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ORIGINAL PAPER

Components of Sleep Quality as Mediators of the Relation Between Mindfulness and Subjective Vitality Among Older Adults

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Abstract We examined the potential contribution of sleep quality to the relation between mindfulness and subjective vitality, a marker of physical and psychological energy. Seven components of the Pittsburgh Sleep Quality Index were investigated as potential mediators of the association between dispositional mindfulness and subjective vitality in our sample of 219 older adults. Mindfulness, sleep quality, and subjective vitality were significantly and positively associated with each other. Sleep quality partially mediated the relation between mindfulness and subjective vitality, with two components responsible for this effect: habitual sleep efficiency and sleep-related problems experienced during the daytime. Implications of the association between mindfulness and subjective vitality in older adults via sleep quality are addressed, including the potential for interventions to improve sleep quality and well-being among older adults by inclusion of mindfulness training.

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Introduction

Well-being among older adults represents an increasingly important area of study. The average population age of developed countries has been steadily rising for decades, and this trend is likely to continue for the foreseeable future (Pool 2010). For instance, among more developed nations, less than 15 % of the population was over age 60 in 1960, but this statistic is expected to be approximately 30 % by 2030. In addition to lower fertility rates, this historical shift is largely due to improvements in emergency medical care that delay mortality (Pool 2010). Remaining alive, however, is not sufficient for experiencing health and well-being. Indeed, longer life may equate to more years of disability and infirmity rather than productivity (Hertzog et al. 2008), which can result in suffering for those that are living yet unhealthy as well as economic distress for the general public who may be responsible for covering associated healthcare costs. Therefore, research into cost-effective factors that promote well-being and functionality among older adults is of crucial importance for promoting successful aging and healthy societies (Hertzog et al. 2008).

Mindfulness, conceptualized as an open and accepting conscious awareness of and attentiveness to immediate experience (Brown and Ryan 2003), has received growing attention among health researchers for two important reasons. One, being mindful has salutary effects on physical, sociological, and psychological health (see Grossman et al. 2004; Reibel et al. 2001). As an example, in an experiment with older adults experiencing chronic low back pain, mindfulness promoted adaptive acceptance of their pain and better physical functioning (Morone et al. 2008). Two, there is evidence that people

can become more mindful with intentional practice (Brown et al. 2007). For instance, older adults that complete an 8-week mindfulness-based stress reduction intervention exhibit significant improvements in dispositional mindfulness post-intervention (Creswell et al. 2012; Moynihan et al. 2013).

One of the less-researched well-being correlates of mindfulness that may be particularly relevant to older adults is subjective vitality, which has been described as a "…conscious experience of possessing energy and aliveness" (Ryan and Frederick 1997, p. 530). It is well-established that maintaining a physically and socially active life can preserve health and delay the physical and cognitive declines associated with advancing age (Hertzog et al. 2008), and individuals who experience more subjective vitality report feeling more capable of engaging in such life pursuits (Ryan and Frederick 1997).

Ryan and Deci (2008) argue that subjective vitality is a unique and important indicator of eudaimonic well-being, which differs from hedonic well-being in its emphasis on meaning and enhanced functioning rather than the experience of pleasure. Eudaimonic well-being may be of particular importance to older adults. A recent study of the gene transcriptional correlates of markers of well-being found eudaimonic well-being to be associated with lower proinflammatory genes and an overall better antiviral response, whereas hedonic well-being was associated with increased proinflammatory genes and decreased antiviral response (Fredrickson et al. 2013). Given the causal role that proinflammatory genes play in chronic conditions associated with aging, such as cardiovascular disease and diabetes, it may be especially important to research factors that contribute to eudaimonic well-being among older adults.

Levels of subjective vitality are dependent upon both psychological factors (e.g., the extent to which individuals experience sufficient autonomy, competence, and relatedness in their social environments) and physical functioning (Ryan and Frederick 1997; Vlachopoulos and Karavani 2009), which typically decline with increasing age (Manini and Pahor 2009). The negative effect of diminishing physical status on subjective vitality, however, may be partially mediated by individuals' perceptions of and beliefs about their physical limitations (Ryan and Frederick 1997), which suggests that adaptive psychological coping, including mindfulness, can protect from decreases in subjective vitality even in the face of somatic impairment.

