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Stress is associated with exercise differently among individuals with higher and lower eating disorder symptoms: An ecological momentary assessment study

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Abstract

Objective: Stress is associated with the maintenance of eating disorders and exercise behaviors. However, it is unclear how stress is associated with exercise and vice-versa among individuals with higher levels of eating disorder symptoms in daily life. The current study tested the moderating effect of eating disorder symptoms on the relationships between: (1) daily stress and later exercise behavior and (2) daily exercise behavior and later stress.

Method: Female college students [$N = 129$, mean age = 19.19 ($SD = 1.40$)] completed the Eating Disorder Inventory-2. Participants then completed measures of stress and exercise four times daily across seven days using an automated telephone ecological momentary assessment system. Data were analyzed using multilevel models.

Results: Drive for thinness, bulimic symptoms, and body dissatisfaction significantly moderated the relationship between daily stress and later exercise ($ps = .01–.05$), such that higher daily stress predicted higher later exercise only in individuals who were low (but not average or high) in drive for thinness, bulimic symptoms, and body dissatisfaction symptoms.

Discussion: Stress is associated with exercise differentially depending on individuals' eating disorder symptoms. Our findings suggest that only individuals with lower levels of eating disorder symptoms exercise when stressed.

KEYWORDS
affect, eating disorders, ecological momentary assessment, exercise, stress

1 | INTRODUCTION

1.1 | Eating disorders and stress

Stress is relevant to both exercise behavior and eating disorders (e.g., Berger & Owen, 1988; Rojo, Conesa, Bermudez, & Liviano, 2006). Stress refers to the perception that demands exceed the individual's ability to cope (Lazarus, 1993), and may include major acute life events and/or daily hassles (i.e., chronic strains on everyday life) (Lazarus & Folkman, 1984). Both chronic and acute stress are associated with the development of eating disorders (e.g., Rojo et al., 2006). Individuals with eating disorders report experiencing more stressful life events than healthy individuals (Raffi, Rondini, Grandi, & Fava, 2000), and they perceive more stress in their lives (Cattanach, Malley, & Rodin, 1988). In addition, they experience daily hassles as more stressful than controls (Crowther, Snaftner, Bonifazi, & Shepherd, 2001) and appear to cope with daily stressors by engaging in eating disorder behaviors

(Woods, Racine, & Klump, 2010; Wolff, Crosby, Roberts, & Wittrock, 2000).

1.2 | Exercise to regulate stress in the context of eating disorders

Exercise can be used to cope with stress. Research shows that at least some forms of exercise are associated with reductions in stress in healthy individuals (Berger & Owen, 1988). However, the extent to which exercise is followed by reductions in stress in individuals with higher levels of eating disorder symptoms is unclear. It is possible that the relationship between stress and exercise is different in individuals with higher levels of eating disorder symptoms.

First, it is currently unclear whether individuals with eating disorders are more or less likely to exercise when stressed than controls. Some research suggests that individuals with higher levels of eating disorder symptoms may not exercise when stressed because they view exercise as a way to change their weight and shape (Mond & Calogero, 2009) rather than as a form of stress-relief. In contrast, other literature suggests that individuals with eating disorders endorse exercising for stress/mood management (Bardone-Cone et al., 2016) or negative reinforcement (Noetel et al., 2016) purposes at higher rates compared to individuals without eating disorders.

Second, it is unclear whether individuals with eating disorders experience decreases in stress after exercising. It is possible that individuals with higher levels of eating disorder symptoms may exercise in a way that makes them more likely to experience increases (rather than decreases) in stress after exercise. For example, individuals with eating disorders often exercise excessively (Davis et al., 1997) and are more likely to exercise for weight and shape reasons but less likely to exercise for enjoyment than healthy controls (Mond & Calogero, 2009). Exercising for appearance-related (vs. functionally related) reasons has been shown to contribute to a more negative body image and unhealthy behaviors (LePage & Crowther, 2010), which individuals with higher levels of eating disorder symptoms may experience as stressful. On the contrary, other research suggests that some individuals with eating disorders experience decreases in negative affect after exercising (Engel et al., 2013; Goldschmidt et al., 2013). However, no study has investigated whether individuals with higher levels of eating disorder symptoms experience decreases in stress specifically after exercising.

