APPLIED PSYCHOLOGY: Health and Well-Being

APPLIED PSYCHOLOGY: HEALTH AND WELL-BEING, 2020, *12* (1), 188–211
doi:10.1111/aphw.12179

An 8-Week Relaxation Program Consisting of Progressive Muscle Relaxation and Mindfulness Meditation to Reduce Stress and Attenuate Stress-Driven Eating

Tasmiah Masih*, James A. Dimmock and Kym J. Guelfi

The University of Western Australia, Perth, Western Australia, Australia

Elissa Epel

University of California, San Francisco, CA, USA

Background: Stress is often associated with the intake of energy-dense palatable foods. This trial examined the feasibility and preliminary efficacy of an 8-week worksite-based relaxation intervention to address psychological stress and unhealthy food intake. **Methods:** Thirty-six men and women were exposed to an acute stressor, while physiological and psychological responses were assessed, prior to being offered a test meal. Participants were then randomised to a relaxation intervention (RELAX; face-to-face classes and daily home practice of progressive muscle relaxation and mindfulness meditation), or a wait-list control (CON). All measures were repeated after the intervention. **Results:** Intervention compliance was high (80% ± 19% face-to-face; 79% ± 18% home practice), and each session acutely reduced perceived stress ($p < .001$) and increased relaxation ($p < .001$). After 8 weeks, trait mindfulness was increased ($p = .025$), along with reduced tension ($p = .013$) and increased relaxation ($p < .05$) post-acute stressor in the intervention group. There was no effect of the intervention on palatable eating, cravings, or energy intake at a laboratory test meal, with small associated effect sizes ($d = 0.01$–0.3). **Conclusions:** The program studied here is feasible and sessions transiently reduce perceived stress and improve mindfulness; however, the program may not influence the physiological response to an acute stressor or appetite and eating variables.

Keywords: mindful, relaxation, stress-eating, stress management, worksite-based

*Address for correspondence: Tasmiah Masih, School of Human Sciences (Exercise and Sport Science), The University of Western Australia, Perth, Western Australia, Australia. Email: tasmiah.masih@research.uwa.edu.au

INTRODUCTION

Exposure to stress is inevitable in our modern lives, and results in a physiological response involving stimulation of the sympathetic nervous system, the endocrine system, and limbic structures (Pruessner et al., 2010). This "flight or fight" response is intended to ensure survival of the organism; however, unnecessary, excessive, and/or chronic elicitation of the stress response (often referred to as "distress") can have deleterious effects on the body in the long term, including increased worry, anxiety, weight gain, blood pressure, and inflammatory processes associated with atherosclerosis (Harding et al., 2013; Kyrou & Tsigos, 2009). There is also a growing body of research based in both laboratory (for example, Rutters, Nieuwenhuizen, Lemmens, Born, & Westerterp-Plantenga, 2009; Sproesser, Schupp, & Renner, 2014) and free-living settings (for example, Groesz et al., 2012; Sims et al., 2008) suggesting that stress often influences food choice, with increased preference for the intake of unhealthy energy-dense highly palatable foods and drinks; although it should be acknowledged that there is significant inter- and intra-individual variation in the precise effect of stress on total energy intake (Wallis & Hetherington, 2009; Yeomans & Coughlan, 2009).

The relaxation response is the physiological and psychological opposite of the stress response (Wallace, Benson, & Wilson, 1971). Intuitively therefore, the practice of relaxation may attenuate both the stress response and any subsequent effect on eating behaviour; however, the latter has never been empirically tested. There is some evidence that relaxation can affect appetite, with 1 week of daily abbreviated progressive muscular relaxation (PMR) reducing feelings of evening hunger in individuals suffering from night-eating syndrome (Pawlow, O'Neil, & Malcolm, 2003). Nonetheless, the question of whether regular practice of relaxation techniques can reduce stress and associated eating in a non-clinical population remains unanswered.

In attempting to test the hypothesis that regular elicitation of the relaxation response can attenuate the stress response and subsequent stress-induced eating, one must consider that there are many methods by which relaxation can be achieved (Benson, Greenwood, & Klemchuk, 1975). Although PMR is one of the most widely documented techniques in relaxation research (Chellew, Evans, Fornes-Vives, Pérez, & Garcia-Banda, 2015; Jacobsen, 1934), another method through which the relaxation response may be achieved is mindfulness meditation (MM) (Benson et al., 1975). Indeed, some researchers have questioned whether part of the benefit associated with MM is a result of the relaxation response (Benson et al., 1975; Jain et al., 2007). When directly compared, mindfulness practice and a relaxation training (including PMR) have been shown to improve positive states of mind and reduce distress to a similar extent (Agee, Danoff-Burg, & Grant, 2009; Jain et al., 2007). However, PMR may be more effective in reducing somatic aspects of stress (Rausch, Gramling, & Auerbach, 2006), while mindfulness practice appears more effective in addressing cognitive

components of stress (Jain et al., 2007; Muangnapoe, Morris, & Kuan, 2016). Since both cognitive and physiological elements of stress may play a role in promoting the intake of palatable food (Masih, Dimmock, Epel, & Guelfi, 2017), the combination of PMR and MM in a single intervention may offer a promising approach to reducing stress-induced eating.

As with PMR, there is some evidence that mindfulness approaches might affect appetite and/or eating behaviour. Corsica, Hood, Katterman, Kleinman, and Ivan (2014) demonstrated reduced self-reported stress and stress-eating amongst overweight volunteers following 6 weeks of Mindfulness-Based Stress Reduction and cognitive-behavioural training designed to target stress-eating (involving a once-weekly 80-minute class and daily home-based activities totalling 30–45-minutes per day). These benefits persisted after an additional 6 weeks of follow-up. Daubenmier et al. (2011) observed a reduction in trait anxiety and eating in response to external cues in overweight/obese women following a 4-month modified Mindfulness-Based Stress Reduction program aimed at stress-eating (consisting of nine 2.5-hour classes, a one-day silent retreat, and daily home assignments including up to 30 minutes of practice). No further follow-up was conducted.

Preliminary evidence suggests that both PMR and mindfulness approaches may influence appetite and/or eating behaviour. In addition, the elicitation of relaxation through these two approaches may influence stress and eating through different mechanisms (i.e. somatic versus cognitive elements). Hence, the present pilot study aimed to test the feasibility and preliminary efficacy of an 8-week worksite intervention combining the practice of PMR and MM on stress and stress-induced eating. More specifically, the aim was: (1) to establish the feasibility of such an intervention in terms of recruitment, fidelity, dose, and acceptability, and (2) to provide preliminary evidence of the effect an 8-week mindful relaxation intervention on physiological (heart rate, blood pressure, salivary cortisol) and psychological (mood states, perceived stress) features of stress. The effect on indicators of stress-induced eating (i.e. *ad libitum* intake, cravings) was examined secondary to this. It was hypothesised that the 8-week worksite relaxation intervention would be feasible to conduct, as well as effective for attenuating the stress response when faced with an acute stressor and reducing indicators of stress-induced eating.

METHODS

Study Participants

Healthy men and women aged 18–60 years were invited to take part in a research project investigating the effect of an 8-week worksite-based mindful relaxation course on the physiological and psychological effects of stress. Volunteers expressing interest were emailed an information sheet detailing the

experimental protocol. This was followed by a phone interview to confirm suitability based on the following inclusion criteria: a BMI between 20 and 35 kg/m^2, weight stable (no change greater than 2 kg in last 6 months and currently within 2.5 kg of maximum adult weight), no diagnosed medical conditions or fear of needles. Further exclusion criteria included a history of substance abuse, heavy drinking or smoking, the use of prescription medications, current/recent dieting, previous regular practice of relaxation techniques, excessive exercise (>2 hours/day), an irregular work/sleep schedule, and irregular breakfast intake. Women who were pregnant/lactating or had an irregular menstrual cycle were also excluded. Although extensive, these criteria were enforced given the various factors that may influence outcomes of both stress and appetite (Dweck, Jenkins, & Nolan, 2014; Kudielka, Hellhammer, & Kirschbaum, 2007; Tomiyama et al., 2010). This study was approved by the University Human Research Ethics Committee, registered at the Australian New Zealand Clinical Trials Registry (ID number ACTRN12616001337460), and written informed consent was obtained from all participants.

