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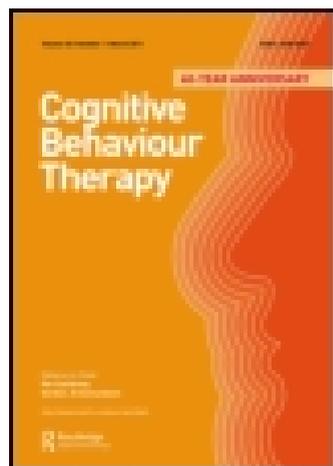
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# The Effects of a Hatha Yoga Intervention on Facets of Distress Tolerance

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**Abstract.** Individuals with low distress tolerance (DT) experience negative emotion as particularly threatening and are highly motivated to reduce or avoid such affective experiences. Consequently, these individuals have difficulty regulating emotions and tend to engage in maladaptive strategies, such as overeating, as a means to reduce or avoid distress. Hatha yoga encourages one to implement present-centered awareness and non-reaction in the face of physical and psychological discomfort and, thus, emerges as a potential strategy for increasing DT. To test whether a hatha yoga intervention can enhance DT, a transdiagnostic risk and maintenance factor, this study randomly assigned females high in emotional eating in response to stress ( $N = 52$ ) either to an 8-week, twice-weekly hatha (Bikram) yoga intervention or to a waitlist control condition. Self-reported DT and emotional eating were measured at baseline, weekly during treatment, and 1-week post-treatment. Consistent with prediction, participants in the yoga condition reported greater increases in DT over the course of the intervention relative to waitlist participants (Cohen's  $d = .82$ ). Also consistent with prediction, the reduction in emotional eating was greater for the yoga condition than the waitlist condition (Cohen's  $d = .92$ ). Importantly, reductions distress absorption, a specific sub-facet of DT, accounted for 15% of the variance in emotional eating, a hallmark behavior of eating pathology and risk factor for obesity. *Key words:* Hatha yoga; distress tolerance; intervention; exercise.

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Individuals with low distress or affective tolerance experience negative emotions as particularly threatening and are highly motivated to alter such experiential states (Simons & Gaher, 2005). As a result of their intolerance of distress, these individuals tend to engage in coping strategies that pose mental and physical health risks, such as cigarette smoking (Brown, Lejuez, Kahler, Strong, & Zvolensky, 2005; Buckner, Keough, & Schmidt, 2007; Bujarski, Norberg, & Copeland, 2012), and binge eating and purging (Anestis, Selby, Fink, & Joiner, 2007), as a means to reduce or avoid emotional distress. Accordingly, distress intolerance has been implicated as a transdiagnostic risk and maintenance factor for psychopathology (Zvolensky, Bernstein, & Vujanovic, 2011), particularly in disorders characterized by heightened

emotional reactivity and avoidance, such as substance use, anxiety, eating, and personality disorders (Leyro, Zvolensky, & Bernstein, 2010; Zvolensky et al., 2011).

Extant research has conceptualized and approached measurement of affective intolerance in diverse ways and among heterogeneous samples (Bernstein, Zvolensky, Vujanovic, & Moos, 2009; McHugh & Otto, 2012). This has resulted in the emergence of various domain-specific affective intolerance sub-constructs that can be challenging to integrate (Bernstein et al., 2009). For example, "intolerance of uncertainty," particularly relevant to pathology of generalized anxiety (Dugas, Buhr, & Ladouceur, 2004) and obsessive-compulsive disorders (Holaway, Heimberg, & Coles, 2006; Tolin, Abramowitz, Brigidi, & Foa, 2003), reflects a

cognitive-affective intolerance for uncertain outcomes. In comparison, “discomfort intolerance” (DI; Schmidt, Richey, & Fitzpatrick, 2006) and “anxiety sensitivity” (AS; Maller & Reiss, 1992) include aversion to somatic sensations of autonomic arousal, which are cornerstone to panic disorder psychopathology.

Deviating from a specific distress domain in their operationalization of the construct, Simons and Gaher (2005) define “distress tolerance” (DT) by facets involved in the process of managing and regulating subjective emotional distress. These include (1) one’s general perceived *Tolerance* of negative or threatening emotions, (2) one’s *Appraisal* or value judgment about feeling distressed or upset, as well as (3) the resulting *Absorption* of attention in the distress itself, and (3) the propensity for action aimed at *Regulation* or reduction of distress (Simons & Gaher, 2005). In support of this conceptualization, scores on the self-report-based Distress Tolerance Scale (DTS; Simons & Gaher, 2005) have predicted symptom severity and problem behavior in a range of clinical populations (Anestis et al., 2007; Leyro et al., 2010).

Studies examining the psychometric properties of various affective intolerance assessments also evidence support for the existence of a common, domain-general emotional intolerance construct. For example, a factor analysis (McHugh & Otto, 2012) of different self-report assessments of the construct yielded a single-factor latent structure of affective intolerance captured by the Discomfort Intolerance Scale (Schmidt et al., 2006), Anxiety Sensitivity Index (Reiss, Peterson, Gursky, & McNally, 1986), and DTS (Simons & Gaher, 2005). The authors concluded that these measures likely tap a common underlying core trait of affective intolerance, which is most-directly assessed by the DTS (McHugh & Otto, 2012). Thus, DT, as measured by the DTS, appears to be a good option for investigations examining the relationship of affect intolerance to psychopathology and intervention effects.

