Sleep Health 2 (2016) 8–11

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: http://www.elsevier.com/locate/sleh

Insights from the OppNet initiatives on psychosocial stress and sleep: themes for multidisciplinary team science research

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ARTICLE INFO

Article history:
Received 5 August 2015
Received in revised form 8 January 2016
Accepted 13 January 2016

Keywords:
Psychosocial stress
Sleep
Basic behavioral research
OppNet

ABSTRACT

Understanding the multilevel and bidirectional factors and basic mechanisms linking psychosocial stress, sleep, and their interactions to health outcomes is critical to building successful interventions and promoting population health. We report here on the first gathering of the National Institutes of Health Basic Behavioral and Social Sciences Research Opportunity Network grant recipients in the separate but interrelated topics of psychosocial stress and sleep. The meeting provided an opportunity for investigators to present their research methods and discuss emerging findings, gain insight into new research directions, and form innovative collaborations. Several recurring themes were identified: contextualizing behavioral processes as they unfold in the real world, developing and using novel measurement techniques, and looking over time and across the lifespan. The need for multidisciplinary team science was also identified as a key determinant of success. These themes suggest useful future research directions.

Introduction

Basic biopsychosocial research engenders an implicit appreciation of the relationship between behavior and health, and combines basic behavioral and social sciences with basic and applied biological sciences. Representative disciplines include behavioral genetics and epigenetics; behavioral, cognitive, social, and economic neurosciences; and psychoneuroimmunology. Sleep and psychosocial stress (hereafter referred to as *stress*) are biobehavioral phenomena that have garnered considerable research attention, with a growing recognition that these constituents of daily life have bidirectional effects that can profoundly impact wellness and the full range of health-relevant conditions. Yet, despite the substantial research concerning stress, sleep, and their effects on health outcomes, our understanding of how these 2 factors interact has been hampered by our extant conceptual models and research methodology.

The areas of stress and sleep were identified in 2010 as high priority by the National Institutes of Health (NIH) Basic Behavioral and Social Sciences Research Opportunity Network (OppNet). The NIH developed OppNet in 2009 to foster trans-NIH multidisciplinary basic behavioral and social science research (http://oppnet.nih.gov/). In the first 5-year phase of the program, 24 NIH Institutes and Centers and 5 program coordination areas within the Office of the Director collectively managed OppNet. This management ensured an interdisciplinary approach to support research into the mechanisms, processes, and pathways of individual and group behavior related to health and underlying multiple diseases and conditions. Using results from a Request for Information that solicited input from the scientific community, OppNet concept teams identified and further developed specific topics of interest around stress and sleep. For the funding initiatives focused on stress, the topics identified included scientifically rigorous identification of pathways leading from stress to health-related behaviors, contextual issues during vulnerable periods that may be particularly relevant to the stress-health relationship, and biopsychosocial factors associated with resilience to and recovery from stress. For the funding initiatives focused on sleep, the topics identified included: the biopsychosocial consequences of sleep loss; detailed identification of sleep patterns across life stages, cultures, and behavioral habits; and social and behavioral influences on sleep behaviors, including parent-child sleep interactions.

The NIH staff recognized the significant potential for synthesis across these topics. Overlapping concepts include: the relationships between sleep and stress; the need for prospective, accurate, and feasible measurement of sleep and stress; and assessment of sleep and stress over the developmental lifespan. Thus, the concept teams proposed that a joint conference of grantees could provide an innovative opportunity for discussion and development of cohesive hypotheses, experimental designs, and collaborations in these separate but interrelated areas. The meeting was held May 14-15, 2014, in Bethesda, MD, and was designed

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http://dx.doi.org/10.1016/j.sleh.2016.01.002
2352-7218/

to allow grantees to consider the integration of behavioral, social, environmental, and physiological processes for both phenomena. A key focus for the meeting was to identify areas of synergy among the various research topics and investigators and to identify future directions. A basic understanding of the linkages between psychological stress and sleep, of the mechanisms underlying these linkages, and of how these factors interact in real-world situations and in real time is critical to ultimately developing interventions that can improve health behaviors and outcomes. The current article presents a synthesis of the common themes that emerged during the discussion periods of the conference.

Emerging themes

Contextualizing behavioral processes relevant to stress and sleep as they unfold in the real world

Contextual factors operating at varying levels of analysis affect sleep, stress, and their interaction as they influence health outcomes. These factors include: intentional vs imposed sleep loss (eg, work schedules, family demands); environmental and cultural imperatives regarding sleep and life demands; life stage; individual- and neighborhood-level socioeconomic factors such as safety, noise, and access to health-promoting activities and foods; and the location and timing of sleep. Collectively, the methods and preliminary findings of the OppNet projects emphasize the importance of evaluating stress and sleep in ecologically meaningful contexts, which capture these multilevel social, environmental, and behavioral influences.

