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Anger tendencies and sleep: Poor anger control is associated with objectively measured sleep disruption

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ABSTRACT

This study investigated whether trait anger linked to actual sleep behavior and what anger tendencies play the most important role for particular aspects of sleep. Data from 436 adults in Midlife of the United States Study were used to link anger tendencies to both objectively (actigraphy) and subjectively (daily diary) assessed sleep across a week. Overall, individuals who had poor anger control also had worse objectively and subjectively measured sleep and these relations were robust to effects of gender, age, race, socioeconomic status, and stress. The findings tie actual sleep behavior to individual differences in anger, suggesting poor anger control plays the most important role, and add to the growing evidence that anger and sleep depend on each other.

1. Introduction

Personality differences in anger and hostility have been linked to important behavioral and health consequences such as heightened aggression, worse cardiovascular health, and poor relationships among the anger-prone (Bettencourt, Talley, Benjamin, & Valentine, 2006; Chida & Steptoe, 2009; Kassinove, Roth, Owens, & Fuller, 2002; Suls, 2013). Whereas the aggressive and cardiovascular consequences of trait anger have received ample attention, research has often neglected the role of trait anger in the sleep-wake cycle. This gap is notable because proper sleep plays a critical role in physiological restoration and psychological functioning. To address this gap, the aim of the current study was not only to tie individual differences in anger to actual sleep behavior, but also to identify which anger tendencies are the most important predictors. To meet this goal, we employed data from a large sample of community adults and linked anger tendencies to both subjectively and objectively measured sleep.

1.1. Anger tendencies and sleep

Trait anger is a dispositional tendency to experience feelings of anger and is related to propensities toward hostile thought and aggressive behavior (Martin, Watson, & Wan, 2000). The general propensity to become angry can be further broken into more specific forms of anger experience and what people tend to do with anger once it occurs (Buss & Perry, 1992; Spielberger, 1988). In terms of experiencing anger, people often differ in the frequency in which they experience anger, what provokes anger, and how quickly they become angry. In terms of reacting to feeling angry, people differ in the frequency in which they suppress or hold anger in, express anger outwards towards people or objects, and control or dissipate feelings of anger (Novaco, 2003; Spielberger, 1988).

Why should anger propensities predict sleep? First, individuals who are more likely to feel anger may experience worse sleep because they are more likely to perceive and ruminate on provocation, to respond with anger, and to insufficiently regulate these perceptions and reactions (Wilkowski & Robinson, 2010). These cognitive and affective characteristics may induce physiological and cognitive arousal that opposes the calmness needed to fall and stay asleep (Deffenbacher et al., 1996; Wolk, Gami, Garcia-Touchard, & Somers, 2005). Feelings of anger before sleep increase physiological arousal (i.e. cardiovascular activity) both before and during sleep, while cognitively ruminating on an anger-provoking event can further maintain or increase angry emotions, thoughts, and physiological arousal (Gerin, Davidson, Christenfeld, Goyal, & Schwartz, 2006; Pedersen et al., 2011; Schwartz, Weinberger, & Singer, 1981; Shapiro, Jamner, & Goldstein, 1997). In turn, physiological and cognitive arousal have been associated with delayed sleep onset, poor sleep integrity, and insomnia (Harvey, 2000; Pillai, Steenburg, Ciesla, Roth, & Drake, 2014; Radstaak, Geurts, Beckers, Brosschot, & Kompier, 2014; Thomsen, Mehlsen, Christensen, & Zachariae, 2003). Thus, anger and angry

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dispositions may induce mental restlessness and amplify physiological arousal, undermining initiation and maintenance of sleep.

To date, existing evidence supports a link between greater angry dispositions and worse sleep, implicating anger as a contributing factor to difficulties falling and staying asleep. Children with greater angry temperament and externalization of anger are more likely to have problems falling and staying asleep, sleep problems, and higher daytime sleepiness (Chervin, Dillon, Archbold, & Ruzicka, 2003; Kidwell, Van Dyk, Guenther, & Nelson, 2016; Reid, Hong, & Wade, 2009). Surveyed adults who tend to become angry or to suppress angry feelings also report worse sleep integrity in terms of difficulty falling asleep and unwanted awakenings during the night (Caska et al., 2009; Ottoni, Lorenzi, & Lara, 2011; Shin et al., 2005). Additionally, after an interpersonal conflict, individuals with more hostile views of others report greater difficulties falling asleep and staying asleep (Brissette & Cohen, 2002).

While this evidence clearly implicates anger in sleep, it is worth noting that much of this evidence comes from cross-sectional studies. Although existing evidence suggests that angry feelings can undermine sleep, evidence also suggests that disrupted sleep may increase anger (Kamphuis, Meerlo, Koolhaas, & Lancel, 2012; Krizan & Hisler, 2016). These possibilities suggest that the relation between anger tendencies and sleep is bi-directional. We consider these distinct possibilities in the discussion, with our study focused on anger tendencies as predictors of sleep.

Because past research has considered different aspects of anger mainly in isolation (e.g. overall frequency of anger or reactions to feeling angry; Caska et al., 2009; Shin et al., 2005, respectively), it is critical to simultaneously model the influence of different aspects of anger on sleep to identify which aspects are the most important. We speculated that the tendency to control and dissipate angry feelings is likely to be especially important for sleep as past research simultaneously modeling the influence of anger tendencies on other health outcomes, such as cardiovascular disease and wound healing, has suggested anger-control to be the most important feature of chronic anger (Gouin, Kiecolt-Glaser, Malarkey, & Glaser, 2008; Haukkala, Konttinen, Laatikainen, Kawachi, & Uutela, 2010). Individuals with greater anger-control engage in more active and reappraisal-based coping strategies, and such strategies have been associated with reduced stress reactivity that can damage physical health and impair healthy sleep (Diong et al., 2005; McEwen, 2008; Sladek, Doane, Luecken, & Eisenberg, 2016). Additionally, anger-control may reflect self-control more broadly, which has been linked to better sleep. Individuals with poorer self-control exhibit worse bed-time habits and poor sleep (Kroese, Evers, Adriaanse, & de Ridder, 2016), and individuals with poor or insufficient sleep show difficulties inhibiting cognitive and emotional responses (Killgore, 2010; Krizan & Hisler, 2016).

