An ecological momentary assessment of the effect of fasting during Ramadan on disordered eating behaviors

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ARTICLE INFO

ABSTRACT

Dietary restriction contributes to disordered eating (DE) behaviors and associated cognitions. However, it is unclear how these outcomes are impacted by dietary restriction for religious purposes, such as fasting observed by Muslims during Ramadan. Using ecological momentary assessment, this study assessed the impact of Ramadan fasting on DE behaviors and correlates. Muslim participants fasting during Ramadan ($n = 28$) and a control group of non-fasting participants ($n = 74$) completed baseline measures assessing demographic characteristics and eating pathology. A mobile phone application then prompted participants six times per day for seven days to self-report on dietary restriction efforts, body satisfaction, temptation to eat unhealthily, feelings of guilt or shame following food, and DE behaviors including bingeing, vomiting, and other purging behaviors (use of laxatives, diuretics, or diet pills). After controlling for eating pathology, multilevel modeling indicated that, as expected, the Ramadan fasting group spent significantly more time restricting food intake than the non-fasting group. The Ramadan fasting group also experienced significantly greater temptation to eat unhealthily than their non-fasting counterparts. However, this difference disappeared once models were adjusted for differences in time spent restricting food intake. There were no other significant differences between the groups on any DE variables. These findings suggest that while dietary restriction for health or appearance-related reasons is a known contributor to DE, dietary restriction for religious purposes, such as that observed during the practice of Ramadan, may not confer increased risk of DE symptoms.

1. Introduction

Dietary restriction refers to effortful attempts to limit the type and amount of food one consumes (Wadden, Brownell, & Foster, 2002). According to the dietary restraint model, dietary restriction promotes disinhibited eating behaviors such as binge eating due to a temporary disruption of cognitive control and as a physiological response to counteract the body's calorific deficit (Polivy & Herman, 1985; Stice, 2001). In line with this, engagement in dietary restriction practices have been shown to contribute to disordered eating (DE) behaviors, including purging (Woods, Racine, & Klump, 2010) and binge eating (Dakanalis et al., 2014; Puccio, Kalathas, Fuller-Tyszkiewicz, & Krug,

2016) as well as related cognitions, such as increased temptation to eat unhealthy food (Moreno-Domínguez, Rodríguez-Ruiz, Fernández-Santaella, Ortega-Roldán, & Cepeda-Benito, 2012). In addition to health-related reasons for dieting (i.e., managing weight status to improve health), many cases of dietary restraint are driven by appearance-related concerns and the desire to attain a socially prescribed physique (Rodgers, Paxton, & McLean, 2014; Stice, 2001; Vartanian & Hopkinson, 2010). To date, much less attention has been given to religious reasons for engaging in dietary restriction and the consequences of such practices on eating behaviors. We sought to address this gap by exploring – in daily life – the dietary patterns of Muslims fasting during Ramadan.

1.1. Dietary restriction and disordered eating behaviors

Dietary restriction is considered to be a significant risk factor in the development and maintenance of DE behaviors and associated cognitions (Allen, Byrne, & McLean, 2012; Johnson & Wardle, 2005; Puccio et al., 2016; Salafia & Gondoli, 2010; Stice, Davis, Miller, & Marti, 2008; Woods et al., 2010), which if left untreated, may develop into full threshold eating disorders (Schaumberg & Anderson, 2016). Restricting caloric intake to levels below energy requirements through fasting, skipping meals, or reducing portion sizes (De Young et al., 2014) is commonly used to control body weight (Schaumberg & Anderson, 2016). Indeed, it is estimated that up to 50% of young adults engage in dieting behaviors (Field, Haines, Rosner, & Willett, 2010).