1.3 | Using ecological momentary assessment to study stress and exercise in eating disorders

An ideal way to assess the relationship between exercise and stress as it occurs in everyday life is ecological momentary assessment (EMA). EMA is an assessment approach that tracks near real-time data by involving momentary ratings and repeated assessments over time, thus addressing some of the limitations and biases of retrospective reports and increasing ecological validity (Trull & Ebner-Priemer, 2009). EMA allows for the momentary examination of how stress relates to exercise behavior within individuals and is thus an ideal approach to explore stress antecedents and consequences after engaging in daily exercise behavior in individuals with varying levels of eating disorder symptoms.

1.4 | The current study

Overall, it is unclear exactly how exercise is associated with subsequent stress and how stress is associated with subsequent exercise among individuals with higher levels of eating disorder symptoms in daily life. In the current study, we first examined the relationship between daily stress and exercise behavior (and vice-versa), and we then tested the moderating effect of eating disorder symptoms on the relationship between: (1) daily stress and later exercise behavior and (2) daily exercise behavior and later stress. We hypothesized that, (a) higher stress would predict more exercise, and that (b) more exercise would predict lower stress. Although the existing literature is mixed on whether individuals with elevated eating pathology exercise to a greater or lesser degree for stress reduction, we also hypothesized that in individuals with higher levels of eating disorder symptoms, higher stress would be associated with less later exercise behaviors because individuals with higher levels of eating disorder symptoms may exercise to manage their body weight and shape rather than to relieve stress. We also hypothesized that in individuals with higher eating disorder symptoms more exercise would be associated with higher later stress because individuals with higher levels of eating disorder symptoms may exercise in a stressful way (e.g., excessively, vigorously, with an appearance-based focus).

2 | METHOD

2.1 | Participants

A total of 129 female undergraduate students from a Midwestern university participated in this study. Participants were given either course credit or payment for their participation. Participants ranged in age from 17 to 23 years old ($M = 19.19$, $SD = 1.40$). Participants were European American ($n = 66$, 51.2%), Asian ($n = 34$, 26.4%), multiracial ($n = 13$, 10.1%), Hispanic ($n = 8$, 6.2%), and Black ($n = 7$, 5.4%). One participant did not report her ethnicity.

2.2 | Measures

2.2.1 | The eating disorder inventory-2

The eating disorder inventory-2 (EDI-2; Garner, 1991; Garner, Olmstead, & Polivy, 1983) is a self-report questionnaire that measures core features associated with eating disorder psychopathology. In this study, we utilized three subscales: (1) drive for thinness, (2) body dissatisfaction, and (3) bulimic symptoms. We used these subscales because they are commonly associated with eating disorders. For example, drive for thinness (seven items, e.g., *I am terrified of gaining weight*) is a core feature of anorexia nervosa (AN) and also relevant to other eating disorders (Bruch, 1973; Garner et al., 1983). Body dissatisfaction (seven items, e.g., *I think that my stomach is too big*) is present in both AN and BN (Garner et al., 1983). Bulimic symptoms (nine items, e.g., *I eat or drink in secrecy)* are commonly associated with BN (Garner et al., 1983).

Participants responded to the items on a scale ranging from 1 (*never)* to 6 (*always)*. The factor structure, reliability, and validity of the EDI-2 have been demonstrated in clinical and nonclinical samples (Eberenz & Gleaves, 1994; Spillane, Boerner, Anderson, & Smith, 2004; Thiel & Paul, 2006). In the current study, internal consistencies were good (αs = .84–.91).

2.2.2 | EMA stress

The stress items from the depression, anxiety, and stress (DASS-21) subscale were used to assess momentary stress. The DASS-21 is a short-form of the Lovibond and Lovibond (1995) 42-item measure of depression, anxiety, and stress. The DASS-21 is ideal for EMA because it assesses short-term negative mood states and has previously been used in EMA protocols (e.g., Heron & Smyth, 2013). The items used were: *finding it hard to wind down*, *having lots of nervous energy*, *feeling agitated*, *finding it difficult to relax*, *feeling touchy*, and *feeling stressed*. These items were assessed on a Likert scale from one (not at all) to five (extremely). The DASS-21 has adequate reliability and validity (Antony, Bieling, Cox, Enns, & Swinson, 1998; Clara, Cox, & Enns, 2001; Henry & Crawford, 2005). In the current study, internal consistency was excellent ($\alpha = 0.90$).

2.2.3 | EMA exercise

Exercise was assessed by asking participants "How long did you exercise since your last check in?" to create an item measuring amount of time engaged in exercise.