In addition to past research neglecting to investigate what anger tendencies are the most important for sleep, virtually all prior evidence is based on self-reports of sleep and no study has tied anger tendencies to *actual* (i.e. objectively measured) sleep. Given the important theoretical ties between anger dispositions and sleep, it is imperative to establish if these dispositions predict actual sleep behavior rather than just sleep self-reports.

1.2. Shortcomings of sleep self-reports

The need to establish a link between actual sleep and angry tendencies is crucial because the reliance on self-reports of sleep in past research limits confidence in prior evidence. Specifically, subjective reports of sleep can both inflate and suppress the relation between sleep and anger. In addition, self-reports of sleep are inherently limited in their ability to accurately assess specific sleep characteristics which may be important for a comprehensive understanding of the relation between anger and sleep.

1.2.1. Inflation

Self-reports of sleep can often be influenced by individuals' negative reporting styles. Individuals high in neuroticism (a disposition towards feeling negative affect) are more likely than those low in neuroticism to both report and *over*-report negative symptoms such as sleep loss and distress about sleep (Fernandez-Mendoza et al., 2011; Suls & Howren, 2012; Watson & Pennebaker, 1989). Thus, self-reports can inflate the relation between sleep and anger because individuals with negative dispositions may be more likely to report and over-report disturbed sleep and feelings of anger and frustration. Moreover, other sources of common method variance (e.g., tendencies to agree with any survey questions) shared by self-report measures can further lead to inflation (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

1.2.2. Suppression

While self-reports may inflate the relation between sleep and anger, self-reports of sleep may also suppress this relation due to extraneous influences on perceptions of sleep that reduce reliability. When studied across individuals, self-reported sleep shows limited convergence with objective polysomnographic and actigraphic sleep (Grandner, Kripke, Yoon, & Youngstedt, 2006; Keklund & Akerstedt, 1997). This poor convergent validity likely reflects that self-reports of sleep integrity and amount are often measured with only one or two questions relying on memory of recent sleep or general beliefs. In contrast, actigraphy and polysomnography use moment-to-moment measurements of sleep-wake state over a sample of days to assess sleep integrity and amount, yielding indices of sleep which avoid errors of memory or self-perception, yet also specific to a time-window. Using aggregate self-reports of sleep may thus capture more measurement noise and mask any relation between sleep and anger.

1.2.3. Crudeness

In addition to possibly inflating and suppressing the relation of anger and sleep, self-reports of sleep are often crude in their assessment of finer characteristics of sleep. For instance, a self-report item such as "How many hours of actual sleep do you get at night?" does not take into account how long a person was in bed and trying to fall asleep nor if that individual's sleep was fragmented by periods of wakefulness (i.e., does not capture sleep efficiency, the time sleeping relative to time in bed). Such a question would equate an individual who slept continually for six hours to an individual who slept for six total hours, but was in bed for eight hours and woke up for four thirty-minute periods. The sleep between these two individuals is not equivalent because the former individual had better sleep as sleep integrity mainly reflects sleep continuity and efficiency (Akerstedt, Hume, Minors, & Waterhouse, 1994). Even if self-reports of sleep specifically accounted for fragmentations in sleep amount, it would be questionable to expect a respondent to accurately recall the number and duration of arousals from sleep, which may not involve coming to full consciousness. Objective assessment methods such as actigraphy, however, easily track and measure such nuanced characteristics of sleep and can reveal specific aspects of sleep most important for anger.

1.3. Purpose

In sum, this study sought to address two pressing issues. First, past research tying anger and sleep has exclusively relied on subjective reports of sleep which are prone to reporting biases that could inflate (e.g., over-reporting) or suppress (e.g., lack of insight)

this relation. Second, because no past study has comprehensively assessed anger propensities with respect to sleep, it is unclear what specific aspects of anger are the most important. Examining which individual differences in anger (e.g. feeling angry, controlling anger, holding anger in) relate to real sleep behavior (e.g., amount of time it takes to fall asleep, number of awakenings from sleep) will provide more targeted assessment points for future work examining how individual differences in anger propensities disturb sleep and for interventions seeking to reduce these disturbances.

To address these issues, data from a large sample of adults were used to examine the relation between anger tendencies and both *objective* and *subjective* sleep. Because not all objective sleep measures had parallel subjective sleep measures (and vice versa; i.e. wake after sleep onset is only objectively measured, and a subjective rating of sleep quality has no objective equivalent) we examined the link between anger tendencies and sleep separately for objective and subjective sleep assessments. Linking anger dispositions to objectively and subjectively measured sleep will shed light on how anger relates to both actual sleep behavior and subjective perceptions of sleep. In addition, the multiple dimensions of anger allowed us to use an advanced statistical technique, Multivariate Relative Weights Analysis, to *simultaneously* model which aspects of anger are the most predictive of overall sleep (LeBreton & Tonidandel, 2008). We generally hypothesized that anger propensities would be markedly associated with both self-reported and behaviorally-measured sleep assessments, namely that individuals who experience, express, or fail to restrain anger will be more likely to experience sleep disruption, i.e., exhibit shorter and less consolidated sleep (Hypothesis 1). We also expected individual differences in anger *control* to be uniquely important for both objectively and subjectively recorded sleep given that anger-control has been implicated as particularly important for other health outcomes, is associated with better coping strategies, and may more broadly reflect self-control processes linked to sleep (Diong et al., 2005; Gouin et al., 2008; Haukkala et al., 2010; Kroese et al., 2016). As a result, we anticipated that individuals with worse anger control would exhibit more disrupted sleep (Hypothesis 2). Lastly, after identifying the most important aspects of anger for sleep, we included gender, age, socioeconomic status factors, race, and perceived stress as covariates in our final analyses to account for the potential contributions of these factors to the link between anger and sleep.