Because DT is a pervasive contributor to psychopathology, several existing evidence-based treatments specifically aim to target DT. Promisingly, initial intervention research demonstrates that DT can be enhanced and that increases in DT correspond to improvements in symptom severity (Brown et al., 2008; Leyro et al., 2010). These interventions have typically taken a mindfulness-based and/or

exposure-based, cognitive-behavioral approach. Dialectical behavior therapy (DBT; Linehan, 1993), for example, is an integrative approach that includes a DT skills training component for reducing emotional reactivity, and it has shown efficacy for treating borderline personality (Linehan, 1993; Linehan, 1987; Neacsiu, Rizvi, & Linehan, 2010), eating pathology (Telch, Agras, & Linehan, 2001; Telch et al., 2001), and substance use disorders (Dimeff & Linehan, 2008). Brown and colleagues have recently developed a novel, combined mindful acceptance/cognitive behavioral therapy (CBT) intervention targeting DT for smoking cessation in adults who have previously failed cessation attempts (Brown et al., 2008). By enhancing resilience to distress during critical early abstinence periods, such as the withdrawal phase, this treatment has shown efficacy for difficult-to-treat smokers (Brown et al., 2013).

The mind-body practice of yoga, which is conceptually akin to the interventions just described, may hold similar promise for enhancing DT. Hatha yoga is a branch of yoga described as “moving meditation,” a physical practice of yoga (Iyengar & Menuhin, 1995). Hatha yoga requires one to focus attention on interoceptive cues and breath (*pranayama*) during and while transitioning to challenging, potentially uncomfortable physical postures called *asanas* (Hewitt, 1990; Iyengar & Menuhin, 1995). From the Eastern philosophical tradition of mindfulness, hatha yoga encourages one to implement present-centered awareness, non-reaction, and non-judgmental acceptance of one’s present state despite physical or psychological discomfort. In combination with promotion of mindful awareness and acceptance, hatha yoga, especially when practiced at moderate to vigorous intensities, may promote habituation to distress in low-DT persons. Indeed, exposure-based methods of behavioral therapy, including programmed aerobic exercise interventions, have proved effective for reducing sensitivity to autonomic arousal in anxious populations (Broman-Fulks & Storey, 2008; Smits et al., 2008).

Furthermore, evidence from a number of sources has accumulated for the beneficial effects of yoga on mental health problems, including anxiety (Dunn, 2010; Kirkwood, Rampes, Tuffrey, Richardson, & Pilkington, 2005; Smith, Hancock, Blake-Mortimer, & Eckert, 2007), depression (Shapiro et al., 2007;

Uebelacker et al., 2010), disordered eating (Carei, Fyfe-Johnson, Breuner, & Brown, 2010; McIver, O'Halloran, & McGartland, 2009), and psychological distress secondary to medical conditions (Curtis, Osadchuk, & Katz, 2011; Shapiro et al., 2007). Yoga also has received support for reducing perceived stress and enhancing overall well-being in sub-clinical populations (Brisbon & Lowery, 2011; Granath, Ingvarsson, von Thiele, & Lundberg, 2006; Huang, Chien, & Chung, 2013; Smith et al., 2007; Uebelacker et al., 2010).

Despite the promise for improving psychological health in distress-sensitive persons, there have been no published reports of the efficacy of yoga for increasing DT. In addition to the theoretical promise of using yoga to improve DT, the importance of this research is further underscored by the increasing popularity of yoga in Western culture as an alternative approach to stress management and psychological well-being (Barnes, Bloom, & Nahin, 2008). Yoga's positive reputation only enhances its potential to become an acceptable and accessible intervention for many people.

In this paper, we test the hypothesis that practicing hatha yoga can increase DT. This hypothesis was tested using data collected as part of a larger investigation examining the feasibility, acceptability, and efficacy of a hatha yoga intervention for targeting physiological stress reactivity in women high in affective eating and risk for obesity (Hopkins, 2014). The parent trial draws rationale for testing its hypothesis from the obesity and eating disorder literatures, which describe emotional or stress-induced eating as a major contributor to clinically diagnosable eating disorders, such as binge eating disorder, as well as to rates of obesity, particularly among females (Adam & Epel, 2007). The need to enhance affective coping capacity in this population provides rationale for the present investigation's examination of DT as an avenue by which yoga may reduce disordered eating behavior.

Accordingly, under this parent study, we randomized 52 females at risk for eating disorders and obesity to either an 8-week hatha yoga intervention (YOGA) or a waitlist control condition (WL). Self-reported emotional eating and DT were measured at baseline, weekly during treatment, and 1-week

post-treatment. Our second aim was to examine increases in DT as a mechanism of change accounting for reduced behavioral symptoms of psychopathology resulting from the yoga intervention. Given the sample recruited for the parent study, we examined increases in DT as a mediator of the intervention effects on emotional eating. We hypothesized that, relative to waitlist participants, those in the yoga condition would report greater increases in DT over the course of the intervention, and that these increases in DT would mediate the effects of yoga on emotional eating.

