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The association of fatigue with dispositional mindfulness: relationships by levels of depressive symptoms, sleep quality, childhood adversity, and chronic medical conditions

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ABSTRACT

Although mindfulness-based interventions may be effective in addressing the common symptom of fatigue, no population-based studies have examined the relationship between mindfulness and fatigue. We determined whether higher levels of dispositional mindfulness were associated with lower levels of fatigue. Cross-sectional data were obtained through the Pennsylvania Head Start Staff Wellness Survey, a 2012 web-based survey in which 2199 of 3375 (65%) eligible staff participated. The analytic sample was restricted to the 2083 female respondents with complete data on dispositional mindfulness (Cognitive and Affective Mindfulness Scale-Revised) and fatigue (Fatigue Severity Scale). We determined the mean covariate-adjusted fatigue scores in each quartile of dispositional mindfulness. This relationship was examined in the overall sample and within subgroups defined by levels of four variables: depressive symptoms, poor sleep quality, childhood adversity, and chronic medical conditions. The sample was 86% non-Hispanic White, and 61% had a bachelor's or more advanced degree. The mean (SD) Fatigue Severity Scale score was 3.3 (1.3). The adjusted mean fatigue score decreased significantly and in a graded manner across higher quartiles of mindfulness, with the adjusted fatigue score 1.4 points lower (95% confidence interval: −1.5, −1.2) among those in the highest quartile of dispositional mindfulness compared to the lowest. This significant graded relationship was present within each subgroup examined, and there was not a statistically significant interaction between dispositional mindfulness and any subgroup variable. Future trials of mindfulness-based interventions should consider assessing the outcome of fatigue in both clinical and non-clinical populations.

1. Introduction

Fatigue is a common symptom in the general population, and it often presents in medical practice (Cathébras et al., 1992; David et al., 1990; Finsterer and Mahjoub, 2014; Kroenke and Price, 1993; Kroenke et al., 1999; Pawlikowska et al., 1994; Ricci et al., 2007; van't Leven et al., 2009). Fatigue can significantly impair function, but has no definitive treatment. The biologic mechanisms underlying fatigue remain unknown. However, they appear to involve immune system dysregulation in the brain and/or the body, and this dysregulation is subjectively experienced as fatigue, a feeling of being tired or having little energy, either physically or mentally (Dantzer et al., 2014; Karshikoff et al., 2017).

Because mindfulness-based interventions are associated with increased plasticity in neural circuits (Davidson and McEwen, 2012) and altered immunity (Black and Slavich, 2016), they have potential to impact the biology and symptoms of fatigue. Despite the plausible mechanisms linking mindfulness and fatigue, few randomized controlled trials of mindfulness-based interventions have assessed fatigue as an outcome. These trials have primarily involved small samples of patients with chronic diseases (< 600 patients across all trials) (Cash et al., 2014; Grossman et al., 2010; Johansson et al., 2012; Kearney

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et al., 2016; Rimes and Wingrove, 2013; van der Lee and Garssen, 2012; Zangi et al., 2012) rather than non-clinical populations in which even fewer participants have been evaluated (< 300 total) (Huang et al., 2015; Querstret et al., 2017). At the same time, we are aware of no population-based studies examining whether those who report higher levels of mindfulness in daily life (dispositional mindfulness) have lower levels of fatigue. Such evidence would provide a basis to support randomized trials of mindfulness-based interventions to address functionally-impairing fatigue in the general population.

Among the many challenges of conducting rigorous trials of mindfulness-based interventions (Van Dam et al., 2018), one is to plan for the possibility that the intervention may have different impacts on fatigue across the heterogeneous groups who experience fatigue (Deaton and Cartwright, 2018). For example, fatigue often co-occurs with symptoms of depression (Bültmann et al., 2002; Fuhrer and Wessely, 1995) and poor sleep quality (Neu et al., 2010), which are both symptoms that may improve with mindfulness-based interventions (Dang et al., 2018; Hofmann et al., 2010; Neuendorf et al., 2015; Rash et al., 2019). In the general population, those who report impairing levels of fatigue more commonly have experienced childhood adversity (Cho et al., 2012; Collin et al., 2015), especially when the fatigue is accompanied by depressive symptoms (Collin et al., 2016). At the same time, mindfulness-based interventions may have negative impacts on those with trauma histories (Baer et al., 2019; Lindahl et al., 2017; Van Dam et al., 2018). Finally, fatigue is a frequent symptom that occurs in a range of common chronic medical conditions (Watt et al., 2000), from obesity (Resnick et al., 2006) and diabetes (Fritschi and Quinn, 2010) to headaches (Peres et al., 2002) and back pain (Feuerstein et al., 1987). Fatigue is usually not an isolated symptom, so it is important to understand whether the relationship between dispositional mindfulness and fatigue differs in groups with and without common experiences and conditions that often co-occur with fatigue.