2. Methods

2.1. Participants

From 1995 to 1996, MIDUS (Midlife in the United States) recruited 7108 adults across the Midwest of U.S. ranging from 25 to 75 to complete a survey assessing behavioral and psychosocial factors in age related differences in physical and mental health (Ryff, Seeman, & Weinstein, 2013). During 2004–2006 MIDUS contacted participants who completed the initial survey to complete a longitudinal follow up (MIDUS II, N = 4963). In addition, to broaden the scope of MIDUS II and better examine health issues in minority populations, a sample of African Americans from Milwaukee were recruited to complete the MIDUS II survey (N = 592). All participants who completed the MIDUS II survey were also able to participate in additional MIDUS II projects with more targeted assessments. One such project, the Biomarker project (N = 1255) occurred from 2004 to 2009. In this project participants traveled to a clinic to complete additional psychosocial (e.g. anger and stress) and physiological measurements. After completing the clinic measurements participants completed a daily sleep diary for the next seven days. While all Biomarker participants had the opportunity to complete the daily sleep diary, objective measures of sleep only occurred at the clinic in University of Wisconsin site where 441 participants wore an actigraph during the same week they completed a daily sleep diary.

2.2. Measures

2.2.1. Anger tendencies

Individual differences in experiencing and expressing anger were measured with the State-Trait Anger Expression Inventory across two distinct scales: the *Trait Anger Inventory* and the *Anger Expression Inventory* (Forgays, Forgays, & Spielberger, 1997; Spielberger, 1988). Individual differences measured through these scales substantially converge with other measures of trait anger (Garcia-Leon et al., 2002; McCloskey et al., 2009; Spielberger et al., 1985). Example items are abbreviated to protect copyright.

2.2.1.1. Trait Anger Inventory. The Trait Anger Inventory consists of 15 items asking participants how they generally feel from 1 (“Almost never”) to 4 (“Almost always”). Scores on this inventory can be added together to generate an overall trait anger score, as well as to assess two sub-dimensions of trait anger, namely the tendencies to become angered quickly and easily (*Angry temperament*) and to react angrily to *specific* provocations and frustrations (*Angry reaction*). Because we were interested in evaluating how more specific aspects of anger relate to sleep we separately examined the Angry temperament and Angry reaction subscales (as the overall trait anger score may reflect distinct contributions of these subscales). All items were assessed on a scale from 1 (“Almost never”) to 4 (“Almost always”).

1. *Angry temperament* (4 items such as, “Quick tempered.”; $\alpha = 0.83$).
2. *Angry reaction (4* items such as, “Furious when criticized by others.”; $\alpha = 0.74$).

2.2.1.2. Anger Expression Inventory. The Anger Expression Inventory contains 20 items that measure three distinct ways in which people handle their feelings of anger *once already angry*. Specifically, this inventory measures the frequency of which individuals hold in and internalize angry feelings when angry (Anger-In, e.g., brooding), the degree to which individuals express and externalize feelings of anger (Anger-Out, e.g., huffing), and the degree to which individuals attempt to control and dissolve anger (Anger-Control. e.g., taking a pause). All items were assessed on a scale from 1 (“Almost never”) to 4 (“Almost always”).

1. *Anger-In* (8 items such as, “Boil inside, don’t show it.”; $\alpha = 0.83$).
2. *Anger-Out* (8 items such as, “Say nasty things.”; $\alpha = 0.77$).
3. *Anger-Control* (4 items such as, “Keep my cool.”; $\alpha = 0.83$).

2.2.2. Sleep

Participant sleep was simultaneously measured over one week through both actigraphy and daily sleep diaries (from Tuesday to the following Tuesday).

2.2.2.1. Actigraphic assessment of sleep (objective sleep). Participants wore the Mini Mitter Actiwatch-64 on the non-dominant wrist to evaluate sleep-wake state at every 30-s epoch through measurement of wrist movement. The Mini Mitter Actiwatch-64 has been validated with polysomnography to show that it reliably estimates sleep indices, though it does systematically underestimate sleep efficiency and sleep amount while overestimating sleep fragmentation (Rupp & Balkin, 2011). As these misestimates are systematic

across all participants, they should not produce confounds in our analyses between anger and sleep. Data from the actigraph were used to generate weekly averages of:

1. *Sleep amount* - total time recorded asleep in minutes.
2. *Sleep integrity*- continuity and efficiency of sleep.
   a. *Sleep onset latency*- minutes categorized as "resting" before falling asleep.
   b. *Sleep fragmentation*- number of recorded arousals from sleep.
   c. *Wake after sleep onset*- minutes categorized as "awake" after during sleep period.

In our Multivariate Relative Weights Analysis, these criteria were jointly estimated using the best-fitting linear combination of individual variables coded in the direction of more optimal sleep (i.e., longer and more efficient).

2.2.2.2. Daily sleep diary (subjective sleep). Each morning participants reported the time they went to bed, the time they woke up for the day, the time it took to fall asleep, the number of awakenings during the night, and their subjective sleep quality. As with actigraphic data, daily diary data was used to generate weekly averages of:

1. *Sleep amount*- the difference in minutes between reported time in which participants went to bed and woke up the next day minus any self-reported sleep onset latency and sleep fragmentation.
2. *Sleep integrity*- continuity, efficiency, and quality.
   a. *Sleep onset latency* - "How long did it take you to get to sleep last night?" in minutes.
   b. *Sleep fragmentation* - number of reported awakenings from sleep.
   c. *Subjective sleep quality* - Within 10 min of waking each day, participants' reported on depth and overall quality of their sleep the prior night, as well as how well-rested and alert they felt that morning from 1 very deep/well rested/very alert/ very good to 5 very lightly/ poorly rested/ not alert at all/ very poor. These responses were reverse coded and then averaged for an index of subjective sleep quality ($\alpha = 0.93$).

As with objective sleep, in our Multivariate Relative Weights Analysis these subjective sleep criteria were jointly estimated using the best-fitting linear combination of individual variables coded in the direction of more optimal sleep (i.e., longer, more efficient, and better-rated).

2.2.3. Control variables

In the follow-up regression analyses investigating the link between specific anger tendencies and specific sleep indices, participants' reported age, gender, and perceived stress during the Biomarker project were included as covariates. Stress was evaluated using the ten-item Perceived Stress Scale (Cohen & Williamson, 1988). This scale assesses how often participants experienced a variety of stressful situations and feelings in the past month (e.g. "been upset because of something that happened unexpectedly", $\alpha = 0.87$). The scale has been validated in both younger and older adult populations and converges with reports of experiencing major and specific life stressors (Cohen, Kamarck, & Mermelstein, 1983; Cohen & Williamson, 1988; Ezzati et al., 2014).