## Method

### Participants

Participants included adult females from the Dallas community who reported elevated levels of perceived stress, emotional eating, and dietary restraint. Eligibility criteria included score of  $\geq 2.06$  on the emotional eating subscale (DEES) of the Dutch Eating Behavior Questionnaire (DEBQ; Van Strien, Frijters, Bergers, & Defares, 1986), score of  $\geq 15$  on the Restraint Scale (Polivy, Herman, & Howard, 1988), and elevated perceived stress, as defined by scoring  $\geq 0.50$  SD above the community mean on the Perceived Stress Questionnaire (Levenstein et al., 1993). Eligibility also required sufficient command of the English language and providing written physician medical clearance to participate in yoga practice.

Exclusion criteria were: having regularly practiced (i.e., once a week or more) yoga or other mind-body practices (e.g., tai chi, meditation) within the last year; a significant change to physical activity pattern in the past 3 months; current severe depression or substance dependence; lifetime history of anorexia nervosa or severe mental illness (i.e., bipolar or psychotic disorder of any type); pregnancy; medical conditions that could be aggravated by yoga; body mass index  $\geq 40$ ; cognitive dysfunctions or organic brain syndrome that could interfere with capacity to perform study protocol; receiving inpatient psychiatric hospitalization within the past year; or receiving concurrent psychiatric treatment, including both psychotherapy and psychotropic medication.

## Procedures

Participants were recruited through advertisements in local newspapers and flyers that included a link to a secured online eligibility prescreen survey. Respondents who appeared eligible based on their prescreen were invited to the study site for a diagnostic interview (Structured Clinical Interview for DSM-IV-TR Diagnosis of Axis I Disorders; First, Spitzer, Gibbon, & Williams, 1996). Participants who met all eligibility criteria were scheduled for a baseline visit one week prior to the start of the yoga program. At the end of the baseline visit, they were randomized to one of the two conditions (YOGA or WL) using a computerized random number generator.

Those randomized to the yoga condition were asked to attend twice-weekly, 90-min Bikram yoga-style classes at a local yoga studio. Each session consisted of the same series of 26 hatha yoga postures, two breathing exercises, and two savasanas (i.e., a resting/relaxation posture), in a room heated to 104 degrees Fahrenheit, which aids in safe muscle stretching. We selected this type of yoga because it is considered suitable for practitioners of various physical capabilities and, due to its consistent series of postures, it is ideal for a standardized intervention protocol. In addition, the hot temperature would provide an opportunity to learn to become comfortable with the bodily sensations associated with heat exposure (i.e., increase tolerance of physical distress). At the end of each week of the intervention period, as well as at post-intervention (week 9), all participants (both those assigned to YOGA and WL) were prompted by email to complete a 15–20 min online survey containing self-report measures of DT, emotional eating, stress, and mood. Following their completion of the week 9 assessment, WL participants were provided the equivalent 2-month yoga membership at no cost.

## Measures

**Distress tolerance.** The DTS (Simons & Gaher, 2005) is a 15-item self-report scale measuring four facets involved in the expectation of, evaluation of, and reaction to distressing states. In addition to a total DT score, the DTS produces four subscale scores measuring: (1) distress *Tolerance* (i.e., perceived tolerability and aversiveness of distressing feelings; e.g., “I can’t handle feeling distressed or upset”); (2)

*Appraisal* of distress (i.e., acceptability of having the distress; e.g., “My feelings of distress are not acceptable”); (3) *Absorption* (i.e., tendency for distress to disrupt attention and interfere with in-the-moment functioning; e.g., “My feelings of distress are so intense that they completely take over”); and (4) *Regulation* (i.e., the strength of one’s propensity to immediately avoid or attenuate the distress; e.g., “I’ll do anything to avoid feeling distressed or upset”). Participants responded to items on a 5-point Likert-type scale, with ratings ranging from *strongly agree* (1) to *strongly disagree* (5). The DTS has exhibited 6-month temporal stability and internal consistency, evidencing good reliability (Simons & Gaher, 2005). Total DTS scores, as well as each of its subscales have demonstrated adequate construct validity (Bernstein et al., 2009; Leyro, Bernstein, Vujanovic, McLeish, & Zvolensky, 2011; Simons & Gaher, 2005). In the present sample, internal consistency (Chronbach’s alpha) for the DTS total score at baseline was 0.87. Alpha coefficient for the DTS subscales, *Tolerance*, *Absorption*, *Appraisal*, and *Regulation* were .72, .77, .72, and .70, respectively.

