

# *Chronotype, binge-eating, and depression: the mediating effect of skipping breakfast*

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Rola al Balushi & Richard Carciofo

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# Chronotype, binge-eating, and depression: the mediating effect of skipping breakfast

Rola al Balushi and Richard Carciofo 

School of Psychology and Clinical Language Sciences, University of Reading, Reading, UK

## ABSTRACT

Evening chronotype is associated with more frequent binge-eating, depression, and less frequent breakfast consumption. The current study investigated whether skipping breakfast mediates the relationships between chronotype and binge-eating, and chronotype and depression. 272 participants completed an online survey with questionnaire measures of chronotype/morningness-eveningness, binge-eating, depression, and meal skipping. Significant positive correlations were found between eveningness and skipping breakfast, eveningness and depression, skipping breakfast and depression, and skipping breakfast and binge-eating. Eveningness was also correlated with binge-eating, and although this was not statistically significant, mediation analysis revealed a significant indirect effect of eveningness on binge-eating through skipping breakfast. The indirect effect of eveningness on depression through skipping breakfast was not significant, but the indirect effect sequentially through breakfast skipping and binge-eating was significant. The current findings indicate potential mechanisms for the inter-relationships between eveningness, breakfast skipping, binge-eating, and depression, which may be more fully investigated in research utilising longitudinal designs.

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Chronotype;  
morningness-eveningness;  
binge-eating; depression;  
meal skipping

## Introduction

Humans exhibit circadian rhythms, including those for body temperature, the secretion of melatonin, and the sleep-wake cycle (Adan et al. 2012; Çalıyurt 2017). The synchronization of the circadian clock occurs in the suprachiasmatic nucleus (Hofstra and de Weerd 2008), which operates as a circadian pacemaker and is regulated by external cues/zeitgebers, with the light-dark cycle being the most influential zeitgeber (Fabbian et al. 2016). Other external cues include meal timings, physical exercise, and social interactions. Circadian rhythm disruption impacts mental and biological processes, which subsequently increase the risk of developing related disorders (Çalıyurt 2017).

Individual differences in the expression of circadian rhythms are related to an individual's chronotype or circadian typology (Montaruli et al. 2017). Morning chronotypes are characterized by an early sleep and wake cycle, with peak mental and physical

**CONTACT** Richard Carciofo  [r.g.carciofo@reading.ac.uk](mailto:r.g.carciofo@reading.ac.uk)  School of Psychology and Clinical Language Sciences, University of Reading, Reading RG6 6AH, UK

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performance earlier in the day, whereas those with an evening chronotype prefer to sleep and awaken at later times, and peak later in the day. Approximately 40% of the general adult population are classified as morning-type or evening-type, with the remainder having no preference (Montaruli et al. 2017).

A relationship between eveningness and symptoms of depression has been reported in several cross-sectional studies (Chan et al. 2014; Merikanto et al. 2015; Chiu et al. 2017), while a longitudinal study demonstrated the reciprocal interplay between depression and chronotype: depression predicted a greater preference for eveningness among adolescents, while eveningness predicted later depression, thus highlighting the bidirectional relationship between mood and circadian rhythms (Haraden et al. 2017). A disruption in the circadian rhythm causes a disturbance in the pattern of norepinephrine and cortisol regulation which has been shown to contribute to the development of depression (Moret and Briley 2011). Also, poor sleep mediates between eveningness and depression (Bakotic et al. 2017; Zhou et al. 2020). However, compared with eveningness-preference, experiencing less “morning affect” (ease/time required to fully awaken/extent of sleep inertia; Carciofo 2023) may be more strongly associated with depression (Jankowski 2016; Putilov 2018), seasonal changes in mood (Jankowski 2017), and with suicidality (Nowakowska-Domagala et al. 2023), although associations with morning affect may vary for different aspects of affective functioning (Chrobak et al. 2018). Furthermore, morning affect is more strongly associated with emotional eating than is circadian (i.e. time-of-day) preference (Konttinen et al. 2014).