Researchers have studied the relations between mindfulness and varied markers of well-being such as life satisfaction and positive emotional functioning (Jain et al. 2007). In a review of the mindfulness literature, Reibel et al. (2001) concluded that trait mindfulness can diminish negative stress and increase positive states of mind and quality of life. These salutary effects of mindfulness on well-being can be direct, via enhanced richness in moment-by-moment experiences, as people approach even mundane activities with persistent interest and acceptance, and they can be indirect via improvements in awareness of and attentiveness to healthy self-regulatory behaviors that align with individuals' personal values (Brown et al. 2007; Howell et al. 2008). For instance, mindfulness involves attentiveness to numerous aspects of present moment experiences—including psychological, environmental, and somatic facets—that may be important for enhancing individuals' ability to regulate themselves toward satisfaction of their intrinsic needs (Brown and Ryan 2003; Brown et al. 2007; Shapiro and Schwartz 2000).

Although mindfulness has been shown to be positively related to subjective vitality as a marker of wellness (Brown and Ryan 2003), few studies have examined potential mechanisms in the connection between mindfulness and subjective vitality. One potential mediator that may be especially relevant among older adults is sleep quality, a complex clinical construct derived from objective and subjective aspects of sleep (Buysse et al. 1989). Objective aspects include quantitative markers such as amount of time sleeping (sleep duration), amount of time one takes to fall asleep (sleep latency), and number of times awakening. Subjective aspects include beliefs about the depth and restfulness of one's sleep (Buysse et al. 1989). Problematic sleep affects an estimated 30–40 % of the adult population, and its negative effects can contribute to psychological distress, sickness, and mortality (Bent et al. 2006; Gallicchio and Kalesan 2009; Lichstein et al. 2006). The importance of sufficient quantity and quality of sleep in older adults has been highlighted by numerous findings linking inadequate sleep to poor cardiovascular, immunological, cognitive, and affective health (Backhaus et al. 2002; Knutson et al. 2006; Newman et al. 1997). Recently, studies have examined relationships between sleep quality and more positive aspects of psychological well-being such as gratitude and life satisfaction (Howell et al. 2010; Wood et al. 2009).

Sleep quality is positively associated with mindfulness (Howell et al. 2008). Higher levels of mindfulness might contribute to improved sleep by reducing cognitive dysfunction that increases pre-sleep arousal and by promoting greater acceptance of sleep onset processes (Lundh 2005). Clinical studies have shown mindfulness-based stress reduction programs to have a positive effect on sleep quality in various samples (Biegel et al. 2009; Klatt et al. 2009; Winbush et al. 2007), including older adults (Morone et al. 2008). However, the mechanistic pathways of these effects have not been examined in older adults, and the particular components of sleep quality responsible for this effect are unknown. A recent experiment involving a small number of college students found that participants who completed a 5-week mindfulness class reported overall improvement in sleep quality, and while only the dimension of daytime dysfunction—impairment experienced during the day due to unsatisfactory sleep—was

significantly improved, other aspects of sleep exhibited meaningful trends toward improvement (Bowden et al. 2012).