**Emotional eating.** The Dutch Eating Behavior Questionnaire (DEBQ; Van Strien et al., 1986) is a widely used and validated 33-item measure that assesses restrained eating, emotional eating, and eating in response to external cues (Van Strien, Frijters, van Staveren, Defares, & Deurenberg, 1986). Each item is rated on a 5-point scale from 1 (never) to 5 (very often). The emotional eating scale (DEES) of the DEBQ, which measures tendency to eat in response to negative emotions, was used to screen for emotional eating, with a score  $\geq 2.06$  indicative of significantly elevated distress-induced eating tendencies. In the present sample, internal consistency (Chronbach’s alpha) for the DEES at baseline was 0.92.

## Data analytic strategy

In order to analyze changes in self-reported DT and emotional eating assessed over the intervention period, we used mixed effects multilevel modeling (MLM) in SPSS® Version 20, which allows for the analysis of longitudinal data both within and between subjects (Raudenbush, Bryk, Cheong, & Congdon, 2004; Singer & Willet, 2003). MLM has several advantages over other strategies commonly used to analyze longitudinal data (MacKinnon, 2008; Singer &

Willet, 2003; Zhang, Zyphur, & Preacher, 2009). For example, as a form of intent to treat analysis (ITT), MLM allows for the inclusion of subjects with missing data, whereby it is able to estimate a longitudinal change trajectory for each subject using the number of completed assessments available. In addition, MLM allows for modeling of the error covariance within-subjects, which was modeled as autoregressive [AR(1)] in this study.

In line with standard guidelines for MLM (Singer & Willet, 2003), we tested a series of 2-level models to measure rates of improvement (Level 1) in self-reported levels of distress tolerance (DTS) and emotional eating (DEES) as a function of study condition (Level 2). Level 1 of the MLM model estimates outcome as a function of time within individual (i.e.,  $\text{Outcome}_{ij} = b_{0i} + b_{1i} * \text{Time}_{ij} + \varepsilon_{ij}$ , where  $i$  represents each individual subject and  $j$  represents each assessment point). Level 2 of the model allows for between-individual characteristics (i.e., study condition [COND], coded "0 = Yoga", "1 = WL") to influence outcome. The equations for Level 2 are  $b_{0i} = \gamma_{00} + \gamma_{01} * \text{COND}_i + u_{0i}$ , and  $b_{1i} = \gamma_{10} + \gamma_{11} * \text{COND}_i + u_{1i}$ . Level 2 is nested into the Level 1 equation, forming a composite 2-level model with the equation,  $\text{Outcome}_{ij} = \gamma_{00} + \gamma_{10} * \text{Time} + \gamma_{01} * \text{COND} + \gamma_{11} * \text{COND} * \text{Time} + (\varepsilon_{ij} + u_{0i} + u_{1i} * \text{TIME})$ .

In order to determine the most accurate MLM model reflective of changes over time in our main outcomes (DTS, DEES), we compared linear, quadratic, and logarithmic growth curves for each outcome based on their deviance statistics (Bayesian Information Criterion [BIC]). For both DTS and DEES outcomes, the logarithmic growth curve was found to be the best fit to the data. Therefore, the logarithmic transformation of time [ $\ln(\text{Time})$ ] was used in all tests analyzing these measures longitudinally.

Guidelines for estimating power to detect polynomial change using MLM in longitudinal studies have been published by Raudenbush and Xiao-Feng (2001), taking into account study duration, assessment frequency, and sample size. For our purpose of measuring weekly change in our outcomes over a 10-week period, a sample of  $N \geq 44$  was predicted to be adequate for achieving  $> 80\%$  power to be able to detect a large effect (Raudenbush & Xiao-Feng, 2001).

*Mediation analyses.* Establishing mediation in randomized trials requires demonstrating that the change in the mediator causes a change in the outcome. Enhancing the causal interpretation of our mediation test, we used a multilevel (MLM) cross-lagged panel analysis to test the mediating effect of DTS on *subsequent* reductions in DEES (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001; Kraemer, Wilson, Fairburn, & Agras, 2002). To test the size and significance of the proposed mediator, DTS, we employed MacKinnon and colleagues' asymmetric distribution of products test (Fritz & MacKinnon, 2007; MacKinnon, Fairchild, & Fritz, 2007; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Significance of a proposed indirect mediated pathway is determined based on confidence intervals for the product of the indirect paths of coefficients  $A*B$  (see Figure 4). If the 95% confidence interval for the  $A*B$  product does not include 0, the mediated effect is considered significant (MacKinnon, Lockwood, & Williams, 2004).

The coefficient for the interaction term (i.e., COND\*Time effect on DTS) represents the A Path of our model (labeled  $A_3$  in Figures 1 and 4). In order to control for temporal order of effects between mediator and outcome using a cross-lagged panel strategy, we lag-transformed the original variable DEES by one time point ( $\text{DEES}_{j+1}$ ). Thus, the B Path of our mediation model represents the coefficient for the effect of DTS<sub>*j*</sub> on  $\text{DEES}_{j+1}$  controlling for  $\text{DEES}_j$  (levels of the mediator DTS predicting future levels of the outcome (DEES); see Figures 1 and 4).