2.3 | Procedure

Participants were recruited from an undergraduate subject pool for a study about personality, daily exercise, mood, and eating. At baseline, participants came into the lab, completed the EDI-2, were given instructions on how to use the automated telephone system, TelEMA (Fernandez, Johnson, & Rodebaugh, 2013), and completed a sample EMA telephone survey to ensure they understood the system with a trained member of the study personnel. In addition, participants selected a 12-hr waking time block. This 12-hr block was divided into four blocks, and EMA surveys were administered randomly within each of these blocks. This approach was chosen to ensure that the surveys would span throughout the day. Participants then began the EMA protocol, which consisted of automated telephone calls four times per day for seven days. Each telephone survey lasted approximately four minutes and included the measures mentioned above. If participants did not immediately answer the phone, a voicemail message would be left telling them that they had a survey to complete. Participants specified at baseline if they wanted to be called back if they did not answer or whether they wanted to call back the system. If the participant specified that she preferred to call the system back, the participant had one and a half hours after the voicemail message to call the system and complete their survey. If the participant specified that she preferred to be called back, the participant was called back after a period of time specified by the participant. If a participant did not complete the survey within one and a half hours of being called, the survey was considered incomplete and the data were recorded as missing. Participants were debriefed at the end of the study. This study was approved by the Institutional Review Board at Washington University in St. Louis.

2.4 | Data analysis

Data were analyzed using SPSS Version 21.0. We tested the moderating effect of drive for thinness, bulimic symptoms, and body dissatisfaction on the relationship between: (1) daily stress with later exercise behavior and (2) daily exercise behavior with later stress.

We analyzed the relationships between the variables within-subjects over time, using multilevel modeling (MLM). MLM analyses are robust to missing data. We used a one-assessment lag to test for temporal precedence. For example, exercise at time *t* was predicted by stress at *t*–1. Cross-day predictions were not included in the analysis, as it was unlikely that stress at night affected exercise the next day and vice-versa, and preliminary analyses confirmed that there were no cross-day effects (i.e., stress was not associated with exercise behavior the next day nor vice-versa). Because the exercise distribution was skewed with zero minutes of exercise reported at almost half of (46.3%) all assessments, we used a generalized linear mixed model (GLMM; MLM for non-normally distributed outcomes) for the analyses in which exercise behavior was the outcome (Atkins & Gallop, 2007). This GLMM assumed a negative binomial distribution for the outcome, and used a log linking function. In the reverse analyses (with exercise as a predictor and stress as the outcome), standard MLM was used (since these outcomes were normally distributed) but exercise (as a predictor) was log transformed to reduce skewness.

In addition, the time varying predictors (TVPs) (i.e., stress, exercise) were disaggregated into the person's mean across all 28 assessments (TVP_{mean}; the between-person component) and their deviation from their mean at each session ($TVP_{deviation;}$ the within-person component; $TVP_{dev} = TVP_{raw} - TVP_{mean}$) (Bolger & Laurenceau, 2013; Curran & Bauer, 2011).

Significant lagged TVP_{dev} effects can be interpreted as reflecting effects of changes in the predictor on the outcome, whereas significant TVP_{mean} effects can be interpreted as between-subjects covariation between the predictors and the outcomes (e.g., people with higher average levels of stress might exercise more/less). Given that the goal of the study was to make inferences on how stress and exercise are associated with each other within individuals, we limit our reporting to TVP_{dev} effects, although TVP_{mean} effects were included in all analyses (as was necessary to accurately assess the TVP_{dev} effects) (Hamaker, Kuiper, & Grasman, 2015). All findings reflect exclusively TVP_{dev} effects.

The eating disorder variables were treated as continuous moderators in these models. In order to understand the form of the interactions, we graphed the effect of each independent variable (i.e., stress, exercise) on outcome at different levels of the moderator (i.e., different levels of drive for thinness, bulimic symptoms, body dissatisfaction) (Aiken & West, 1991). This method allowed us to illustrate the specific nature of each significant interaction (e.g., Hayes, 2013). Following the

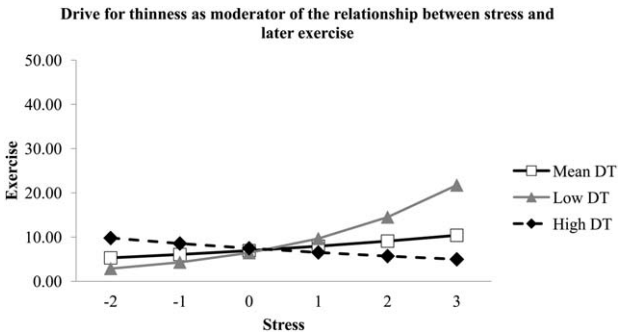

FIGURE 1 Drive for thinness as a moderator of the relationship between stress and later exercise *Note*: Low drive for thinness is one standard deviation below mean drive for thinness; high drive for thinness is one standard deviation above mean drive for thinness

recommendations of Aiken and West (1991) and others (e.g., Hayes, 2013), we plotted the relation between the independent variable and outcome at three levels of the moderator: "low" (1 *SD* below the mean), "average" (at the mean), and "high levels" (1 *SD* above the mean) (see Figure 1).