The purpose of this study was to determine, in a population-based sample, whether higher levels of dispositional mindfulness were associated with lower levels of fatigue and whether this relationship was present across levels of depressive symptoms, sleep quality, childhood adversity, and chronic medical conditions. To address this question, we used data from a survey of female staff employed in Head Start—a federally sponsored early childhood education program for low-income children under 5 years of age.

2. Methods

2.1. Study population

The data used in the present study were collected in 2012 in the Pennsylvania Head Start Staff Wellness Survey, a web-based survey of the staff working in 66 of Pennsylvania's 91 (73%) Head Start and Early Head Start programs. The survey protocol, which was approved by Temple University's Institutional Review Board, has been previously described (Whitaker et al., 2013). Participation in the survey was anonymous and voluntary. Of the 3375 staff members (managers, lead/assistant teachers, home-visitors, and family support staff) in the 66 participating programs, 2199 (65%) responded to the survey. To assess the pattern of non-response, we used federal program-level data available on characteristics of teachers and home-visitors (US Department of Health and Human Services, 2011). Across all teachers and home-visitors in the 66 participating programs, the federal data showed that 57% had a bachelor's or associate's degree in early childhood education and 85% were White. This compared to 55% and 88%, respectively, among the teachers and home-visitors who responded to the survey.

2.2. Fatigue

The 9-item Fatigue Severity Scale (FSS) was used as a self-report measure of fatigue (Krupp et al., 1989). The items assess the effects of fatigue on daily functioning (e.g., "Fatigue interferes with my work, family, or social life," "My fatigue prevents sustained physical functioning"). Participants indicated their degree of agreement to the nine statements on a Likert scale of 1 to 7 (strongly disagree = 1 to strongly agree = 7). In alignment with the validated instrument, no time frame was given in a preamble to the nine questions (Krupp et al., 1989), but present time frame was implied. The scale scores, which were a mean of the item responses, had a possible range from 1 to 7, with higher scores representing greater fatigue. The scale scores had a statistically normal distribution and an internal consistency (Cronbach's alpha) of .90. While varying cut points have been used to indicate high fatigue (e.g., mean FSS ≥ 4 (Krupp et al., 1994) or ≥ 5 (Lerdal et al., 2005)), we used the fatigue score as a continuous measure in our analysis, given no single, established cut point.

2.3. Dispositional mindfulness

The 12-item Cognitive and Affective Mindfulness Scale-Revised (CAMS-R) was used as a self-report measure of the tendency or disposition to be mindful in daily life (Feldman et al., 2007). In this single factor scale, each item describes an attitude or approach towards the experience of one's emotions or thoughts in four areas—focusing attention, being oriented to the present moment, being aware of an experience, and having an attitude of acceptance or nonjudgment towards an experience (e.g., "It is easy for me to concentrate on what I am doing," "I am able to focus on the present moment," "I try to notice my thoughts without judging them," "I can accept things I cannot change"). Participants indicated how often (rarely/not at all = 1, sometimes = 2, often = 3, and almost always = 4) each item describes how they relate to their emotions and thoughts. The scale scores, which were a sum of item responses, had a possible range from 12 to 48, with higher scores representing greater levels of dispositional mindfulness. The scale scores had a statistically normal distribution and an internal consistency (Cronbach's alpha) of .85. To facilitate interpretation, the scores were divided into quartiles for analysis: low (12 − 30), medium-low (31–34), medium-high (35–38), and high (39–48). These quartile cut points were based on the sample distribution and used previously in analyses unrelated to fatigue (Whitaker et al., 2014).

