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Emotional responding and distress tolerance in women at high vs. low risk for eating disorders in response to physical and cognitive stress

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Abstract

Background: Disordered eating has been theorised to function as a maladaptive way of coping with negative affect. The current study aimed to comprehensively assess emotional responding and distress tolerance to a cognitive and a physical distress tolerance task using physiological (heart rate), self-report and behavioural measures (latency to quit task).

Methods: 56 women at high vs. 58 at low eating disorder risk completed the "Paced Auditory Serial Addition Task-Computerised" (PASAT-C) and the "Breath-holding Task" (BHT) and provided their affective ratings upon completion of the tasks. Heart rate was recorded during both tasks. Distress tolerance was assessed via a self-report measure, while latency to quit each task was used as a behavioural index of distress tolerance.

Results: Participants at high risk for eating disorders had higher heart rate during both tasks and reported significantly more unpleasantness and less control after the PASAT-C compared to the low-risk group. Shorter latency to quit the PASAT-C was evidenced in the high vs. low-risk group suggesting lower tolerance for cognitive distress. Breath-holding duration did not differ between the two groups.

Conclusions: Greater physiological and subjective arousal to distressing situations in high-risk individuals indicates a potential hypersensitivity to negative affect, possibly increasing eating disorder vulnerability. Potential implications for eating disorder prevention and management are discussed.

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1. Introduction

Eating disorders (EDs) constitute serious mental health conditions with increasing prevalence rates especially among young women (Nagl et al., 2016; van Eeden et al., 2021). They are considered a major public health concern as they are associated with one of the highest mortality rates among psychiatric conditions (Klump et al., 2009) and/or present with high comorbidity with other serious mental health issues such as anxiety, depression and stress (Tolsa & Malas, 2022; Beroš et al., 2021), alexythymia and substance use (Biolcati et al., 2021; Pace et al., 2019). Individuals with EDs are found to have a worse quality of life while yearly healthcare costs are 48% higher than in the general population (van Hoeken & Hoek, 2020).

Emotion has been increasingly recognised as an important element in understanding the aetiology and maintenance of EDs. Emotional processing deficits, such as difficulties in emotion recognition and regulation (Harrison et al., 2009; Harrison et al., 2010), alexithymia (Schmidt et al.,1993), reduced interoceptive awareness (Merwin et al., 2010; Di Nardo et al., 2020) and reduced perception of bodily signals (Pollatos et al., 2008) have been found to lie at the core of EDs. Previous studies have shown that individuals with EDs use maladaptive eating behaviours, such as binging, purging and extreme food restriction, as a way to avoid or cope with negative affect (Heatherton & Baumeister, 1991, Fairburn et al., 2003, Haynos & Fruzzetti, 2011). They have also been found to be less accepting of their emotions and internal experiences (Merwin, 2010), showing higher levels of avoidance of affect (Corstorphine et al., 2007; Rawal et al., 2010) and higher levels of avoidance of emotionally-valenced stimuli compared to non-affected individuals (Davies et al., 2011; Davies et al., 2013).

Despite the well-observed emotional difficulties seen in ED populations, experimental studies integrating information from multiple emotion response systems, such as physiological, behavioural, and self-reported affect, in response to negative affect are scarce. Based on limited available data, women with an ED diagnosis showed similar physiological (respiratory sinus arrhythmia, skin conductance responses, and tonic skin conductance levels) and behavioural responses (termination of task, latency to quit task) to a distress tolerance task as healthy controls (HC) but reported higher negative affect (Yiu et al., 2018). A similar pattern of results has been documented in other studies. Hilbert et al. (2011) found that women with an ED reported greater sadness compared to HCs after and during exposure to stress but showed similar physiological (heart rate) responding as HCs. Overall greater levels of negative affect and state anxiety were reported by women with binge eating disorder compared to an obese group of individuals after exposure to stress, while no differences in heart rate reactivity were observed

between the two groups (Klatzkin et al., 2015). Adolescent girls recovering from anorexia nervosa reported overall greater negative affect compared to HCs but showed similar heart rate responses (Miller et al., 2009). These findings suggest a discordance between self-reported emotional experience and physiological/behavioural responses to emotion in patients with EDs. In addition, higher subjective emotional responses to distress are possibly attributed to the way that patients with EDs interpreted the distress tolerance tasks as compared to HCs. An alternative interpretation of the latter finding would involve the perception and/or interpretation of patients' internal physiological responses to the distress tolerance tasks and not just the interpretation of the distress tolerance tasks per se.

Individuals at high risk for developing an eating disorder present with body shape/weight concerns and unhealthy weight control behaviours but do not currently meet the criteria for an ED diagnosis (Jacobi et al., 2004). Even though studies focusing on the affective psychophysiological responding among populations at high ED risk are scarce, the limited data that do exist point towards similar difficulties in coping with negative affect as those seen in clinical populations. Based on the limited data available concerning individuals at high ED risk, a physiological hyper-reactivity/sensitivity to unpleasant stimuli has been observed. For example, increased startle modulation was observed in response to body-related words in participants with high body dissatisfaction (Herbert, et al., 2013), while another study demonstrated that women at high ED risk had higher heart rate in response to both general and pathology-specific stimuli compared to women at low ED risk (Koushiou, et al., 2019). Haynos and Fruzzeti (2011) suggest that in the sub-clinical stages of EDs hypersensitivity to somatic affective experience may lead to the engagement of pathology-related behaviours (e.g. food restriction) in an attempt to attenuate negative experience.