Sustained restriction efforts may have both physiological and psychological influences on eating behaviors. Physiologically, severe restriction of energy intake may produce an energy deficit, which encourages overeating in order to restore balance (Berg et al., 2009; Hajek, Myers, Dhanji, West, & McRobbie, 2012). Psychologically, self-deprivation of amount or type of foods has been shown to increase food cravings (Fedoroff, Polivy, & Herman, 2003; Polivy, Coleman, & Herman, 2005), as well as reinforce cognitions often associated with dieting, such as an obsessive drive to be thin, intense fear of weight gain, or distorted body image (Walsh, 2013; Zunker et al., 2011). For individuals who engage in such restrictive behaviors, successful weight loss may also increase feelings of self-control, self-esteem and body satisfaction (Brockmeyer et al., 2013; Walsh, 2013), further reinforcing dieting behaviors and their DE sequelae.

Traditionally, the effects of dieting on eating behaviors and cognitions have been examined in lab-based experimental studies (e.g., Benau, Orloff, Janke, Serpell, & Timko, 2014; Nijs, Muris, Euser, & Franken, 2010). Although these studies are able to control for various confounds to isolate the consequences of dieting, such rigorous control may come at a cost, as it is often infeasible to follow-up participants beyond a single lab session or to test frequency of these behaviors and associations for an individual. Moreover, the ways that restraint is operationalized in laboratory studies may not accord with dieting behavior in everyday life (Tomiyama, Mann, & Comer, 2009).

More recent efforts have been made to study dietary restriction in daily life using ecological momentary assessment methods (EMA; also referred to as the experience sampling method). EMA involves repeated in-the-moment (e.g., "How hungry are you *right now*?") or near-the-moment assessments (e.g., "Have you engaged in a binge episode in the past 30 min?") of target emotions or behaviors for extended periods of time (e.g., 5–10 assessments per day for a period of 1–2 weeks). These studies confirm food restriction efforts as an antecedent to binge-eating, food craving, and desire to binge for both clinical and non-clinical populations (Engelberg, Gauvin, & Steiger, 2005; Grange, Gorin, Catley, & Stone, 2001; Holmes, Fuller-Tyszkiewicz, Skouteris, & Broadbent, 2014a; Sherry & Hall, 2009; Zunker et al., 2011), and also suggest that chronicity of dieting efforts increases the likelihood of a binge episode (Holmes et al., 2014a). Several of these studies have demonstrated that the frequency of dieting and strength of association to DE symptoms are related to individual difference factors (Holmes, Fuller-Tyszkiewicz, Skouteris, & Broadbent, 2014b; Steiger, Lehoux, & Gauvin, 1999). For example, trait level negative body image has been shown to partially account for individual differences in daily experiences of restraint and DE (Freeman & Gil, 2004; Holmes et al., 2014b). However, far less is known about the impact of dietary restriction for religious purposes on state-level DE behaviors in daily life.

1.2. Ramadan fasting and changes in eating behaviors

The practice of fasting during Ramadan is a religiously motivated occurrence of dietary restriction among Muslims from dawn to sunset during the ninth month of the Islamic calendar each year (Bakhotmah, 2011). As the Islamic calendar is based on the lunar cycle, the dates of Ramadan vary annually (Sadeghirad, Motaghipisheh, Kolahdooz, Zahedi, & Haghdoost, 2014) and the duration of fasting may also vary in different regions of the world depending on geographical location and season (Akgul, Derman, & Kanbur, 2014).

During Ramadan, Muslims who fast usually eat two meals per day: a lighter meal before dawn and a heavier meal after sunset (Toda & Morimoto, 2004). As such, there are some potential differences in the manner of restriction efforts of Muslims during Ramadan versus individuals restricting food intake for health or appearance-related reasons. Whereas those dieting for health or appearance-related reasons may attempt restriction of certain types or amount of food for undefined or indefinite time periods, Muslims fasting during Ramadan only prohibit intake of any food or water/fluids between dawn and sunset each day. This form of dieting may increase the likelihood of food over-consumption during periods where consumption is permissible (e.g., pre-dawn and post-sunset) (Hajek et al., 2012). Indeed, as the goal of fasting Muslims is to completely restrict food and fluid intake during the day, food consumption before dawn or after sunset may be seen as a reward for abstinence during the day, rather than as a guilty or shameful counter-regulatory act against one's dieting goals. The permissibility of large meals may also encourage overeating during these times as a strategy to offset anticipated lack of food during coming restriction periods (Akgul et al., 2014; Hajek et al., 2012).