Numerous studies have explored sleep as a mediating variable in a variety of contexts, such as the relationship between stress and immune functioning, social support and cardiovascular health, and socioeconomic status and health (Hall et al. 1998; Nordin et al. 2008; Van Cauter and Spiegel 1999), yet few studies have investigated sleep as an explanatory factor in the relationship between mindfulness and health outcomes. In a cross-sectional analysis utilizing a college student sample, dispositional mindfulness was positively related to sleep quality and emotional well-being, and mediation analyses supported sleep quality as a mediator of the positive relationship between mindfulness and well-being (Howell et al. 2008). In a similar study, Howell et al. (2010) found that more adaptive sleep functioning, such as better sleep hygiene, relatively less sleep effort and pre-sleep arousal, and fewer sleep-related cognitive distortions, partially explained the relationship between mindfulness and well-being. These studies by Howell and colleagues helped to establish the importance of sleep and sleep quality as explanatory mechanisms by which mindfulness might benefit well-being; however, there are significant differences between younger and older adults in sleep quality, and it is unknown if the model can be generalized to older adult samples. Additionally, more research is needed to determine the dimensions of sleep quality that may be responsible for the mediating effect. As such, we examined specific aspects of sleep quality as potential mediators of the relations between dispositional mindfulness and subjective vitality in a community sample of older adults. We hypothesized that dispositional mindfulness would be associated with improved sleep quality and increased subjective vitality, that better sleep quality would be associated with relatively higher subjective vitality, and that sleep quality would mediate the relations between dispositional mindfulness and subjective vitality. In addition, we explored the relative importance of each component of sleep quality mediating relations between mindfulness and subjective vitality.

Methods

Procedures

As part of a larger study, data were collected from older adults who were recruited from the community via advertisement or from one of two extended-stay care facilities in the northeastern USA. Extended-stay residents that were identified by nursing and physician staff as having adequate sensory and cognitive capacity to participate in research on mindfulness-based stress reduction were informed of the study. All individuals expressing interest in the study were administered the Mini Mental Status Exam (MMSE; Folstein et al. 1975) in a brief interview; those who showed minimal or no cognitive impairment (MMSE ≤25) were eligible for voluntary participation. In the current sample, the average MMSE score was 28.79 (SD=1.29), suggesting minimal cognitive impairment. All participants completed identical baseline questionnaires. The present study assesses the cross-sectional baseline data. A description of the larger study from which these analyses were completed is given in Moynihan et al. (2013).

Participants were 219 older adults, including 81 (37.0 %) males and 138 (63.0 %) females, ranging in age from 64 years and 11 months to 91 years and 7 months (M_{age}=72.88; SD=6.75 years) and primarily White (n=215, 98.17 %). Participants had an average education level of 16.35 years (SD=2.78). Most participants (n=137, 62.56 %) were married, 38 (17.35 %) were widowed, 29 (13.24 %) were divorced, 14 (6.39 %) were single never married, and 1 (0.46 %) was legally separated.

Measures

The *Subjective Vitality Scale* (SVS) is a seven-item scale that assesses the extent to which individuals generally report feeling alive and full of energy (Ryan and Frederick 1997; Ryan and Deci 2008). In its development, special attention was given to ensure that the items did not merely capture general fatigue or sleepiness. Sample items include "I have energy and spirit" and "I look forward to each new day." Items are scored on a seven-point Likert scale ranging from "not at all" to "very true." One item is reverse-scored before being summed with the remaining items to create a total score; higher values reflect greater subjective vitality. The scale items display good internal consistency (Cronbach's alpha (α)=.88 in the current study) and low to moderate 8-week test–retest reliability (r=.64; Ryan and Frederick 1997).

We used the *Mindful Attention Awareness Scale* (MAAS) to assess dispositional mindfulness (Brown and Ryan 2003). We summed and averaged the 15 items to create an overall score with higher scores indicating greater dispositional mindfulness. The MAAS displayed good internal consistency (α=.82) and 4-week test–retest reliability (r=.81) in university student samples. Its convergent validity has been supported by expected correlations with well-being and self-monitoring (Brown and Ryan 2003). Although the psychometric properties of the MAAS have not been examined in older adults, reliability and validity have been supported among other samples experiencing health distress including chronic pain and cancer patients (McCracken and Thompson 2009). In the current study, the MAAS internal consistency (α) was .89.