Towards this direction, Bruch (1962) theorised that patients with ED present with an inability to correctly identify, interpret and respond to bodily sensations. Adding to this theoretical observation, empirical evidence suggests that women with a current diagnosis of anorexia nervosa or a history of anorexia nervosa show higher somatosensory sensitivity and attempt to avoid sensory experiences compared to HC (Zucker et al., 2013). Pollatos et al. (2008), on the contrary, found an impaired ability in individuals with anorexia nervosa to accurately perceive their own heartbeat, but results in this study were influenced by the physical problems observed in the acute or chronic stages of the disorder and thus may not reflect a true decrease in visceral sensitivity. Several studies identified that individuals who perceive bodily signals with higher degree of accuracy experience more intense emotions and vice versa (Critchley et al., 2004; Katkin et al., 2001; Pollatos et al., 2005; Wiens et al., 2000). Based on this premise, Merwin

(2011) proposed that in the early stages of EDs, individuals show more accurate awareness of their somatosensory experience which may intensify the unpleasantness of internal states and thus account for the maladaptive attempts to avoid or escape these experiences. A study investigating emotional reactivity to unpleasant stimuli found that individuals at high risk for EDs demonstrated heightened emotionality, as evidenced by their heart rate and self-report responses to unpleasant affect (Koushiou et al., 2019), providing support for the assumption of hypersensitivity to negative affect at the pre-morbid stages of the disorder. This is to be contrasted with hyposensitivity to somatosensory experience which manifests in the later stages of EDs due to the physical effects of the disordered and/or the prolonged self-imposed starvation and strengthening of avoidant behaviours, that might impair one's ability to detect and adaptively respond to bodily signals (Merwin, 2011).

Distress tolerance, conceptualised as the ability to withstand negative psychological states (Simons & Gaher, 2005), is an important component of emotional processing that has been associated with disordered eating (Haynos & Fruzzetti, 2011; Lavender et al., 2014; Mallorquí-Bagué et al., 2018; Puttevils et al., 2021). Evidence suggests that women with an ED diagnosis report higher levels of avoidance of negative affect as compared to controls with no ED history (Corstorphine et al., 2007), while low distress tolerance significantly predicts bulimic symptoms even after controlling for depression and anxiety levels (Anestis et al., 2007). Low tolerance of negative internal events in relation to one's body image has been found to mediate the relation between weight concerns and ED symptoms in non-clinical university samples (Koushiou et, al., 2021). This evidence supporting the association of low tolerance of negative affect and disordered eating relies mainly on subjective, self-reported data and thus cannot aid in understanding other aspects (e.g., physiological) of the experience of individuals with disordered eating. The majority of studies investigating the relationship between distress tolerance and ED are conducted with clinical ED populations whose emotional experience and physiological reactivity are compromised due to the physical symptoms observed in the acute or chronic stages of the disorder (e.g., bradycardia associated with low weight; Mitchell & Crow, 2006).

Given the role that negative affect play in disordered eating, the present study aims to examine the psychophysiological experience of responding and tolerating emotional distress in individuals at high risk for EDs - who do not yet suffer from the physical consequences of the illness - thus addressing this gap in the literature. Examination of this population's responses to a cognitive and a physical distress tolerance task can offer a better understanding of their emotional experience with an emphasis on the context/type of distress, while studying at risk

populations can help clarify the role of affective psychophysiological responding and more specifically, distress tolerance in the development of ED symptoms. This association could inform interventions aiming to prevent the development of full criteria for an ED diagnosis and adverse health outcomes.

1.1 Study aims

The present study used a well-controlled experimental design to comprehensively examine emotional responses to a cognitive (the Paced Auditory Serial Addition Task-Computerised; PASAT-C) and a physical distress tolerance task (the Breath-holding task; BHT) in women at high vs. low ED risk, using physiological (heart rate) and self-report measures. Behavioural responses to the two distress tolerance tasks (i.e., latency to quit each task) and responses to the Distress Tolerance Scale (DTS; Simons & Gaher, 2005), a self-report measure of distress tolerance, were recorded and differences between the two risk groups on their distress tolerance levels were explored. Performance on the two tasks was compared between and within groups.

1.2 Study hypotheses

Based on previous research findings the following hypotheses were formulated:

1. Based on Koushiou et al. (2019) findings, we expected high ED risk participants to exhibit higher distress on the tasks as recorded via their higher heart rate and higher self-reported affect compared to low-risk participants.
2. Lower distress tolerance was expected in the high vs. low ED risk group as indicated via shorter latency to quit on the tasks and higher scores on the self-report measure of distress tolerance.

To our knowledge, the BHT has not been used in an ED population before, therefore no specific hypotheses were formulated regarding the differences between responses to the physical vs. the cognitive distress tolerance tasks.

2. Materials and Methods

2.1 Participants

Based on G*power analysis (Faul et al., 2007) the minimum number of participants needed is 51 participants per group for an independent samples t-test (a = 0.05, power = 0.80 and d = 0.05) and 48 participants per group in a Repeated Measures ANOVA (a = 0.05, power = 0.90 and f = 0.15).

The sample consisted of 114 female participants. Young woman adults were selected as an appropriate age group to participate in this study since young adulthood and being a woman are two factors which have both been associated with a greater risk for developing an ED (Soet & Sevig, 2006; Striegel-Moore et al., 2009).

Eligible participants were women, 18-25 years of age, with a good working knowledge of the English language. Following the example of previous research in the field (Koushiou et al., 2019; Silva et al., 2017; Nikolaou et al., 2021), individuals who scored ≥ 52 on the Weight Concerns Scale (WCS; see self-report measures; Killen et al., 1994) were assigned to the high ED risk group (N = 56), while those scoring below the above-mentioned threshold were assigned to the low-risk group (N = 58). Individuals (N = 3) who met diagnostic criteria for an ED based on the Eating Disorder Diagnostic Scale (EDDS; Stice et al., 2000) were not eligible to participate in the study and were referred for further assessment.