Experimental Overview

Participants attended a 90-minute familiarisation session at their workplace during which they were informed of the full experimental protocol and informed that the stress condition involved a "verbal ability task". Single saliva samples were obtained for familiarisation, and a brief overview of the PMR and the MM practice should they be randomised to the intervention group was provided. Additionally, each participant completed a series of questionnaires in which demographic information and more specific aspects of health and well-being were assessed (detailed later). Following this familiarisation session, each participant was required to attend the university laboratory on a separate occasion for baseline (pre-intervention) testing after which they were randomised to an 8-week relaxation (RELAX) group or wait-list control (CON) group using sealed envelope randomisation. After the 8-week period, each participant attended the university laboratory for post-intervention assessments (see Figure 1A for overview) and following study completion, those randomised to CON were offered the 8-week program.

Relaxation Intervention

Participants assigned to the RELAX group attended a once-weekly 30-minute, worksite-based class comprising either a 20-minute guided PMR or MM practice (alternated every 2 weeks), and the completion of a brief pre- and post-practice questionnaire. All practice was limited to <30 minutes with the intention of enhancing compliance given that time demands are often a barrier for participation in such programs (Carmody & Baer, 2009). The practice of abbreviated

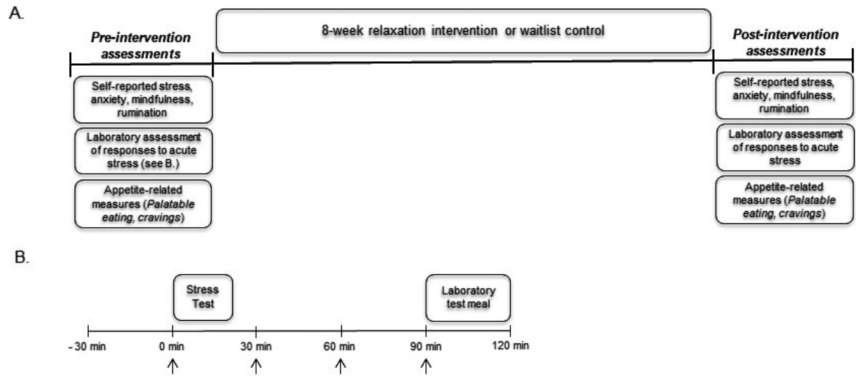


FIGURE 1. Overview of (A) experimental design including pre- and post-intervention assessments and (B) the timeline of the laboratory assessment of responses to acute stress. Arrows in (B) indicate timing of assessment of physiological (BP, HR, salivary cortisol) and psychological responses (mood, perceived stress/relaxation, perceived appetite) to stress test. BP, HR, and perceived stress/relaxation were also assessed 120 minutes after the test meal.

PMR consists of sequential tensing and relaxing of 16 muscle groups (as described by Bernstein & Borkovec, 1973), in order to release muscular tension and subsequently relieve mental tension. Participants were asked to focus on the contrasting sensations of tension and release as they engaged in the technique (Bernstein & Borkovec, 1973). The MM session was based on a script by Kabat-Zinn (2002), in which participants are asked to draw attention to the present by using the breath as an anchor (Kabat-Zinn, 2002). In addition to the face-to-face sessions, participants were provided with 20-minute audio recordings of the guided MM and the PMR (performed by TM) for the maintenance of daily home practice. During the 8 weeks, participants were given reminders to change from the PMR to the MM audio recording every 2 weeks.

Assessment of Intervention Feasibility

Aspects of recruitment, fidelity, dose, and acceptability of the experimental protocol and intervention were monitored (Saunders, Evans, & Joshi, 2005). The specific measures of compliance, dose, and acceptability of the mindful relaxation classes are outlined below.

Assessment of Preliminary Efficacy

Before and after the 8-week intervention period, each participant attended the university laboratory at 0800 h in fasting state. Participants were required to eat

the same standard meals and snacks, and abstain from caffeine, alcohol, and exercise for 24 hours prior to each experimental session (confirmed using nutrient analysis software [FoodWorks; Xyris Software, Kenmore Hills, Qld, Australia]). Upon arrival at the laboratory, participants rested for 30 min, after which a number of baseline physiological and psychological measures were recorded (detailed later). Following baseline measures, participants took part in the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), which is a 15-minute laboratory-based stressor comprising elements that most reliably increase cortisol response: public speaking, a numerical exercise, the presence of spectators, and the threat of a negative outcome (Kirschbaum et al., 1993). In brief, participants were requested to present a 5-minute talk in order to convince a two-member mock selection panel that they were suitable candidates for a job (or a promotion) they had applied for. This was followed by a numerical exercise that involved reverse counting. In addition, participants in the TSST were informed that their performance would be video recorded for later analysis (Kirschbaum et al., 1993). In order to reduce the stress adaptation likely associated with stressor familiarity during the second (post-intervention) TSST, the mock selection panellists were different individuals, and participants were informed that their performance during the first TSST was assessed as "being in the lower range and that this was an opportunity to better their score" (Hoge et al., 2017). After the completion of the TSST, participants viewed a nature documentary on plant life for the remaining duration of the laboratory session with physiological and psychological measures repeated at standardised times throughout each trial (see Figure 1B for overview). A full debrief was provided following post-intervention testing and confirmation by the participants that they were unaware of the true aims of the study.

Measures

Intervention Feasibility. Attendance at the weekly sessions was recorded, and each participant documented their frequency of home practice. In addition, during the weekly face-to-face classes, participants were asked to complete a 100-mm visual analogue scale (VAS) pre- and post-practice in order to assess the acute effects on state mindfulness, stress, and relaxation (adapted from Fisher, Lattimore, & Malinowski, 2016). The pre-practice questionnaire consisted of two questions: (1) "How stressed do you feel now?" and (2) "How relaxed do you feel now?" The post-practice VAS included questions (1) and (2) as above, in addition to (3) "How demanding was the [relaxation] exercise for you?" and (4) "How enjoyable was the [relaxation] exercise for you?" In order to specifically address state mindfulness, the post-MM practice questionnaire also asked (5) "During the guided session, I felt myself getting carried away by my thoughts rather than just noticing them"; (6) "During the guided session, I paid attention to my thoughts and feelings"; (7) "During the guided session, I

was aware of my thoughts, feelings and bodily sensations"; (8) "During the guided session, I paid attention to my thoughts and feelings without judging them"; and (9) "During the guided session, I was aware of my thoughts, feelings and bodily sensations with a sense of acceptance" (adapted from Fisher et al., 2016).

Intervention Efficacy: Self-Reported Stress, Anxiety, and Mindfulness. A number of questionnaires were administered pre- and post-intervention including the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983), the trait subscale in the State-Trait Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003), and the Rumination Response Scale-Trait (RRS; Treynor, Gonzalez, & Nolen-Hoeksema, 2003). Internal consistency estimates (α) for scores derived from each of these scales were as follows: PSS ($\alpha = 0.883$), STAI-Trait ($\alpha = 0.913$), MAAS ($\alpha = 0.902$), RRS ($\alpha = 0.902$).