2.4. Co-occurring experiences and chronic medical conditions

2.4.1. Depressive symptoms

The 20-item Center for Epidemiologic Studies Depression Scale (CES-D) was used to assess depressive symptoms (Radloff, 1977). Participants were asked to reflect on the previous week and rate the frequency of symptoms on a scale of 0 (less than once a week) to 3 (5–7 days a week). The scale scores, which were a sum of item responses, had a possible range of 0 to 60, with higher scores indicating greater depressive symptoms. The internal consistency (Cronbach's alpha) of the 20 items in the present sample was .91. Participants were divided into three levels of depressive symptoms, using previously established cut points of the CES-D score: low (0–7), medium (8–15), and high (≥ 16) (Cohen et al., 2010; Cohen et al., 2005; Radloff, 1977).

2.4.2. Sleep quality

The 19-item Pittsburgh Sleep Quality Index (PSQI) was used to assess subjective sleep quality and disturbance in the prior one-month period (Buysse et al., 1989). This index assesses seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction. Each component was scored on a scale ranging from 0 (better) to 3 (worse) sleep quality. The overall scores, which were a sum of all components, had a possible range from 0 to 21, with higher scores representing *worse* sleep quality. The internal consistency (Cronbach's alpha) of the 19 items in the present sample was .72. A binary variable (yes/no) was used for poor sleep quality, defined as a score above the established cut point of 5 (Buysse et al., 1989).

2.4.3. Childhood adversity

Participants were asked whether they experienced each of eight categories of childhood adversity related to abuse and household challenges: emotional abuse, physical abuse, sexual abuse, mother treated violently, parental separation or divorce, household substance abuse, household mental illness, and incarcerated household member. As reported previously (Whitaker et al., 2014), the item wording and scoring were aligned with the Adverse Childhood Experiences Study, conducted among adults enrolled in the Kaiser Health Plan in San Diego, CA (Anda et al., 1999; Felitti et al., 1998). A score (0 to 8) was made by summing the number of categories of adversity, and for analysis, participants were divided into three groups based on the childhood adversity score (0, 1–2, and 3–8).

2.4.4. Chronic medical conditions

As previously described (Whitaker et al., 2013), participants were asked about six chronic medical conditions, which are common in midlife and associated with perceived stress and fatigue: obesity, asthma, hypertension, diabetes/prediabetes, severe headache/migraine, and lower back pain. Obesity (body mass index ≥30 kg/m^2) was based on self-reported height and weight (pre-pregnant weight if pregnant). The other conditions were based on "yes/no" questions identical to those in the National Health Interview Survey (Centers for Disease Control and Prevention, 2019). The questions on severe headache/migraine and lower back pain referenced the prior three months, and the questions on asthma, hypertension, and diabetes/prediabetes (other than during pregnancy) referenced "ever [being] told by a doctor or other health professional" that they had the condition. A score (0 to 6) was made by summing the number of conditions, and for analysis, participants were divided into three groups based on the number of chronic health conditions (0, 1–2, 3–6).

2.5. Covariates

In our analyses, we adjusted fatigue scores for six variables, which were selected because they were considered potential confounders of the relationship between mindfulness and fatigue. We asked participants about their age, race/ethnicity, education, marital status, and job position (manager/non-manager). A sixth variable, a count of economic hardships, was created by summing "yes" responses to five categories of economic hardships that participants reported experiencing during the prior year (Whitaker et al., 2015): household food insufficiency (sometimes or often not having enough to eat), receipt of benefits from the Supplemental Nutrition Assistance Program, not enough money for housing, not enough money for utilities, and not enough money for healthcare. For analysis, the economic hardships were categorized into four groups (0, 1, 2, and 3–5 economic hardships).

2.6. Statistical analysis

For the present study, we restricted our analysis to females because the overall sample contained few males. Of the 2122 females with completed surveys, we excluded 39 (2%) who were missing data on either mindfulness or fatigue, leaving an analytic sample of 2083 females. To examine the association between dispositional mindfulness and fatigue, linear regression was used with fatigue (FSS) score as the dependent variable and mindfulness (quartiles) as the predictor. Unadjusted FSS means were determined for each quartile of mindfulness. For multivariable analyses, 72 cases (4%) of the sample were missing ≥1 of the six covariates (Table 1). Missing data for these covariates were imputed (Cummings, 2013) using sequential regression imputation (Raghunathan et al., 2001) to create 20 imputed data sets, each with 2083 cases (Graham et al., 2007). We then used linear regression models on the imputed datasets, and reported model parameters were aggregated across datasets (Schafer and Graham, 2002). Regression-based margins standardized to the distribution of covariates in the study population were used to estimate adjusted fatigue score means for each quartile of mindfulness. The adjusted differences describe the standardized mean fatigue score in those with high, medium-high, and medium-low mindfulness, relative to the standardized mean fatigue score in those with low mindfulness.