2.2 Measures

2.2.1 Physiological Measures and Apparatus

The experiment was built and run on the OpenSesame software (Mathôt et al., 2012). For the acquisition and processing of physiological data BIOPAC MP150 for Windows and AcqKnowledge 5.0.2 data acquisition software (Biopac Systems Inc, Santa Barbara, CA) were used. Heart rate data was collected using Ag/ AgCl shielded electrodes that were placed on the participants' inner forearms. A BIOPAC ECG100C bioamplifier was used to filter raw ECG, which was sampled at 1000Hz and was used to calculate beats per minute (BPM) to assess heart rate. Mean scores for heart rate were computed for the 5-min baseline period, for the BHT and for PASAT-C separately.

2.2.2 Demographic Data

Participants were asked to complete a personal information questionnaire including gender, age, level of studies, height and weight – used to calculate Body Mass Index (BMI), involvement in exercise/sports, smoking, medication/health (chronic illness) and knowledge of a musical instrument - to check for possible covariates linked to the performance to the physical distress tolerance task used (i.e., the BHT).

2.2.3 Eating Disorder Diagnoses

The Eating Disorder Diagnostic Scale (EDDS; Stice et al., 2000) is a 22-item self-report scale assessing DSM-IV eating disorder diagnoses. This scale was used to detect individuals who meet criteria for an ED diagnosis for exclusion purposes. The scale has shown high internal

consistency (a = .89) and test-retest reliability (r =.87) in previous studies (Stice et al., 2000) within adolescent and adult samples. The EDDS demonstrated satisfactory internal consistency in this sample (a = .74).

2.2.4 Eating Disorder Risk

The Weight Concerns Scale (WCS; Killen et al., 1994) is a 5-item self-report questionnaire assessing worry about weight and shape, fear of weight gain, diet history, importance of weight, and perceived fatness. Scores of 52 and above have been associated with increased risk for developing an ED within 4 years (Killen et al., 1996). This threshold has been used in other similar studies (Silva et al., 2017, Karekla et al., 2022). The scale was used to identify participants who are at high risk for developing an ED. The WCS has shown adequate psychometric properties (a > .70) in previous studies (Killen et al., 1994; Killen et al., 1996; Jacobi et al., 2004). Satisfactory internal consistency has been reported in a Greek-Cypriot sample of university students (a = .75; Koushiou et al., 2019) and in this sample (a = .76).

2.2.5 Self-report Distress Tolerance

Distress Tolerance Scale (Simons & Gaher, 2005) is a 15-item questionnaire assessing the degree to which individuals can withstand negative emotion. Responses are given on a 5-point Likert Scale ranging from *1 = strongly agree* to *5 = strongly disagree*. Items are summed to yield a total distress tolerance score, with higher scores reflecting greater tolerance for negative emotional experience. The scale demonstrates excellent internal consistency (a = .91) and criterion validity (Simons & Gaher, 2005). Excellent internal consistency in this sample as well (a = .90).

2.2.6 Distress Tolerance Tasks

(i) Physical Distress Tolerance Task. The Breath-holding Task (BHT; Hajek et al., 1987) is a behavioural index of physical distress tolerance which was originally developed to examine breath-hold endurance among smokers and assess their ability to tolerate uncomfortable physical sensations. This task was used to induce *physical* distress and assess participants' ability to tolerate it. The task requires participants to hold their breath after a full, normal expiration. To maximise experienced distress during the task, participants were asked to hold their breath for as long as they can, even if they felt the urge to breathe again. The same procedure was then repeated after a 60-second rest period. The longer duration of the two trials was used as the index of maximum breath-holding duration (Zvolensky et al., 2010). Higher breath-holding durations reflect greater ability to tolerate physical distress. The BHT has shown good test-retest reliability previously (r = .67; Sütterlin et al., 2013) and in the current study (r = .87).

(ii) Cognitive Distress Tolerance Task. The "Paced Auditory Serial Addition Task – Computerised" (PASAT-C; Lejuez et al., 2003) is a behavioural distress tolerance task which has been shown to induce negative affect (Daughters et al., 2005; Holdwick & Wingenfeld, 1999). During the task single-digit numbers are sequentially presented on a computer screen and the participant is required to add the current number on screen to the previously presented number before the next one appears on the screen. There are three levels to the task; Level 1-low difficulty (3 minutes); Level 2-medium difficulty (3 minutes); and Level 3-high difficulty (3 minutes). Numbers are presented more quickly with each level, with Level 1 providing a 3-s latency between number presentations, a 2-s latency during the second level, and a 1-s latency during the final level. Level 3 is considered to be the distress tolerance phase of the task as the latency between digit presentations exceeds the participant's skill level, thus inducing distress. Before starting Level 3 participants are informed that once the final level begins, they can terminate exposure to the task by pressing the QUIT button. Participants are notified that they will win one point for each correct response, while incorrect scores or not responding will not impact their score. Distress tolerance is indexed as latency in seconds to quit level 3 of the task.

2.2.7 Affect Ratings

The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) is a self-report measure made up of two scales; the Positive Affect (PA) and the Negative Affect (NA) Scales. The PA scale consists of 10 positive adjectives (e.g. excited) and the NA scale of 10 negative adjectives (e.g. upset). Only the NA subscale was used in this study and was administered to participants immediately prior to and following the completion of the BHT and the PASAT-C, to capture emotional responses to the two tasks. The subscale showed high internal consistency previously (a = .85; Watson et al., 1988) and in this sample (a = .83).

The Self-Assessment Manikin (SAM; Bradley & Lang, 1994) is a non-verbal picture-oriented instrument developed to assess momentary feelings of pleasure, arousal, and dominance in response to an event. The SAM was administered to participants immediately after completion of the BHT and the PASAT-C to assess their emotional response to the two tasks along the principal affective dimensions of valence, arousal and dominance. Each dimension on the SAM contains five graphical figures defining a 9-point scale. The pleasure dimension of SAM ranges from a frowning, unhappy figure *(1= unpleasant)* to a happy, smiling figure *(9= pleasant)*. The arousal dimension ranges from a relaxed, calm figure *(1= calm)* to an excited, wide-eyed figure *(9= aroused)*. Lastly, the dominance dimension (ranging from *1= without control*, to *9= in control*) represents changes in control reflected in changes in the size of the figure with the large figure

indicating maximum control over the situation. Participants are asked to place an 'x' on any of the figures of each dimension, or between any two figures, which results in a 9-point rating scale for each dimension. The SAM was administered to participants immediately after completion of the BHT and the PASAT-C.