Whether these differences in motives and timing of dietary restraint manifest in different quantities or patterns of restraint and DE remains unclear. Although a meta-analysis by Sadeghirad et al. (2014) found slight yet significant weight loss during Ramadan ($M = 1.24$ kg) across 35 studies, the few studies that have evaluated the effects of Ramadan on DE symptoms have found little evidence of a link (e.g., Akgul et al., 2014; Erol, Baylan, & Yazici, 2008; Savas, Ozturk, Tanriverdi, & Kepekci, 2014). For instance, Savas et al. (2014) followed a sample of 34 obese women before and after Ramadan, and found no significant differences in self-reported eating behavior across the two time-points. Similarly, Erol et al. (2008) found no significant changes in DE symptomatology from pre-to post-Ramadan for adolescent boys and girls. While a significant worsening of DE symptom severity was observed for girls for one of the two DE indices used (the Bulimic Investigatory Test, Edinburgh; Henderson & Freeman, 1987), the average increase in severity on this measure was far below clinically meaningful levels.

Although the findings from Savas et al. (2014) and Erol et al. (2008) suggest that Ramadan may have negligible effects on DE, it is important to note that the measures used in these studies comprised a broad range of symptoms, with focus on multiple behavioral and attitudinal components of both appearance and food related constructs. As such, this approach is insensitive to change at the symptom-level. For example, it is possible that increases in binge eating occur without coinciding increases in guilt or shame for overeating, overvaluation of appearance, or desire to lose weight (Jambekar, Masheb, & Grilo, 2003). Moreover, DE symptoms in these studies were examined only prior to and following Ramadan, rather than repeatedly during the period of Ramadan itself. A comparison of participants fasting during Ramadan against a general population of individuals (including those restricting for health or appearance-related reasons) not engaging in Ramadan fasting would help to further determine whether patterns of restraint and DE are meaningfully different during Ramadan.

1.3. The current study

Using EMA, the current study aimed to assess the impact of Ramadan fasting on a range of DE behaviors and correlates, which were operationalized using the following variables: dietary restraint, body satisfaction, temptation to eat unhealthy food, feelings of guilt and shame following food consumption, binge eating, vomiting, and other

purging behaviors (use of laxatives, diuretics, and diet pills). Participants who were fasting during Ramadan in 2015 (18 June to 17 July) or 2016 (6 June to 5 July) were compared to a control group of non-fasting participants. Group differences in the daily experience of these DE variables were evaluated while controlling for potential group differences at baseline in trait-level eating pathology.

Based on the aforementioned literature, we predicted that the Ramadan fasting group would spend a greater amount of time in dietary restriction than the non-fasting group and would therefore report: (i) greater temptation to eat unhealthy foods, and (ii) more frequent engagement in binge eating as these are the natural consequences of restriction. As the primary motivation for fasting for the Ramadan fasting group was religious reasons primarily rather than appearance- or dieting-related reasons, it was also hypothesized that the Ramadan fasting group would: (iii) show no differences from the control group in body satisfaction; (iv) report less frequent engagement in vomiting and other purging behaviors; and (v) report lower guilt or shame following food consumption.

2. Material and methods

2.1. Participants

Participants were recruited from the research participation program at a university in Melbourne, and from the general public through collaborating academics and various Islamic societies in Victoria, Australia. A total of 129 participants took part in the study. Based on previous EMA studies, seven participants who completed less than three EMA surveys were excluded from analyses (Hox, Moerbeek, & van de Schoot, 2010). The remaining 122 participants (94 females) included 28 Muslim participants (14 females) who were fasting during the Ramadan periods of 18 June to 17 July 2015 or 6 June to 5 July 2016, and 94 participants (80 females) of various religious backgrounds who were not fasting for any reason. Control group participants were recruited between June 2015 and July 2016. This sample exceeded the recommended size of 50 individuals with three observations each required for adequate power to detect cross-level interactions (Maas & Hox, 2005). Participants recruited through the university received course credit for participation, while participants from the general public were entered into a draw to win one of three $100 gift cards. Ethical approval was obtained for the study from a university in Melbourne.