*Size of the mediated effect.* In order to estimate the proportion mediated by the proposed mediator (PM; (Shrout & Bolger, 2002), an effect size was calculated using the formula  $(A_3 * B) / C$ . The PM represents the proportion of the total effect of the hatha yoga intervention on emotional eating (i.e., the C Path) that was mediated by DT.

## Results

### Sample characteristics

We aimed to recruit a sample of women at-risk for obesity due to high levels of emotional/stress-induced eating. Out of 650 individuals who filled out the online prescreen survey of demographics, eating behavior, perceived stress, depression, and body mass index

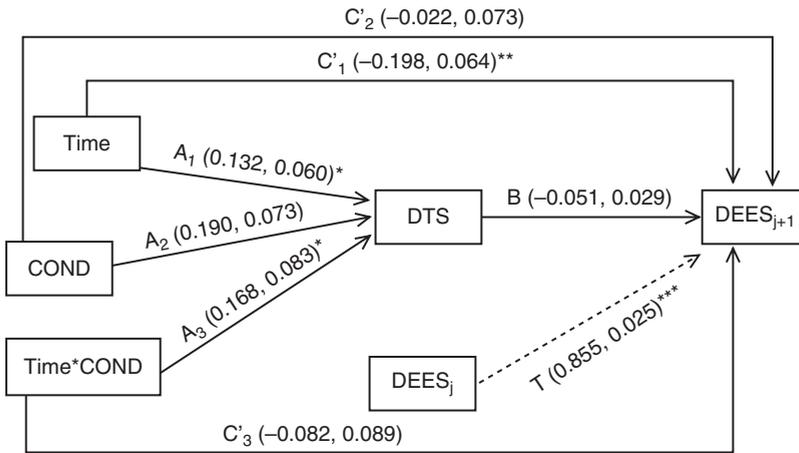


Figure 1. Cross-lagged mediation model for DTS. Note. (Coefficient *b*, std. error);  $p < .001^{***}$ ,  $p < .01^{**}$ ,  $p < .05^*$ .

(BMI), 573 did not meet initial eligibility criteria, and 25 declined participation. Seventy-three of the remaining women completed the diagnostic screening visit. Fifty-two eligible women attended the baseline orientation visit, where 27 were randomized to YOGA and 25 to WL.

Our final sample of 52 women ( $M_{age} = 33.52$ ,  $SD = 6.43$ ) had an average BMI within the overweight range at baseline. Prescreen emotional eating (DEES) scores for those randomized were approximately 2 SDs above normative scores for both obese and non-obese women (Ouwens, van Strien, & van der Staak, 2003; Van Strien et al., 1986; Van Strien & Ouwens, 2003). The sample consisted primarily of non-Hispanic White participants (75%,  $n = 39$ ). Ten (19.2%) of participants identified as Hispanic/Latina. Participants were well-educated and predominantly middle to upper-middle class with 60% reporting an annual household income of below \$75,000. All but one participant reported receiving either a college degree or some college, and 100% reported completing high school. See Table 1 for specific baseline descriptive statistics.

The study conditions did not differ at baseline on BMI, race/ethnicity, or annual income, nor were there differences in baseline assessments of DTS or DEES ( $p$ 's  $> .14$ ). Conditions differed by age, with the YOGA group being significantly younger ( $F(1,50) = 5.96$ ,  $p = .02$ ). We therefore controlled for age in all analyses.

Overall, 17% ( $n = 9$ ) of our sample dropped out of the intervention (i.e., missed both post-treatment laboratory visit and survey). Seven (26%) YOGA participants dropped out, whereas only two (8%) WL participants dropped out. However, chi-square analyses revealed that attrition did not differ significantly between conditions ( $\chi^2 = 2.91$ ,  $p = .09$ ). Study completers did not differ from the 10 dropouts in baseline levels of BMI, age, or DEES and DTS scores (Table 2).

Average weekly yoga attendance for the 27 participants randomized to yoga ranged from 0.13 to 3.25 sessions per week ( $M = 1.56$ ,  $SD = 0.82$ ). Ten (27%) participants met ( $n = 3$ ) or exceeded ( $n = 7$ ) the prescribed two classes per week. On average, yoga participants completed 60% of the 16 prescribed yoga sessions, and sixteen (84%) completed at least 75% (12 of 16 classes) of the intervention.

Table 1. Baseline clinical and demographic characteristics.

Variable	Yoga ( <i>N</i> = 27)		Waitlist ( <i>N</i> = 25)		Total ( <i>N</i> = 52)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	31.52	5.47	35.68	6.80	33.60	6.09
BMI	28.38	4.08	26.60	5.94	27.4	5.09
DTS	3.22	0.68	3.30	0.85	3.26	0.75
DEES	3.60	0.81	3.44	0.68	3.52	0.74

Table 2. Descriptive data and zero-order relations among predictor and criterion variables