There has been increasing research on chrononutrition, i.e. the influence of chronotype on eating behaviours and dietary patterns (Mazri et al. 2019), which has revealed associations between eveningness and unhealthy eating habits among people of all ages (Beşoluk 2018; Phoi et al. 2021; Rodríguez-Cortés et al. 2022). Evening-types may experience “social jetlag”, i.e. misalignment of the (later) body clock and the (earlier) social clock (determined by social demands such as related to school or work), resulting in accumulated sleep debt and compensatory sleep on free days (Wittmann et al. 2006). Thus, evening-types must often rise at a time when the core body temperature is closer to its night-time nadir; this may influence hormones responsible for appetite regulation and glucose metabolism which are necessary functions in maintaining a healthy body weight and preventing obesity (Scheer et al. 2009; Roenneberg et al. 2012). Evening-types report eating breakfast, lunch, and dinner at later times, and may also show more “eating jetlag”, i.e. more variability in the timing of meals between weekdays and weekends (Nakade et al. 2009; Lucassen et al. 2013; Reutrakul et al. 2013; Silva et al. 2016; Zerón-Rugério et al. 2019); they also show increased levels of caloric intake, consume more calories at night, and more frequently skip meals, being twice more likely to skip breakfast than morning types (Toktaş et al. 2018; Mazri et al. 2019).

Eating or skipping breakfast has been highlighted as important for the quality of an individual’s nutritional habits and metabolic health (Teixeira et al. 2017). Breakfast consumption is useful in regulating appetite and increasing insulin sensitivity which enhances metabolic health (Ma et al. 2020). Compared with breakfast-eaters, breakfast-skippers are more likely to be evening-types, and have a greater caloric, carbohydrate, and lipid intake (Teixeira et al. 2017). In patients with type-2 diabetes, both breakfast skipping and eveningness were associated with poorer glycaemic control (Reutrakul et al. 2013). Furthermore, a randomized control trial revealed that

skipping breakfast caused a disruption in the expression of genes involved in both the circadian clock and metabolism (Jakubowicz et al. 2015), highlighting the interplay between breakfast consumption, circadian typology, and metabolic health. Skipping lunch and dinner may also have serious health implications such as developing obesity, binge-eating disorder, and depression (Lee et al. 2017; Yamamoto et al. 2021).

Binge-eating refers to the overconsumption of food in a short period of time even when not hungry, and to the point of discomfort (Harb et al. 2012). Skipping breakfast may be followed by more frequent snacking throughout the day, potentially leading to binge-eating episodes (Masheb and Grilo 2006). Evening-type students reported more uncontrolled eating than those with a morningness preference (Schubert and Randler 2008). Also, among participants from a nutritional clinic, increased binge-eating was associated with eveningness preference (Harb et al. 2012), and, among adults with bipolar disorder, those with an evening preference had higher rates of binge-eating behaviour at night, more frequent breakfast skipping, lower intake of vegetables and fruits, and a greater intake of fried foods and snacks (Romo-Nava et al. 2020).

The importance of breakfast consumption was highlighted in a study which aimed to reduce the frequency of binge-eating in patients with eating disorders (ED) by maintaining a three-meal pattern. Sivy et al. (2020) hypothesized that a regular eating pattern mediates the effect of cognitive behavioural therapy on binge-eating frequency. Their results revealed a significant decrease in binge-eating episodes after a few weeks of consistently eating three meals a day, suggesting that skipping meals may maintain binge-eating behaviours in ED patients. Such research indicates the plausibility of skipping breakfast as a potential mediator of the effect of chronotype on binge-eating.

Much research suggests that people with depressive symptoms report consuming more snacks and high energy foods (Goldschmidt et al. 2013). A study of obese individuals found that those with elevated depressive symptoms were more likely to engage in binge-eating behaviour and emotional eating (Goldschmidt et al. 2013). Moreover, emotional eating has been proposed as a mediator linking depression and obesity (Konttinen et al. 2010). Such behaviours occur in response to negative emotions and operate as a coping mechanism to temporarily relieve the distress (van Strien 2018). Furthermore, depressive symptoms were found to mediate the association between circadian preference and emotional eating, and between morning affect and emotional eating (Konttinen et al. 2014), suggesting an indirect effect of circadian preference on emotional eating through depressive symptoms.