Intervention Efficacy: Responses to Acute Laboratory Stressor. To assess the physiological responses to the acute laboratory stressor, blood pressure (BP) and heart rate (HR) were recorded (Omron HEM 7211, Hoofddorp, The Netherlands) at standardised intervals throughout each session (baseline, 30, 60, and 90 minutes following commencement of the TSST—an additional measure of BP was taken after the laboratory test meal outlined later). At the same intervals, saliva was sampled using a salivette (Sarstedt, Numbrecht, Germany), with the sample collected centrifuged at 4°C for 5 minutes at 1300 *g* and the supernatant frozen at −80°C until assayed for cortisol (as per Jensen, Hansen, Abrahamsson, & Nørgaard, 2011).

To assess the psychological responses to the acute laboratory stressor, a series of questionnaires were administered at baseline, 30, 60, and 90 minutes following commencement of the TSST. Mood was assessed using the Profile of Mood States-Adolescence (POMS-A). This scale has been validated for use in adult samples (Terry, Lane, & Fogarty, 2003) and internal consistency estimates (α) for the subscales ranged between $\alpha = 0.813$ and 0.935. At the same times, a 100-mm VAS was completed to assess the level of stress and relaxation felt (i.e. "How stressed (or relaxed) do you feel?") (Fisher et al., 2016; Neseliler et al., 2017).

Intervention Efficacy: Appetite-Related Measures. The Palatable Eating Motives Scale (PEMS; Burgess, Turan, Lokken, Morse, & Boggiano, 2014) and the craving subscale of the Food Craving Inventory-British (FCI; Nicholls & Hulbert-Williams, 2013) (adapted for suitability for the Australian diet) were completed pre- and post-intervention. In addition, the Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, Frijters, Bergers, & Defares, 1986) and the 16-item Disinhibition subscale in the Three Factor Eating Questionnaire (TFEQ;

Stunkard & Messick, 1985) were completed pre-intervention to provide additional descriptive characteristics of the sample. Internal consistency estimates for scores derived from each of these scales were: PEMS ($\alpha = 0.841$), FCI ($\alpha = 0.870$), DEBQ ($\alpha = 0.935$), TFEQ ($\alpha = 0.826$).

To assess the appetite response to the acute laboratory stressor, participants completed a 100-mm VAS to gauge perceived level of hunger (Flint, Raben, Je, & Astrup, 2000) at regular intervals before and after completing the TSST. Ninety minutes after the onset of the TSST, participants were offered a pre-weighed selection of commonly eaten healthy and unhealthy foods. The timing between acute stress exposure and access to the laboratory test meal was based on previous work on stress-induced eating (Appelhans, Pagoto, Peters, & Spring, 2010; Raspopow, Abizaid, Matheson, & Anisman, 2010). Food provided included breakfast cereal, croissants, toast, a choice of spreads, breakfast biscuits, yoghurt, tea/coffee, a jar of candy, and chocolate. Participants were told that the food offered was in recognition of their time, and because they had been in a prolonged fasting state. Each participant was then left alone to eat as desired for 30 minutes. Following their departure, the remaining food was re-weighed, and energy intake determined.

Statistical Analyses

The feasibility and acceptability of the intervention was assessed based on compliance, enjoyment, and acute outcomes of the relaxation classes. A comparison of the observations from each RELAX participant's initial and final class was carried out using a two-way ANOVA (session (initial session versus final) × time (pre-class versus post-class)), for perceived stress and relaxation. Single post-practice outcomes (e.g. degree of enjoyment, perception of demand, and levels of mindfulness achieved), were analysed using one-way ANOVA between the first and final sessions. To compare aspects of PMR versus MM, three-way (practice type (MM vs. PMR) × session (initial vs. final) × time (pre-class vs. post-class)) ANOVA was conducted for stress and relaxation, while a two-way ANOVA (practice type × session) was conducted for enjoyment and demand.

To assess the preliminary efficacy of the intervention, variables with a single value measured pre- and post-intervention (i.e. perceived stress over the prior month, trait anxiety, rumination, and mindfulness) were compared using two-way (group (RELAX vs. CON) × time (pre-post)) repeated measures ANOVA. Variables with multiple measures over time within the pre- and post-intervention laboratory session (e.g. BP, HR, mood, perceived stress) were compared using three-way (group (RELAX vs. CON) × time (pre-post) × time (within the session)) repeated measures ANOVA. In addition, Cohen's *d* effect sizes were determined to assess the practical significance of changes as a result of the intervention. Effect sizes were interpreted as <0.5 small, 0.5–0.8 moderate and >0.8 large (Lakens, 2013). A minimum sample size of 15 per treatment arm was

targeted to detect a medium (0.3–0.7) effect size with 90 per cent power and two-sided 5 percent significance based on the recommendations of Whitehead, Julious, Cooper, and Campbell (2016) given that a formal power calculation was inappropriate with standardised effect sizes unknown.

RESULTS

Intervention Feasibility

Recruitment. A total of 172 individuals were assessed for eligibility for the study between October 2016 and July 2017, with 28 per cent (n = 48) meeting the criteria for inclusion. Of these, 37 completed baseline assessments and were randomised (Figure 2), with the remaining 11 declining to participate due to a

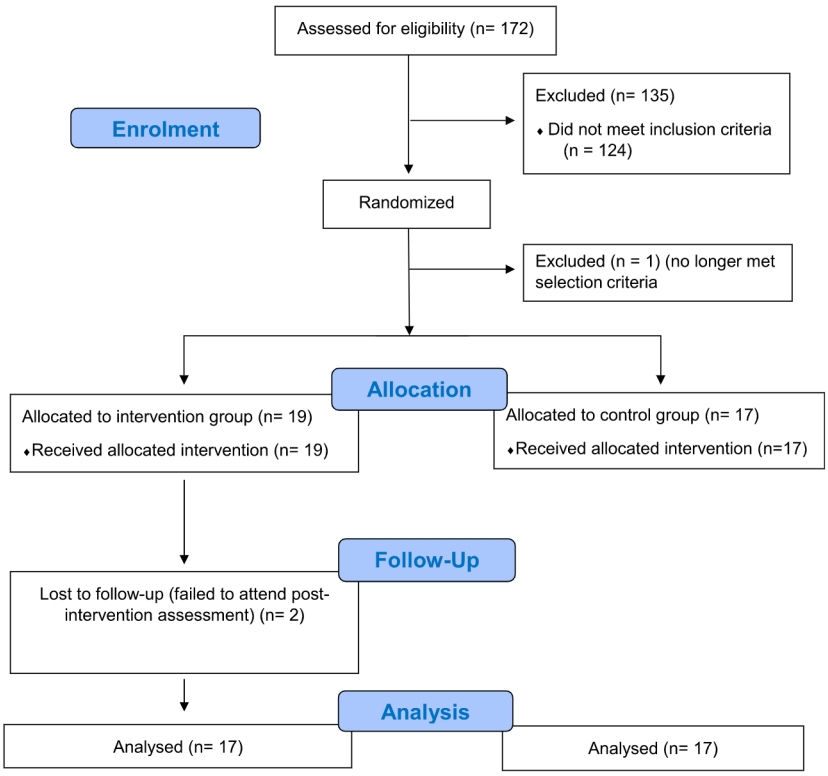


FIGURE 2. Consolidated Standards of Reporting Trials (CONSORT) flow diagram (Schulz, Altman, & Moher, 2010).

lack of time. Following baseline assessment, one participant was found to no longer meet the inclusion criteria (due to the commencement of medication), leaving 36 individuals randomised. A further two participants in the RELAX group were unable to attend the post-intervention assessment after completion of the 8-week trial. Based on the study selection criteria, the most common reasons for exclusion were maintenance of a special diet (13.6%), weight instability (10.4%), irregular menstrual cycle (10.4%), and psychopathology (9.6%). The final sample mainly comprised employees from two large corporations and the university. Baseline characteristics are shown in Table 1. The groups were well matched at baseline, with no differences in these characteristics.