2.2. Procedure

Participants who took part in the study in 2015 were required to own an iPhone with iOS8 (or newer) operating system, while those who took part in 2016 could access an updated version of the EMA mobile phone application using either an Android version 4.0 (or newer) phone or an iPhone (Instant Survey; Richardson, 2016). Following online informed consent, participants completed a baseline questionnaire followed by a seven day EMA phase. On the day after baseline, the application began signaling six times per day, buzzing briefly at random intervals between 8am and 11pm for seven days, resulting in a maximum of 42 assessments per participant over the seven-day period. The signals alerted participants to complete a short survey on the application, which would remain accessible for 30 min. If the survey was not completed during this time, the time point was counted as missing. A sampling period of seven days with six assessments a day served to reduce participants' response burden yet still attain ecologically valid information by minimizing the influence of atypical responses and/or extraneous influences (Beal & Weiss, 2003). This choice of sampling period has been commonly used in related EMA studies (Colautti et al., 2011; Mills, Fuller-Tyszkiewicz, & Holmes, 2014).

3. Measures

3.1. Baseline: trait measures

3.1.1. Demographics

The baseline questionnaire obtained information regarding age, gender, nationality, current city, ethnicity, religion, first language, marital status, highest level of education completed, current employment status, current height and weight, and whether the participant was, at the point of the study, fasting during Ramadan or fasting for any other reasons. Body Mass Index (BMI) was calculated based on current height and weight.

3.1.2. Eating pathology

Eating pathology, included in the study as a control variable, was assessed using the *Eating Attitudes Test* (EAT-26; Garner, Olmsted, Bohr, & Garfinkel, 1982). The EAT-26 consists of 26 items and is made up of three subscales – dieting, bulimia and food preoccupation, and oral control. Items were rated on a 6-point scale from 0 (*never*) to 5 (*always*). Higher scores on the EAT-26 indicate greater levels of eating pathology, with scores of 20 or above indicating a high level of risk for problematic eating behavior. In the present study, the total EAT-26 score was used and achieved a good internal consistency of 0.92.

3.2. EMA: state measures

3.2.1. Body satisfaction

Participants reported their response to the question, "*Right now, how satisfied are you with your physical appearance?*" on an 11-point Likert scale from 0 (*extremely dissatisfied*) to 10 (*extremely satisfied*). This single item approach is consistent with several prior investigations of body satisfaction (e.g., Pomerleau & Saules, 2007; Rogers, Fuller-Tyszkiewicz, Lewis, Krug, & Richardson, 2017; Sonneville et al., 2012) and has established criterion validity in these studies.

3.2.2. Disordered eating behaviors and cognitions

Several study-specific items were used to probe restriction efforts and other DE constructs. Dietary restraint was assessed by asking participants the questions, "*How many hours has it been since you last had a full meal?*" and "*How many hours has it been since you last had a snack?*" using a 24-hr continuous scale. Results revealed similar findings for both items. Since the focus on Ramadan fasting is related to full food restriction and not snacking (Al-Hourani & Atoum, 2007), we decided to only include the "*full meal*" item in the subsequent analyses.

Temptation to eat unhealthy food was addressed by answering the question, "*How tempted are you at the moment to eat unhealthy food that you otherwise wouldn't?*" using an 11-point continuous scale (0 = *not at all* to 10 = *extremely*).

Participants were also asked to indicate 'yes' or 'no' to the following questions to assess: (1) binge eating behavior, "*Referring to the last time you ate something, have you engaged in binge eating, that is, eating a large amount of food relative to what others would eat in the same situation and feelings of loss of control while eating?*"; (2) vomiting, "*Referring to the last time you ate something, did you engage in vomiting to control your weight or shape?*"; and (3) other purging behaviors, "*Referring to the last time you ate something, did you use laxatives, diuretics and/or diet pills to control weight?*" This approach is consistent with other studies assessing DE behaviors using EMA (e.g., Drutschinin, Fuller-Tyszkiewicz, De Paoli, Lewis, & Krug, 2017).