Table 1
Characteristics of participants.

	No. (%)[a]
Age, years	
18–29	363 (18)
30–39	539 (26)
40–49	489 (24)
≥50	641 (32)
Race/ethnicity	
White, non-Hispanic	1782 (86)
Black, non-Hispanic	122 (6)
Other race, non-Hispanic	52 (2)
Hispanic, any race	117 (6)
Education	
High school	411 (20)
Associate's degree	404 (20)
Bachelor's degree	1057 (51)
Master's or doctoral degree	198 (10)
Married	
Yes	1286 (62)
No	781 (38)
Manager job position	
Yes	455 (22)
No	1628 (78)
Number of economic hardships[b]	
0	1296 (62)
1	351 (17)
2	254 (12)
3–5	173 (8)
Level of depressive symptoms[c]	
Low	946 (46)
Medium	623 (30)
High	508 (24)
Poor sleep quality[d]	
Yes	1054 (51)
No	1008 (49)
Number of categories of childhood adversity[e]	
0	848 (41)
1–2	746 (36)
3–8	477 (23)
Number of chronic medical conditions[f]	
0	486 (23)
1–2	1132 (54)
3–6	459 (22)

[a] $N = 2083$. Percentages across levels of a characteristic may not add to 100% due to rounding. Participants were missing data on characteristics as follows: age (51), race/ethnicity (10), education (13), married (16), number of economic hardships (9), depressive symptoms (6), poor sleep quality (21), chronic health conditions (6), and categories of childhood adversity (12).

[b] Sum of five indicators of economic hardship experienced during the prior 12 months: food insufficiency, receipt of Supplemental Nutrition Assistance Program benefits, not enough money for housing, not enough money for utilities, and not enough money for healthcare.

[c] Level of depressive symptoms defined using the global score on the 20-item Center for Epidemiologic Studies Depression Scale (CES-D), with low (0–7), medium (8–15), and high (≥16).

[d] Poor sleep quality (yes/no) defined as a global score on the 19-item Pittsburgh Sleep Quality Index (PSQI) > 5.

[e] Count of 8 categories of adverse childhood experiences: emotional abuse, physical abuse, sexual abuse, mother treated violently, parental separation or divorce, household substance abuse, household mental illness, and incarcerated household member.

[f] Count of 6 chronic medical conditions: severe headache or migraine, lower back pain, obesity, hypertension, diabetes or prediabetes, and asthma.

Using datasets with fully-imputed covariates, the association between mindfulness and fatigue was examined separately by levels of co-occurring experiences and chronic medical conditions: depressive symptoms (3 levels), poor sleep quality (yes/no), childhood adversity (3 levels), and number of chronic medical conditions (3 levels). To determine whether the association between mindfulness and fatigue differed by level of the co-occurring experience or condition (e.g., across levels of depressive symptoms), the Wald test was used to assess the interaction term (e.g., mindfulness [CAMS-R score] X depressive symptoms [categories]) in the fully-adjusted model.

3. Results

Of the 2083 included in the sample, 56% were ≥40 years of age, 86% were non-Hispanic White, and 61% had obtained a bachelor's or more advanced degree (Table 1). Twenty percent reported that they had experienced ≥2 of 5 economic hardships during the prior year.

The mean (SD) fatigue (FSS) score was 3.3 (1.3); 33% and 13% had scores ≥4 and ≥5, respectively. The mean (SD) dispositional mindfulness (CAMS-R) score was 34.6 (5.8). The mean (SD) depressive symptoms (CES-D) score was 11.0 (9.5), and 24% reported experiencing a high level of depressive symptoms (CES-D ≥ 16) (Table 1). The mean (SD) sleep quality (PSQI) score was 6.3 (3.6), and 51% reported experiencing poor sleep quality (PSQI > 5). Of the 8 categories of childhood adversity, 23% reported experiencing ≥3; and of the 6 chronic medical conditions, 22% reported having ≥3. Fatigue scores were significantly correlated to depressive symptoms (CES-D, $r = 0.45$, $p < .001$), sleep quality (PSQI, $r = 0.37$, $p < .001$), the number of categories of childhood adversity ($r = 0.16$, $p < .001$), and the number of chronic medical conditions ($r = 0.25$, $p < .001$).