The *Pittsburgh Sleep Quality Index* (PSQI) was designed to be used in practice and research for discriminating between good and poor sleepers (Buysse et al. 1989) and is composed of 19 self-report items that create seven domain scores: (1) *subjective sleep quality* is a subjective assessment of sleep

quality, (2) *sleep latency* is the amount of time spent lying in bed before falling asleep, (3) *sleep duration* is the amount of time spent sleeping each night, (4) *habitual sleep efficiency* is a calculation of the amount of time spent sleeping compared with the amount of time spent lying in bed, (5) *sleep disturbances* is a rating of the frequency of experience of barriers to sleep such as bad dreams or pain, (6) *sleep medications* refers to use of prescribed or non-prescribed sleep aids, and (7) *daytime dysfunction* refers to common daytime consequences of poor sleep such as difficulty staying awake during routine activities. Internal consistency has been supported across samples with alphas ranging from .77 to .83 (Buysse et al. 1989; Carpenter and Andrykowski 1998; Doi et al. 2000), and test–retest reliability has been supported among nursing home residents (average 19-day interval, r=.82; Gentili et al. 1995), primary insomnia patients (2-day interval, r=.90 and 45.6-day average interval, r=.86; Backhaus et al. 2002), and both healthy and sleep-disturbed individuals (average 28.2-day interval, r=.85; Buysse et al. 1989). In the current study, using the seven component scores as items in the global score (Buysse et al. 1989), internal consistency was acceptable (α=.76). A global score of ≥6 is indicative of disturbed sleep, and cutoffs of ≥6 and ≥7 yielded high sensitivity (98.7 and 93.4 %, respectively) and specificity (84.4 and 100 %, respectively) in distinguishing individuals diagnosed with primary insomnia versus healthy controls (Backhaus et al. 2002).

Statistical Analyses

We used Pearson's product-moment correlation coefficient (r) to assess bivariate relations among variables and to assess independence of study variables. Using simple mediation techniques proposed by Baron and Kenny (1986), we assessed the overall PSQI score as a potential mediator of the relation between mindfulness and subjective vitality by first regressing subjective vitality on sleep quality. Second, following a significant relation in the first step, we regressed sleep quality on mindfulness. Finally, we conducted another regression of subjective vitality on mindfulness that included sleep quality. We used the Sobel test to determine the presence of a significant mediating effect.

In all regression models, we controlled for age, which is positively associated with physical and psychological distress that can diminish well-being (Smyth 2008); sex, which is a common influence on well-being (Nolen-Hoeksema and Rusting 1999); race, which is associated with psychosocial distress that can impact well-being, particularly for elderly members of minority groups (Utsey et al. 2002); cognitive impairment (MMSE; Folstein et al. 1975), which is negatively associated with well-being in older adults (Vinkers et al. 2004); and overall physical activity level (Stewart et al. 1997), due to the influence of physical activity and functional impairment on well-being (Ryan and Frederick 1997).

To explore the relative importance of sleep quality dimensions, we used the multiple mediation techniques presented by Preacher and Hayes (2008) that apply a bootstrapping resampling procedure that is more sensitive to mediation effects than the sequential techniques proposed by Baron and Kenny (1986) and that allows for the inclusion of several mediators in the same analysis. The multiple mediation analysis simultaneously assesses the possibility of a direct effect of the independent variable on the outcome and whether or not this relation is reduced, either partially or fully, with the inclusion of the potential mediators. Unlike simple mediation, it is possible with multiple mediation analyses to detect an indirect effect in the absence of a direct effect (Preacher and Hayes 2008). Figure 1 illustrates the statistics produced by the multiple mediation procedure, and these include unstandardized regression coefficients for the following pathways: (1) mindfulness to each of the seven potential mediators, (2) each potential mediator to subjective vitality, (3) the total effect of mindfulness and the potential mediators on subjective vitality, and (4) the direct effect of mindfulness on subjective vitality after accounting for the effects of the potential mediators. The 95 % confidence intervals for each possible indirect pathway are included in Table 3.

