RESEARCH ARTICLE

Sleep: An Important Factor in Stress-Health Models

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Abstract

A growing body of literature supports the notion that psychological stress negatively impacts physical health. In parallel to this programme of stress/health investigations, researchers are demonstrating the deleterious health effects of poor sleep. The current study simultaneously examines the association of both stress and sleep with health. Two hundred and eighteen subjects completed an anonymous survey packet that included stress, sleep and health measures. Psychological stress (as assessed by both life-events and by self-perceived stress), daytime sleepiness and poor sleep quality, but not sleep quantity, were all negatively associated with health. A regression model that integrated both stress measures was a statistically significant predictor of health. Adding the sleep measures to the stress-health model accounted for a statistically significantly greater proportion of the variance in health scores, with the stress + sleep model accounting for 39–56 per cent of the variance in health scores depending on the health measure used. These results suggest that studies of stress and health may benefit from the inclusion of sleep measures and that, from a practical standpoint, poor sleep might be best understood not simply as a sequela of psychological stress but rather as a factor that should be actively addressed as part of the treatment programme.

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Keywords

stress; sleep quality; sleep quantity; sleep; health

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There now exists an extensive body of research supporting the role of psychological stress in health and illness. The impact of short-lived, acute, stress has frequently been studied through controlled laboratory experiments in which the stress levels of research participants are purposefully manipulated via participation in stress tasks or exposure to stressful situations (e.g. Altemus, Rao, Dhabhar, Ding, & Granstein, 2001; Benham, 2007; Bosch, de Geus, Veerman, Hoogstraten, & Nieuw Amerongen, 2003; Fan et al., 2009). The study of chronic stress in humans relies on non-experimental designs in which naturally occurring stress levels or naturally occurring events (e.g. academic exams) are examined for evidence of association with self-reported health or physiological indices of health (e.g. Cohen, Tyrrell, & Smith, 1991; Jemmott & Magloire, 1988). Both methods provide valuable data for the field of stress and health, particularly because of the increasing evidence that the physiological effects of chronic stress may differ greatly from those of acute stress (Bosch, de Geus, Ring, & Amerongen, 2004).

Studies investigating the health impacts of chronic stress typically rely on group comparisons between those experiencing high levels of stress and those who are not, or on establishing correlations between a measure of stress and some health/physiology outcome variable. In the latter non-experimental approach, stress is frequently measured through self-reports, e.g. via measures of self-perceived stress or via measures of life-events. Research supports the notion that chronic psychological stress is associated with both self-reported health (e.g. Faulkner & Smith, 2009; Flores et al., 2008; Smolderen, Vingerhoets, Croon, & Denollet, 2007) and more objective measures of health such as immune functioning (Ellard, Barlow, & Mian, 2005; Segerstrom & Miller, 2004).

In parallel to this programme of stress/health investigations, researchers are demonstrating the deleterious health effects of inadequate sleep (Åkerstedt, Kecklund, Alfredsson, & Selen, 2007b; Ayas et al., 2003; Beihl, Liese, & Haffner, 2009; Hall et al., 2008). As with stress, methods and measures used to quantify sleep are varied. Methods include self-report, behavioural observation, actigraphy and electroencephalographic assessments. Sleep measures may assess sleep quantity, sleep quality and daytime sleepiness.

Data from sleep surveys suggest that many individuals obtain insufficient amounts of sleep each night. According to a recent national US poll, 20 per cent of Americans sleep less than 6 h per night, a sharp increase from the 13 per cent reported in 2001 (National Sleep Foundation, 2009). As with chronic stress, research has demonstrated an association between naturally occurring insufficient sleep duration and self-reported health/illness (Steptoe, Peacey, & Wardle, 2006; Stranges et al., 2008) along with a variety of health variables including metabolic syndrome (Hall et al., 2008), hypertension and heart disease (Ayas et al., 2003; Gangwisch et al., 2006; Gottlieb et al., 2006), diabetes (Beihl et al., 2009; Gottlieb et al., 2005; Knutson, Ryden, Mander, & Van Cauter, 2006), obesity (Cappuccio et al., 2008), pro-inflammatory cytokines (Patel et al., 2009) and susceptibility to the common cold (Cohen, Doyle, Alper, Janicki-Deverts, & Turner, 2009).