Depression has also been associated with skipping meals, particularly breakfast (Lee et al. 2017; Lee and Kim 2019; Anderson 2020). For example, a cross-sectional study in Iran compared breakfast consumers to breakfast skippers, finding that the former were 60% less likely to report depressive symptoms (Milajerdi et al. 2019). While this may be related to a loss of appetite experienced by some sufferers of depression, skipping breakfast may itself increase the risk of depression (Ren et al. 2020); the increased glucose following breakfast consumption may reduce cortisol levels, lowering stress and increasing positive mood (Lee et al. 2017). In addition, eating breakfast results in the formation of tryptophan, which is a precursor

protein to serotonin, a chemical involved in the regulation of depressive symptoms (Ferrer-Cascales et al. 2018). Skipping breakfast may therefore be a potential mediator of the relationship between eveningness and depression.

## The present study

To summarize, previous research suggests that eveningness is associated with depression and with disturbed eating behaviours, including binge-eating and meal skipping (particularly skipping breakfast); binge-eating and depression are also linked with skipping breakfast. Based on these findings, this study aimed to replicate the established associations and further understanding by examining the potential mediating role of skipping breakfast on the association between chronotype and mental health in two hypotheses: (1) skipping breakfast mediates the relationship between chronotype and binge-eating; (2) skipping breakfast mediates the relationship between chronotype and depression. Associations between morning affect, meal skipping, and binge-eating were also explored.

## Method

### Participants

Invitations to participate in the online survey were posted on a research platform at the University of Reading (for psychology student participants, who were compensated with course credits), and on the first Author's social media platforms (for other participants who did not receive compensation); stated inclusion criteria were being aged 18/older, and English-speaking.

Following Cohen's (1992) guidelines small, medium, and large effect sizes may be shown by correlation coefficients of .10, .30, and .50 respectively, with  $N = 85$  suggested to establish a medium effect size with 80% power at  $p = .05$ ; for a small effect size,  $N = 783$ .

Previous research demonstrating correlations between eveningness, binge-eating, depression, and skipping breakfast indicates correlations in the range of small to medium (e.g. Hasler et al. 2010; Harb et al. 2012; Bakotic et al. 2017), so (using the power calculator available at: <https://www2.ccrb.cuhk.edu.hk/stat/other/correlation.htm>) a target minimum sample size was set at  $N = 194$  to establish small to medium correlations ( $r = 0.20$ ) with 80% power at the 0.05 significance level. At the end of the available data collection period a total of 383 participants had been recruited. After excluding incomplete responses  $N = 272$  (age range = 18–55 years;  $M = 24.58$ ,  $SD = 6.80$ ); 215 were female, 55 male, and two “other”.

The survey began with a briefing which explained the purpose of the study, followed by electronic consent. Participation was voluntary, anonymous, and could be withdrawn at any time. Ethical approval for the study was provided by the Research Ethics Committee of the School of Psychology and Clinical Language Sciences, University of Reading (approval number: 2022–066-RC).

## Materials

*Demographics* questions were age, gender (male/female/other), and whether English is the respondent's first language, and whether the participant has ever been diagnosed with depression, an eating disorder, a sleep disorder, and/or other mental disorder (each answered yes or no). After demographics, the following questionnaires were presented in sequence.

The 13-item *Composite Scale of Morningness* (CSM; Smith et al. 1989) assessed morningness-eveningness/circadian preference. Scores range from 13 (extreme eveningness) to 55 (extreme morningness). A subset of items (3, 4, 5, and 12) provide a measure of morning affect. The CSM has shown validity and reliability with high school and university samples (Önder et al. 2013).

The 10-item *Center for Epidemiologic Studies Depression Scale Revised* (CESD-R-10), assessed depression (e.g. "I was bothered by things that usually don't bother me"), with items scored on a 0–3 scale; higher scores indicate more depression. This scale has shown very good internal consistency (Miller et al. 2007).

The 16-item *Binge Eating Scale* (BES) assessed binge-eating behaviours and the associated cognitive symptoms, with scores ranging from 0 to 32; higher scores indicate more severe binge-eating symptoms. The BES has shown very good internal consistency (Grupski et al. 2012).

*Meal-skipping* was assessed with three new items, asking how often the respondent skipped breakfast, lunch, and dinner in the past week, with options of "rarely or never" (less than 1 day), "some or a little of the time" (1–2 days), "occasionally or a moderate amount of time" (3–4 days), "all the time" (5–7 days), scored from 0 to 3, respectively.