Finally, participants also responded to a question measuring feelings of guilt or shame following food consumption: "*Referring to the last time you ate something, how much guilt and shame did you feel after eating?*". Response options ranged from 0 (*none*) to 10 (*a great deal*). Overall, the complete EMA survey took less than two minutes to complete per occasion.

3.3. Data analytical strategy

A multilevel modeling (MLM) framework was adopted to handle non-independence of data arising from repeated assessment in the EMA phase of this study. For dichotomous outcomes (binge eating, vomiting, and other purging behaviors), multilevel binary logistic regression with Bernoulli distribution was undertaken. For the remaining continuous outcome variables (temptation to eat unhealthy food, dietary restraint, body satisfaction, and guilt/shame after eating), multi-level regression with a Gaussian distribution was used. In both types of models, the intercept was allowed to vary across individuals, and this variation was regressed onto group (Ramadan fasting vs non-fasting, with Ramadan fasting coded as 1 and non-fasting as 0), gender (male = 0, female = 1), age, BMI, and eating pathology. Given the expectation of group differences in duration of dietary restraint efforts, and the link between restraint and other DE variables in this study, these MLMs were run twice; once without adjustment for dietary restraint, and once adjusting results for dietary restraint. Level 2 predictors (i.e., trait measures collected at baseline) were grand-mean centered (Enders & Tofighi, 2007) and alpha was set at 0.05. All analyses were conducted using Mplus version 7.1 (Muthén & Muthén, 1998-2015).

4. Results

4.1. Preliminary analyses

Table 1 provides details on the demographic characteristics of the sample. There were significant differences between the Ramadan fasting and non-fasting groups on most of the demographic variables, which may be because the non-fasting group largely comprised individuals who had not yet completed a university degree (i.e., they were first year undergraduate students) and were mostly younger, Caucasian, and female, while the Ramadan fasting group was largely

Table 2
Descriptive statistics for Level-1 and Level-2 variables.

Level	Variable	M	Fasting (n = 28)			M	Non-fasting (n = 94)		
			SD	Range	ICC		SD	Range	ICC
Level-1	Body satisfaction	5.20	1.68	0–10	.75	5.23	1.61	0–10	.72
	Binge eating[c]	0.08	0.19	0–1	.56	0.07	0.18	0–1	.51
	Vomiting[c]	0.04	0.12	0–1	.49	0.05	0.16	0–1	.60
	Guilt/Shame	2.35	2.09	0–10	.60	2.25	2.13	0–10	.57
	Other purging behaviors[c]	0.18	0.15	0–1	.18	0.18	0.19	0–1	.26
	Temptation to eat unhealthy	2.17	1.53	0–10	.32	2.18	1.42	0–10	.29
Level-2	EAT-26	7.50	7.46		n/a	12.26	9.46		n/a

Note. Level-1 variables are state measures, whereas the Level-2 variable is a trait measure. n/a = not applicable. EAT-26 = Eating Attitudes Test, ICC = intra-class correlation. [c] categorical variables; for categorical variables, M corresponds to the frequency of engagement in the behavior and ranges from 0 to 1.

recruited from the general public. Importantly, there was no significant difference between the groups in BMI.

4.2. Multilevel models

The average number of EMA surveys completed per participant was 23.60 (SD = 11.96) out of 42 possible assessments (56.2%).

Table 2 presents the means, standard deviations, and possible range of scores for the Level 1 variables collected during the EMA phase (body satisfaction, temptation to eat unhealthy, guilt/shame, dietary restraint, binge eating, vomiting, other purging behaviors) and Level 2 variable collected at baseline (eating pathology).

Table 1
Demographic characteristics of the sample.