In addition, participants' self-reported income, education level, and race from MIDUS 2 were also included as covariates in these analyses to control for socioeconomic and racial disparities in sleep (Grandner, Williams, Knutson, Roberts, & Jean-Louis, 2016). Participants' self-reported income from personal earnings, pension, and social security over the past year using a rating scale with different ranges of monetary income from A "Less than $0 (Loss)" to WW " $1,000,000 or more". Income from personal earnings, pension, and social security were then summed to create a total income index; however, this index is capped at $200,000 in the MIDUS 2 data. Education level was measured by participants' responses to "What is the highest grade of school or year of college you completed?" Responses to this question were coded from 1 "No school or some grade school" to 12 "PH.D., ED.D., MD, DDS, LLB, LLD, JD, or other professional degree". Participant's race was measured by their responses to "What are your main racial origins?" Participants then indicated whether they identified as "White", "Black and/or African American", "Native American or Alaska Native Aleutian Islander/Eskimo", "Asian", Native Hawaiian or Pacifica Islander", "Other", or "Don't know". Because 97% of the sample identified as White or Black and/or African American, race was dummy coded as 0 for White and 1 for all other racial identities.

2.3. Analytic sample, missing data, and power

As our key analyses involved evaluating how participant's anger tendencies related to objective (actigraphic) and subjective (daily diary) sleep measures, only data from participants who completed both actigraphic *and* daily diary measures of sleep were used in the analyses ($N = 436$). The mean age of participants was 56.91 years ($SD = 11.49$ years; Range = 35–85 years) and 60.3 percent of the participants identified as female. In addition, 69% of the participants identified as Caucasian, 28% identified as African American, and the final 3% identified as Native American/Eskimo, Asian, or Other. Missing data in the analytic sample occurred only in the control variables and constituted in less than 3% of cases. Given the exceptionally low rate of missing data, these cases were excluded pairwise.

Although data was excluded pairwise, all analyses involving only anger and sleep had a sample size of 436. Given this was the data used in key analyses, this sample size was used in G*Power (version 3.1.9.2) to calculate the smallest detectable effect when power was set to 0.80 in a multiple regression with five predictors (Faul, Erdfelder, Buchner, & Lang, 2009). This analyses indicated that a sample of this size would detect an R-squared of 0.014 80% of the time.

2.4. Analytic strategy

To examine how anger tendencies relate to sleep as a whole, we first used Multivariate Relative Weights Analysis (MRWA) to model the total and relative contribution of distinct anger tendencies in predicting sleep assessments (separately for objective and subjective sleep). This analysis allows for evaluating both how much *overall* variance in a group of outcomes (namely their best linear combination) is explained by a set of predictors, as well as how much variance is *uniquely* explained by each predictor variable in a set of collinear predictors (LeBreton & Tonidandel, 2008). We used MRWA to assess how much variance in sleep is accounted by anger because it addresses issues of multicollinearity that obscure interpretation in more traditional regression methods. Briefly, MRWA does this by applying a transformation to the predictor and outcome variables (separately) to create a new set of predictors that are orthogonal to each other and a new set of outcome variables that are orthogonal to each other (see Tonidandel & LeBreton, 2011 for an introduction to relative weights analysis). Once transformed, the set of orthogonal outcome variables are regressed on the set of orthogonal predictor variables. Importantly, the variance estimates from this regression avoid multicollinearity issues because predictors are orthogonal to

each other and outcomes are orthogonal to each other. These estimates are then back transformed to their original metric to facilitate interpretation. Moreover, this analysis generates 95% confidence intervals around estimates of explained variance in the outcome variables allowing for evaluation of the significance and precision of the estimates. Thus, this analysis will allow for a comprehensive examination of which anger tendencies explain unique variance in sleep. As a supplement to the MRWA, we also provide the results of multiple regressions of each sleep index on all anger tendencies (see Appendix A & B).

After determining the anger tendencies of special importance for objective sleep outcomes via this analysis, we used bivariate correlations to examine which specific characteristics of sleep were predicted by those specific anger tendencies. These analyses were then followed-up with linear regression analyses to examine the robustness of these relations to the potentially confounding influence of age, gender, race, socioeconomic status, and perceived stress. We then repeated these analytic procedures to examine which anger tendencies predicted *subjective* sleep.

3. Results

Bivariate correlations, means, and standard deviations regarding individual differences in anger, all measures of sleep, and control variables appear in Table 1.

3.1. Anger and objective sleep

Multivariate Relative Weights Analysis revealed that as a collective anger predicted 2% of the overall variance in objective sleep outcomes ($P^2 = 0.02$). Among the anger tendencies, only the disposition towards controlling anger uniquely explained a significant amount of variance in objective sleep measures ($P^2 = 0.01$) and accounted for the 61% of the total variance explained in sleep by anger (see Table 2). The multiple regression of each objective sleep index on all anger tendencies are available in the appendix (see Appendix A).

Because only anger-control uniquely predicted variance in objective sleep, we next examined how anger-control related to individual objective sleep indices before and after controlling for age, gender, socioeconomic status, race, and stress. As evidenced by the raw correlations presented in the Table 1, individuals who engaged in more anger control had shorter sleep onset latency (r (436) = −0.11, 95% CI = −0.20 to −0.01), fewer sleep fragmentations (r (436) = −0.12, 95% CI = −0.21 to −0.03), and less time awake during the night (r (436) = −0.21, 95% CI = −0.30 to −0.12). After accounting for the influence of extensive covariates, greater anger control still predicted fewer sleep fragmentations, (β (422) = −0.11; 95% CI = −21, −0.01) and less time awake during the night (β (422) = −0.13; 95% CI = −0.23 to −0.04).