In addition to these non-experimental approaches, a number of researchers have studied the impact of insufficient sleep through the manipulation of sleep quantity in controlled studies. Although total sleep deprivation (extended sleep restriction) has traditionally been more commonly studied (Frey, Fleshner, & Wright, 2007; Gonzalez-Ortiz, Martinez-Abundis, Balcazar-Munoz, & Pascoe-Gonzalez, 2000; Ogawa et al., 2003; Vaara, Kyrolainen, Koivu, Tulppo, & Finni, 2009), investigators are increasingly examining the more ecologically valid concept of sleep debt or chronic partial sleep restriction that involves a limited number of hours of sleep per night over an extended period of time (e.g. Spiegel, Leproult, & Van Cauter, 1999; Van Cauter, Spiegel, Tasali, & Leproult, 2008; Vgontzas et al., 2004). Research also suggests that sleep quality may be equally or more important than measures of sleep quantity in predicting physical health (Cohen, Doyle, Skoner, Rabin, & Gwaltney, 1997; Irwin, 2008, Knutson et al., 2006; Pilcher, Ginter, & Sadowsky, 1997; Pilcher & Ott, 1998).

Research demonstrates that higher psychological stress is related to shorter sleep duration (e.g. Rutledge et al., 2009; Sadeh, Keinan, & Daon, 2004) and poorer sleep quality (e.g. Åkerstedt, Kecklund, & Axelsson, 2007a; Bernert, Merrill, Braithwaite, Van Orden, & Joiner, 2007; Fortunato & Harsh, 2006; Guastella & Moulds, 2007; Knudsen, Ducharme, & Roman, 2007; Suarez, 2008; Williams & Moroz, 2009). However, the correlation between these two measures is far from perfect, raising the possibility that a model predicting health from stress might be improved by integrating sleep as a predictor variable. It has been suggested that the impact of stress on health can best be understood as a result of allostatic load: the cumulative physiological strain of repeated adaptation to stressful situations (McEwen, 2000). More recently, McEwen (2006) has proposed that sleep deprivation can be considered as an additional contributor to allostatic load. Figure 1 presents a stress-health model in which (a) stress and sleep have a reciprocal relationship, (b) both psychological

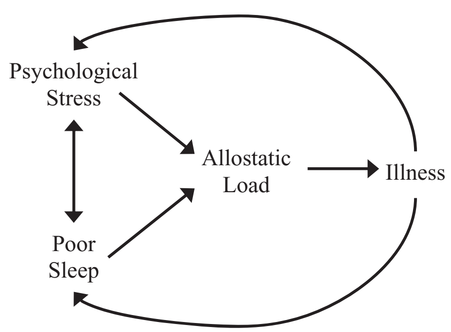

Figure 1 Stress-health model in which both sleep and psychological stress contribute to illness as a result of increased allostatic load. Psychological stress negatively impacts sleep and poor sleep leads to increased psychological stress. Physical illness affects both sleep and stress

stress and poor sleep contribute to allostatic load (which, in turn, contributes to illness) and (c) ill-health affects both psychological stress and sleep.

The current study set out to simultaneously examine the association of both stress and sleep with health. Specifically, we hypothesized that symptom reporting (ill health) would relate positively to both self-reported stress and self-reported sleep. Additionally, we hypothesized that self-reported sleep would improve the predictive power of a stress-health regression model.

Methods

Participants

Two hundred and eighteen undergraduate students from the University of Texas–Pan American participated in this study. Participants ranged in age from 18 to 48 ($M = 22.6$, SD = 5.2), 74 per cent were female, and 93 per cent were Hispanic.