Variable name	1	2	3	4	5	6	7	8	9
1. DTS total	–	.86**	.85**	.80**	.78**	.39**	–.40**	–.02	–.05
2. DTS tolerance	–	–	.70**	.60**	.53**	.36	–.47**	–.15	–.08
3. DTS absorption	–	–	–	.57**	.47**	.49**	–.40**	.02	.00
4. DTS Appraisal	–	–	–	–	.56**	.32*	–.24	.14	.04
5. DTS regulation	–	–	–	–	–	.10	–.17	–.04	–.16
6. FFMQ	–	–	–	–	–	–	–.41**	.03	–.16
7. DEES	–	–	–	–	–	–	–	.03	.11
8. BMI	–	–	–	–	–	–	–	–	.26
9. Condition	–	–	–	–	–	–	–	–	–

Notes: \* $p < .05$ ; \*\* $p < .01$

### Hypothesis testing

**Intervention effects on distress tolerance.** As hypothesized, the Condition-by-Time interaction was significant ( $b = -0.168$ ,  $t(128) = -2.014$ ,  $p = 0.046$ ), revealing that the log-linear rate of increase in DT was significantly greater in YOGA than WL (Figure 2). We calculated a Cohen's  $d$  effect size for the between-group effect using the approach recommended by Raudenbush and Xiao-Feng (2001) in multilevel mixed effects models. This yielded a standardized effect size (Cohen's  $d$ ) of .82, suggesting that the between-group effect on slope of improvement in DTS was large. This suggests that the average YOGA-treated participant fared better than 79% of those in WL on DT enhancement.

**Intervention effects on DTS subscales.** Additional analyses were conducted to exam-

ine between-group differences in the slopes of change for each of the DTS subscales (i.e., *Tolerance*, *Appraisal*, *Absorption*, and/or *Regulation*). When testing the same model for each of the four subscales, between-group differences were present for *Tolerance* ( $b = 0.226$ ,  $t(149) = 2.154$ ,  $p = .033$ ;  $d = .89$ ) and *Absorption* ( $b = 0.260$ ,  $t(136) = 2.544$ ,  $p = .012$ ;  $d = .97$ ), but not for *Appraisal* ( $b = 0.076$ ,  $t(139) = 0.977$ ,  $p = .330$ ) or *Regulation* ( $b = 0.107$ ,  $t(120) = 0.918$ ,  $p = .361$ ).

**Intervention effects on emotional eating.** As hypothesized, there was a significant Condition-by-Time interaction on DEES ( $b = 0.218$ ,  $t(104) = 2.519$ ,  $p = .013$ ), suggesting that the rate of log-linear reduction in emotional eating was greater for YOGA than WL (Figure 3). This effect was large (Cohen's  $d = .92$ ), indicating that the average YOGA participant fared

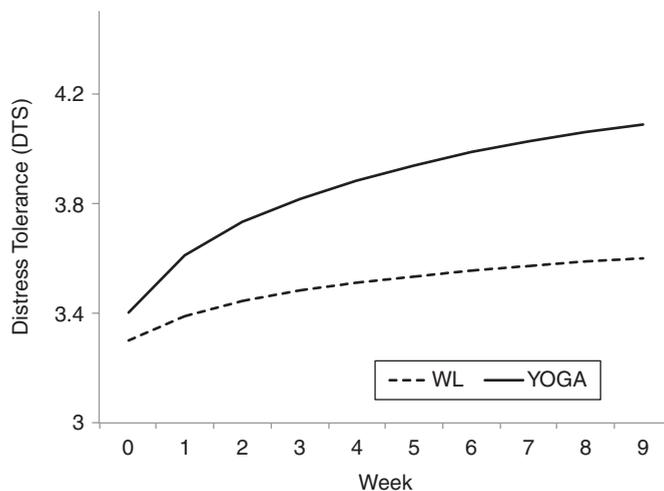


Figure 2. Changes in distress tolerance (DTS) over time by condition.

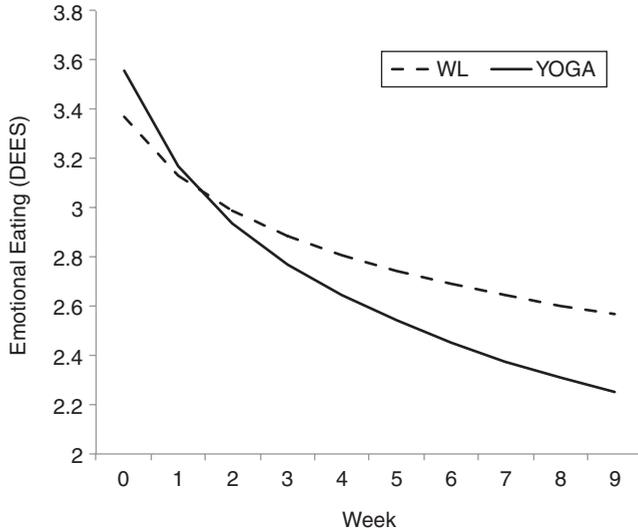


Figure 3. Changes in emotional eating (DEES) over time by condition.

better than 82% of those in WL on emotional eating.