2.2.8 Confounding Variables

Depression, anxiety and stress have been found to affect affective experience (Stice et al., 2011) and thus were assessed as possible confounders. The Depression Anxiety Stress Scales-21 (DASS-21; Brown et al., 1997) was used in this study as a measure of depression, anxiety, and stress. The DASS-21 subscales demonstrated satisfactory internal consistency in the present study (a = .76 for depression, a = .70 for anxiety, a = .74 for stress).

BMI has been found to affect physiological reactions in ED populations (e.g. see Dapelo et al., 2015), thus was assessed as a possible confound. BMI was calculated based on the participants' subjective measures of height and weight.

Physical activity level was assessed as a possible confound for differences in physiological reactions between individuals at high and low ED risk (Klaperski et al., 2013). Participants' activity level was measured using the Stanford Brief Activity Survey (SBAS; Taylor-Piliae et al., 2006), a short 2-item, self-report survey which assesses the usual amount and intensity of physical activity. The first item describes different kinds of at-work activities and the second item describes leisure-time activities. Based on the responses on the two items, respondents' overall physical activity intensity is classified as follows: (1) inactive, (2) light, (3) moderate, (4) hard, and (5) very hard.

2.3 Procedure

2.3.1 Screening Phase

This study was approved by the Cyprus National Bioethics Committee and written informed consent was obtained from all participants prior to participation. Potential participants were identified and invited to take part in the study from a sample recruited during a wider campaign ("XX Mental Health Screening Days 2019: Eating Attitudes and Behaviours") conducted at the University of XX. Individuals were contacted via email only in case they provided their consent to be contacted for participation in future studies. Further participants were recruited based on opportunistic sampling by online and on campus advertisement of the study. Participation in the study was voluntary. Eligible participants completed a battery of self-report questionnaires prior to their visit at the lab.

2.3.2 Experimental Phase

During the experimental phase, participants were first asked to fill in the PANAS (Watson et al., 1988) and were then fitted with physiological monitors. There was a 5-minute baseline period before beginning the tasks to stabilise physiological signals. Then, participants went on to complete either the BHT or the PASAT-C in a counterbalanced order. Physiological measurements of heart rate were collected during both tasks. Affect ratings were collected post-BHT and post-PASAT-C. All participants received debriefing at the end of the study.

2.4 Data Analyses Plan

Independent samples t-tests were conducted to assess for group differences in all demographic variables, except for activity level and level of studies that were assessed using chi-square tests.

Following the procedure employed by previous experimental studies in the field (e.g. Koushiou et al., 2018), PANAS-NA score was used to examine whether the BHT and the PASAT-C were successful in stress induction. Repeated-Measures ANOVA was conducted with Time (baseline, post-BHT, post-PASAT-C) as the within-subjects variable and the PANAS-NA as the dependent variable.

Next, Repeated Measures ANOVAs were conducted for analysis involving the physiological index of heart rate and the self-reported emotions with Time (baseline, BHT, PASAT-C) as the within-subjects variable and ED risk group (high vs. low) as the between-subject variable. Five repeated measures Time x ED risk group ANOVAs were conducted with heart rate, PANAS-NA score, SAM-valence, SAM-arousal and SAM-control as dependent variables. The assumption of sphericity was violated for heart rate and PANAS-NA score and thus Huynh-Feldt corrected degrees of freedom were used to assess the significance of the corresponding F-ratio. Simple effect analysis with Bonferroni adjustment was used to break down significant interactions.

Two independent samples t-tests were conducted to examine group differences in PASAT-C latency to quit and breath-holding duration on the BHT. One more independent samples t-test was conducted to examine group differences in self-reported distress tolerance.

3. Results

3.1 Preliminary Analyses

Due to the lack of significant differences on the levels of depression, BCa 95% CI [-2.95, 1.30], t (112) = -.75, p = .45, anxiety, BCa 95% CI [-4.15, 0.17], t (103.60) = -1.90, p = .06, stress, BCa

95% CI [-2.22, 2.34], t (112) = -.05, p = .96, and BMI, BCa 95% CI [-0.26, 2.30], t (112) = .51, p = .12 between individuals at high and low ED risk, these were not included as covariates in subsequent analyses. In addition, physical activity was not correlated with heart rate or breath-holding duration therefore was not included as a covariate in subsequent analyses. Table 1 shows sample's characteristics based on the self-report questionnaires.

Table 1. Sample characteristics, behaviours and attitudes and between-group comparisons