## Data analysis

Descriptive statistics include the mean, standard deviation, internal consistency (Cronbach's alpha), skewness, and kurtosis, for all scales. Pearson correlations were computed between the variables, and the indirect/mediation effects of breakfast skipping were tested with the PROCESS macro (Preacher and Hayes 2008; Hayes 2017), utilising 5000 bootstrapped samples generating 95% confidence intervals (CI) for which the exclusion of zero indicates a significant mediation effect.

## Results

### Descriptive statistics

Regarding whether participants had ever had a disorder (lifetime experience), 23.5% reported having had a diagnosis of depression, 10.3% an eating disorder, 8.5% a sleep disorder, and 20.6% for other disorder. Also, 114 participants (41.9%) reported English as their first language.

All scales showed a wide range of scores, distributions approximated normality, and all showed good internal consistency (Table 1). However, Cronbach's alpha for the three meal-skipping questions together was 0.41, suggesting that the three items were not strongly associated, and instead measure distinct constructs (Tavakol and Dennick 2011).

**Table 1.** Descriptive statistics for scales.

	Mean (Standard Deviation)	Actual range (possible range)	Cronbach's alpha	Skewness	Kurtosis
Morningness-Eveningness	32.38 (7.51)	15–51 (13–55)	.87	.25	–.31
Morning affect	9.60 (2.68)	4–16 (4–16)	.77	–.02	–.61
Binge-eating	12.63 (9.13)	0–44 (0–46)	.90	.86	.23
Depression	12.43 (6.35)	0–30 (0–30)	.85	.43	–.35
Skip breakfast	1.60 (1.19)	0–3 (0–3)	-	–.14	–1.50
Skip lunch	.78 (.90)	0–3 (0–3)	-	.92	–.07
Skip dinner	.70 (.86)	0–3 (0–3)	-	1.04	.20

Notes:  $N = 272$ .**Table 2.** Correlations between study variables.

Variable	Age	Morningness-eveningness	Morning Affect	Binge-eating	Depression	Breakfast	Lunch
Morningness-Eveningness	.42***	-					
Morning affect	.27***	.72***	-				
Binge-eating	–.02	–.098	–.23***	-			
Depression	–.19**	–.29***	–.38***	.29***	-		
Skipping Breakfast	–.09	–.33***	–.27***	.18**	.16**	-	
Skipping Lunch	.05	–.04	–.08	.06	.17**	.33***	-
Skipping Dinner	.01	.07	.001	–.03	.19**	.07	.17**

Notes:  $N = 272$ . \* $p \leq 0.05$ ; \*\* $p \leq 0.01$ ; \*\*\* $p \leq 0.001$ .

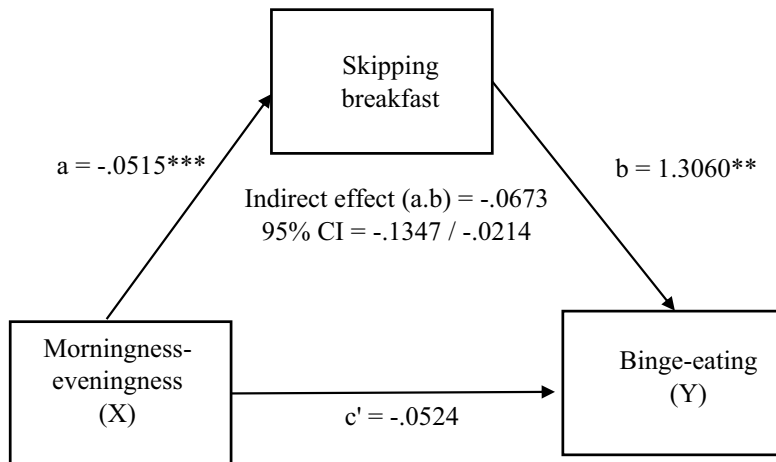
Consequently, further analysis was undertaken for each meal separately, but not for the combined score.

As 158 participants (58.1%) reported that English was not their first language, Cronbach's alpha was re-tested separately for the two language groups. For those reporting English as their first language, the alpha values for morningness-eveningness (CSM total), Morning Affect (CSM), Depression (CES), and Binge-eating (BES) were respectively .886, .796, .831, and .901. The corresponding values for those reporting that English was not their first language were respectively .847, .745, .857, and .888.