**Mediation.** The 95% confidence interval for the mediated effect for DTS score was (-.025, .002). Thus, mediation was not supported for the DTS total score (see Figure 1 for A<sub>3</sub> and B path coefficients). We replicated these analyses using the DTS subscales. These analyses yielded no mediation for any of the subscales except for DTS-Absorption (95% confidence interval for the mediated effect of (-.07, .01); see Figure 4 for A<sub>3</sub> and B path coefficients). Percent of the effect of hatha yoga on emotional eating mediated by DTS-Absorption was 15%.

### Discussion

The primary aim of this study was to test the effects of an 8-week hatha yoga intervention on DT. This investigation was conducted as a secondary aim of its parent trial examining a hatha yoga intervention for physiological stress reactivity and affective eating, a risk factor for disordered eating and obesity. Results showed that, in comparison to a WL control group, an intervention involving twice-weekly hot hatha (Bikram) yoga for 8 weeks resulted in greater improvements in DT (as measured by the DTS) and greater reductions in emotional eating (as

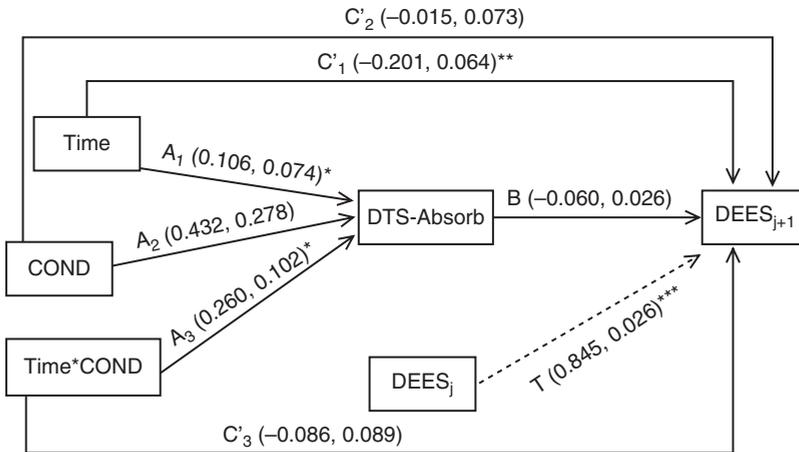


Figure 4. Cross-lagged mediation model for DTS-absorption. Note. (Coefficient *b*, std. error);  $p < .001$ \*\*\*,  $p < .01$ \*\* ,  $p < .05$ \*.

measured by the DEES subscale of the DEBQ). Indeed, by week 9 post-intervention assessment, yoga had produced large and clinically meaningful effects, proving to be approximately 80% more effective than WL for improving both DT and emotional eating.

The yoga intervention's effect on self-reported DT is consistent with results from previous studies showing increases DT resulting from mindfulness and exposure-based behavioral interventions (Baer, 2009; Brown et al., 2008). Our findings for DT suggest potential for yoga interventions to improve affective tolerance in a host of psychological disorders. In addition, our finding that yoga also reduced emotional eating echoes findings from previous studies that provided initial support of yoga in the treatment of eating disorder symptoms (Carei et al., 2010; McIver et al., 2009). Moreover, we expanded on the results of these previous trials by demonstrating yoga's efficacy for treating sub-clinical disordered eating problems and related distress, suggesting its clinical utility as a prevention strategy for females at-risk for future obesity and other adverse health effects caused by dysregulated eating patterns.

Our finding that yoga directly enhanced DTS subscales, *Tolerance* (i.e., meta-cognitions about capacity to handle distress) and *Absorption* (i.e., attentional interference during distress), suggests that 8 weeks of Bikram yoga practice particularly impacted cognitive components involved in distress processing, rather than those involved in emotional and behavioral distress reactivity (i.e., *Appraisal* or *Regulation*). That we found significant between-condition effects over time on these subscales is also consistent with previous studies showing that regular mind-body practice is associated with enhanced capacity to sustain attention while completing a task. One study found that experienced practitioners of yogic meditation performed better on cognitive tasks of attention than non-meditators (Prakash et al., 2010). Another showed that brief mindfulness training beneficially modified attention among alcohol-dependent persons with no previous background in mindfulness (Garland, Gaylord, Boettiger, & Howard, 2010).

As our second aim, we examined increased DT as a mechanism underlying the effects of yoga on a relevant mental health outcome, namely improvements in emotional eating.

Results of the mediation analyses showed that improvements in *DTS-Absorption* scores mediated the yoga intervention's positive effect on self-reported emotional eating. Improved *Absorption* explained 15% of the improvements in emotional eating caused by the yoga intervention. Thus, one way yoga reduces emotional eating, at least in this at-risk sample, appears to be by restoring the ability to concentrate and think clearly (i.e., enhanced cognitive capacity) during times of distress. Although yoga reduced DT in general (i.e., DTS total scores), it is interesting that it was only reductions in the *Absorption* subscale that drove improvements in emotional eating.