For example, the focus of several studies is on systems of dynamic processes and complex relationships, such as the acute disruption of marital separation and divorce (Bootzin, R01 HD069698), the return of a deployed service member to military family (Troxel, R01 HL112646), or the long-term sequelae of child maltreatment (Widom and Brzustowicz, R01 HD072581). Other studies are considering social units such as dependent children and their caregiver parents (Bates and Deater-Deckard, R01 MH099437; Prather and Epel, R21 HL117727), friendship pairs (Franzen, R01 DA033064), and neighborhoods (Grandner, R21 ES022931; Mellman, R01 MD007633).[1] Grantees focus not only on the observable features of a given context but also on the evoked responses of individuals to that environment, such as social vigilance in neighborhoods with increased levels of perceived threat (Ruiz, R01 HL109340). In-depth description of the social context is crucial to elucidate the social and environmental contributions to stress and influences on sleep.[2,3]

Research methods being used highlight ongoing shifts in the field from the laboratory to naturalistic settings, participant-reported to sensor data, small to Big Data, and inferential statistics to computational modeling. Real-world data collection techniques include electronic recorders activated by ambient sound (Bootzin), wrist actigraphy for exercise (Burg and Davidson, R01 HL115941) and sleep (Lauderdale, R01 AG042164; Prather and Epel), ecological momentary assessment (Ruiz), and GPS mapping (Worthman, R21 HD073033). Natural experiments and cultural variations in stress and sleep patterns—as exploited by Worthman and colleagues in a project in Vietnam—also provide real-world opportunities to test hypotheses regarding causal relationships between stress and sleep, as well as their impact on health. As this work expands, it will be necessary to develop new research methods for gathering, cleaning, and analyzing the momentary and multilevel data that sufficiently capture the underlying phenomena.

Developing and using novel measurement techniques, new technologies, and measurement precision

These technological developments provide a wealth of data that monitor a range of physiological indices with the potential to show: momentary, intermediate, and longer-term effects of stress and sleep on the individual; how these effects influence the manner with which that individual interacts with others; and then how these interactions influence stress and sleep, all in an ongoing and feed-forward manner. But the proliferation of these technologies creates challenges for discerning key signals from the resulting large bodies of accrued data. New analytic and statistical tools are increasingly needed to productively use this large and ever-increasing volume of data in the service of public health and individual-level interventions.

Examples of recent technological advances presented at the conference include mobile phone–based devices to monitor sleep behaviors and characteristics of the sleep environment (Wockets Physical Activity Measurement System used in Spilsbury, R21 MD007632) and wrist-worn sensors that detect stress through changing levels of skin conductance (Autosense used in Kumar, R01 DA035502). Wockets, an open-source accelerometer project, and Autosense, a combination of arm- and chest-band sensors, both funded by the NIH GEI Exposure Biology Program, run continuously to provide real-time data points. These techniques significantly increase the amount and quality of available longitudinal data and the ability to detect individual differences over time. Yet the analytic techniques to use such a vast amount of data are still being developed.

Therefore, during the discussion, several investigators emphasized that the decision to incorporate new techniques and emerging technologies must be made with the research question in mind, so existing, validated technology with less precision, yet sufficient to address the research question, should not be ignored. Also, subjective experiences of sleep or stress contribute unique sources of information such as individual perception of key phenomena, including stress and sleep quality, and so should not be discounted merely because of their subjective nature. It is important to understand what type of data a particular technology or measurement tool generates before using it to study a particular phenomenon.

This led naturally to a discussion of Big Data. The NIH Big Data to Knowledge (BD2K) initiative seeks to facilitate the use of biomedical Big Data, to develop and disseminate analytic methods, to enhance training in the associated research methods and analytics, and to establish Big Data centers of excellence. Big Data sources such as cell phones, Twitter accounts, and Internet use provide digital breadcrumbs of the behaviors of a large number of people 24 hours a day. Computational analysis and synthesis of Big Data have resulted in significant mechanistic and clinical advances, among them the identification of single nucleotide polymorphisms associated with cardiometabolic disease and outcomes by functional genomic analysis.[4] These approaches have also been used to model multiple health care self-management approaches to improve our understanding of influences on health, including sleep health and other behaviors,[5] and for testing theories of human behavior to improve our understanding of what influences health behaviors such as physical activity.[6] Ultimately, researchers may be able to develop a behavioral model of precision medicine as Burg and Davidson are attempting as they develop the “stress fingerprint,” a personalized model of daily stress sources associated with decreased exercise.

Evaluating stress and sleep over time and across the lifespan

The interaction of stress and sleep is dynamic in that it is bidirectional and influenced by momentary, intermediate, and long-term patterns. These phenomena interact in complex ways over the day, as a function of the work week, seasonally, across developmental periods, and throughout lifetimes. Basic behavioral and social science can be conducted with a disease context to illuminate an underlying mechanism or process. For example, Tonelli (R01 MH097676), McCullough (R01 NS077769), and Steel (R01 CA176809) are using