There were no significant gender differences in morningness-eveningness, morning affect, binge-eating, depression, and skipping meals, except for skipping dinner: males,  $M = .49$ ,  $SD = .66$ , females,  $M = .76$ ,  $SD = .90$ ;  $t(110.71) = 2.46$ ,  $p = .02$  (the two participants who identified as "other" were omitted from this analysis).

## Correlations between variables

Pearson correlations (Table 2) showed that morningness-eveningness, and morning affect, had small/medium negative correlations with depression and breakfast skipping (more eveningness, and less morning affect, associated with more depression and more breakfast skipping); both were also negatively correlated with binge-eating, although the correlation with morningness-eveningness did not



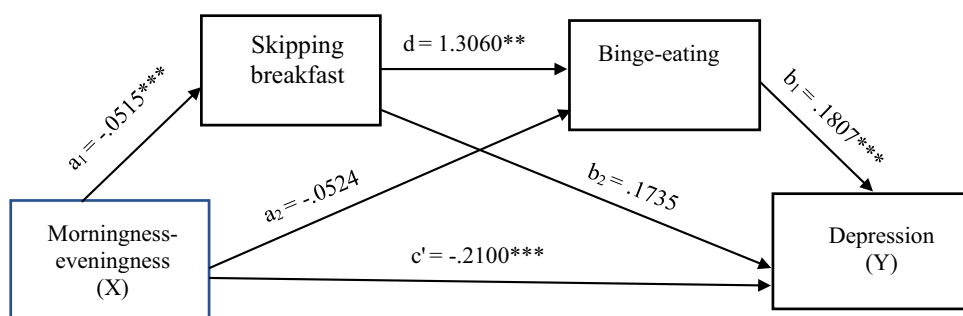
**Figure 1.** Mediation model with morningness-eveningness as predictor, breakfast skipping as mediator, and binge-eating as the outcome variable. Notes: Values represent unstandardized regression coefficients.  $**p \leq 0.01$ ;  $***p \leq 0.001$ .

reach statistical significance. Binge-eating had small/medium positive correlations with depression and breakfast-skipping; depression had small/medium correlations with skipping breakfast/lunch/dinner. Older age was positively correlated with more morningness and morning affect, and with less depression.

### Mediation analysis

Hypothesis 1 stated that skipping breakfast mediates the relationship between chronotype and binge-eating. A weak/small negative correlation was shown between morningness-eveningness and binge-eating. Although this correlation was not significant it indicated that, as expected, more eveningness was associated with more binge-eating. Given that a statistically significant association between the predictor and the criterion is not necessary for significant mediation effects to exist (Preacher and Hayes 2008) the proposed hypothesis was tested. This showed a significant indirect effect of morningness-eveningness on binge-eating through skipping breakfast, supporting the hypothesis (Figure 1). This was still significant after including the demographic variables as covariates.

Hypothesis 2 stated that skipping breakfast mediates the relationship between chronotype and depression, and significant correlations in the expected directions were found between these variables (Table 2): eveningness correlated with more depression, and more breakfast skipping, and more depression correlated with more breakfast skipping. However, the indirect effect of morningness-eveningness on depression through skipping breakfast was not significant as the 95% confidence interval included zero (95% CI = -.0572/.0089), while morningness-eveningness retained a significant direct effect. This indicates no significant mediating effect of skipping breakfast on the association between morningness-eveningness and depression, therefore rejecting the second hypothesis.



**Figure 2.** Serial mediation model with morningness-eveningness as predictor, breakfast skipping and binge-eating as mediators, and depression as the outcome variable. Notes: Indirect effect =  $-.0122$  (95% CI =  $-.0278/-0.0038$ ). The values represent unstandardized regression coefficients. \*\* $p \leq 0.01$ ; \*\*\* $p \leq 0.001$ .

A further exploratory mediation model was developed by extending the two previous models: skipping breakfast and binge eating were included as serial/sequential mediators in the relationship between morningness-eveningness and depression. This showed a significant indirect effect (Figure 2). This indirect effect was still significant after including the demographic variables as covariates.