We can offer only speculation concerning the mixed findings among DTS subscales, given the paucity of literature providing context in which to interpret our findings. Little empirical attention has been paid to the relative clinical relevance and malleability of the individual DTS subscales in response to intervention (McHugh & Otto, 2012). One possibility is that the DT sub-facets change at different times or at different rates in response to intervention. Though our analyses cannot account for this idea, it may be that an 8-week yoga intervention can enhance general self-efficacy for handling distress (i.e., perceived *Tolerance*), which, in turn, makes the distress less salient in-the-moment, thus improving one's ability to approach distress with greater cognitive flexibility (i.e., decreased *Absorption*). Longer interventions and additional follow-up assessments should be used in future research to examine this hypothesis.

The conjecture that yoga enhances one's ability to shift attention beyond the sensation of discomfort, toward other stimuli in the immediate environment, is supported by the mindfulness literature (Baer, 2009; Gard et al., 2012; Garland et al., 2010). For example, Garland and colleagues found that a mindfulness intervention for alcohol-dependent participants resulted in improved ability to shift attention away from visual alcohol cues, as well as decreased reliance on thought-suppression strategies, a form of experiential avoidance. Although this study lacked a control condition, it provides preliminary support for the use of mindfulness interventions for preventing stress-induced alcohol relapse (Garland et al., 2010). We speculate that ultimately, with greater capacity to

sustain attention mindfully (i.e., reduced distress absorption), individuals become able to endure or cope healthfully with distress, rather than turning to food to dampen their feelings. Replication and extension of our findings will help more fully explain the relationship between yoga, mindfulness, absorption, and emotional eating.

We would like to note that we only focused on one of several potential psychological therapeutic mechanisms (i.e., DT) in this study, and cannot rule out the possibility that changes in DT are merely a byproduct of a change in some other perhaps more critical mechanism. Some alternative mechanisms for yoga's effects may be related to the physiological impact of exercise, such as peripheral and/or central nervous system stimulation (Broman-Fulks & Storey, 2008; Smits et al., 2008; Stoller, Greuel, Cimini, Fowler, & Koomar, 2012) or modulating cortisol reactivity to stress (Berger & Owen, 1988; Schell, Allolio, & Schoneke, 1993). In one study, moderate-intensity physical activity, which induces repeated autonomic arousal, was negatively associated with frequency of binge eating among individuals who were fearful of such autonomic sensations (i.e., high AS, a construct related to DT) and had a tendency to eat as a means of coping with negative affect (DeBoer et al., 2012).

There are several limitations to our study that are worth noting and that can guide future investigations. First, our limited sample size and, thus, statistical power may explain our mixed findings among DTS subscales. Though power estimates for determining our sample size were gathered using published guidelines (Raudenbush & Xiao-Feng, 2001), a greater number of participants and/or more-frequent assessments could have enhanced power for detecting clinically meaningful condition differences.

Second, using additional behavioral measures of DT would have corroborated our findings using self-reported DTS. Measuring broad DT or general affect intolerance is difficult at this time, however. Current laboratory behavioral measures of DT (e.g., breath holding challenge, computerized frustration tasks) tend to tap only domain-specific types of distress (e.g., physical discomfort, frustration) and, consequently, have been poorly correlated with each other and with other self-report measures (Leyro et al., 2010; McHugh & Otto, 2012). This problem calls for

development of additional behavioral DT measurement methods that can assess both the overarching construct of emotional DT, as in the DTS, as well as its subcomponents.

Without the inclusion of additional active study conditions, our study cannot make conclusions regarding the comparative effects of yoga to traditional exercise, to psychotherapy, or to a contact control intervention. We also cannot ascertain whether yoga is better suited as a stand-alone or adjunctive treatment. That is, yoga may best serve as a complimentary intervention to established cognitive-behavioral interventions for emotional and binge eating that also emphasize broader emotion regulation skills. In short, we are limited in our ability to draw conclusions concerning the specificity of yoga's effects. Attrition represents a related limitation, as 25% of the yoga treatment condition prematurely terminated the study. Thus, we cannot confirm the effects found here to be a result of intended "dose" of yoga. Future studies should assess reasons for yoga dropout and dose underperformance to guide further yoga implementation strategies.

Further research is needed to investigate how and for whom yoga interventions will be most useful. It is possible that some groups require integrative treatment strategies to reduce their avoidant coping behaviors. One study showed that low DT and poor use of emotion regulation strategies were additively predictive of experiential avoidance (McHugh, Reynolds, Leyro, & Otto, 2013). This has application to our results, suggesting that enhanced cognitive capacity for handling distress (i.e., reduced *Absorption*) through yoga may be less relevant for emotional eaters who do not have available alternative emotion regulation strategies. For these individuals, yoga may be more useful as an adjunct to other cognitive and behavioral skills training.

## Conclusion

This study offers preliminary evidence for the benefits of yoga interventions for problems characterized by elevated stress and poor affect regulation. First, our findings underscore the promise of hatha yoga practice for increasing DT and reducing emotional eating tendencies. Second, our mediation analyses revealed a particular component of the

cognitive processing of distress – *Absorption* – mediated the effects of yoga on disordered eating. Interventions that aid in affect modulation and enhanced coping are crucial for reducing the public health burden of an array of psychological disorders, and this study provides support for further development of specialized, mind-body interventions for those low in DT.

## Disclosure statement

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