Procedures and measures

The current study was part of a larger protocol examining psychological and behavioural factors in health. As part of the larger study, participants were invited to attend one of a number of scheduled research sessions where they anonymously completed a survey packet that included a demographic questionnaire and the measures detailed below. Surveys were completed in group settings (groups ranged in size from 3 to 18 students) where each participant completed the survey packet in his/her own time and then returned it to the investigator. The study was approved by the university's Institutional Review Board and all participants provided informed consent prior to participation.

The Perceived Stress Scale (PSS: Cohen & Williamson, 1988)

The PSS is a 10-item Likert-type scale that asks respondents 'In the last week, how often have you . . .' and includes items such as 'felt nervous and stressed?', 'felt that you were unable to control the important things in your life?' Response choices range from (0) 'never' to (4) 'very often'. The 10-item version of the scale is a revision of the originally published 14-item version, has been shown to provide a slight gain in psychometric quality over the longer version, and is recommended over the 14-item version by the scale's authors (Cohen & Williamson, 1988). The PSS has been reported as a better predictor of psychological symptoms, physical symptoms, and health service utilization than life-event scales (Cohen, Kamarck, & Mermelstein, 1983). Possible scores range from 0 to 40 and were calculated by summing up the 10-item ratings (after reverse scoring specific items). Higher PSS scores represent more stress. Cronbach's alpha was 0.89 in the present study.

Inventory of College Students' Recent Life Experiences (ICSRLE; Kohn, Lafreniere, & Gurevich, 1990)

The ICSRLE is comprised of 49 items that reflect everyday stressors or hassles commonly experienced by college students. For each item, respondents rated the intensity of their experience with the stressor over the past month on a four-point Likert scale (1: *not at all part of my life* to 4: *very much part of my life*). Possible scores range from 49 to 196 and were calculated by summing up the 49 item ratings. Higher ICSRLE scores represent more stress. The ICSRLE has previously shown to be statistically significantly correlated with the PSS ($r = 0.59$; Kohn et al., 1990). Cronbach's alpha was 0.90 for the present sample.

The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989)

The PSQI consists of 19 questions and provides a global measure of sleep quality. The global PSQI score is based on seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction over the last month, each of which is weighted equally on a 0–3 scale. Scores on the PSQI range from 0 to 21 with higher scores indicating worse sleep quality. A global score greater than 5 provides a sensitive and specific measure that distinguishes poor from good sleepers (Buysse et al., 1989) and has thus been established as a standardized cutoff score for the PSQI. Based on the seven PSQI component scores, Cronbach's alpha was 0.70 for the current study.

The Epworth Sleepiness Scale (ESS; Johns, 1991)

The ESS is an eight-item scale that evaluates daytime somnolence through subjects' self-ratings of

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their chances of dozing off in each of eight different situations. Each item is rated on a four-point scale (0: *would never doze* to 3: *high chance of dozing*) with a total ESS score ranging from 0 (best) to 24 (worst). Higher ESS scores represent greater daytime sleepiness. Cronbach's alpha for the ESS was 0.76 in the present sample.

The Cohen–Hoberman Inventory of Physical Symptoms (CHIPS; Cohen & Hoberman, 1983)

The CHIPS is a 33-item Likert-type scale that asks respondents to rate how much a particular symptom has bothered or distressed them during the last month, and includes items such as 'back pain' and 'diarrhea'. Responses range from (0) 'not been bothered by the problem' to (4) 'the problem has been an extreme bother'. The final score ranges from 0 to 4 and is calculated as the average of the 33-item ratings. Higher CHIPS scores represent higher physical symptom reporting. In the present study, Cronbach's alpha was 0.93.