	Total Sample N = 114	High risk n = 56	Low risk n = 58	Between-group comparisons t (df)
	M (SD)	*M (SD)*	*M (SD)*	
Age (years)	21.46 (2.01)	21.57 (1.99)	21.34 (2.04)	.60 (112)[1]
BMI (kg/m^2)	22.10 (3.54)	22.62 (4.02)	21.59 (2.95)	.51 (112)[1]
	N (%)	N (%)	N (%)	χ^2 (df)
Ethnicity				
Cypriot	96 (84.2)	46 (82.1)	50 (86.2)	
Greek	14 (12.3)	8 (14.3)	6 (10.3)	
Other	4 (3.5)	2 (3.6)	2 (3.4)	
Level of Studies[1]				4.09 (1)[2*]
Undergraduate	63 (55.3)	36 (64.3)	27 (46.6)	
Graduate	50 (43.9)	19 (33.9)	31 (53.4)	
Physical Activity Intensity				11.82 (4)[3*]
Inactive	12 (10.5)	2 (3.6)	10 (17.2)	
Light	55 (48.2)	31 (55.4)	24 (41.4)	
Moderate	35 (30.7)	20 (35.7)	15 (25.9)	
Hard	10 (8.8)	3 (5.4)	7 (12.1)	
Very hard	2 (1.8)	-	2 (3.4)	
	M (SD)	*M (SD)*	*M (SD)*	t (df)
WCS	48.60 (21.75)	66.96 (7.60)	30.86 (15.18)	16.14 (84.56) **
DASS-21[4] -Depression subscale	6.04 (5.94)	5.61 (5.49)	6.45 (6.37)	-.75 (112)
DASS-21[4] - Anxiety subscale	5.82 (5.85)	4.79 (4.76)	6.83 (6.62)	-1.90 (103.604)
DASS-21[4] - Stress subscale	10.79 (6.56)	10.82 (6.12)	10.76 (7.01)	-.05 (112)

Note. *M* = mean; *SD* = standard deviation; *BMI* = Body Mass Index; WCS = Weight Concerns Scale; DTS = Distress Tolerance Scale; DASS-21 = Depression Anxiety Stress Scale-21.

[1] = Independent Samples t-test with bootstrapping (1,000 re-samples); [2] = Chi-Square test (Pearson Chi-Square); [3] = Chi Square test (Likelihood Ratio); [4] = analysis for this variable included 113 cases, high risk = 55, low risk = 58

*$p \leq 0.05$, **$p \leq 0.001$

3.2 Manipulation Checks

Results indicate a significant effect of time on PANAS-NA ($F_{(1.73, 195.87)} = 80.14$, $p < .001$, $\eta_p^2 = .42$). Pairwise comparisons showed that participants reported significantly lower negative affect at baseline than after the BHT ($p < .05$) and after the PASAT-C ($p < .001$). Overall, participants' affect ratings after the two distress tolerance tasks significantly differed from baseline, suggesting that the two tasks were successful in stress induction.

3.3 Main Analyses

Table 2 shows the means and standards deviations of participants' physiological and self-report emotional reactions to the BHT and the PASAT-C.

Table 2. Means and SDs for the physiological and self-report emotional responses of ED Risk Groups across the distress tolerance tasks.

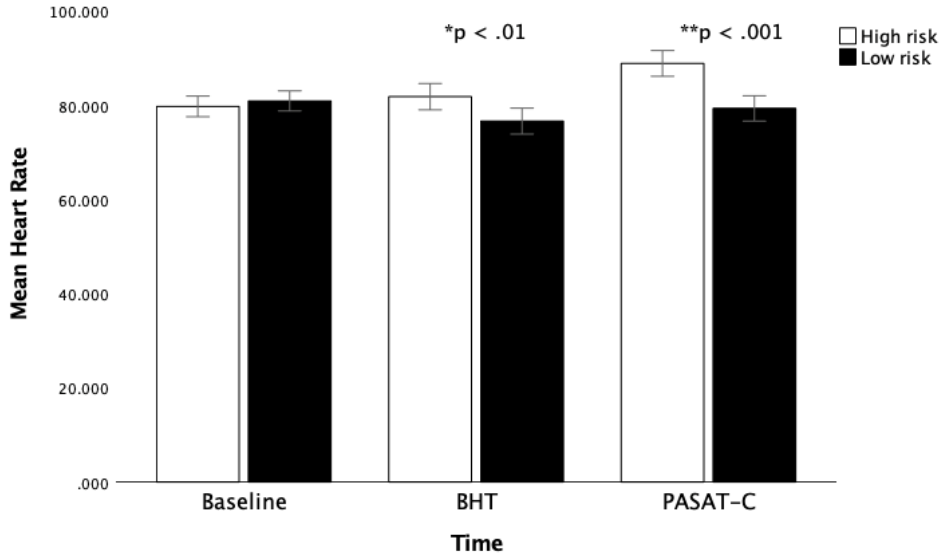
	High risk (n = 56)			Low risk (n = 58)			p values (between-group)[1]
	Baseline	BHT	PASAT-C	Baseline	BHT	PASAT-C	
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	
HR	79.82 (7.43)	81.90 (11.08)	88.96 (11.10)	80.99 (8.97)	76.70 (10.05)	79.41 (9.52)	.008
PANAS-NA	11.95 (3.43)	13.30 (3.56)	18.29 (4.76)	11.40 (2.58)	11.71 (2.30)	15.72 (5.44)	.002
SAM-Valence	-	5.98 (1.21)	4.54 (1.51)	-	6.41 (1.16)	6.02 (1.43)	< .001
SAM-Arousal	-	5.46 (1.75)	6.52 (1.54)	-	5.12 (1.81)	5.76 (1.82)	.054
SAM-Control	-	6.05 (1.43)	3.46 (1.75)	-	6.69 (1.66)	5.33 (1.59)	< .001

Note. HR = Heart Rate; PANAS-NA = Positive and Negative Affect Scale, Negative Affect Score; SAM = Self-Assessment Manikin

[1] = significance of group main effect across conditions

3.4 Hypothesis 1: Group Differences in Affective Responding

1. Heart Rate. Results suggest a significant main effect of time ($F_{(1.94,217.34)} = 30.41$, $p < .001$, $\eta_p^2 = .21$). Participants' mean heart rate during the PASAT-C was significantly higher compared to baseline ($p < .001$) and BHT ($p < .001$). In addition, results revealed a significant main effect of ED risk group ($F_{(1,112)} = 7.37$, $p < .01$, $\eta_p^2 = .06$) with high-risk participants presenting higher overall mean heart rate compared to low risk. There was also a significant ED risk x Time interaction ($F_{(1.94,217.34)} = 33.60$, $p < .001$ $\eta_p^2 = .23$). Post-hoc tests showed that high-risk participants' mean heart rate during the PASAT-C was significantly higher than at baseline and during the BHT. Also, significant group differences were observed only for mean heart rate during the two distress tolerance tasks (BHT [$F_{(1, 112)} = 6.89$, $p < .01$]; PASAT-C [$F_{(1, 112)} = 24.32$, $p < .001$]; see Figure 1, with the high-risk group exhibiting significantly higher mean heart rate during both tasks compared to the low-risk group.