3 | RESULTS

3.1 | Descriptive information and zero-order correlations

Please see Table 1 for descriptive information and zero-order correlations. Participants provided 2,371 separate EMA recordings, but only 1,759 recordings were used after dropping cross-day predictions. Compliance averaged 66% (range 14–96%). Of note, drive for thinness, bulimia symptoms, and body dissatisfaction levels were higher in our sample than in other college samples, suggesting that our sample had relatively high levels of eating disorder symptoms (e.g., Spillane et al., 2004). In our sample, 12.4% of women scored in the clinical range on the drive for thinness subscale for the EDI-2, 7.1% on bulimic symptoms, and 13.3% on body dissatisfaction (Garner, 1991; Thiel & Paul, 2006). Eating disorder symptoms were significantly associated with each other, and all three eating disorder symptoms were significantly associated with mean EMA stress. Only body dissatisfaction was significantly associated with mean EMA exercise behavior.

3.2 | MLM analyses: Overall relationships

Surprisingly, stress ($b = 0.18$, $SE = 0.15$, $p = .23$) did not predict subsequent exercise. In addition, exercise did not predict subsequent stress ($b = -0.01$, $SE = 0.01$, $p = .30$).

3.3 | MLM analyses: Do eating disorder symptoms moderate the relationship between stress and later exercise behavior?

3.3.1 | Drive for thinness

Drive for thinness moderated the relationship between stress and later exercise ($b = -0.033$, $SE = 0.02$, $p = .047$), such that, within individuals over time, higher stress just failed to reach significance towards predicting more later exercise for those who were low in drive for thinness ($b = 0.40$, $SE = 0.21$, $p = .052$), but did not predict later exercise in individuals who were average ($b = 0.13$, $SE = 0.14$, $p = .34$) or high ($b = -0.13$, $SE = 0.18$, $p = .47$) in drive for thinness (see Figure 1).

3.3.2 | Bulimic symptoms

Bulimic symptoms moderated the relationship between stress and later exercise ($b = -0.06$, $SE = 0.03$, $p = .017$), such that, within individuals over time, higher stress predicted more later exercise for those who were low in bulimic symptoms ($b = 0.54$, $SE = 0.22$, $p = .016$), but not in individuals who were average ($b = 0.19$, $SE = 0.15$, $p = .19$) or high ($b = -0.15$, $SE = 0.19$, $p = .42$) in bulimic symptoms (see Figure 2).

3.3.3 | Body dissatisfaction

Body dissatisfaction moderated the relationship between stress and later exercise ($b = -0.05$, $SE = 0.01$, $p = .001$), such that, within individuals over time, higher stress predicted more later exercise for those who were low in body dissatisfaction ($b = 0.65$, $SE = 0.20$, $p = .001$), but not in individuals who were average ($b = 0.16$, $SE = 0.14$, $p = .25$) or high ($b = -0.33$, $SE = 0.18$ $p = .08$) in body dissatisfaction (see Figure 3).

TABLE 1 Descriptive information and zero-order correlations

	M (SD)	Range	DT	Bul.	BD	Stress	Exercise
DT	21.69 (8.19)	7.00–42.00	—				
Bul.	14.25 (5.84)	7.00–36.00	.60**	—			
BD	31.65 (10.46)	9.00–54.00	.65**	.44**	—		
Stress	2.05 (0.96)	1.00–5.33	.24**	.30**	.29**	—	
Exercise	11.59 (13.15)	0.00–83.06	.08	.01	-.14*	.01	—

Note. DT = drive for thinness, Bul. = bulimic symptoms, BD = body dissatisfaction. Drive for thinness, bulimic symptoms, and body dissatisfaction reflect baseline values. EMA values reflect mean individual levels. Spearman's rank order correlation coefficients.
**$p < .01$ *$p < .05$.