The Pennebaker Inventory of Limbic Languidness (PILL; Pennebaker, 1982)

The PILL is a 54-item scale that assesses the frequency of occurrence of 54 common physical symptoms and sensations such as racing heart, heartburn and sore throat. The response options range from 'never or almost never' to 'more than once every week'. The final PILL score ranges from 0 to 54 and is calculated by summing up the total number of items on which individuals rate the symptom as occurring once or more per month. Higher PILL scores represent higher physical symptom reporting. The Cronbach's alpha for the present study was 0.94

Data reduction and analyses

SPSS Version 15.0 software (SPSS Inc., 2006 Chicago IL) was used to analyse data in the present study. Descriptive statistics were computed to present demographic data. Of the 218 subjects who attended the appointed sessions, all completed the survey packet to a sufficient degree for inclusion of their responses in the data analysis. A number of the variables deviated from the normal distribution, thus Spearman's rho was used to calculate correlation coefficients. Square-root transformations of the PILL, CHIPS and PSQI resulted in normal distributions and these transformed values were used in the regression analyses.

Results

Sixteen per cent of the participants categorized themselves as smokers. Of the female participants, 2 per cent reported that they were pregnant and 14.5 per cent reported that they were 'currently taking birth control pills'. Seventeen per cent of participants reported that they felt that they suffered from insomnia and 71 per cent reported that they often slept in on Saturday or Sunday mornings to catch up on lost sleep. Table I shows means and standard deviations for correlations for the self-report stress, sleep and health measures and selected demographic questionnaire items.

The two health measures (CHIPS and PILL) were highly correlated. Both stress measures (PSS and ICSRLE) correlated statistically significantly with both health/illness measures (CHIPS and PILL); higher stress was associated with poorer health. Daytime sleepiness (ESS) and sleep quality (PSQI) correlated statistically significantly with both health/illness measures (CHIPS and PILL); poorer sleep quality and greater daytime sleepiness were associated with poorer health. The average number of hours slept per night was not

Table I. Means and SDs for stress, sleep, health and Questionnaire measures

	PSS	ICSRLE	PSQI	ESS	Hours	CHIPS	PILL	BMI	Exer.	Relax
N	218	217	209	217	218	217	218	218	216	214
M	18.0	97.4	6.2	8.7	6.5	0.91	12.78	25.2	4.3	14.6
SD	(7.1)	(18.6)	(3.0)	(4.3)	(1.3)	(0.64)	(9.31)	(5.6)	(5.9)	(12.0)

PSS: The Perceived Stress Scale; ICSRLE: Inventory of College Students' Recent Life Experiences; PSQI: The Pittsburgh Sleep Quality Index; ESS: The Epworth Sleepiness Scale; Hours: Self-Reported Average Number of Hours Slept per Night; CHIPS: The Cohen–Hoberman Inventory of Physical Symptoms; PILL: The Pennebaker Inventory of Limbic Languidness; BMI: Body Mass Index (calculated from self-reported height and weight); Exer.: Self-Reported Average Number of Hours Exercised Per Week; Relax: Self-Reported Average Number of Hours that Participants have 'to themselves' to Relax Per Week; SD: Standard Deviation.

Table II. Spearman's rho correlation coefficients for stress, sleep, health, and questionnaire measures

	PSS	ICSRLE	PSQI	ESS	Hours	CHIPS	PILL	Age	BMI	Exer.
Stress										
PSS										
ICSRLE	0.63**									
Sleep										
PSQI	0.34**	0.33**								
ESS	0.41**	0.49**	0.38**							
Hours	0.00	−0.05	−0.48**	−0.23**						
Illness										
CHIPS	0.46**	0.53**	0.64**	0.54**	−0.26**					
PILL	0.39**	0.45**	0.51**	0.51**	−0.21**	0.76**				
Other										
Age	−0.05	−0.05	0.08	0.00	0.03	0.02	0.02			
BMI	−0.08	−0.01	0.03	0.04	−0.20**	0.05	−0.03	0.19**		
Exercise	−0.37**	−0.22**	−0.09	−0.08	−0.11	−0.19**	−0.13*	−0.08	0.06	
Relax	−0.17**	−0.13*	−0.23**	−0.23**	0.17**	−0.25**	−0.15*	−0.21**	0.19**	0.19**