There was a graded relationship between the level of dispositional mindfulness and fatigue, with the mean fatigue score decreasing across each higher quartile of mindfulness (Table 2). After adjusting for the six covariates, the mean fatigue score was 1.4 points lower (95% confidence interval [CI]: −1.5, −1.2) among those in the highest quartile of mindfulness compared to the lowest quartile.

This graded relationship was also present at each level of the four co-occurring experiences/conditions we examined: depressive symptoms, poor sleep quality, childhood adversity, and chronic medical conditions (Fig. 1). At each level of the four stratifying variables, the difference in fatigue score between those in the highest and lowest quartile of mindfulness was statistically significant (Supplemental Table 1). For example, in those with low levels of depressive symptoms, this fatigue score difference was −0.8 (95% CI: −1.1, −0.5), compared to −0.6 (95% CI: −1.1, −0.2) among those with high levels of depressive symptoms. Within levels of poor sleep quality, childhood adversity, and chronic medical conditions, the differences in fatigue scores between those in the highest and lowest quartiles of mindfulness were all statistically significant, similar in magnitude, and greater than −1.0 (Supplemental Table 1). In a formal test of interaction, the association between mindfulness and fatigue did not differ significantly by level of depressive symptoms ($p = .58$), poor sleep quality ($p = .20$), childhood adversity ($p = .94$), or chronic medical conditions ($p = .42$).

4. Discussion

4.1. Key findings

In a population-based sample of employed females working in early childhood education, we showed that higher levels of dispositional mindfulness were associated with lower levels of fatigue. A similar, graded relationship between dispositional mindfulness and fatigue was present across levels of depressive symptoms, poor sleep quality, childhood adversity, and chronic medical conditions.

4.2. Findings in context

Despite the high prevalence of functionally-impairing fatigue in the general population and the potential of mindfulness-based interventions to address this symptom, we are not aware of any population-based studies that have examined the relationship between dispositional mindfulness and fatigue. However, in several small randomized trials, mindfulness-based interventions have shown significant impacts on fatigue. This includes two trials in non-clinical, employed populations (Huang et al., 2015; Querstret et al., 2017) as well several trials across diverse clinical populations, such as patients with chronic fatigue syndrome (Rimes and Wingrove, 2013), multiple sclerosis (Grossman et al., 2010), rheumatoid arthritis (Zangi et al., 2012), cancer (van der Lee and Garssen, 2012), Gulf-War illness (Kearney et al., 2016), stroke and traumatic brain injury (Johansson et al., 2012), and fibromyalgia (Cash et al., 2014).

None of these trials used the Fatigue Severity Scale. However, in our study, the mean score on the Fatigue Severity Scale among those in the lowest quartile of mindfulness was relatively high (4.1). The score was below the level seen in patients with multiple sclerosis (4.8), systemic lupus erythematosus (4.7) (Krupp et al., 1989), chronic fatigue syndrome (5.7) (Krupp et al., 1994), and post-polio syndrome (5.2) (On et al., 2006); but, the score was higher than in patients with Parkinson's disease (3.3) (Chou et al., 2017) or chronic hepatitis C (3.4) (Jacobson et al., 2014). The covariate adjusted difference in FSS score between those in the lowest and highest quartiles of mindfulness (1.4) was approximately one standard deviation in our sample. This magnitude of difference is above the difference of 0.7, which is considered clinically meaningful (Rosa et al., 2014), and it exceeds, for example, the difference of 0.5 found between patients successfully and unsuccessfully treated for chronic hepatitis C on the basis of achieving undetectable plasma levels of hepatitis C virus RNA (Bernstein et al., 2002).