In sum, the tendency to control anger was the most influential anger tendency in objective sleep and was the most *uniquely* important anger tendency for objective sleep. Moreover, anger-control only seemed to be associated with indices of sleep integrity, and *not* sleep amount, such that individuals who engaged in more frequent control of angry feelings only had better sleep integrity. Finally, this association remained after accounting for gender, age, socioeconomic status, race, and stress.

3.2. Relations between anger and subjective sleep

Multivariate Relative Weights Analysis revealed that anger tendencies altogether predicted 5% of the variance in *subjective* sleep outcomes. Of the anger tendencies, the dispositions towards controlling anger and holding in anger each explained a significant

Table 1
Descriptive statistics of and correlations among study variables (N = 422–436).

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	Mean (SD)
1. Sleep amount (A)	–																		369.08 (67.68)
2. Sleep onset latency (A)	−.37*	–																	31.41 (31.79)
3. Sleep fragmentation (A)	0.19*	0.13*	–																32.29 (10.08)
4. Wake after sleep onset (A)	−0.10*	0.37*	0.67*	–															49.11 (24.50)
5. Sleep amount (D)	0.61*	0.26*	0.45*	0.42*	–														440.37 (73.24)
6. Sleep onset latency (D)	−0.06	0.29*	0.12*	0.25*	−0.08†	–													21.53 (18.05)
7. Sleep fragmentation (D)	0.23*	−0.07	0.19*	0.22*	0.17*	0.11*	–												1.94 (1.34)
8. Subjective sleep quality (D)	0.04	−0.10*	−0.08†	−0.16*	0.04	−0.40*	−0.27*	(0.93)											3.66 (0.71)
9. Anger-In	0.03	0.03	−0.01	−0.02	0.01	0.06	0.06	−0.27*	(0.83)										1.85 (0.53)
10. Anger-Out	−0.07	0.01	−0.03	0.01	−0.04	−0.05	0.03	−0.13*	0.22*	(0.77)									1.62 (0.42)
11. Anger-Control	−0.04	−0.11*	−0.12*	−0.21*	−0.14*	−0.14*	−0.05	0.20*	−0.10*	−0.25*	(0.83)								2.47 (0.56)
12. Angry-Temperament	−0.07	0.10*	0.02	0.08†	0.04	0.02	−0.01	−0.16*	0.34*	0.59*	−0.25*	(0.83)							1.30 (0.44)
13. Angry-Reaction	−0.04	−0.03	−0.03	−0.03	−0.04	−0.03	−0.04	−0.12*	0.38*	0.31*	−0.06	0.28*	(0.74)						1.93 (0.59)
14. Age	0.06	0.00	−0.04	0.00	0.05	0.06	0.18*	0.15*	−0.25*	0.20*	0.03	−0.18*	−0.08†	–					56.91 (11.49)
15. Gender	0.20*	−0.14*	−0.15*	−0.04	0.05	0.08†	0.01	−0.04	−0.03	0.07	−0.10*	0.07	−0.01	−0.09*	–				60% Female
16. Stress	−0.07	0.21*	0.08	0.18*	0.09†	0.15*	0.04	−0.33*	0.46*	0.23*	−0.31*	0.32*	0.24*	−0.16*	0.08	(0.87)			2.27 (0.64)
17. Income	−0.07	−0.09†	−0.04	−0.14*	−0.13*	−0.15*	−0.02	0.13*	−0.06	0.00	0.10*	0.10*	0.06	−0.11*	−0.18*	−0.14*	–		37,215 (34,724)
18. Education level	0.06	−0.18*	0.03	−0.07	−0.07	−0.15*	−0.02	0.05	−0.07	−0.02	0.14*	−0.12*	0.06	−0.07	−0.05	−0.12*	0.35*	–	7.26 (2.56)
19. Race	−0.26*	0.28*	0.05	0.28*	0.01	0.21*	−0.09†	−0.15*	0.03	0.10*	−0.21*	0.14*	−0.07	−0.10*	0.16*	0.24*	−0.19*	−0.22*	69% White

Note. (A) = Actigraphic measure, (D) = Daily diary measure. Gender was coded as 1 = Male, and 2 = Female. Race was coded as 0 = White, 1 = all other racial identities.
† $p < 0.1$.
* $p < 0.05$. Numbers in parentheses on the diagonal indicate scale reliability where applicable.

Table 2
Multivariate relative weights of anger dimensions predicting average objective sleep.

	Raw relative weight (P^2)	Rescaled relative weight (% of overall model P^2 explained)	95% CI of relative weight statistical significance
Anger-out	0.002	10.1	−0.004: 0.009
Anger-in	0.002	7.4	−0.005: 0.007
Anger-control	0.013	61.0	0.004: 0.025
Angry temperament	0.004	15.8	−0.004: 0.011
Angry reaction	0.001	5.6	−0.005: 0.006
Total	0.022		

Table 3
Multivariate relative weights of anger dimensions predicting average subjective sleep.

	Raw relative weight (P^2)	Rescaled relative weight (% of overall model P^2 explained)	95% CI of relative weight statistical significance
Anger-out	0.005	12.9	−0.002: 0.013
Anger-in	0.015	32.7	0.004: 0.028
Anger-control	0.016	34.6	0.005: 0.028
Angry temperament	0.004	10. 6	−0.003: 0.013
Angry reaction	0.004	9.26	−0.003: 0.012
Total	0.046		

amount of variance in subjective sleep measures (both $P^2 = 0.02$, 95% CIs = 0.004–028). Anger-control and anger-in each accounted for around 33% of the total variance explained in subjective sleep by anger tendencies, accounting for about 66% together (see Table 3). The multiple regression of each subjective sleep index on all anger tendencies are available in the appendix (see Appendix B).

Because anger-control and anger-in each uniquely predicted variance in subjective sleep, we next examined how these anger tendencies related to individual subjective sleep indices both before and after controlling for age, gender, race, socioeconomic status, and stress. Individuals who engaged in more anger-control reported less time sleeping (r (436) = −0.14, 95% CI = −0.23 to −0.04), reported falling asleep more quickly (r (436) = −0.14, 95% CI = −0.23 to −0.04), and reported having better subjective sleep quality (r (436) = 0.20, 95% CI = 0.11–0.30). In contrast to objectively recorded number of awakenings, anger-control did not relate to the subjective recall of the number awakenings during the night. After accounting for the covariates, greater anger-control still predicted reporting less time sleeping (β (422) = −0.11; 95% CI = −22 to −0.01) and better subjective sleep quality (β (422) = 0.10; 95% CI = 0.01–0.20). In regards to anger-in, a greater tendency to hold in angry feelings only predicted reports of worse subjective sleep quality (r (436) = −0.27, 95% CI = −0.36 to −0.18), with the relation robust to the impact of the study covariates (β (422) = −0.15; 95% CI = −0.25 to −0.05).