PSS: The Perceived Stress Scale; ICSRLE: Inventory of College Students' Recent Life Experiences; PSQI: The Pittsburgh Sleep Quality Index; ESS: The Epworth Sleepiness Scale; Hours: Self-Reported Average Number of Hours Slept Per Night; CHIPS: The Cohen–Hoberman Inventory of Physical Symptoms; PILL: The Pennebaker Inventory of Limbic Languidness; BMI: Body Mass Index (calculated from self-reported height and weight); Exer.: Self-Reported Average Number of Hours Exercised Per Week; Relax: Self-Reported Average Number of Hours that Participants have 'to themselves' to Relax Per Week.

Note: All values represent Spearman's rho, 1-tailed; $^{**}p < 0.01$, $^{*}p < 0.05$. The n for pairwise comparisons ranges from 209 to 218.

statistically significantly correlated with either of the health/illness measures (Table II).

A regression model using the two stress measures as predictors of health was statistically significant for both the CHIPS and the PILL, with stress accounting for 30 per cent of the variance in CHIPS scores and 22 per cent of the variance in PILL scores (see Table III). Both self-perceived stress and life-events contributed statistically significantly to the model.

In order to examine whether sleep measures added to the predictive model of stress and health, a two-stage regression model was tested for both the CHIPS and the PILL health measures. The two stress scores (PSS and ICSRLE) were entered at the first stage and the three sleep scores (sleep duration, sleep quality and daytime sleepiness) were entered at the second stage. The addition of sleep measures to the stress-health model resulted in a statistically significant increase in R^2 for both the CHIPS ($\Delta R^2 = 0.259$) and the PILL ($\Delta R^2 = 0.173$). The final model was statistically significant for both the CHIPS and the PILL, accounting for 56 per cent of the variance in CHIPS scores and 39 per cent of the variance in PILL scores (see Table III). In the final models, life-events, sleep quality and daytime sleepiness all contributed statistically significantly as predictor variables for CHIPS; sleep quality and daytime sleepiness contributed statistically significantly as predictor variables for PILL.

Discussion

Our results support prior research demonstrating the association between stress and health. Two measures of health both correlated statistically significantly with self-perceived stress and life-events and a regression model incorporating both stress measures predicted between 22 per cent (PILL) and 30 per cent (CHIPS) of the variance in health, depending on the health measure used. As hypothesized, the stress-health model was improved by adding sleep measures as predictors. The resultant stress + sleep model predicted between 39 per cent (PILL) and 56 per cent (CHIPS) of the variance in health. It is not clear why the predictor variables accounted for a greater proportion of the variance in CHIPS scores than the variance in PILL scores; many of the symptoms listed (e.g. dizziness, constipation) were similar across the two measures. However, the PILL was based on individuals stating the *frequency* with which they experienced the symptoms, whereas the CHIPS was based on individuals rating the *extent to which they had been bothered* (not at all bothered to extreme bother) during the past month.

Table III. Results of regression analysis examining self-reported stress and sleep as predictors of self-rated health

	R	R^2	ΔR^2	*F*	df	*B*	β weight
CHIPS Model 1							
Stress	0.550	0.303	0.303**	44.25	2,204		
PSS						0.076	0.275**
ICSRLE						0.036	0.332**
CHIPS Model 2							
Step 1 (Stress)							
PSS						0.034	0.123
ICSRLE						0.017	0.158*
Step 2 (Sleep)	0.749	0.561	0.259**	51.46	5,201		
PSQI						1.456	0.467**
ESS						0.112	0.245**
Hours						0.059	0.039
PILL Model 1							
Step 1 (Stress):	0.469	0.220	0.220**	28.93	2,205		
PSS						0.044	0.221**
ICSRLE						0.023	0.295**
PILL Model 2							
Step 1 (Stress)							
PSS						0.019	0.094
ICSRLE						0.011	0.137
Step 2 (Sleep):	0.627	0.393	0.173**	26.19	2,205		
PSQI						0.797	0.355**
ESS						0.085	0.258**
Hours						0.062	0.057