Intervention Fidelity. Overall, the 8-week mindful relaxation intervention was implemented as intended. All components of the experimental protocol were conducted by a single researcher (TM; an Accredited Practicing Dietitian, a qualified mindfulness meditation and yoga teacher), with the exception of panellists required to conduct the TSST. The setting, timing, relaxation script used, equipment used, and foods served were standardised for all participants. The replication of diet, sleep, and physical activity 24 hours preceding the pre- and post-intervention assessment session was also verified. There was no difference in energy intake in the 24 hours preceding the laboratory session (across groups and over time), indicative of dietary compliance ($p = .43$). The debrief provided to participants after completion of the post-intervention laboratory session indicated that the blinding of participants to the appetite component of the investigation was successful.

Dose and Acceptability. Delivery of the once-weekly classes was completed as planned. Compliance with the face-to-face classes was 80 per

TABLE 1
Baseline Characteristics of Participants Allocated to a Wait-List Control (CON) or Relaxation Intervention (RELAX) (Mean ± *SD*)

	CON group (n = *17)*	*RELAX group* (n = *19)*	p-*value*
Age (yrs)	33 ± 12	39 ± 10	.08
Sex	M (35%), F (65%)	M (32%), F (68%)	.81
BMI (kg/m^2)	24.4 ± 3.3	26.1 ± 4.3	.20
Perceived Stress Scale	25.24 ± 7.5	23.42 ± 14	.51
Trait anxiety	43.00 ± 10.16	40.63 ± 8.41	.45
Trait rumination	40.41 ± 10.81	38.95 ± 8.25	.65
Mindfulness	3.60 ± 0.83	3.55 ± 0.90	.87
Restrained eating	2.48 ± 0.75	2.35 ± 0.82	.62
Emotional eating	2.48 ± 0.84	2.00 ± 0.62	.07
External eating	3.2 ± 0.7	2.99 ± 0.61	.40
Disinhibition	6.29 ± 3.31	5.88 ± 3.57	.73

cent ± 19 per cent, while participants completed 79 per cent ± 18 per cent of the home practice sessions. The face-to-face sessions acutely reduced perceived stress and increased relaxation based on the pre-post session measures obtained at each class (Table 2), with a main effect for time (pre-post session) for stress ($F_{(1,\ 16)} = 41.18$, $p < .001$), and relaxation ($F_{(1,\ 16)} = 30.39$, $p < .001$). When the PMR and MM classes were compared, both were effective for acutely reducing stress ($F_{(1,\ 16)} = 63.77$, $p < .001$), and increasing perceived relaxation ($F_{(1,\ 16)} = 85.62$, $p < .001$), with PMR inducing a greater level of relaxation ($F_{(1,\ 16)} = 7.02$, $p < .05$). Measures of state mindfulness obtained after the face-to-face MM sessions remained constant over the course of the 8 weeks, except for item: "During the guided session, I paid attention to my thoughts and feelings without judging them", which increased in rating over time from the first class ($M = 64 \pm 20$ mm) to the final class ($M = 72 \pm 16$ mm, $p = .049$) and item: "During the guided session, I was aware of my thoughts, feelings, and bodily sensations with a sense of acceptance", which also increased in rating between the first and the final classes (63 ± 20 versus 76 ± 16 mm, $p = .003$), indicating that the repeated practice of MM positively affected elements of state mindfulness. The degree of enjoyment derived from the face-to-face practice was high for both PMR and MM, similar between session types, and did not change over the course of the 8 weeks ($p = .59$). How demanding the PMR or MM practice felt also did not change over the course of the 8 weeks; however, a main effect of practice type ($F_{(1,\ 16)} = 8.42$, $p = .010$) distinguished MM as more demanding than PMR. Associated effect sizes are shown in Table 2. For those randomised to the control group, 41 per cent took up the option to complete the 8-week program after completion of the study.

Intervention Efficacy

Self-Reported Stress, Anxiety, and Mindfulness. The preliminary efficacy of the intervention for altering self-reported psychological variables (including perceived stress over the prior month, trait anxiety, rumination, and mindfulness) is summarised in Table 3. There was no significant main effect for time or significant interaction of group and time, and the associated effect sizes were small, for trait rumination and trait anxiety ($p > .05$). For mindfulness, there was a main effect for time ($F_{(1,32)} = 4.85$, $p = .035$), and an interaction effect approaching significance ($F_{(1,\ 32)} = 3.97$, $p = .055$), with a significant increase in mindfulness within the intervention group over the 8-week intervention ($p = .025$; $d = 0.53$), but no change in the control group ($p = .85$). Perceived stress over the prior month (based on the PSS) decreased over the experimental period ($F_{(1,32)} = 4.31$, $p = .046$), with a main effect for time but no difference between groups.

Effect on the Acute Stress Response. The acute stress response was elicited pre- and post-intervention by the laboratory stressor (TSST), as evidenced by a

TABLE 2
Perceived Stress, Relaxation, Enjoyment, and Demand of Face-to-Face Sessions of an 8-week Relaxation Intervention Consisting of Abbreviated Progressive Muscle Relaxation (PMR) and Mindfulness Mediation (MM) (Mean ± *SD*)

	PMR						*MM*					
	Initial session		*Cohen's d*	*Final session*		*Cohen's d*	*Initial session*		*Cohen's d*	*Final session*		*Cohen's* d
	Pre	*Post*		*Pre*	*Post*		*Pre*	*Post*		*Pre*	*Post*	
Perceived stress (mm)	38 ± 28	13 ± 13[c]	***−1.15***	33 ± 24	13 ± 13[c]	***−1.04***	45 ± 29	22 ± 18[c]	***−0.95***	32 ± 18	15 ± 19[c]	***−0.92***
Perceived relaxation (mm)	47 ± 26	82 ± 11[c]	***1.75***	55 ± 20	83 ± 13[c]	***1.66***	47 ± 26	68 ± 29[c]	***0.76***	58 ± 24	79 ± 22[c]	***0.91***
Enjoyment (mm)	–	86 ± 14	–	–	86 ± 14	0	–	77 ± 22	–	–	80 ± 20	0.14
Demand (mm)	–	12 ± 13	–	–	15 ± 19	0.09	–	32 ± 28	–	–	29 ± 31	−0.10

Moderate-large effect sizes are denoted in bold.
[a]Indicates significant difference pre- to post- session ($p < .05$).

TABLE 3
Effect of an 8-week Relaxation Intervention (RELAX) or Wait-List Control (CON) on Self-Reported Psychological Variables (Mean ± *SD*)