3.3. Differences in typical sleep between those high and low in anger-control

Because anger-control systematically related to sleep across both subjective and objective sleep measurements, we sought to meaningfully display the (apparently small) relation between sleep and controlling angry feelings. To do so we compared averages on objective and subjective sleep indices between those who reported engaging in anger control "often" or "almost always" (i.e. those who averaged '3′ or higher on anger-control; $N = 126$) against those who reported engaging in anger control "sometimes" or "almost never" (i.e. those who averaged '2′ or lower on anger-control; $N = 131$). In terms of objective sleep, individuals who indicated that they often or almost always engaged in anger control fell asleep around 9 min sooner ($M = 28.16$, SE = 2.78 vs. $M = 36.83$, SE = 3.78; $d = -0.25$; t (255) = −1.97, 95% CI of mean difference = −17.33 to −0.009), were aroused from sleep three less times ($M = 30.79$, SE = 0.87 vs. $M = 33.92$, SE = 0.97; $d = -0.30$; t (255) = −2.39, 95% CI of mean difference: −5.71 to −0.55), and were awake during the night for 13 min less ($M = 42.95$, SE = 1.71 vs. $M = 56.42$, SE = 2.42; $d = -0.57$; t (255) = −4.51, 95% CI of mean difference: −19.34 to −7.58), than individuals who sometimes or almost never engaged in anger control (see Fig. 1). In terms of

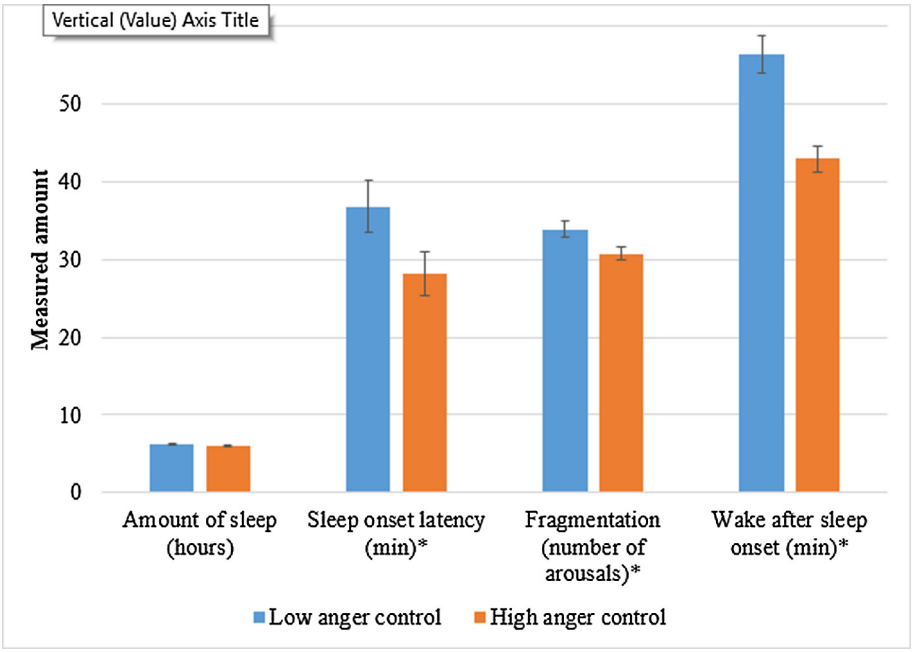

Fig. 1. Objective sleep for those with low and high anger-control. Note. Bars represent standard error of the mean. *p < 0.05.

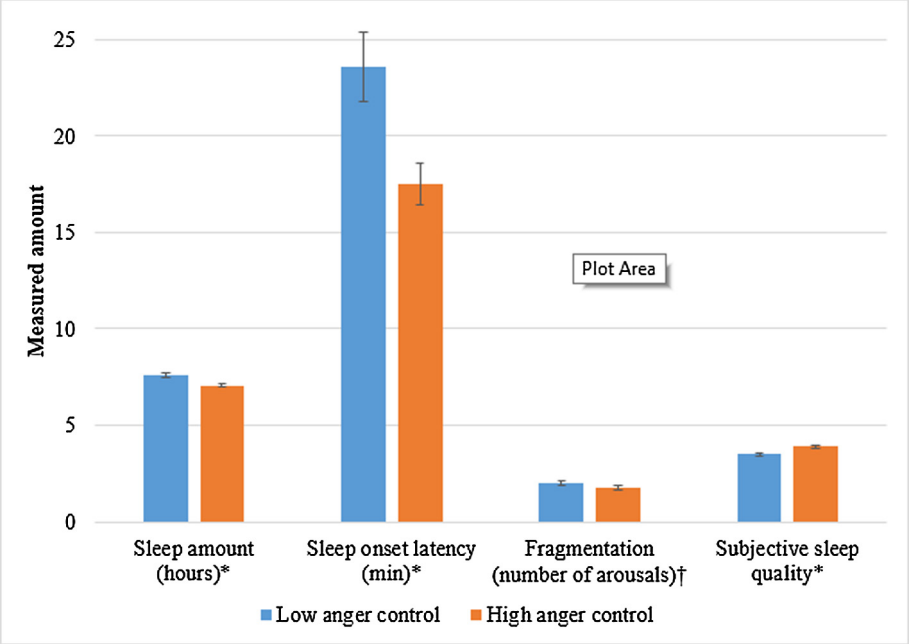

Fig. 2. Subjective sleep for those with low and high anger-control. Note. Bars represent standard error of the mean. †p < 0.1, *p < 0.05.

subjective sleep, individuals high in anger-control reported sleeping for around 32 min less (M = 423.44, SE = 5.60 vs. M = 455.06, SE = 7.68; d = −0.42; t (255) = −3.31, 95% CI of mean difference = −50.46 to −12.79), reported fallings asleep 6 min sooner (M = 17.55, SE = 1.08 vs. M = 23.61, SE = 1.82; d = −0.37; t (255) = −2.85, 95% CI of mean difference = −10.26 to −1.87), and tended to report one in four less awakenings during the night (M = 1.76, SE = 0.09 vs. M = 2.03, SE = 0.12; d = −0.23; t (255) = −1.81, 95% CI of mean difference = −0.58–0.02) (see Fig. 2).