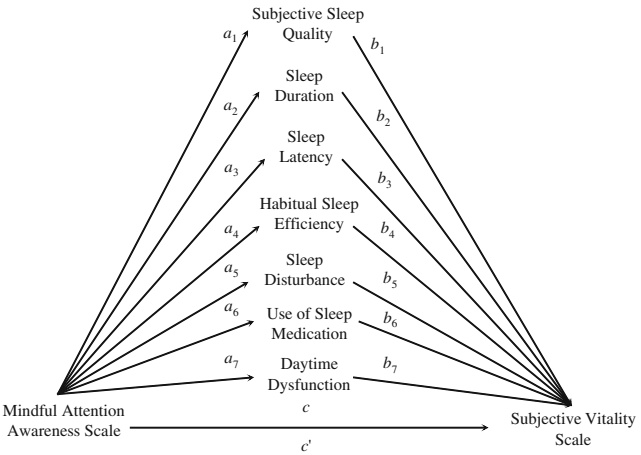

Fig. 1 Illustration of an indirect effects model: sleep quality mediating mindfulness and subjective vitality. c total effect: mindfulness affects subjective vitality, without accounting for components of sleep quality; ab total indirect effect: mindfulness affects subjective vitality through each of the seven dimensions of sleep quality on the Pittsburgh Sleep Quality Index; a_1b_1 specific indirect effect: mindfulness affects subjective vitality through subjective sleep quality; a_2b_2 specific indirect effect: mindfulness affects subjective vitality through sleep duration. This pattern continues for a_3b_3 through a_7b_7. c' direct effect: mindfulness affects subjective vitality after accounting for a total indirect effect. Full mediation=c is reduced to a non-significant c' by ab and/or a_1b_1 and/or a_2b_2 and/or… (remaining pathways). Partial mediation=c is reduced, by ab and/or a_1b_1 and/or a_2b_2 and/or… (remaining pathways), but c' remains significant. Indirect only effect=ab and/or a_1b_1 and/or a_2b_2 and/or… (remaining pathways) but no c and no c' in the first place. Adapted from Preacher and Hayes (2008)

Results

The mean PSQI score was 5.80 (median=5; SD=3.72), indicating that, on average, the sample reported disturbed sleep (Buysse et al. 1989). One hundred and twenty-five participants (57.60 %) scored at or above the cutoff of 5, and 93 (42.86 %) scored at or above the more stringent cutoff of 6, which has been strongly associated with diagnoses of sleep disorders (Backhaus et al. 2002). The mean score on the MAAS was 4.63 (SD=.77), which is similar to means reported for samples of general community adults (Carlson and Brown 2005); we were unable to find any published studies of older adults reporting MAAS scores. For the SVS, the average sum of the seven items was 34.18 (SD=8.39), which is comparable to SVS scores from studies of young and middle-aged adult samples (Ryan and Frederick 1997; Vlachopoulos and Karavani 2009); again, no reported data appear to have utilized the SVS among older adults.

Bivariate Associations

As hypothesized, higher values on the MAAS were significantly associated with relatively lower PSQI (r=−.32, p<.001) and relatively higher SVS scores (r=.48, p<.001), and the PSQI was negatively associated with the SVS (r=−.35, p<.001), which is consistent with our second hypothesis (note that lower PSQI scores indicate better sleep quality). Further, dispositional mindfulness was significantly associated with each component of the PSQI except for sleep medication use, which may be partially attributable to the relative lack of variation in sleep medication use in 66.2 % of the sample (n=145) that denied any use. In each significant relationship, higher mindfulness was associated with improved sleep quality (r range=−.17 to−.38; all ps<.05). A similar pattern was found for subjective vitality, except that it was not significantly associated with sleep duration or sleep medication use (r range=−.16 to−.52; all ps<.05; for more detailed correlation results, please see Tables 1 and 2).

Mediation Analyses

In the simple mediation analysis, mindfulness remained a significant predictor of subjective vitality when sleep quality was included in the model (t=6.58, p<.001); however, partial mediation was supported (Sobel=2.77, p<.01), such that increased mindfulness was associated with improvements in sleep quality, which was associated with higher subjective vitality.

In addition to overall score, we also tested the seven individual components of PSQI as potential mediators of the relationship between mindfulness and subjective vitality. The pathways between the independent variable, mediators, and dependent variable are shown in Fig. 2. Beyond the effects of covariates, the only significant mediators were habitual sleep efficiency (indirect effect=.56, bias-corrected bootstrap 95 % confidence interval (CI) .04, 1.30) and daytime dysfunction (indirect effect=1.69, bias-corrected bootstrap 95 % CI 1.03, 2.63); in both cases, the mediator helped account for variance in the positive relationship between mindfulness and subjective vitality (see Table 3). The total indirect effect was statistically significant (indirect effect=1.98, bias-corrected bootstrap 95 % CI 1.22, 3.11), and beyond the effects of covariates and potential mediators, mindfulness remained significantly related to increased subjective vitality (t=4.80, p<.001).