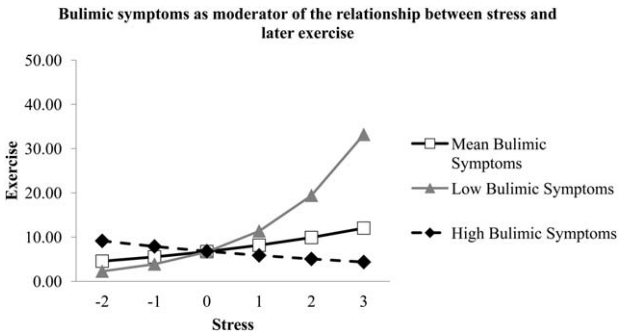

FIGURE 2 Bulimic symptoms as a moderator of the relationship between stress and later exercise *Note*: Low bulimic symptoms is one standard deviation below mean bulimic symptoms; high bulimic symptoms is one standard deviation above mean bulimic symptoms

3.4 | MLM analyses: Do eating disorder symptoms moderate the relationship between daily exercise behavior and later stress?

Drive for thinness ($b = 0.00$, $SE = 0.00$, $p = .68$), bulimic symptoms ($b = 0.00$, $SE = 0.00$, $p = .09$), and body dissatisfaction ($b = 0.00$, $SE = 0.00$, $p = .78$) did not moderate the relationship between exercise and later stress.

4 | DISCUSSION

Using EMA of stress and exercise, we found that eating disorder symptoms moderate the relationship between daily stress and later exercise, but we did not find evidence that eating disorder symptoms moderate the relationship between exercise behavior and later stress. Partially supporting our first hypothesis that in individuals with higher eating disorder symptoms, higher stress would be associated with less later exercise behaviors, only individuals who were lower in eating disorder symptoms were more likely to exercise when stressed. In contrast, we did not find evidence that individuals who were higher in eating disorder symptoms exercise when stressed. Our findings help explain how the relationship between exercise and stress varies in the context of various eating disorder symptoms.

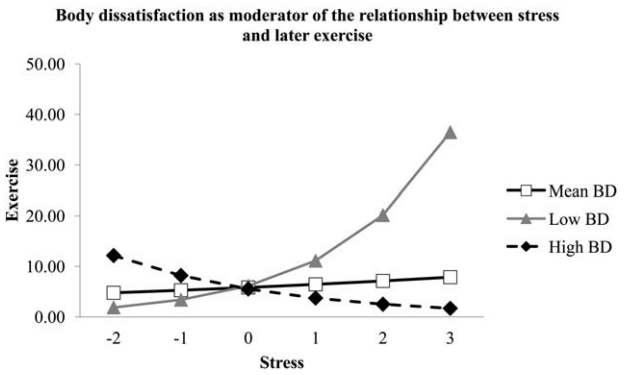

FIGURE 3 Body dissatisfaction as a moderator of the relationship between stress and later exercise *Note:* BD = body dissatisfaction; low body dissatisfaction is one standard deviation below mean body dissatisfaction; high body dissatisfaction is one standard deviation above mean body dissatisfaction

We found that only individuals who are lower in eating disorder symptoms exercise when stressed. This finding at first seems inconsistent with earlier research that has found that individuals with eating disorder symptoms endorse exercising in response to high negative affect (Holtkamp, Heberbrand, & Herpertz-Dahlmann, 2004) and that individuals who endorse exercising in response to negative affect have higher levels of eating disorder symptoms (De Young & Anderson, 2010). Our results may differ from previous research because previous research did not look at stress specifically and was cross-sectional. We used EMA, cross-lagged analyses, and disaggregation, and examined specific eating disorder symptoms and investigated stress, rather than negative affect. It is possible that the relationship between stress and exercise behavior is different than the relationship between negative affect and exercise behavior because individuals with eating disorders may find exercise stressful.

The findings did not support our second hypothesis that in individuals with higher eating disorder symptoms, more exercise would be associated with higher later stress. Specifically, we did not find that exercise is differentially associated with later stress in individuals with low, average, or high levels of eating disorder symptoms. In addition, exercise was not associated with any changes in stress for any group. It is possible that even though exercise is not associated with decreases in stress immediately, it may be associated with lower stress in the long-term. For example, it is possible that an individual may not experience immediate momentary decreases in stress after exercising (i.e., at the next time point), but experience decreases in trait stress levels over time (e.g., Salmon, 2001).