4. Discussion

The current study sought to examine (1) how personality differences in anger relate to objectively measured sleep and (2) what aspects of anger and sleep are the most important for this relation, hypothesizing that anger-control would predict better sleep. Critically, the findings supported of our first hypothesis that anger tendencies would predict participants' actual sleep, providing evidence that anger-prone individuals do not just report worse sleep, but also actually have worse sleep. Moreover, by evaluating how a range of conceptually distinct anger tendencies uniquely predicted sleep we identified aspects of angry personalities especially important for sleep. Specifically, anger-control consistently predicted both objective and subjective weeklong measurements of sleep, supporting our second hypothesis that the specific tendency to control anger would predict better sleep and implicating the control of angry impulses as especially important for the link between anger and sleep. The only other anger propensity that predicted sleep was anger internalization, and this tendency only predicted subjective sleep quality. Altogether, these findings add to the growing understanding of anger and sleep by demonstrating personality differences in anger predict real behavioral differences in how people sleep, as well as placing anger-control at the core of this relation.

4.1. Theoretical Implications and limitations

4.1.1. How strongly is anger tied to sleep?

Although chronic anger systematically predicted sleep, it accounted for only two percent of the variance in objective sleep and roughly five percent of the variance in subjective sleep. Although such effect sizes are small according to conventions, they nevertheless reveal anger tendencies to be important for sleep. First, trait anger, which is relatively stable and enduring, predicted sleep (which is quite variable) over a "random" week from the participant's life. Specifically, in the case of objective sleep, self-reports about general anger predicted actigraphically-recorded aggregates of wakefulness in bed and sleep interruptions. Given such methodological divergence we would not expect large effects. In this vein, smoking may explain less than 1% of variance in 25-year incidence of lung cancer (Meyer et al., Table 1, 2001), yet this is undoubtedly an important link (Iso-Ahola, 2017). Moreover, analyses contrasting *typical* sleep of those high and low in anger-control demonstrate meaningful differences in sleep patterns over a week (e.g., 20 more minutes of unwanted wakefulness in bed a night for those lower in anger control).

Moreover, as it is important to not only consider where a person is but also where a person is going, these small differences in typical sleep may lead to important future differences in health given the vital role of sleep in maintaining physical and emotional functioning (Friedman, 2000). Future research may want to consider disrupted sleep as a potential mechanism through which worse anger-control contributes to poorer health outcomes (e.g., greater cardiovascular disease incidence, slower wound healing, and more inflammatory markers (Boylan & Ryff, 2013; Gouin et al., 2008; Haukkala et al., 2010). Finally, in our regression analyses where we include age, gender, stress, income, education, and race as covariates we further demonstrate that anger-control predicts sleep above and beyond these theoretically important covariates, implicating that the variance in sleep accounted by anger control is unique to these factors. For all these reasons, we believe that while two percent of variance accounted for is indeed "small", the consequences of this variance are not.

4.1.2. Personality and sleep problems

Finding that less frequent anger control predicted both poorer subjective and objective sleep might inform why particular personality traits link to sleep patterns. Specifically, individuals who are more conscientiousness (and more specifically have greater self-control) tend to have better sleep, whereas more neurotic individ-

uals tend to have worse sleep and are more likely to have insomnia (Gray & Watson, 2002; Hintsanen et al., 2014; Kroese et al., 2016; Van de Laar, Verbeek, Pevernagie, Aldenkamp, & Overeem, 2010). Especially problematic is the combined influence of low conscientiousness and high neuroticism that seems to result in even more disturbed sleep (Duggan, Friedman, McDevitt, & Mednick, 2014). While individuals who are more conscientious or have more self-control may sleep better because they have better sleep habits, it may also be that greater conscientiousness and self-control predict better sleep because such individuals are more likely to sufficiently regulate emotional arousal before bed (Gray & Watson, 2002; Hintsanen et al., 2014; Kroese et al., 2016). Additionally, because propensities toward anger and volatility are one key aspect of neuroticism, anger that is not sufficiently regulated may be one reason neuroticism foreshadows insomnia (DeYoung, Quilty, & Peterson, 2007; Van de Laar et al., 2010).

4.1.3. Subjective vs. objective sleep

Interestingly, among the sleep indices that were measured both objectively and subjectively (sleep amount, sleep onset latency, sleep fragmentation), anger-control tended to relate to different sleep indices depending on the mode of measurement. After controlling for covariates, anger-control predicted objective, but not subjective, sleep fragmentation and predicted subjective, but not objective, sleep amount. To the extent these differences do not reflect sample idiosyncrasies, they likely reflect that self-reports of sleep rely on an individual's accurate perception of sleep and that these reports can't capture sleep characteristics that people are less conscious of, such as the number of short or subtle arousals from sleep. These differences might also reflect the extraneous influence of factors that can influence subjective, but not objective, measures of sleep, such as a negative responding style for amount of sleep. Such discrepant findings between objective and subjective measurements of sleep are consequential because relying only on self-reports of sleep could lead to an incomplete or inaccurate understanding of how anger affects sleep. Future research investigating personality and sleep should keep in mind that different relations may emerge depending on whether sleep is measured through self-reports or through more objective behavioral assessments such as actigraphy.

Why did anger-control predict both objective and subjective sleep while anger-in only predicted subjective sleep? The answer to the question is revealed through inspection of correlations in Table 1. Anger-in predicted subjective sleep because, of all the sleep outcomes, anger-in only correlated with subjective sleep quality which is a purely subjective measure and therefore does not have a parallel objective sleep measure. Anger-control in contrast related to sleep outcomes that are represented in both subjective and objective sleep (i.e. sleep onset latency and sleep fragmentation). Additionally, anger-in may have only related to subjective sleep quality because both constructs likely tap into introspections and feelings of general distress.