Discussion

With aging, experiences of chronic pain, illness burden, psychological stressors, and other factors may increasingly impair sleep quality and diminish well-being (Smyth 2008). Encouragingly, our findings suggest that an individual-level characteristic, mindfulness, is associated with better sleep quality and higher subjective vitality among older adults. At the bivariate level, and in support of our hypothesis, mindfulness and subjective vitality were individually associated with six of the seven components of the PSQI in directions that suggest

Table 1 Descriptive statistics and intercorrelations for study variables

Variable	M	SD	Sex	Age	Income	Mindfulness	Sleep Quality
Age	72.88	6.75	−.12	–	–	–	–
Income	5.79	2.24	−.26***	−.05	–	–	–
Mindfulness	4.63	.77	−.11	.09	.00	–	–
Sleep quality	5.80	3.72	.18*	−.09	−.10	−.32***	–
Subjective vitality (sum)	34.18	8.39	.11	−.07	.05	.48***	−.35***

Income (annual): nine categories ranging from "<$10,000" to ">$150,000"

PSQI is scored so that higher values signify poorer sleep quality

*p<.05; **p<.01; ***p<.001

Table 2 Correlations of trait mindfulness and subjective vitality with each component of sleep quality on the Pittsburgh Sleep Quality Index

Variable	Mindfulness	Subjective vitality	Subjective sleep quality	Sleep latency	Sleep duration	Habitual sleep efficiency	Sleep disturbances	Sleep medication use
Subjective vitality	.48***	–						
Subjective sleep quality	−.27***	−.26***	–					
Sleep latency	−.17*	−.16*	.45***	–				
Sleep duration	−.19**	−.13	.50***	.33***	–			
Habitual sleep efficiency	−.31***	−.30***	.54***	.49***	.59***	–		
Sleep disturbances	−.21**	−.19**	.48***	.32***	.36***	.42***	–	
Sleep medication use	−.07	−.13	.25***	.25***	.17*	.23**	.23**	–
Daytime dysfunction	−.38***	−.52***	.32***	.19**	.27***	.25***	.30***	.12

Items related to sleep are scored so that higher values indicate poorer sleep quality (N=219)

MAAS Mindful Attention Awareness Scale, *SVS* Subjective Vitality Scale

*p<.05; **p<.01; ***p<.001

better sleep functioning. Neither was significantly related to the use of sleep medication, but approximately two thirds of the sample denied any current sleep medication use. Consistent with our hypotheses, mediation analyses supported sleep quality as a potential mechanism in the relationship between mindfulness and subjective vitality, and multiple mediation analyses indicated that this effect is driven by one's reported sleep efficiency and related daytime dysfunction.

Our finding that sleep quality partially mediates the relationship between mindfulness and subjective vitality is consistent with theory that describes mindfulness as having beneficial effects on well-being partially via stress reduction and enhancing self-regulation of health behaviors (Brown and Ryan 2003; Brown et al. 2007), and our study extends previous findings from college students and working adults (Allen and Kiburz 2012; Howell et al. 2008; Murphy et al. 2012) to older adults. Importantly, our use of subjective vitality as a dependent variable differed from past research on mindfulness and sleep quality (Howell et al. 2008, 2010) in that it emphasized a central indicator of eudaimonic well-being that has been related to both psychological and physical wellness (Allen and Kiburz 2012; Ryan and Deci 2008). Considered an essential quality of a fully functioning and psychologically healthy individual, rather than a pleasurable emotion or experience (Ryan and Deci 2001), subjective vitality may have important implications for engagement in volitional, values-directed activities such as investing time in younger generations, as well as for immunological health as highlighted by recent research that found eudaimonic rather than hedonic well-being to be associated with lower proinflammatory genetic expression (Fredrickson et al. 2013). Healthcare workers seeking to augment older adult's psychological and physical health may find that focusing on improving mindfulness and