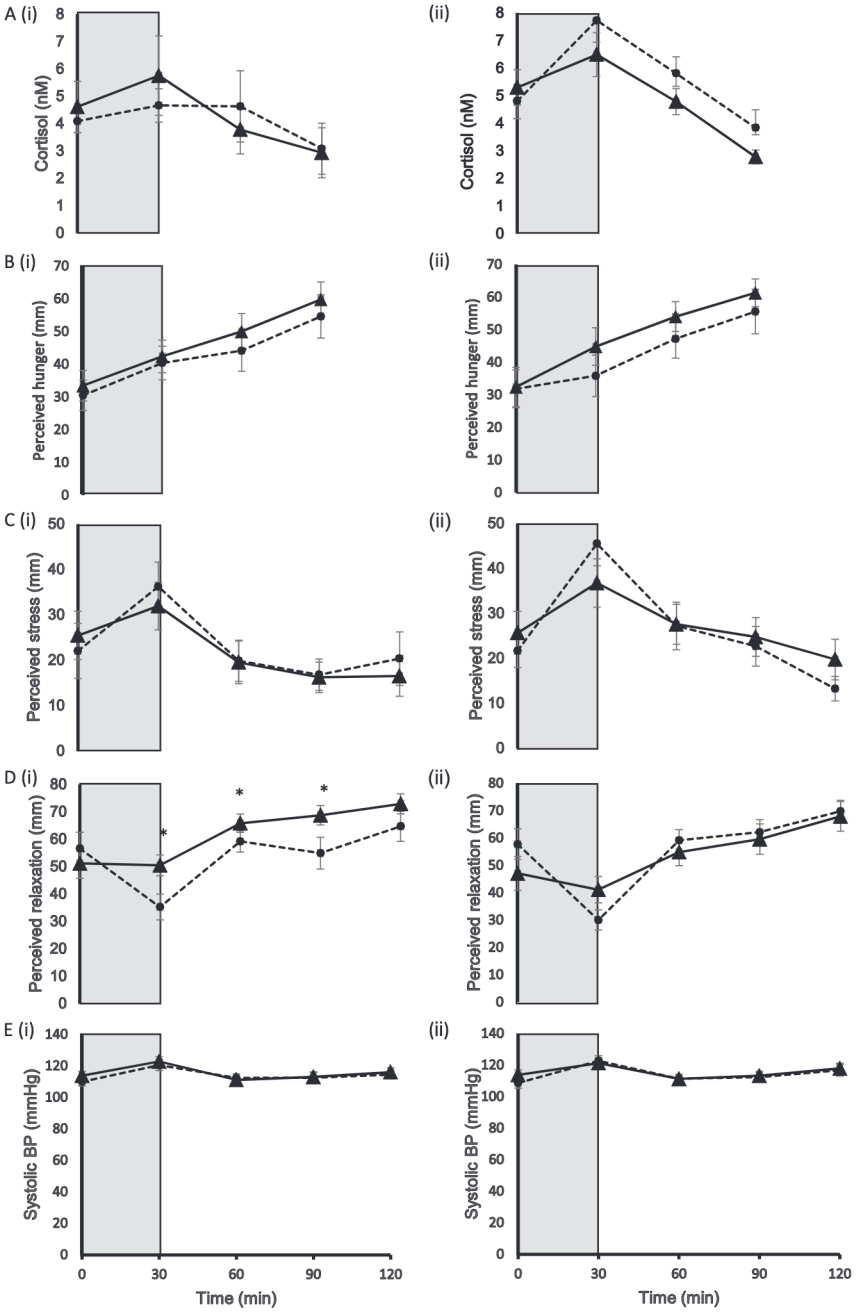
	CON (n = *17*)			*RELAX* (n = *17*)		
	Pre	*Post*	*Cohen's* d	*Pre*	*Post*	*Cohen's* d
Perceived Stress Scale[a]	25.23 ± 7.50	23.53 ± 5.28	−0.30	23.00 ± 9.24	19.47 ± 8.25	−0.40
Trait anxiety	43.00 ± 10.16	42.41 ± 7.10	−0.07	41.00 ± 8.44	39.65 ± 8.99	−0.15
Trait rumination	40.41 ± 10.81	40.53 ± 11.28	0.01	38.18 ± 8.25	37.00 ± 9.11	−0.14
Mindfulness	3.60 ± 0.83	3.62 ± 0.70	0.03	3.51 ± 0.93	3.98 ± 0.83[b]	***0.53***

Moderate-large effect sizes are denoted in bold.
[a]indicates a significant main effect for time ($p < .05$).
[b]indicates significant difference from pre- to post-intervention ($p < .05$).

main effect of time (within each laboratory session) for perceived stress ($F_{(4, 128)} = 18.83$, $p < .001$), cortisol ($F_{(1.66, 49.90)} = 19.15$, $p < .001$), systolic BP ($F_{(4, 128)} = 28.64$, $p < .001$), diastolic BP ($F_{(4, 128)} = 26.85$, $p < .001$), and HR ($F_{(3.25, 103.94)} = 29.02$, $p < .001$), all of which consistently increased in response to the TSST (Figure 3). Meanwhile, a time (pre- to post-intervention) × group interaction ($F_{(1, 31)} = 4.39$, $p = .045$) was obtained for self-reported relaxation in response to the TSST. Unlike the CON group, the RELAX group reported greater levels of relaxation within the post-intervention laboratory session (immediately, 60 minutes, and 90 minutes post-stressor) compared to pre-intervention ($p < .05$).

Anger ($F_{(2.40, 76.86)} = 5.87$, $p = .002$), depression ($F_{(2.43, 77.66)} = 6.43$, $p = .001$), confusion ($F_{(2.28, 72.83)} = 17.41$, $p < .001$), tension ($F_{(2.22, 71.18)} = 27.54$, $p < .001$), and vigour ($F_{(3.00, 96.27)} = 7.95$, $p < .001$) increased in response to the TSST, based on a main effect of time (within the laboratory sessions), followed by a gradual decline. This pattern of response was consistent

FIGURE 3. The response of (A) salivary cortisol, (B) perceived hunger, (C) perceived stress, (D) perceived relaxation, and (E) systolic BP to acute stress pre- (dashed lines) and post-intervention (solid lines) in a (i) relaxation group and (ii) wait-list control group (mean ± *SE*). The grey box represents the period during which the acute laboratory stressor (TSST) was administered. A main effect of time was evident for hunger, perceived stress, cortisol, and systolic BP ($p < .001$). *Indicates a significant difference between pre- and post-intervention ($p < .05$).



pre- to post-intervention for all, but for tension, where the interaction effect of the intervention (pre- to post-) × time (within the laboratory session) × group approached significance ($F_{(2.90,\ 92.92)} = 2.44$, $p = .07$). Post-hoc analyses indicated that the RELAX group reported less tension immediately following the post-intervention TSST ($M = 1.82 \pm 2.01$), compared to pre-intervention ($M = 3.65 \pm 2.69$; $p = .013$), a result not demonstrated in the CON group ($p = .114$).

Effect on Appetite-Related Measures. There was no change over time or differences between groups in the frequency of self-reported palatable food intake based on the PEMS ($p > .05$), and associated effect sizes were small. Likewise, there were no differences in the degree of craving, of fast foods, sweet foods, high fat foods, and carbohydrate foods between groups over the 8-week period ($p > .05$) and only small effect sizes were noted (Table 4). Despite the lack of differences here, mindfulness was negatively correlated with both palatable food intake ($r = -0.490$, $p = .003$) and overall craving ($r = -0.404$, $p = .018$) after the intervention period.

The acute appetite response to the laboratory stressor (TSST) indicated that there was a main effect for time within each session for perceived hunger ($F_{(2.37,\ 75.79)} = 72.39$, $p < .001$; Figure 3B), which gradually rose over the course of the laboratory session until the test meal was consumed; however, there was no difference between groups. Likewise, there were no differences in total energy intake from the laboratory test meal pre- to post-intervention or between groups (RELAX group; 2753 ± 1045 kJ (pre-intervention) and 3190 ± 1359 kJ (post-intervention); (CON group 3036 ± 1264 kJ (pre-intervention) and 3104 ± 1291 kJ (post-intervention) ($F_{(1,32)} = 1.48$, $p = .233$). Further analysis indicated no differences between groups in the energy intake derived specifically from unhealthy foods: RELAX group: 1476 ± 804 kJ (pre-intervention) and 1765 ± 1087 kJ (post-intervention); CON group: 1570 ± 883 kJ (pre-intervention) and 1757 ± 1028 kJ (post-intervention) ($F_{(1,32)} = 0.19$, $p = .67$), with small associated effects sizes (RELAX: $d = 0.30$, and CON: $d = 0.20$).