Demographic variable	Statistics				
	Ramadan fasting (n = 28)	Non-fasting (n = 94)	Total (N = 122)	t/X	p
Age (M ± SD)	25.54 ± 5.59	19.87 ± 3.65	21.17 ± 4.79	−6.32	< .001
BMI (M ± SD)	22.36 ± 3.68	21.39 ± 2.99	21.61 ± 3.17	−1.42	.16
Gender (%)				15.04	< .001
Male	50.0	14.9	23.0		
Female	50.0	85.1	77.0		
Ethnicity (%)				22.61	.001
Caucasian	10.7	51.1	41.8		
Asian	32.1	28.7	29.5		
Others	57.1	20.2	28.7		
Religion (%)				90.33	< .001
Christianity	0	39.4	30.3		
Islam	100	7.4	28.7		
No religion	0	20.2	15.6		
Others	0	33	25.5		
Highest education completed (%)				39.03	< .001
Year 12 or below	25.0	80.9	68.1		
Certificate/Diploma	10.7	7.5	8.2		
Bachelor	32.1	8.5	13.9		
Postgraduate	32.1	3.2	9.8		
Employment status (%)				17.56	.002
Employed	28.6	46.8	42.7		
Unemployed	3.6	2.1	2.5		
Student	67.9	51.1	54.9		
Relationship status (%)				8.04	.045
Single	82.1	94.7	91.8		
Married	17.9	3.2	6.6		
Divorced	0	1.1	0.8		
Separated	0	1.1	0.8		

Note. BMI = Body Mass Index (kg/m^2). Significant p values are bolded. All p values are two-tailed.

Table 3
Multilevel Modeling Results for Behavioral Outcomes (without adjusting for restraint).

Predictors	Dietary restraint			Binge eating			Vomiting			Other purging behaviors		
	b	se	p	b	se	p	b	se	p	b	se	p
Group	3.23	0.86	**< .001**	0.39	0.99	.691	−1.50	1.00	.133	0.03	0.45	.939
Gender	1.65	0.67	**.015**	−0.77	1.15	.502	−2.23	0.82	**.006**	0.18	0.37	.617
Age	0.07	0.07	.285	−0.10	0.11	.331	−0.05	0.08	.483	0.01	0.04	.786
BMI	0.07	0.09	.458	−0.08	0.12	.469	−0.22	0.11	**.049**	−0.02	0.05	.683
EAT-26	0.03	0.03	.296	0.05	0.04	.189	0.06	0.04	.151	0.03	0.02	.153

Notes. b = unstandardized coefficients, BMI = Body Mass Index, EAT-26 = Eating Attitudes Test, *se* = standard error. Significant *p* values are bolded. All *p* values are two-tailed.

Table 4
Multilevel Modeling Results for Cognitive Outcomes (unadjusted for restraint).

Predictors	Body Satisfaction			Temptation to eat unhealthy food			Guilt/shame		
	b	se	p	b	se	p	b	se	p
Group	−0.17	0.45	.710	1.06	0.42	**.013**	0.23	0.38	.544
Gender	−0.91	0.41	**.026**	0.42	0.32	.185	0.99	0.35	**.005**
Age	0.06	0.04	.197	−0.07	0.03	**.045**	−0.09	0.03	**.006**
BMI	−0.11	0.05	**.017**	0.07	0.05	.173	0.13	0.06	**.042**
EAT-26	−0.06	0.02	**.001**	0.04	0.02	**.011**	0.11	0.02	**< .001**

Notes. b = unstandardized coefficients, BMI = Body Mass Index, EAT-26 = Eating Attitudes Test, *se* = standard error. Significant *p* values are bolded. All *p* values are two-tailed.

Models without adjusting for dietary restraint. As demonstrated in Table 3 (behavioral DE outcomes) and 4 (cognitive DE outcomes), MLM analyses of the EMA data unadjusted for hours spent restricting food intake showed that those in the Ramadan fasting group reported a significantly longer duration of food restriction, and significantly increased temptation to eat unhealthy food than the non-fasting group. Although not central to the research question, a number of other significant relationships were found, including that compared to males, females were significantly more likely to engage in dietary restriction, less likely to engage in vomiting behavior, less likely to experience body satisfaction and more likely to feel guilt or shame following food consumption. In addition, people with higher BMI had lower body satisfaction, were less likely to engage in vomiting behavior, and more likely to have guilt following food consumption than people with lower BMI, and older people were less likely to experience temptation to eat unhealthy food or feel guilt or shame following food consumption than people of a younger age. Finally, higher scores on the EAT-26 were significantly associated with lower body satisfaction, greater temptation to eat unhealthy food and increased guilt or shame following food consumption.