4.3. Possible mechanisms

In this study both dispositional mindfulness and fatigue were measured by reports of subjective experiences that involve biologic mechanisms in both brain and body that are poorly understood. However, there are plausible mechanisms by which greater levels of dispositional mindfulness could reduce fatigue and the functional impairment arising from it. Fatigue may be caused by brain inflammation that is mediated by inflammation in the body through several channels of brain-body

Table 2
Association between dispositional mindfulness and fatigue.

Quartile of mindfulness	Fatigue Severity Scale Score			
	No. in category	Unadjusted mean (95% CI)	Adjusted mean (95% CI)[a]	Adjusted difference (95% CI)[a]
Low	512	4.1 (4.0, 4.2)	4.0 (4.0, 4.2)	Reference
Med-Low	517	3.5 (3.4, 3.6)	3.5 (3.4, 3.6)	−0.5 (−0.6, −0.4)
Med-High	516	3.1 (3.0, 3.2)	3.1 (3.0, 3.2)	−0.9 (−1.1, −0.8)
High	538	2.7 (2.6, 2.8)	2.7 (2.6, 2.8)	−1.4 (−1.5, −1.2)

[a] Adjusted for the following variables: age, race/ethnicity, education, number of 5 economic hardships experienced during the prior 12 months, married (yes/no), and manager job position (yes/no).

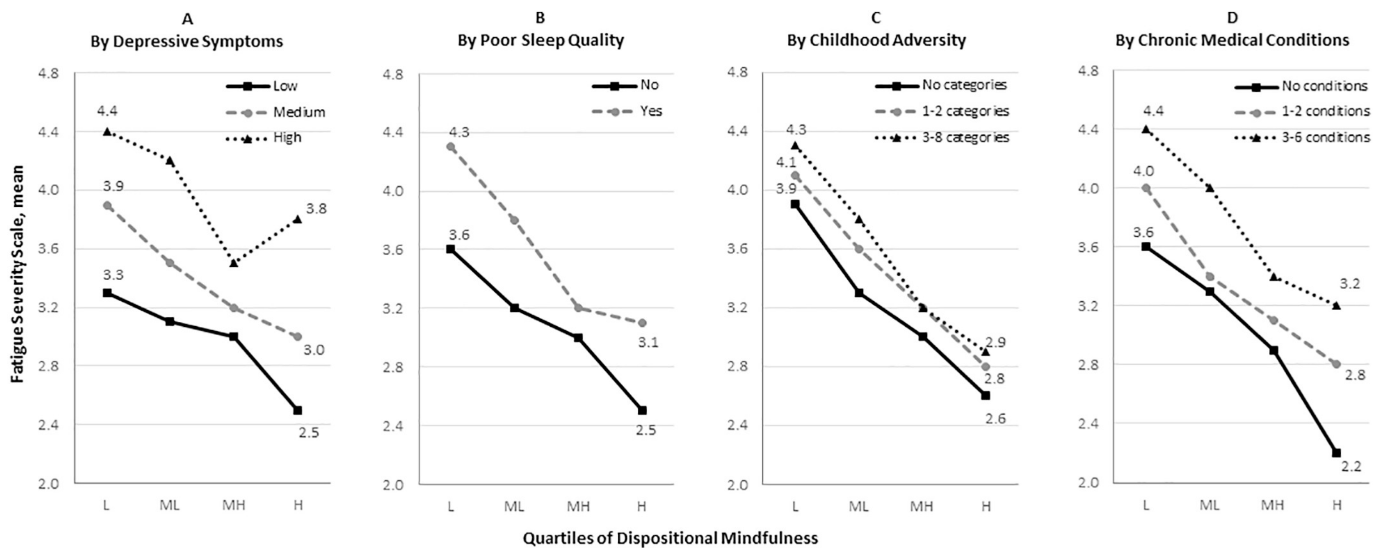

Fig. 1. Association between dispositional mindfulness and fatigue by levels of depressive symptoms, poor sleep quality, childhood adversity, and chronic medical conditions.