PSS: The Perceived Stress Scale; ICSRLE: Inventory of College Students' Recent Life Experiences; PSQI: The Pittsburgh Sleep Quality Index; ESS: The Epworth Sleepiness Scale; Hours: Self-Reported Average Number of Hours Slept Per Night; CHIPS: The Cohen–Hoberman Inventory of Physical Symptoms; PILL: The Pennebaker Inventory of Limbic Languidness; BMI: Body Mass Index (calculated from self-reported height and weight); Exer.: Self-Reported Average Number of Hours Exercised Per Week; Relax: Self-Reported Average Number of Hours that Participants have 'to themselves' to Relax Per Week.
Note: ** $p <= 0.01$, * $p <= 0.05$; β represents beta for each variable in final model with all variables entered.

These results suggest that the effect sizes obtained in studies of stress and health could be increased by incorporating measures of sleep. Although self-reported stress measures correlated statistically significantly with sleep quality (as assessed by the PSQI) and daytime sleepiness (as assessed by the ESS), partial correlations between stress and health measures were still statistically significant when controlling for sleep. Thus, poor sleep appears to be something more than a simple epiphenomenon of psychological stress.

Poor sleep has itself been conceived of as a chronic stressor exerting cumulative wear and tear on the body through a process of allostatic load (McEwen, 2006). It is interesting to note that chronic stress and poor sleep share similar physiological effects: both have been shown to activate the hypothalamic pituitary adrenal and sympathetic adrenal medullary systems and to adversely impact both the immune system and memory. Increasingly, researchers are focusing on the role of cytokines in the complex relationships between stress, immune function, depression and sleep behaviour (Irwin, 2002; Matalka, 2003); such research may provide clues to the common physiological mechanisms through which sleep, stress and illness interact.

Life events, rather than self-perceived levels of stress, were a better predictor of illness symptoms in our study, a result that contrasts with Cohen's original data on the PSS. Our findings would suggest that, in relation to health, the appraisal of one's level of stress may not be as important as the number of recent stressful life experiences. However, it should also be noted that the life events measure used in the current study was based on the previous month's experiences, while the perceived stress measure was based on the previous week; thus the discrepancy might alternatively be explained by the period of time on which the stress responses were based, particularly given that the illness symptomology measures were tied to a more extended period.

Previous research has shown sleep quantity to be an important factor in health, but our data found sleep quantity to be a weaker predictor of health than either sleep quality or daytime sleepiness. Given that individuals differ in their *sleep needs* (Van Dongen, Rogers, & Dinges, 2003), subjective sleep quality and daytime sleepiness are perhaps better indicators of whether a given individual is obtaining sufficient sleep to meet his/her personal needs.

Limitations

The current study was limited to a convenience sample of undergraduate, predominantly Hispanic, psychology students. Although this limits the generalizability of the results, Hispanics are frequently underrepresented in such research and therefore the findings are an important replication and extension of prior research in this field. Established measures of stress, sleep and health were used in the study; however, the results reported here are based exclusively on self-report data, and as such, associations between variables may be inflated by individual differences in the manner that participants underplayed or exaggerated their experiences and behaviours. It is quite possible that individuals who report high levels of stress also tend to overestimate their ill-health, or are simply more focused on physical symptoms. Indeed, research suggests that negative affectivity (the tendency to experience a wide range of negative emotions), may account for a large proportion of the shared variance between self-perceived stress and physical health reports (Chen & Spector, 1991). In light of this, some researchers have argued that negative affectivity needs to be statistically controlled for in stress research (McCrae, 1990; Moyle, 1995); however, others have argued that such procedures are inappropriate, particularly if the measures share similar items (Spector, Zapf, Chen, & Frese, 2000). Negative affectivity measures in which contaminating items are removed (e.g. items addressing somatic symptoms or psychological distress) may be a more appropriate measure of negative affectivity as applied to this area of research (Fortunato, 2004; Fortunato & Stone-Romero, 1999). Additionally, the current study suffers from the problem of common methods' variance because both the predictor and dependent variables are based on self-reports provided during a single survey administration session. The possibility for contamination between measures could be reduced by administering the measures independently, either at slightly different times or under different contexts. One way to largely eliminate the common methods' variance problem would be to limit the use of self-report measures to the predictor variables and rely on archival health data as the dependent variable.