Models adjusting for restraint. Once models were adjusted for individual differences in food restriction efforts, there were no significant differences on any of the behavioral DE outcomes (see Table 5) or cognitive DE outcomes (see Table 6) between the Ramadan fasting and non-fasting groups. All other significant relationships found in the unadjusted models remained significant in the adjusted models.

5. Discussion

This study examined the impact of Ramadan fasting on a range of DE behaviors and correlates. Overall, findings suggested that the DE symptoms that may be directly attributable to the practice of Ramadan are limited. As expected, those observing Ramadan tended to report longer hours of continuous food restriction. The Ramadan fasting group was also marginally more likely to report a greater temptation to eat unhealthy foods relative to the control group, although this difference disappeared once the models controlled for differences in time spent restricting food intake. This suggests that there may be a flow-on effect from the extended fasting during Ramadan. Despite the desire to eat unhealthily, those in the Ramadan fasting group were no more likely to engage in binge eating than their non-fasting counterparts, nor did they exhibit elevated patterns of cognition and behaviors commonly associated with DE, such as negative feelings towards one's appearance (reduced body satisfaction) or relationship to food (e.g., guilt/shame associated with food consumption), or vomiting or other purging behaviors (e.g., laxative, diuretic and diet pill use).

A notable strength of this study was the use of EMA to evaluate DE patterns in real time during Ramadan. These factors have traditionally been studied using retrospective self-report measures (Al-Hourani & Atoum, 2007; Poh, Zawiah, Ismail, & Henry, 1996), which are unable to capture moment-to-moment changes in eating behaviors and may be subject to memory limitations (Engel et al., 2016). By collecting data in

Table 5
Multilevel Modeling Results for Behavioral Outcomes (adjusting for restraint).

Predictors	Binge eating			Vomiting			Other purging behaviors		
	b	se	p	b	se	p	b	se	p
Group	0.23	0.99	.815	−1.85	0.96	.053	−0.45	0.47	.340
Gender	−0.89	1.14	.435	−2.44	0.83	**.003**	−0.06	0.37	.879
Age	−0.11	0.11	.280	−0.06	0.08	.425	0.01	0.05	.874
BMI	−0.08	0.12	.464	−0.22	0.11	**.046**	−0.03	0.06	.558
EAT-26	0.05	0.04	.207	0.06	0.04	.161	0.02	0.02	.225
Dietary restraint	0.07	0.02	**< .001**	0.12	0.03	**< .001**	0.13	0.02	**< .001**

Notes. b = unstandardized coefficients, BMI = Body Mass Index, EAT-26 = Eating Attitudes Test, *se* = standard error. Significant *p* values are bolded. All *p* values are two-tailed.

Table 6
Multilevel Modeling Results for Cognitive Outcomes (adjusted for restraint).

Predictors	Body Satisfaction			Temptation to eat unhealthy food			Guilt/shame		
	b	se	p	b	se	p	b	se	p
Group	− 0.15	0.45	.734	0.74	0.44	.090	0.12	0.38	.745
Gender	− 0.93	0.41	**.025**	0.27	0.34	.434	0.94	0.35	**.008**
Age	0.06	0.04	.197	− 0.08	0.04	**.034**	− 0.10	0.03	**.005**
BMI	− 0.11	0.05	**.018**	0.06	0.05	.236	0.12	0.06	**.045**
EAT-26	− 0.06	0.02	**.001**	0.04	0.02	**.017**	0.11	0.02	**< .001**
Dietary restraint	0.00	0.01	.697	0.10	0.02	**< .001**	0.03	0.01	**.006**

Notes. b = unstandardized coefficients, BMI = Body Mass Index, EAT-26 = Eating Attitudes Test, se = standard error. Significant p values are bolded. All p values are two-tailed.

participants' natural environment, EMA provides greater ecological validity (Engel et al., 2016), which may allow a more accurate understanding of the potential impact of Ramadan fasting on changes in eating patterns.