Note. Error bars: 95% CI

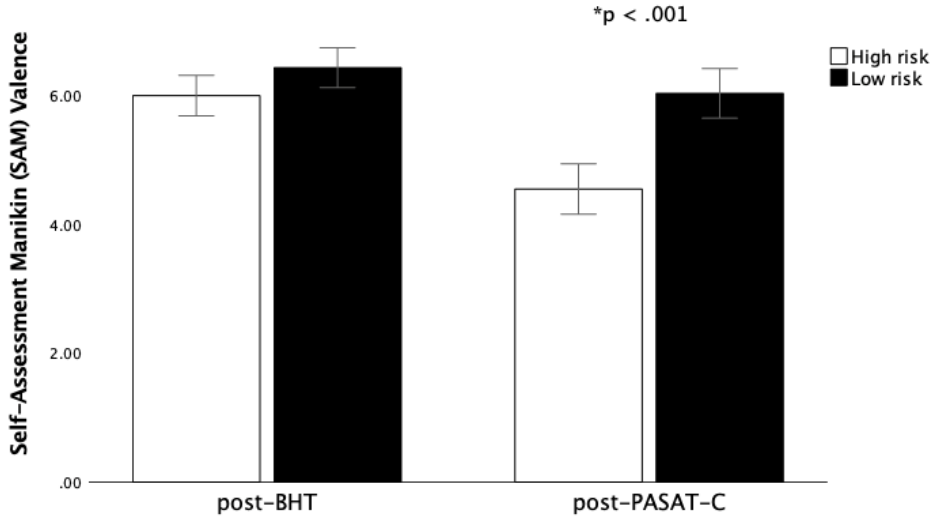
Figure 1. Estimated Marginal Means for the Time x Group Interaction on Mean Heart Rate

2. Self-reported Emotions. Results showed a significant main effect of time for PANAS-NA score ($F_{(1.76,197.16)} = 81.65, p < .001, \eta_p^2 = .42$), SAM-Valence ($F_{(1,112)} = 48.45, p < .001, \eta_p^2 = .30$), SAM-Arousal ($F_{(1,112)} = 27.99, p < .001, \eta_p^2 = .20$), SAM-Control ($F_{(1,112)} = 118.36, p < .001, \eta_p^2 = .51$). Post hoc tests showed that participants reported significantly ($p < .001$) higher negative affect after the BHT and after the PASAT-C compared to baseline, while negative affect reported after the PASAT-C was significantly higher compared to negative affect reported after the BHT ($p < .001$). Moreover, participants assessed the cognitive distress tolerance task as more unpleasant ($p < .001$) and more arousing ($p = .05$) than the physical distress tolerance task and reported less control over the situation ($p < .001$) during the cognitive distress tolerance task compared to the physical.

A significant main effect for ED risk groups was found for PANAS-NA score ($F_{(1,112)} = 9.87, p < .005, \eta_p^2 = .08$), SAM-Valence ($F_{(1,112)} = 20.27, p < .001, \eta_p^2 = .15$), SAM-Arousal ($F_{(1,112)} = 3.81, p \leq .05, \eta_p^2 = .03$), and SAM-Control ($F_{(1,112)} = 26.83, p < .001, \eta_p^2 = .19$). High-risk participants reported overall higher negative affect, unpleasantness, arousal and lower control over the situations than their low-risk counterparts.

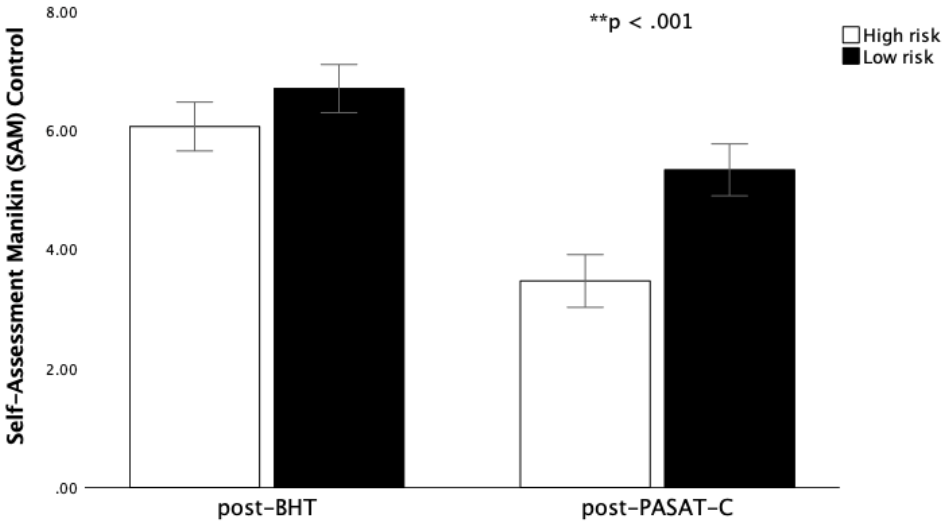
A significant ED risk x Time interaction was observed only for SAM-Valence ($F_{(1,112)} = 15.72, p < .001, \eta_p^2 = .12$) and SAM-Control ($F_{(1,112)} = 11.42, p \leq .001, \eta_p^2 = .09$). Based on Bonferroni corrected post hoc tests, high-risk participants reported significantly more unpleasantness and less control over the situation following the PASAT-C than following the BHT ($t(55) = 7.80, p < .001$). Furthermore, compared to low-risk participants, individuals at high ED risk reported

significantly greater unpleasantness (see Figure 2) and less control over the situation (see Figure 3) only after the PASAT-C. Unpleasantness (SAM-Valance) and dominance (SAM-Control) ratings after the BHT did not differ between the the two groups (p = .05).