DISCUSSION

This study examined the feasibility and preliminary efficacy of an 8-week worksite-based relaxation intervention for reducing physiological and psychological features of stress and indicators of stress-induced eating. Overall, we have shown that this intervention is practically viable in terms of recruitment, fidelity, dose, and acceptability. The 8-week relaxation intervention was effective for acutely reducing perceived stress and increasing relaxation during face-to-face sessions; however, perceived stress over the prior month was not significantly altered pre- to post-intervention. Likewise, the response to an acute stressor was minimally impacted with no change in the physiological (heart rate, blood pressure, salivary

TABLE 4
Effect of an 8-week Relaxation Intervention (RELAX) or Wait-List Control (CON) on Palatable Food Intake and Cravings (Mean ± SD)

	CON group (n = *17)*			*RELAX group* (n = *17)*		
	Pre	*Post*	*Cohen's* d	*Pre*	*Post*	*Cohen's* d
Palatable food intake	8.72 ± 1.99	8.41 ± 2.39	−0.14	8.12 ± 2.21	7.71 ± 2.80	−0.16
Cravings						
Fast food	5.47 ± 3.61	5.71 ± 2.85	0.07	5.53 ± 3.28	4.65 ± 4.20	−0.23
Sweet food	7.59 ± 4.85	7.24 ± 4.40	−0.08	7.41 ± 6.13	6.00 ± 5.05	−0.25
High fat food	4.47 ± 2.98	3.88 ± 3.08	−0.19	4.53 ± 2.72	4.18 ± 2.72	−0.13
Carbohydrate food	8.41 ± 4.39	7.18 ± 4.07	−0.30	6.77 ± 6.02	6.94 ± 5.78	0.03
Overall	25.94 ± 10.54	24.00 ± 10.28	−0.19	24.23 ± 15.02	21.76 ± 14.55	−0.17

No significant differences noted.

cortisol) or psychological responses (mood states, perceived stress) except for reduced feelings of tension and increased feelings of relaxation transiently following the TSST. The effect on appetite and food intake variables also appeared limited.

Study Feasibility

Recruitment was an onerous process that lasted 8.5 months. This was likely attributed to a number of factors. First, there was substantial time commitment involved in participation in the study, particularly the lengthy (3-hour) pre- and post-intervention assessments. These assessments required full-time employees to take two half days off work in order to attend the laboratory. As a result, a frequently quoted reason for the unwillingness of corporate companies to participate was the financial loss associated with staff absence, despite verbal recognition by company representatives that employee mental health is important. Second, although the intervention was designed for broad application in workplace contexts, only a small sample could be included due to resource constraints associated with the research component of the intervention. That being the case, we imposed numerous selection criteria for recruitment to ensure that the control and intervention groups were similar on key variables (focusing on both stress and dietary behaviour). This resulted in only 28 per cent of those expressing interest in the study meeting the strict criteria for inclusion.

Despite a large proportion of volunteers being excluded from participation, once randomised, study attrition was low compared with other workplace-based stress management interventions (e.g. Bartlett, Lovell, Otahal, & Sanderson, 2017), with only two participants being lost to follow-up. These two individuals completed the 8-week intervention but were unable to attend the post-intervention assessment due to lack of time. Notably, there was no attrition in the control group, although they did not immediately receive the treatment for which they were likely drawn to participate in the study, with 41 per cent opting to complete the 8-week course after completion of the study. Furthermore, compliance with the intervention itself was excellent, with 80 per cent of scheduled face-to-face sessions attended, and 79 per cent of daily home practice adhered to, which is comparable to the high rates of compliance reported by others (Bartlett et al., 2017; Corsica et al., 2014). While the face-to-face sessions were conducted in the workplace in an attempt to maximise convenience, the high compliance to the home-based sessions may be attributed to the high ratings of enjoyment (Lehrer, 1996), together with the reduced time commitment for the face-to-face component compared with other interventions of this nature (Corsica et al., 2014; Daubenmier et al., 2011). The mindful relaxation program in the present study was specifically designed to optimise the potential benefit of interoceptive practice, yet minimise the time commitment, and thereby encouraging compliance and integration into day-to-day life. This is important given that

interoceptive practice is considered to be the honing of a mental skill with cumulative benefits (Conrad & Roth, 2007), and an intervention of greater length may be required to address long-standing, habit-driven behaviours (such as stress-induced eating).

Another aspect of feasibility to note is that the multiple components of the experimental protocol in this study (including recruitment, pre- and post-laboratory assessment, and weekly worksite-based classes) were conducted by a single researcher (with the exception of panellists required to conduct the TSST). Hence, despite being a laborious study protocol, it was completed with minimal manpower. The coordination and implementation of the study by a single researcher also likely facilitated the building of rapport between experimenter and participant, possibly minimising attrition. Overall, the demonstrated acceptability and feasibility of the worksite-based aspect of this intervention underscores the potential of relaxation programs implemented in the workplace benefitting employee well-being, whilst causing minimal disruption to the working day as also demonstrated by previous research (for example, Krajewski, Sauerland, & Wieland, 2011).

With regard to levels of perceived stress and relaxation following an isolated practice, the pre- and post-class measures of the once-weekly class reflected a consistent decrease in perceived stress, and an increase of perceived relaxation and enjoyment, despite MM being considered a more demanding task than PMR, as also found by Lumma, Kok, and Singer (2015). The immediate calming effect of a single brief dose of relaxation (Dolbier & Rush, 2012; Krajewski et al., 2011; Rausch et al., 2006) and mindfulness meditation (Creswell, Pacilio, Lindsay, & Brown, 2014; Rausch et al., 2006) techniques have been reported previously.

Study Efficacy

The accompanying aim of this study was to explore the preliminary efficacy of the intervention for altering perceived stress over the last month, the physiological and psychological features of the acute stress response, and indicators of stress-eating. Despite the excellent compliance with the intervention, and the consistent reduction of stress experienced during the face-to-face classes, the reported reduction in overall perceived stress over the prior month was equivalent in both groups. It is possible that merely taking part in the study (irrespective of group assignment) may have induced a change in participants' general perceptions of stress, which may then have influenced their stress responses. Alternatively, a greater duration or potency of intervention may be needed to elicit differences between groups, particularly when stress is high. The baseline perceived stress level over the prior month in both groups was considerably higher than the Australian average PSS score (~16; Casey, 2013). What constitutes "chronic stress" and the degree to which it interacts with the acute stress

response is still to be defined (Hammen, Kim, Eberhart, & Brennan, 2009). However, it is conceivable that the high PSS attained in the present study may have mitigated the potential stress-alleviating effects of a relaxation program limited to 8 weeks. Likewise, trait anxiety and rumination were not altered by the intervention despite research demonstrating that mindfulness may potentially reduce anxiety (Bamber & Schneider, 2016) and ruminative thinking, while promoting positive mood (Jain et al., 2007). Meanwhile, trait mindfulness was increased in the intervention group, which is encouraging given the brief nature of the daily practice. In support of the present results, Zeidan, Johnson, Diamond, David, and Goolkasian (2010) also found improvements in trait mindfulness with as little as daily 20-minute mindfulness training over 4 days.

In relation to the effect of the 8-week intervention on the acute stress response, the majority of physiological (cortisol, BP, and HR) and psychological (perceived stress) variables examined were unchanged from pre- to post-intervention. However, 8 weeks of relaxation practice appeared to reduce the level of tension felt and increase the relative degree of relaxation in response to the acute stressor. These beneficial changes suggest that further research should delineate the incongruency between the physiological and psychological findings. Interestingly, Zeidan et al. (2010) suggest that consistency of physiological and self-report measures after interoceptive practice increases with greater practice. Accordingly, future research should focus on longitudinal effects.

The preliminary efficacy of the intervention for altering stress-driven eating was also examined. Associated effect sizes were small for the effect of the intervention on self-reported palatable food intake, cravings, and the responses of appetite and *ad libitum* intake to an acute exposure to stress (the TSST). Although previous research has demonstrated efficacy for regular abbreviated PMR (Pawlow et al., 2003) and for mindfulness practice (Jordan, Wang, Donatoni, & Meier, 2014) to reduce appetite, no studies have been focused on the effects of relaxation practice on energy intake directly after an acute stress induction. The observation of a lack of alteration in appetite-related variables occurred despite an increase in trait mindfulness with the present intervention. This finding may reinforce the notion that general mindfulness training may not be as potent in affecting eating due to stress, compared with programs specifically focused on dietary behaviour, as exemplified by others (Arch et al., 2016; Fisher et al., 2016). However, it is interesting to note that trait mindfulness was negatively correlated with reported palatable food intake and overall craving after the present intervention, suggesting trends worthy of investigation in future trials.