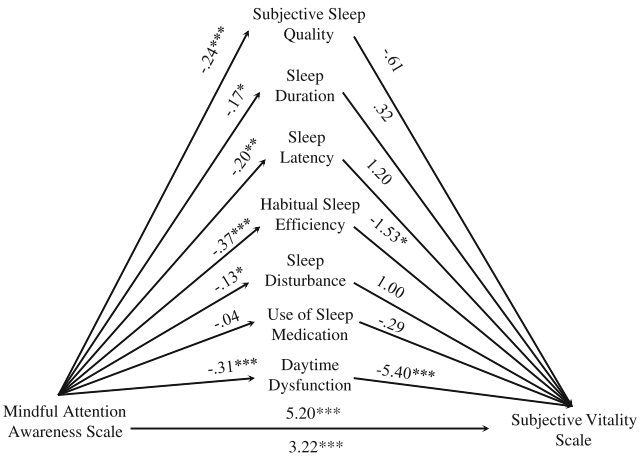

Fig. 2 Indirect effects model: mindfulness and subjective vitality mediated by sleep quality. Coefficients are unstandardized. *p≤.05; **p≤.01; ***p≤.001

Table 3 Indirect effects between mindfulness attention awareness scale and subjective vitality scale as mediated by components of Pittsburgh sleep quality index

Pathway	Point estimate	BCa 95 % CI lower	BCa 95 % CI upper
ab	1.98	1.22	3.11
a_1b_1	.15	−.27	.66
a_2b_2	−.06	−.38	.17
a_3b_3	−.24	−.77	.07
a_4b_4	.56	.04	1.30
a_5b_5	−.14	−.62	.09
a_6b_6	.01	−.04	.21
a_7b_7	1.69	1.03	2.63

Point estimate coefficients are unstandardized

5,000 bootstrap samples

Full DV Model (FDVM) r^2 =.42 (p<.0001)

BCa 95 % CI bias-corrected and accelerated 95 % confidence interval, ab total indirect effect, a_1b_1 specific indirect effect through first component of Pittsburgh Sleep Quality Index, a_2b_2 specific indirect effect through second component of Pittsburgh Sleep Quality Index, a_3b_3… (follows pattern)

sleep quality will result in higher subjective vitality in their older adult patients (APA 1993; Kasser and Ryan 1999); indeed, past research has demonstrated the efficacy of mindfulness interventions for sleep problems among older adults (Grossman et al. 2004; Hoch et al. 2001).

It is important to understand our pattern of findings because sleep quality is a complex construct composed of many aspects of sleep (Buysse et al. 1989); only two of which, when jointly considered, were responsible for our mediation effect. First, daytime dysfunction, which refers to problems experienced during waking hours that often result from poor sleep (Buysse et al. 1989), was the most robust mediator. Perhaps mindfulness, in the form of connectivity with the present moment, may reduce daytime problems associated with poor sleep, such as losing the ability to remain focus and alert during mundane routines. Remaining engaged with one's environment may improve ability to derive interest and gratification from activities, resulting in higher reported subjective vitality. The present-moment processing characteristic of mindfulness, which is related to reduced risk for anxiety, perceived stress, and illness stemming from poor immune functioning (Brown et al. 2007), may be the catalyst for less daytime dysfunction and greater subjective vitality. It is noteworthy that, conceptually, subjective vitality and daytime dysfunction overlap. The SVS, in part, reflects the availability of energy needed to successfully complete life pursuits, and daytime dysfunction suggests a lack of arousal needed to complete objectives, such as staying awake while "…driving, eating meals or engaging in social activities." Although both assessments involve physiological arousal, the SVS specifically targets a positive sense of energy and eudaimonic well-being, while the PSQI is less specific. Supporting their independence as separate constructs, they shared approximately 27 % of their variance in our sample. Also, Bowden et al. (2012) found that participants who completed 5-week mindfulness training exhibited significant improvement in daytime dysfunction but did not yet show a significant change in subjective vitality at post-treatment. Their sample lacked sufficient power to conclude that the mindfulness training did not improve subjective vitality, but the differential effects of mindfulness training on daytime dysfunction and subjective vitality further support the constructs' independence.