Our sleep quantity measure was based on retrospective self-report, a method that can underestimate sleep quantity when compared with more objective actigraphy and polysomnography measures (Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008; Tryon, 2004). However, research on sleep quality suggests that subjective ratings may correspond well with objective measures of sleep efficiency (time asleep/time in bed; Åkerstedt, Hume, Minors, & Waterhouse, 1994), which is one plausible explanation for why sleep quality appeared to be a better predictor of health than sleep duration. Thus, the current findings provide some compelling evidence in support of the proposed association between stress, poor sleep and health, but future research that employs more objective measure of sleep (e.g. actigraphy and polysomnography) and health (e.g. immune function, susceptibility to the common cold, etc.) would strengthen this notion, and would reduce the problem of common methods' variance. Finally, it is recognized that the methodology used in this study does not allow causal attributions to be made. Our general framework for this study is based on the assumption that stress and sleep impact health, but it is also plausible that ill-health leads to more sleep problems and increased psychological stress.

Implications and future directions

Although some have argued that the association between stress and health might be explained through stress-induced alterations in sleep quality/quantity (Cruess et al., 2003), poor sleep quality might best be conceived as an important factor which supplements, rather than explains away, the association between stress and health. Our results suggest that the predictive power of a simple stress-health model is increased by the addition of sleep data, but a substantial amount of unexplained variance in health remains. Not all individuals need the same amount of sleep to maintain optimal daily functioning. Partially determined by genetics (He et al., 2009), these inter-individual differences in sleep need may be one reason why stronger associations amongst stress, sleep and health are not evident. It is also likely that some of this variance can be accounted for by behavioural factors; those who are stressed are more likely to smoke (Booker et al., 2008; Ng & Jeffery, 2003), exercise less frequently (Nguyen-Michel, Unger, Hamilton, & Spruijt-Metz, 2006) and have poorer nutritional practices (Roohafza et al., 2007); and sleep duration has also been shown to be associated with smoking, alcohol use and leisure-time physical inactivity (Schoenborn & Adams, 2008). The results of the current study suggest that it may also be critical to distinguish between sleep duration and sleep quality. Future studies investigating the health consequences of poor sleep must be careful to evaluate the relative (and perhaps interactive) influence of quantity versus quality. Such studies are not limited to non-experimental methodologies; researchers are already beginning to disentangle the relative impact of disrupted sleep quality (e.g. selective paradoxical sleep deprivation) from restricted sleep duration (Zager, Andersen, Ruiz, Antunes, & Tufik, 2007).

From a practical standpoint, clinicians who implement stress-reduction interventions might be advised to view poor sleep not only as a sequela of psychological stress but also as a factor that can be actively addressed as part of the treatment program. Indeed, given that stress reduction strategies may be effective for improving sleep (Carlson & Garland, 2005; Shapiro, Bootzin, Figueredo, Lopez, & Schwartz, 2003; Winbush, Gross, & Kreitzer, 2007), it is likely that the beneficial health effects of stress-reduction programmes (e.g. Koh, Lee, Beyn, Chu, & Kim, 2008) are already a result of both reductions in stress and improved sleep. Research investigating the potential for stress-reduction strategies to improve health would benefit from the inclusion of both stress and sleep measures so that the impact on these two factors could be simultaneously examined.

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