CONCLUSION

In summary, this randomised controlled pilot study has demonstrated the feasibility of a worksite-based, 8-week relaxation intervention in terms of fidelity, dose, and acceptability. In addition, we have examined the potential efficacy of

such an intervention on perceived stress, the acute stress response (physiological and psychological components), and subsequent indicators of stress-induced eating. Future research should consider the limitations imposed by the laboratory-based pre- and post-assessments of this pilot study. Choice of foods eaten, timing, and setting of stress-eating can be specific for an individual (Liu et al., 2017; Pool, Delplanque, Coppin, & Sander, 2015; Wallis & Hetherington, 2009); hence the recording of dietary intake 24 hours beyond the assessment session may also be warranted in future studies. Furthermore, a follow-up of overall acceptability of the 8-week course, and the likelihood of long-term practice, would inform the planning of future research. Nonetheless, the preliminary findings of this study underscore the feasibility of investigating abbreviated practice regimes of relaxation in the context of general well-being in the workplace and lay a preliminary foundation for investigating its impact on stress-induced appetite.

ACKNOWLEDGEMENTS

The cortisol analysis for this work was performed by the CMCA (Metabolomics Australia) which is supported by infrastructure funding from the Western Australian State Government in partnership with the Australian Federal Government, through the National Collaborative Research Infrastructure Strategy (NCRIS).

CONFLICTS OF INTEREST

No conflict of interest to declare.

REFERENCES

Agee, J.D., Danoff-Burg, S., & Grant, C.A. (2009). Comparing brief stress management courses in a community sample: Mindfulness skills and progressive muscle relaxation. *Explore: The Journal of Science and Healing*, *5*(2), 104–109.

Appelhans, B., Pagoto, S., Peters, E., & Spring, B. (2010). HPA axis response to stress predicts short-term snack intake in obese women. *Appetite*, *54*(1), 217–220. https://doi.org/10.1016/j.appet.2009.11.005.

Arch, J.J., Brown, K.W., Goodman, R.J., Della Porta, M.D., Kiken, L.G., & Tillman, S. (2016). Enjoying food without caloric cost: The impact of brief mindfulness on laboratory eating outcomes. *Behaviour Research and Therapy*, *79*, 23–34.

Bamber, M., & Schneider, K.J. (2016). Mindfulness-based meditation to decrease stress and anxiety in college students: A narrative synthesis of the research. *Educational Research Review*, *18*, 1–32. https://doi.org/10.1016/j.edurev.2015.12.004.

Bartlett, L., Lovell, P., Otahal, P., & Sanderson, K. (2017). Acceptability, feasibility, and efficacy of a workplace mindfulness program for public sector employees: A pilot randomized controlled trial with informant reports. *Mindfulness*, *8*(3), 639–654.

Benson, H., Greenwood, M.M., & Klemchuk, H. (1975). The relaxation response: Psychophysiologic aspects and clinical applications. *International Journal of Psychiatry in Medicine*, *6*(1–2), 87–98.

Bernstein, D.A., & Borkovec, T.D. (1973). *Progressive relaxation training*. Champaign, IL: Research Press.

Brown, K.W., & Ryan, R.M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*(4), 822–848.

Burgess, E.E., Turan, B., Lokken, K.L., Morse, A., & Boggiano, M.M. (2014). Profiling motives behind hedonic eating: Preliminary validation of the Palatable Eating Motives Scale. *Appetite*, *72*, 66–72.

Carmody, J., & Baer, R.A. (2009). How long does a mindfulness-based stress reduction program need to be? A review of class contact hours and effect sizes for psychological distress. *Journal of Clinical Psychology*, *65*(6), 627–638. https://doi.org/10.1002/jclp.20555. PMID: 19309694.

Casey, L. (2013). Stress and wellbeing in Australia survey 2013. Retrieved from: http://www.psychology.org.au/Assets/Files/Stress%20and%20wellbeing%20in%20Australia%20survey%202013.pdf.

Chellew, K., Evans, P., Fornes-Vives, J., Pérez, G., & Garcia-Banda, G. (2015). The effect of progressive muscle relaxation on daily cortisol secretion. *Stress*, *18*(5), 538–544.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, *24*, 385–396.

Conrad, A., & Roth, W.T. (2007). Muscle relaxation therapy for anxiety disorders: It works but how? *Journal of Anxiety Disorders*, *21*(3), 243–264.

Corsica, J., Hood, M.M., Katterman, S., Kleinman, B., & Ivan, I. (2014). Development of a novel mindfulness and cognitive behavioral intervention for stress-eating: A comparative pilot study. *Eating Behaviors*, *15*(4), 694–699.

Creswell, J., Pacilio, L., Lindsay, E., & Brown, K. (2014). Brief mindfulness meditation training alters psychological and neuroendocrine responses to social evaluative stress. *Psychoneuroendocrinology*, *44*, 1–12. https://doi.org/10.1016/j.psyneuen.2014.02.007.

Daubenmier, J., Kristeller, J., Hecht, F. M., Maninger, N., Kuwata, M., Jhaveri, K., … Epel, E. (2011). Mindfulness intervention for stress eating to reduce cortisol and abdominal fat among overweight and obese women: An exploratory randomized controlled study. *Journal of Obesity*, *2011*, 651936.

Dolbier, C.L., & Rush, T.E. (2012). Efficacy of abbreviated progressive muscle relaxation in a high-stress college sample. *International Journal of Stress Management*, *19*(1), 48–68.

Dweck, J., Jenkins, S., & Nolan, L. (2014). The role of emotional eating and stress in the influence of short sleep on food consumption. *Appetite*, *72*, 106–113. https://doi.org/10.1016/j.appet.2013.10.001.

Fisher, N., Lattimore, P., & Malinowski, P. (2016). Attention with a mindful attitude attenuates subjective appetitive reactions and food intake following food-cue exposure. *Appetite*, *99*, 10–16.

Flint, A., Raben, A., Je, B., & Astrup, A. (2000). Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. *International Journal of Obesity*, *24*(1), 38–48.

Groesz, L.M., McCoy, S., Carl, J., Saslow, L., Stewart, J., Adler, N., . . . Epel, E. (2012). What is eating you? Stress and the drive to eat. *Appetite*, *58*(2), 717–721. https://doi.org/10.1016/j.appet.2011.11.028.

Hammen, C., Kim, E.Y., Eberhart, N.K., & Brennan, P.A. (2009). Chronic and acute stress and the prediction of major depression in women. *Depression and Anxiety*, *26*(8), 718–723.

Harding, J.L., Backholer, K., Williams, E.D., Peeters, A., Cameron, A.J., Hare, M.J., . . . Magliano, D.J. (2013). Psychosocial stress is positively associated with body mass index gain over 5 years: Evidence from the longitudinal AusDiab study. *Obesity*, *22*(1), 277–286.

Hoge, E.A., Bui, E., Palitz, S.A., Schwarz, N.R., Owens, M.E., Johnston, J.M., & Simon, N.M. (2017). The effect of mindfulness meditation training on biological acute stress responses in generalized anxiety disorder. *Psychiatry Research*, *262*, 328–332.

Jacobsen, E. (1934). *You must relax*. New York: McGraw-Hill.

Jain, S., Shapiro, S., Swanick, S., Roesch, S., Mills, P., Bell, I., & Schwartz, G. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: Effects on distress, positive states of mind, rumination, and distraction. *Annals of Behavioral Medicine*, *33*(1), 11–21.