Note. Error bars: 95% CI

Figure 2. Estimated Marginal Means for the Time x Group Interaction on SAM – Valence



Note. Error bars: 95% CI

Figure 3. Estimated Marginal Means for the Time x Group Interaction on SAM – Control

3.5 Hypothesis 2: Group differences in Distress Tolerance

An independent samples t-test showed that there was a significant difference between high vs. low-risk groups in latency to quit the PASAT-C, BCa 95% CI [-62.25, -13.55], t (107.73) = -3.05, p < .005. High-risk participants exhibited shorter latency to quit (M = 88.30, SD = 71.46) than low-risk participants (M = 126.22, SD = 60.55). A second independent samples t-test

showed that breath-holding duration during the BHT did not significantly differ between the two groups (high-risk group: M = 29.35, SD = 13.73; low-risk group: M = 31.10, SD = 12.37, BCa 95% CI [-7.16, 1.57], t (112) = -1.12, p = .26).

Another independent samples t-test was carried out to identify whether the two risk groups differ on their ability to tolerate distress based on their self-report responses on the DTS. Results showed that there were significant differences between the two groups, (BCa 95% CI [-.86, -.32], t (112) = -4.40, p < .001), with the high ED risk being significantly less distress tolerant (M = 2.63, SD = .74) than their low-risk counterparts (M = 3.23, SD = .70).

4. Discussion

The aim of the present study was to assess affective responding and distress tolerance to two distress tolerance tasks in participants at high vs. low risk for EDs, integrating physiological, behavioural, and self-reported affect measures. This is the first study to compare affective responding to a cognitive vs. a physical distress tolerance task of individuals who are at risk for developing an ED but do not meet criteria for an ED diagnosis.

Based on the current findings, high-risk participants exhibited greater physiological arousal (i.e. higher heart rate response) during both tasks compared to low-risk participants. This finding is in line with previous research in the field which also show higher heart rate response in high-risk individuals compared to those at low risk (Koushiou et al., 2019). This result suggests that higher physiological response may be a trait-like feature that exists prior to illness onset and increases vulnerability by making emotions intolerable and thereby engage in attempts to avoid or escape negative-valenced situations and/or experiences (Merwin 2011). This however remains on a speculative level and should be assessed in future studies controlling for factors that might influence such results (e.g., leptin and cortisol levels). The cognitive stress task elicited higher physiological arousal (i.e., higher heart rate) in high-risk participants compared to the physical distress tolerance task. This could be attributed to the very different durations of the two tasks (PASAT-C takes a lot longer to complete than the BHT), nevertheless such a finding may indicate a new perspective in understanding the emotional experience of individuals at high ED risk with an emphasis on the context. When cognitively distressed or challenged, individuals at high ED risk experience hyperarousal which combined with an accurate awareness of more sensations occurring in their body (Merwin, 2011) can make their overall internal experience overwhelming. This finding provides evidence for the Haynos and Fruzzeti (2011) model of emotion regulation suggesting that individuals in the premorbid stages of the illness demonstrate heightened emotionality.

Results on participants' subjective emotional experience (i.e., self-report affect responses) showed that individuals at high ED risk reported greater unpleasantness and less control only after the cognitive distress tolerance task, compared to individuals at low ED risk, confirming the results of previous studies on emotional responding after stress induction. For example, Eichen et al. (2017) found that individuals who endorsed in binge eating were significantly more frustrated and irritated at the end of the PASAT-C compared to the control group. Koushiou et al. (2019) found that individuals at high ED risk reported significantly higher negative affect and higher anxiety after stress induction compared to their low-risk counterparts. Another study found that women with binge eating disorder reported greater levels of negative affect and state anxiety after exposure to stress compared to the obese group (Klatzkin et al., 2015). Patients with anorexia nervosa reported negative emotions significantly more than controls after exposure to stress (Miller et al., 2003), while women with binge eating disorder and bulimia nervosa reported greater sadness compared to controls after and during exposure to stress (Hilbert et al., 2011).

Taken together these findings on higher heart rate reactivity, and greater subjective emotionality after the cognitive distress tolerance task shows that individuals at high ED risk experience more difficulties when encountered with cognitive distress as compared to the physical distress. Nevertheless, future studies should aim to replicate and extend these findings using distress tolerance tasks that are comparable both in terms of their duration and the amount of induced distress, while preventative interventions for individuals at high ED risk may focus on improving one's skills of tolerating and adaptively responding to distress.

Based on the behavioural reactions to the two distress tolerance tasks (i.e., latency to quit each task) used in the current study, the two groups did not differ on latency to quit the physical distress tolerance task, while significant differences were observed for latency to quit the cognitive distress tolerance task. Specifically, high-risk participants exhibited significantly shorter latency to quit the PASAT-C compared to their low-risk counterparts. In the context of increased negative affect that high risk participants experienced during the PASAT-C (as evidenced by higher heart rate and self-reported affect), shorter latency to quit the task provide a behavioural indication of their distress tolerance and their difficulty to withstand negative affect. This finding is in accordance with the high-risk participants' greater self-reported difficulties on the DTS questionnaire compared to low-risk individuals. Overall, these findings are in line with previous cross-sectional and experimental studies demonstrating that individuals with EDs have difficulties tolerating negative affect. For example, a study comparing women