## Discussion

The current study aimed to examine associations between chronotype, eating behaviour, and depression, and to extend previous research by examining the potential pathways involved in the relationships between these variables. It was expected that eveningness would be associated with more depression, binge-eating, and breakfast skipping, and it was hypothesized that: (1) skipping breakfast mediates the relationship between chronotype and binge-eating; (2) skipping breakfast mediates the relationship between chronotype and depression.

### Morningness-eveningness, skipping breakfast, and binge-eating

Consistent with previous research (Schubert and Randler 2008; Harb et al. 2012; Romo-Nava et al. 2020) binge-eating was negatively associated with morningness-eveningness (more eveningness associated with more binge-eating), and was also associated with skipping breakfast (Masheb and Grilo 2006). Although the correlation between binge-eating and eveningness did not reach statistical significance in the current study, there may be factors which influence the strength of this association. For example, while the present study involved a student and general population sample, Harb et al.'s (2012) research involved a clinically obese sample awaiting treatment at a nutritional clinic, and Romo-Nava et al. (2020) studied people with bipolar disorder (BD), so the association between eveningness and binge-eating may be stronger among clinical populations.

The current findings also replicated the association between skipping breakfast and eveningness (Teixeira et al. 2017). Waking at a later time may cause evening-types to miss

breakfast, but also a disruption or delay in the circadian rhythm causes an interrupted signalling within the biological clock to regulate feeding-fasting cycles (Silva et al. 2016). Having an evening chronotype and skipping breakfast are both linked to reduced glycaemic control, a common feature among type-2 diabetics (Reutrakul et al. 2013), thus highlighting the health risks of having an evening chronotype and not maintaining a healthy three-meal diet. The current study also found that breakfast skipping was associated with less morning affect, as was binge-eating.

Based on the previously established associations between eveningness, binge-eating, and skipping breakfast, it was hypothesised that there is an indirect effect of chronotype on binge-eating through skipping breakfast, and this effect was found to be statistically significant. This suggests that being more evening-type increases the likelihood of skipping breakfast which leads to more severe binge-eating symptoms. This result is consistent with a biobehavioural circadian model of restrictive eating and binge-eating which was recently proposed to explain the role of circadian disruption in the development of binge-eating through restrictive eating (De Young and Bottera 2022), which states that a disruption in the circadian rhythm causes diurnal appetitive disruption such as decreased morning appetite making it more likely to skip breakfast. Furthermore, a disruption in the diurnal appetitive rhythm also causes disrupted meal timings and a disruption in the synthesis of appetitive hormones. Such disruptions are associated with increased restrictive eating during the day (skipping breakfast) and binge-eating towards the evening hours.

### **Morningness-eveningness, skipping breakfast, and depression**

The current study found a significant correlation between chronotype and depression: increased eveningness was associated with more symptoms of depression, consistent with previous findings (e.g. Chan et al. 2014; Merikanto et al. 2015; Chiu et al. 2017), with less morning affect showing a stronger correlation with more depression, as previously reported (Jankowski 2016; Putilov 2018). The stronger association with morning affect could be because it reflects constructs related to depressive symptomologies such as reduced energy and increased fatigue (Romans et al. 2007). These findings highlight the importance of separately analysing different components of circadian functioning. Also consistent with previous research (Lee et al. 2017; Lee and Kim 2019; Anderson 2020), increased depression was associated with more breakfast skipping.

However, the hypothesised mediation model, with an indirect effect of eveningness on depression through skipping breakfast, was not significant. This model was based on evidence showing evening-types being more likely to skip breakfast (Teixeira et al. 2017), and skipping breakfast being a possible cause of depression (Lee et al. 2017; Ferrer-Cascales et al. 2018; Ren et al. 2020), but it may be that there are important moderating influences on the indirect effect.

Furthermore, in the current research an exploratory mediation model with skipping breakfast and binge-eating as serial/sequential mediators in the relationship between eveningness and depression was found to be significant. While binge-eating/comfort eating may be a response to depression, perhaps as a coping mechanism (Konttinen et al. 2010; Goldschmidt et al. 2013; van Strien 2018), the proposed mediation model indicates that skipping breakfast may increase the risk of binge-eating, which in turn may increase

the risk of depression, perhaps related to feelings of guilt at over-indulgence (Skinner et al. 2012), or perceived lack of self-control. A bi-directional relationship between binge-eating and depression has been reported in longitudinal research (Skinner et al. 2012), and may potentially develop a vicious cycle, maintaining maladaptive eating patterns.