Each plate represents the association between fatigue score, measured using the Fatigue Severity Scale, and dispositional mindfulness, measured using the Cognitive and Affective Mindfulness Scale-Revised, across four co-occurring experiences/conditions: A) depressive symptoms (levels defined using the score on the Center for Epidemiologic Studies Depression Scale with low (0–7), medium (8–15), and high (≥16); B) poor sleep quality (defined as a score > 5 on the Pittsburgh Sleep Quality Index; C) childhood adversity (count of 8 categories of adverse childhood experiences: emotional abuse, physical abuse, sexual abuse, mother treated violently, parental separation or divorce, household substance abuse, household mental illness, and incarcerated household member); and D) chronic medical conditions (count of 6 chronic medical conditions: severe headache or migraine, lower back pain, obesity, hypertension, diabetes or prediabetes, and asthma). Fatigue Severity Scale score means are adjusted for the following variables: age, race/ethnicity, education, number of 5 economic hardships experienced during the prior 12 months, married (yes/no), and manager job position (yes/no). L = Low, ML = Medium-Low, MH = Medium-High, and H = High correspond to quartiles of dispositional mindfulness.

communication (Dantzer et al., 2014). The brain-body communication could involve the endocrine system, with fatigue reflecting dysregulation in the hypothalamic-pituitary-adrenal axis in response to perceived stress (Adam et al., 2017; Chaudhuri and Behan, 2004). The brain-body communication could also involve the autonomic nervous system, with afferent communication through the vagus nerve consisting of interoceptive signals that reflect the body's capacity for mental or physical functioning that is ultimately initiated by the brain (Evans et al., 2016) (Laborde et al., 2018). Studies on the biologic effects of various mindfulness-based practices suggest that they can modulate the inflammatory response in both the brain and the body (Black and Slavich, 2016). This may occur by directly engaging brain networks, such as the default mode network (Brewer et al., 2011), which may be affected in fatigue (Høgestøl et al., 2019; Shan et al., 2018), or by modulating brain-body communication through the endocrine (Pascoe et al., 2017) and autonomic pathways (Sullivan et al., 2018).

Mindfulness-based intervention studies have shown increases in dispositional mindfulness, as measured by the CAMS-R (6.1 points) (Greeson et al., 2011), at a magnitude that exceeded the difference between the CAMS-R mean score in the lower and upper quartiles of our study population (5.1 points). Inferences from our cross-sectional data cannot be made about potential treatment effects of a mindfulness-based intervention on fatigue. However, our data demonstrate that there are clinically meaningful differences in fatigue levels across the distribution of dispositional mindfulness found in a non-clinical population of adult females. Even in those with depression, poor sleep quality, childhood trauma, or chronic medical conditions, the adjusted differences in Fatigue Severity Scale scores between the upper and lower quartiles of dispositional mindfulness were clinically meaningful.

4.4. Limitations

We cannot infer a causal relationship between dispositional mindfulness and fatigue using these cross sectional data. Although we found a strong-graded relationship between mindfulness and fatigue for which there are plausible bio-psycho-social mechanisms, our design cannot exclude reverse causality. For example, fatigue is associated with impaired attention, which is also a core element of dispositional mindfulness. Although our measures of mindfulness and fatigue were both well-validated and widely used, they are not the only available measures of these constructs, and the use of other measures might lead to different conclusions. We had no measure of participants' mindfulness-based practices, such as meditation. Because both mindfulness and fatigue were self-reported, we cannot exclude the influence of common-rater bias (Podsakoff, 2003).

Although we controlled for some potential confounders related to social status, we did not have data on income. We intentionally did not control for depressive symptoms, sleep quality, childhood adversity, and chronic medical conditions. Because these factors commonly co-occur with fatigue in general medical practice, our aim was to examine whether the association between dispositional mindfulness and fatigue was similar across levels of these factors. This information helps determine whether a priori subgroup evaluations or eligibility restrictions should be considered in trials of mindfulness-based interventions to address fatigue.

4.5. Potential implications

Fatigue is a ubiquitous symptom in the subjective human experience. When fatigue is sufficiently prolonged or severe and is perceived to impair functioning, it is often brought to the attention of healthcare providers. Mindfulness-based interventions may have potential to mitigate fatigue. Our data support that possibility in that they show clinically meaningful differences in fatigue across quartiles of dispositional mindfulness in a population-based sample of employed females. This relationship between dispositional mindfulness and fatigue should be evaluated in additional non-clinical samples that also include males. Future trials of mindfulness-based interventions should consider evaluating fatigue as an outcome. Our data suggest that those planning such trials might expect similar impacts on fatigue across subgroups defined by levels of depressive symptoms, poor sleep quality, childhood adversity, and chronic medical conditions.

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Declaration of competing interest

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