjective social standing, time 1 parent cohort, and interpersonal support

Model 2 adjusted for model 1 + sex, age, daily alcohol use, and BMI