These possibilities again highlight the important relationship between depression and unhealthy eating patterns (Ljungberg et al. 2020), and may be further tested in longitudinal research. Morning affect may also be an important factor that may be further investigated, given its stronger relationship with depression (Jankowski 2016), its mediating role between eveningness and negative emotionality (Carciofo 2020), and the previously established role of depression in the association between morning affect and emotional eating (Konttinen et al. 2014). There may also be inter-relationships with other factors which have been found to mediate the association between eveningness and depression, including sleep quality (Bakotic et al. 2017; Zhou et al. 2020). Further research could also include assessment of the quality of breakfast which may be an important influence on the association with wellbeing (Ferrer-Cascales et al. 2018).

While the relationships between chronotype, breakfast skipping, binge-eating, and depression require further elucidation, the current results are consistent with other research highlighting that eating breakfast, and avoiding binge-eating, may be important for wellbeing. For instance, the restraint model (Fairburn and Wilson 1993) argues that following a restrictive diet, characterized by missing meals, leads to binge-eating and subsequent purging which then leads to increased efforts of restraint. Also, an increase in regular eating may decrease binge-eating frequency (Sivyer et al. 2020). The current findings suggest that interventions could implement a circadian approach in treating binge-eating disorder by incorporating chrono-nutritional elements, such as a synchronized sleep-wake and fast-feed cycle, to reduce symptoms.

## Limitations

While the findings of the present study are informative in the development of effective future interventions, the results must be interpreted with caution given the limitations of the study. This was a cross-sectional study, so the tested mediation models do not establish causal relationships and need to be investigated more fully in longitudinal designs. In addition, a majority of the sample were not native English-speakers, which may have increased the likelihood of misunderstanding questionnaire items. However, the scales showed good reliability (internal consistency) for the whole sample and separately for both native and non-native English-speakers, and previously established inter-relationships between the study variables were replicated, indicating that English literacy did not adversely impact results, while the cultural diversity of the sample may support the generalisability of the findings. However, the current study did not include demographic items about nationality, language spoken, or ethnicity, so these could be included in future studies. Previous research has shown cultural influences on the temporal patterns of eating among different chronotypes (Randler et al. 2014), so the cross-cultural applicability of the proposed mediation models could be more fully investigated. Also, the current sample was relatively lacking in statistical power, mostly comprised of young adults, and was predominantly female. Future research may include larger samples, more balanced across genders and age groups, to test the relationships between the

study variables with more statistical power, and also investigate any interactions between age and gender for the observed effects.

A further limitation was in the assessment of meal skipping, which utilised three items (one each for breakfast/lunch/dinner) developed for the current study. However, the previously reported associations between breakfast skipping and eveningness (Teixeira et al. 2017), binge-eating (Masheb and Grilo 2006), and depression (Lee et al. 2017) were replicated in the current results, supporting the validity of the measure. Nevertheless, formal development and testing of a validated questionnaire to measure the frequency of skipping meals would be a useful contribution to research in this field. Also, data about Body Mass Index (BMI), and whether participants worked night shifts, were not collected in the current study, so are important variables to include in future research.

## Conclusion

The current study contributes to understanding the inter-relationships between chronotype, meal skipping, binge-eating, and depression. The findings, from a general population sample, indicate potential mechanisms of association, with significant indirect effects found from eveningness to binge-eating through breakfast skipping, and from eveningness to depression sequentially through breakfast skipping and binge-eating. Replication of these mechanisms of association in longitudinal designs may subsequently inform the development of psychoeducational programs and interventions to promote healthy eating patterns.

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## ORCID

Richard Carciofo  <http://orcid.org/0000-0003-2069-7047>

## Author contributions

Rola al Balushi: conceptualisation, data collection, data analysis, manuscript drafting. Richard Carciofo: conceptualisation, data analysis, supervision, manuscript drafting.

Both authors have read and approved the final manuscript.

## Data availability statement

The study data is available from the corresponding author.

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