Consistent with existing literature (e.g., Mond, Hay, Rodgers, Owen, & Beumont, 2004), drive for thinness and bulimic symptoms were not significantly correlated with exercise levels, suggesting that individuals with higher levels of drive for thinness and bulimic symptoms generally exercise just as much as individuals with lower levels of drive for thinness or bulimic symptoms. In contrast, higher levels of body dissatisfaction were associated with less exercise. Although this finding contradicts the notion that body dissatisfaction should motivate individuals to exercise, it is consistent with previous literature (e.g., Neumark-Sztainer, Paxton, Hannan, Haines, & Story, 2006) and suggests that individuals with higher levels of body dissatisfaction avoid exercise. Individuals with higher levels of body dissatisfaction may avoid exercise because they may feel anxious about their bodies being judged by others while they are exercising.

4.1 | Strengths and limitations

There are limitations to this study. First, we examined eating disorder symptoms in a nonclinical sample; therefore, it is unclear whether these findings would extend to clinical samples with diagnosable eating disorders. Future research should test whether these findings replicate in a clinical sample. Second, we used self-report measures, which have inherent limitations. However, by using EMA, some of the retrospective bias associated with self-report was limited, especially with regard

to stress and exercise. A third limitation is that we measured exercise through one self-report question asking about length of exercise since the last check-in. We did not measure type of exercise (e.g., aerobic vs. strength), the intensity of the exercise (e.g., moderate vs. vigorous), the motivation behind the exercise, and we did not use accelerometers. Future studies should use accelerometers and should examine if differences in exercise intensity, mode, and quality at least partially account for our findings. It is possible that the relationships in this study might vary depending on the type of exercise that individuals engage in. Previous research suggests that exercise quality but not quantity is robustly associated with eating disorders psychopathology (e.g., Mond et al., 2004). Fourth, we asked about exercise behavior and stress only four times per day, which is less frequent than other EMA protocols in the field (e.g., Haynos et al., 2015). It is possible that the study had too few assessments to reliably capture the momentary relationship between stress and exercise. In addition, we did not prompt individuals to answer questions about stress immediately before, during, and after an exercise session. Fifth, we did not assess all eating disorder symptoms (e.g., restrained eating). Future studies should investigate whether there are unique relationships between specific eating disorder symptoms, stress, and exercise. Sixth, we did not differentiate among the different types of stress (e.g., environmental stress, psychophysiological stress). Higher chronic stress in individuals with higher levels of eating disorder symptoms may be a potential confounding variable in this study, washing out any potential relationships that might exist between stress and exercise behavior in these individuals. Seventh, the sample comprised only undergraduate women. For balancing feasibility and power, we chose to exclude men. Ultimately, this decision was made to increase power for the entire study, as any tests of gender differences would have been required, but underpowered (given the higher prevalence of disordered eating in women [Hudson, Hiripi, Pope, & Kessler, 2007]). However, our exclusion of men is a limitation of the study. Future investigations should examine these relationships in other genders and individuals of other ages. Finally, the compliance rate in this study was not as high as some other EMA studies with eating disorder samples (e.g., Engel et al., 2013), which may have affected the quality or comprehensiveness of the data.

Despite these limitations, the strengths of this study should also be acknowledged. The use of EMA in this study is a major strength, as it allows for (1) the establishment of temporal precedence of stress and exercise behavior in a relatively short-time frame and for (2) the measurement of eating disorder symptoms, exercise, and stress in daily life. Second, we examined within-person associations, which provide more insight into the direction of these processes in daily life. In addition, this is the first study using EMA that investigates the relationships between specific eating disorder symptoms, stress, and exercise. The use of specific types of eating disorder symptoms in this study may help with the better understanding of the relationship between exercise and stress in order to create more targeted interventions.

4.2 | Potential implications and future research

These data suggest that exercise does not appear to function as a stress regulation tool for individuals with higher levels of eating disorder symptoms. It may be that individuals who are higher in eating disorder symptoms may find that other eating disorder behaviors (e.g., binge eating, dieting) are a more efficient (at least temporarily) and rapid way to decrease stress than exercise. Another possibility is that individuals with elevated eating disorder symptoms exercise out of habit (e.g., Steinglass & Walsh, 2006) rather than immediate stress regulation purposes. Of course, these possibilities need be tested further in future research. In addition, future research should explore if these findings have clinical implications.

5 | CONCLUSIONS

In summary, we found that eating disorder symptoms moderated the relationship between stress and later exercise, such that only individuals with lower levels of eating disorder symptoms exercised when stressed. This is the first study to study these relationships using EMA. This study highlights the importance of understanding the relationship between exercise, eating disorder symptoms, and stress in order to better understand how exercise may be able to function as a therapeutic intervention for eating disorders.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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