presenting with an ED diagnosis to women with no prior history of EDs showed that women in the clinical group scored higher in the 'avoidance of affect' and lower on the 'accept and manage' subscales on a self-report scale compared to the non-clinical group (Corstorphine et al., 2007). Another study found that individuals with bulimic symptoms demonstrated lower levels of tolerating distress (Anestis et al., 2007). These findings are in line with previous theoretical accounts (e.g., Heatherton & Baumeister, 1991) suggesting that individuals with EDs exhibit difficulties tolerating negative affect and use disordered eating behaviours to attenuate the experience of it (Corstorphine et al., 2007). A positive association between avoidance of affect and unhealthy eating attitudes has also been demonstrated (Corstorphine et al., 2007). Therefore, based on this finding it could be argued that it is not the presence of negative affect itself that gives rise to ED symptomatology, but rather how one experiences and responds to negative emotional states. In fact, in their study Anestis and colleagues (2007) not only found that DT significantly predicted bulimic symptoms, but also demonstrated that DT mediates the relationship between anxiety sensitivity - the fear of anxiety-related sensations (e.g., accelerated heart rate) - and bulimic symptoms. This finding suggests that the relationship between anxiety sensitivity and bulimic symptoms is due to a general inability to tolerate negative emotional states rather than a specific fear of anxiety symptoms (Anesis et al., 2007). In addition, an experimental study showed that participants who endorsed in binge eating were nearly three times more likely to quit the PASAT-C early than controls (Eichen et al., 2017). Albeit preliminary, results from the present study suggest that difficulties tolerating negative affect are present prior to the presentation of clinical ED diagnoses. Nevertheless, longitudinal studies are needed to examine this association. Also, given the importance of utilizing objective measures, it would be important for future studies to evaluate additional stress inducing- tasks.

Important clinical implications can be derived from these findings. The assessment of distress tolerance could be integrated within clinical assessments of individuals who present with weight concerns to possibly establish the risk of developing an ED. Since those at high risk demonstrate poor distress tolerance, it could be promising to incorporate elements of teaching or enhancing distress tolerance in ED prevention programmes, thus empowering individuals to manage situations that involve strong, negative affect. For example, Dialectical Behaviour Therapy, a form of cognitive-behaviour therapy developed by Linehan (1993), focuses on teaching and improving distress tolerance skills to deal with low levels of distress tolerance found in borderline personality disorder. In fact, there is research supporting the efficacy of DBT in treating individuals with bulimia nervosa and binge eating disorder (Chen et al., 2008). Similarly, acceptance and commitment therapy could also prove helpful in addressing deficits in distress

tolerance in individuals at risk for EDs by promoting greater degrees of emotional acceptance, mindfulness, and self-awareness, to alter maladaptive responses to aversive stimuli (Hayes et al., 2009).

5. Limitations

One limitation of the study were the chosen tasks. The different durations of the two distress tolerance tasks used in this study confounds with their direct comparison. It is also possible that distress produced by the PASAT-C and BHT does not correspond with real-life distress and thus other tasks or procedures that resemble real-life situations could be more useful. Moreover, the use of different physical distress tolerance tasks is recommended in future studies, since breath-holding duration as a behavioural index of physical distress tolerance, may be affected by individual differences in lung capacity. A task that causes gastric sensations might be more useful and suitable for this population than the BHT which creates sensations unrelated to EDs. Another limitation of the present study is the use of a cross-sectional design which makes it difficult to ascertain whether heightened reactivity to distressful stimuli and poor distress tolerance constitute correlates of the development and/or maintenance of ED pathology. Although an initial understanding of the potential role of distress tolerance in ED risk is provided in the current study, future research could replicate this study using a longitudinal design to examine the role of distress tolerance in the onset and maintenance of ED symptoms. Another limitation of this study is the use of a homogenous sample in that most participants were Cypriot and educated either at an undergraduate or graduate level. A more diverse sample in terms of culture, age and educational background may help increase generalizability of results. Investigation of autonomic response to distressful stimuli in the current study was limited to just one physiological index (i.e., heart rate). Future research would benefit from the addition of more valence-specific physiological indices, such as corrugator and eye blink startle reflex, to systematically explore autonomic responses in samples with subthreshold and threshold manifestations of ED.

6. Conclusions

The current study contributes to the ED literature as it is one of the few to have used a well-controlled experimental design to investigate emotional responding and distress tolerance of women at risk for ED, across physiological, subjective and behavioural domains, in response to a cognitive and a physical distress tolerance task. Results suggest that women at high ED risk exhibit an overall hyper-reactivity when cognitively distressed or challenged as evident by their increased heart rate and greater self-reported negative affect during a cognitive distress tolerance

task (i.e. PASAT-C). In this context, high risk participants present lower distress tolerance as they tend to quit the cognitive distress tolerance task sooner than their low-risk counterparts possibly indicating their difficulty in withstanding negative affect states. Overall, these preliminary findings suggest that hyper-reactivity to cognitive stress and associated lower distress tolerance characterise the experience of individuals at high risk for ED. These characteristics may point to dispositional traits that are evident prior to illness development, which might increase risk for EDs. Future research should replicate these novel findings and further investigate how emotional responding is changing over the course of illness and whether it influences symptom presentation over time in individuals at ED risk.

Ethical approval

The research project was reviewed and granted ethical approval by the Cyprus National Bioethics Committee (ref. number: ΕΕΒΚ/ΕΠ/2020/13).

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Data availability statement

The data that support the findings of this study are available from the corresponding author, [MK], upon reasonable request.

Conflict of interest statement: The authors declare that the research was conducted in the absence of any potential conflict of interest.

Authors' contributions

EI: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing – Original draft, Visualization, Project administration; **EC:** Conceptualization, Methodology, Software, Writing – Review & Editing, Visualization, Supervision; **NF:** Conceptualization, Writing – Review & Editing, Visualization, Supervision; **MK:** Conceptualization, Methodology, Writing – Review & Editing, Visualization, Supervision.

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