Jensen, M.A., Hansen, Å.M., Abrahamsson, P., & Nørgaard, A.W. (2011). Development and evaluation of a liquid chromatography tandem mass spectrometry method for simultaneous determination of salivary melatonin, cortisol and testosterone. *Journal of Chromatography B*, *879*(25), 2527–2532.

Jordan, C.H., Wang, W., Donatoni, L., & Meier, B.P. (2014). Mindful eating: Trait and state mindfulness predict healthier eating behavior. *Personality and Individual Differences*, *68*, 107–111.

Kabat-Zinn, J. (2002). 20-minute seated meditation: On guided mindfulness meditation: Series two. Shrewsbury, MA: University of Massachusetts Centre for Mindfulness.

Kirschbaum, C., Pirke, K.M., & Hellhammer, D.H. (1993). The 'Trier Social Stress Test': A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*(1–2), 76–81.

Krajewski, J., Sauerland, M., & Wieland, R. (2011). Relaxation-induced cortisol changes within lunch breaks: An experimental longitudinal worksite field study. *Journal of Occupational and Organizational Psychology*, *84*(2), 382–394.

Kudielka, B.M., Hellhammer, D.H., & Kirschbaum, C. (2007). Ten years of research with the Trier Social Stress Test-revisited. In E. Harmon-Jones & P. Winkielman (Eds.), *Social neuroscience: Integrating biological and psychological explanations of social behavior* (pp. 56–83). New York: The Guilford Press.

Kyrou, I., & Tsigos, C. (2009). Stress hormones: Physiological stress and regulation of metabolism. *Current Opinion in Pharmacology*, *9*(6), 787–793. https://doi.org/10.1016/j.coph.2009.08.007.

Lakens, D. (2013). Calculating and Reporting Effect Sizes to Facilitate Cumulative Science: A Practical Primer for t-tests and ANOVAs. *Frontiers in Psychology*, *4*, 863. https://doi.org/10.3389/fpsyg.2013.00863.

Lehrer, P. (1996). Varieties of relaxation methods and their unique effects. *International Journal of Stress Management*, *3*(1), 1–15.

Liu, Y., Song, Y., Koopmann, J., Wang, M., Chang, C.-H., & Shi, J. (2017). Eating your feelings? Testing a model of employees' work-related stressors, sleep quality, and unhealthy eating. *Journal of Applied Psychology*, *102*(8), 1237–1258.

Lumma, A.-L., Kok, B.E., & Singer, T. (2015). Is meditation always relaxing? Investigating heart rate, heart rate variability, experienced effort and likeability during training of three types of meditation. *International Journal of Psychophysiology*, *97*(1), 38–45.

Masih, T., Dimmock, J.A., Epel, E.S., & Guelfi, K.J. (2017). Stress-induced eating and the relaxation response as a potential antidote: A review and hypothesis. *Appetite*, *118*, 136–143.

Muangnapoe, P., Morris, T., & Kuan, G. (2016). The effect of mindfulness meditation and progressive relaxation training on somatic and cognitive state anxiety. *AJSE*, *1*(1), 1–4.

Neseliler, S., Tannenbaum, B., Zacchia, M., Larcher, K., Coulter, K., Lamarche, M., & Dagher, A. (2017). Academic stress and personality interact to increase the neural response to high-calorie food cues. *Appetite*, *116*, 306–314.

Nicholls, W., & Hulbert-Williams, L. (2013). British English translation of the Food Craving Inventory (FCI-UK). *Appetite*, *67*, 37.

Pawlow, L.A., O'Neil, P.M., & Malcolm, R.J. (2003). Night eating syndrome: Effects of brief relaxation training on stress, mood, hunger, and eating patterns. *International Journal of Obesity and Related Metabolic Disorders*, *27*(8), 970–978.

Pool, E., Delplanque, S., Coppin, G., & Sander, D. (2015). Is comfort food really comforting? Mechanisms underlying stress-induced eating. *Food Research International*, *76* Part 2, 207–215.

Pruessner, J., Dedovic, K., Pruessner, M., Lord, C., Buss, C., Collins, L., . . . Lupien, S. (2010). Stress regulation in the central nervous system: Evidence from structural and functional neuroimaging studies in human populations—2008 Curt Richter Award Winner. *Psychoneuroendocrinology*, 35(1), 179–191. https://doi.org/10.1016/j.psyneuen.2009.02.016

Raspopow, K., Abizaid, A., Matheson, K., & Anisman, H. (2010). Psychosocial stressor effects on cortisol and ghrelin in emotional and non-emotional eaters: Influence of anger and shame. *Hormones and Behavior*, *58*(4), 677–684. https://doi.org/10.1016/j.yhbeh.2010.06.003.

Rausch, S.M., Gramling, S.E., & Auerbach, S.M. (2006). Effects of a single session of large-group meditation and progressive muscle relaxation training on stress reduction, reactivity, and recovery. *International Journal of Stress Management*, *13*(3), 273–290.

Rutters, F., Nieuwenhuizen, A.G., Lemmens, S.G.T., Born, J.M., & Westerterp-Plantenga, M.S. (2009). Acute stress-related changes in eating in the absence of hunger. *Obesity*, *17*(1), 72–77.

Saunders, R.P., Evans, M.H., & Joshi, P. (2005). Developing a process-evaluation plan for assessing health promotion program implementation: A how-to guide. *Health Promotion Practice*, *6*(2), 134–147.

Schulz, K.F., Altman, D.G., & Moher, D. (2010). CONSORT 2010 statement: Updated guidelines for reporting parallel group randomized trials. *Annals of Internal Medicine*, *152*(11), 726–732.

Sims, R., Gordon, S., Garcia, W., Clark, E., Monye, D., Callender, C., & Campbell, A. (2008). Perceived stress and eating behaviors in a community-based sample of African Americans. *Eating Behaviors*, *9*(2), 137–142.

Spielberger, C.D., Gorsuch, R.L., Lushene, R., Vagg, P.R., & Jacobs, G.A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Sproesser, G., Schupp, H.T., & Renner, B. (2014). The bright side of stress-induced eating: Eating more when stressed but less when pleased. *Psychological Science*, *25*(1), 58–65.

Stunkard, A.J., & Messick, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research*, *29*(1), 71–83.

Terry, P.C., Lane, A.M., & Fogarty, G.J. (2003). Construct validity of the Profile of Mood States — Adolescents for use with adults. *Psychology of Sport & Exercise*, *4*(2), 125–139.

Tomiyama, A., Mann, T., Vinas, D., Hunger, J., Dejager, J., & Taylor, S. (2010). Low calorie dieting increases cortisol. *Psychosomatic Medicine*, *72*(4), 357–364. http://www.escholarship.org/uc/item/47c1f07d.

Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy and Research*, *27*(3), 247–259.

Van Strien, T., Frijters, J.E.R., Bergers, G.P.A., & Defares, P.B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders*, *5*(2), 295–315.

Wallace, R.K., Benson, H., & Wilson, A.F. (1971). A wakeful hypometabolic physiologic state. *American Journal of Physiology*, *221*(3), 795–799.

Wallis, D.J., & Hetherington, M.M. (2009). Emotions and eating: Self-reported and experimentally induced changes in food intake under stress. *Appetite*, *52*(2), 355–362.

Whitehead, A.L., Julious, S.A., Cooper, C.L., & Campbell, M.J. (2016). Estimating the sample size for a pilot randomised trial to minimise the overall trial sample size for the external pilot and main trial for a continuous outcome variable. *Statistical Methods in Medical Research*, *25*(3), 1057–1073.

Yeomans, M., & Coughlan, E. (2009). Mood-induced eating: Interactive effects of restraint and tendency to overeat. *Appetite*, *52*(2), 290–298. https://doi.org/10.1016/j.appet.2008.10.006.

Zeidan, F., Johnson, S.K., Diamond, B.J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition*, *19*(2), 597–605.