We also found habitual sleep efficiency, which captures the amount of time one spends lying awake in bed, to be a significant mediator of the association between mindfulness and subjective vitality. Lundh (2005) hypothesized that mindfulness benefits sleep and well-being by promoting cognitive deactivation, which diminishes efforts to control thoughts and feelings and promotes relaxation, and Howell et al. (2010) supported this sequence empirically in a college student sample. In the present study, although bivariate associations showed mindfulness to be related to other aspects of sleep including a subjective assessment of sleep quality and sleep duration, our multivariate data suggest that sleep efficiency better accounts for mindfulness's positive relationship with subjective vitality, over and above the effects of covariates and other sleep variables. In other words, mindfulness may improve one's ability to fall and stay asleep, and efficient sleeping may, in turn, augment one's sense of physical and mental energy and aliveness during the day. Consistent and uninterrupted sleep is also strongly related to psychological health, which may affect feelings of subjective vitality (Lichstein et al. 2006).

The importance of sleep efficiency is highlighted in behavioral interventions for insomnia that restrict overall time spent in bed in order to reduce time spent lying awake (Spielman et al. 1987), an approach that has demonstrated superiority to sleep hygiene interventions in improving sleep and daytime functioning in older adults (Hoch et al. 2001; McCurry et al. 2007). Recently, Ong et al. (2008, 2009) demonstrated initial support for an insomnia intervention combining mindfulness-based stress reduction and a cognitive-behavioral therapy approach that emphasizes sleep restriction; examination of the effects of such a treatment on subjective vitality and other markers of well-being is an important area for future research.

Generalizability of our findings may be limited by the homogeneity of the participants, and research testing the model with a more diverse sample is needed, although it is noteworthy that correlations among our study variables were similar to those in previous research with samples of varying demographics (Allen and Kiburz 2012; Brown and Ryan 2003; Howell et al. 2008). Our analyses are cross-sectional, and a prospective panel longitudinal study would yield better insight into the dynamic interrelationships between mindfulness, sleep quality, and subjective vitality and would allow for investigation of competing models. For instance, subjective vitality might promote mindful processing that contributes to high quality sleep, or sleep quality may promote mindfulness that, in turn, promotes well-being. This latter sequence is consistent with the hypothesis presented by Murphy et al. (2012) in their prospective analysis of the effects of sleep quality and mindfulness on physical health. Ultimately, Murphy and colleagues found similar statistical support for alternative models and concluded that the nature of the relationships among mindfulness, health habits, and health outcomes is complex and multidirectional. Other mindfulness researchers have also concluded that dispositional mindfulness can both improve and be boosted by healthy self-regulated behaviors and well-being (e.g., Brown et al. 2007; Howell et al. 2008). Understanding the nuances of how mindfulness and self-regulatory behaviors interrelate with health outcomes represents an important area for future research that is outside the scope of our cross-sectional analysis.

Although our focus was on subjective vitality, future studies should include other markers of eudaimonic and hedonic well-being. In addition, in our secondary analysis, we were

unable to comprehensively assess aspects of sleep-related self-regulation such as sleep effort and sleep hygiene, which limits our understanding of possible mechanisms in the relationship between mindfulness and subjective vitality. Although our data are consistent with the theory that mindfulness enhances subjective vitality via beneficial effects on sleep efficiency in older adults, we do not know if this might result, for example, from reduced pre-sleep arousal or enhanced attention to bodily sleep-related cues.

Despite these limitations, this and other recent research suggest that mindful individuals, including older adults, experience better well-being as measured in various ways and that more adaptive routine behavior may partially explain this relationship. We hope that future research will continue to investigate potential mediating variables, particularly across time, to better assess the process by which mindfulness may result in beneficial effects on self-regulated behavior and well-being.

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