It is also worth noting that sleep was only measured through daily diaries and wrist actigraphy, neither of which can capture sleep architecture (i.e. progression and duration of sleep stages, assessed via polysomnography). Sleep architecture may also be sensitive to differences in anger so future research should investigate this possibility. Additionally, self-reports and actigraphic measurements of sleep are not perfectly accurate. For instance, the actigraph used in this study (The Mini Mitter Actiwatch-64) systematically underestimate sleep efficiency and sleep amount and overestimates sleep fragmentation in comparison to polysomnography. However, despite these systematic misestimates, it nevertheless strongly converges with sleep estimates derived from polysomnography (Rupp & Balkin, 2011). Critically, as these misestimates are systematic across all participants, they should not produce confounds in our analyses of the relation between anger and sleep, though they will produce over- or under-estimates when interpreting raw means and counts of sleep variables.

4.1.4. What about other aspects of anger?

Although sleep was clearly linked to the tendency to control feelings of anger, it may seem puzzling that sleep was generally not related to other tendencies regarding how anger is managed, such as holding anger in or expressing anger outwardly. We suggest two possibilities. First, controlling anger is a central component of anger and aggression models and is a determinant of whether and how quickly, long, and intensely anger is felt or expressed (Anderson & Carnagey, 2004; Finkel, 2014; Wilkowski & Robinson, 2010). If anger is controlled or dissipated, there is little or no anger to feel and express. While past research has linked other anger tendencies such as anger suppression to sleep, our findings suggest that when anger tendencies are more holistically assessed and their unique contributions examined, perhaps what really matters for sleep is whether anger is likely to be resolved, not how anger is expressed or felt. Thus, other anger tendencies may not tend to predict sleep beyond anger-control or in isolation. Note that the strongest correlations with sleep outside anger control involved angry temperament, supporting the more general conclusion that trait anger is linked to how people sleep.

Second, links between sleep and anger may have been depressed because of the age of the study sample. The MIDUS II Biomarker sample consists of middle-aged, healthy individuals who are between 35 and 85 years old, and 50% of whom are above the age of 55. Detecting relations between sleep and anger expression may be difficult in a predominately older adult sample because personality traits relevant to anger change over the lifespan in such a way that would suggest older adults being more resistant to anger. For instance, aggressive tendencies tend to decrease over the lifespan and individuals' conscientiousness, emotional stability, and agreeableness tend to reach their peak during older adulthood (Huesmann, Eron, Lefkowitz, & Walder, 1984; Roberts, Walton, & Viechtbauer, 2006). Moreover, physical ability and social appropriateness of expressing anger outwards likely declines as people age. The relation between sleep and anger expression may be more relevant in populations for whom angry and aggressive tendencies are more likely, such as adolescents, young adults, and, at-risk individuals (Ireland & Culpin, 2006; Krizan & Herlache, 2016). Thus, the use of a predominately older adult sample (mean age of 56.91 years) limits the generalizability of the current study to other populations and may have restricted critical variance in angry tendencies, reducing the estimated effect size between anger and sleep. However, this limitation suggests that our analyses provided conservative tests and that future research assessing this link may uncover stronger relations between anger and actual sleep.

To check whether age qualified the associations between anger and sleep, we conducted post-hoc interaction analyses between each anger tendency and age predicting each sleep outcome. However, only one interaction out of forty possible interactions emerged as significant in this large number of exploratory analyses. This interaction revealed that younger participants showed no differences in how long it took to fall asleep between those who were high and low in anger control, while older participants who were high in anger control fell asleep the quickest and older participants who were low in anger control took the longest to fall asleep (see Appendix C). Again, our ability to detect such effects is likely limited given that our sample only has an age range of 35–85 and does not capture the younger age range that may be important for detecting such interaction effects (e.g. children and adolescents whose self-control capacities are still developing).

4.1.5. Sleep shaping anger

While the age of the study sample may be one limitation of the study, another is the cross-sectional nature of the study which clouds the causal direction between anger tendencies and sleep. Given that anger tendencies were assessed when sleep measurement began, our results could be interpreted as showing that sleep disruption shapes anger tendencies. Growing evidence that poor sleep can increase anger and hostility and over time fuel chronic anger reinforces this interpretation (Kamphuis et al., 2012; Krizan & Herlache, 2016). While plausible, we argue that our findings may better reflect the influence of individual difference in anger on sleep patterns. Because individual differences are relatively enduring and stable descriptors of how an individual is likely to behave over time and across situations, it seems more likely that pre-existing individual differences in anger played a formative role in week-long sleep rather than that sleep over a week impacted stable differences in individuals' anger propensities. Because experimental evidence suggests that causal impact can go both ways (Kamphuis et al., 2012; Krizan & Herlache, 2016), future investigations should consider reciprocal developmental relations between sleep and anger tendencies. For instance, given that individual differences in sleep and anger are heritable, future research may want to consider the possibility that one reason sleep and anger propensities are intertwined is that both might share genetic bases (Barclay & Gregory, 2013; Giegling, Hartmann, Möller, & Rujescu, 2006; Viola et al., 2007).

5. Conclusion

This study provided the first evidence that anger tendencies predict objectively measured sleep. Importantly, differences in anger control seemed to be at the core of this relation. Altogether, the findings offer strong evidence that anger is related to actual sleep and not an artifact of self-report biases nor reducible to other contributing factors. These findings add to the growing evidence that being prone to anger may lead to poor sleep and that anger and sleep are intimately connected.

Open data access

Data used for this study is not available directly from authors as data from the MIDUS Milwaukee African American sample is protected by a restricted data use agreement.

Preregistration

This study was not preregistered prior to submission.

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Conflict of interest

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Author contributions

GH contributed to study concept and design, data analysis and interpretation, drafting manuscript, and review and final approval of manuscript. ZK contributed to study concept and design, data interpretation, review and final approval of manuscript.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jrp.2017.08.009.

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