The findings of this study suggest against the possibility that dietary restriction during Ramadan fasting confers increased risk of DE symptoms. This is inconsistent with the dietary restraint model, which proposes that dietary restriction promotes disinhibited eating (Polivy & Herman, 1985). Rather, the findings suggest that dietary restriction for religious reasons does not impact eating behavior. This builds upon findings by Sadeghirad et al. (2014), whose review reported small, transient changes in weight because of Ramadan. The observed greater levels of restraint (relative to a non-clinical, non-Ramadan fasting group) in the absence of coinciding increases in bingeing and purging may be attributable to motives for food restriction (religious versus appearance- or health-related). It may be that those engaging in food restriction for religious reasons do not have the same concerns about food consumption, and this may prevent cognitive biases towards and temptation for prohibited foods, as well as counter-regulatory effects once they commence eating after periods of restriction. Alternatively, the permissibility of eating as one wishes pre-dawn and post-sunset may sustain the individual in their restraint efforts, by providing sufficient energy intake in these consumption periods to prevent physiological need to restore an energy deficit. Direct testing of these possibilities would help to identify potential mechanisms that may account for the pattern of findings observed in the present study.

It is important to interpret the findings of this study in the context of design choices and limitations. The present study sought to compare those engaging in Ramadan fasting against a general population sample rather than comparing against an eating disorder population. While many of the study variables are common among, and hence suitable for study within the general population, behaviors such as binging, vomiting and other purging behaviors (e.g. laxatives, diuretics and diet pill use) are less common, and findings should therefore be interpreted cautiously. Given that these study variables should be more severe for individuals with an eating disorder (Edler, Haedt, & Keel, 2007), it is tempting to extrapolate from the null differences between the Ramadan fasting and non-fasting groups in the present study that these behaviors and cognitions (with the possible exception of dietary restraint) may be less extreme for those observing Ramadan than for individuals with an eating disorder. However, future research is needed to confirm this. This further work could also evaluate these behaviors and cognitions over a longer timeframe to allow for evaluation of change in DE pre-, during, and post-Ramadan. Another potential limitation was the compliance rate in the EMA phase, which was in the lower range for EMA studies (e.g., Kukk & Akkermann, 2017; Levinson et al., 2018; Sala, Brosof, Rosenfield, Fernandez, & Levinson, 2017; Smyth et al., 2001). However, signal contingent procedures that signal multiple times per day have been reported to have the lowest compliance rates among EMA designs due to the unpredictability of signals and the burden placed on participants to stop what they were doing to respond

(Christensen, Barrett, Bliss-Moreau, Lebo, & Kaschub, 2003). Future studies could encourage higher compliance through maintaining regular contact with participants during the EMA phase to provide prompts and support and by providing incentives for survey completion (Christensen et al., 2003; Zunker et al., 2011). Finally, although consistent with methods used in prior EMA studies examining DE behaviors (e.g., Drutschinin et al., 2017) the use of a single, dichotomous item as a measure for most of the DE items may not have accurately captured the intended eating behavior. This may have accounted for the overall low frequency of some behaviors reported in the study, such as binge eating. Future studies could consider including items assessing the actual quantity of food consumed or multiple behavioral items so as to assess for the presence, severity, and frequency of the DE variables assessed.

6. Conclusions

This study extends previous findings on the effects of Ramadan fasting on DE and its correlates, through the use of EMA. It was found that, compared to individuals not undergoing religious fasting, those participating in Ramadan reported longer periods of food restriction, and that greater restriction was related to greater temptation to eat unhealthy foods. Despite this, these periods of food restriction did not correspond with increased engagement in DE behaviors (binge eating, vomiting, and other purging behaviors) or commonly co-occurring cognitions, such as lower body satisfaction and feelings of guilt and shame following food consumption. These findings have important implications in extending current understanding of the dietary restraint model by suggesting that, in contrast to fasting for health or appearance-related reasons, fasting during the observance of Ramadan does not appear to confer any increased risk of DE symptoms.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.appet.2018.04.017.

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