

## Why don't more people eat breakfast? A biological perspective

Dear Editor:

Nearly one-quarter of individuals in the United States skip breakfast daily, with an average energy contribution of ~16% of total caloric intake. This is quite small in comparison to other meal times, such as evening (dinner) food consumption, during which ~44% of daily calories are consumed (1). Prompted by such findings, a variety of studies have investigated the potential health benefits associated with breakfast consumption (2–4). In a recent article in this Journal, Chowdhury et al. (3) pointed out that the majority of the literature examining the impact of breakfast consumption on obesity relied on positive cross-sectional associations between breakfast omission and obesity. As such, they used a randomized controlled design and found that neither total caloric intake nor level of physical activity was different between obese individuals who consumed or skipped breakfast for 6 wk. However, the authors did note that fasting during breakfast time may decrease insulin sensitivity. This same group previously found that breakfast consumption was causally linked with an increase in physical activity thermogenesis and more stable glucose response in the remaining hours of the day in lean adults (4). Thus, there is an evolving understanding with regard to the importance of breakfast, with both epidemiologic and experimental data suggesting that breakfast consumption may be beneficial. However, the mechanisms that underlie these behavioral patterns, in our opinion, remain elusive within the literature.

It has been suggested that both personal (age, race-ethnicity, weight status) and geographical factors influence breakfast consumption when examining trends of US adults from 1965 to 1991 (2). All of these factors may play a role in an individual's breakfast habits; however, this study does not mention the potential influence of biological rhythms, which indicate that human biology is not necessarily driven to eat in the early waking hours. As such, we propose that individuals who do not eat breakfast may not be biologically driven to do so, and that many people who do eat breakfast do so, perhaps, because of media-disseminated messages that underscore that breakfast is the most important meal of the day. Furthermore, we suggest that breakfast may be a healthy habit; however, interventions designed to increase breakfast consumption may need to consider this “biological drive,” which may be one of the primary factors influencing eating patterns.

A growing understanding of biological rhythms has provided evidence that behaviors may be governed by a multitude of internal and external clocks, which act as triggers and moderators for behavior and function (5). Pittendrigh (5) suggested that biological rhythms “exploit the challenges and opportunities offered by the periodic nature of the environment,” which is, perhaps, best shown by the sleep-wake cycle. Of interest in the present letter are patterns in diet, because these patterns are potentially influenced by oscillations originating from the suprachiasmatic nucleus of the hypothalamus, with further synchronization from both intrinsic (hormones) and external (light/dark cycle) oscillations.

With regard to diet, there is some indication that we may be more driven to eat food later in the day. For example, the endogenous circadian rhythm of hunger appears to peak in the evening (2000), with the nadir occurring around 0800 (6). This is supported by other rhythms, such as fluctuations in ghrelin, which influences hunger and appears to oscillate independent of food consumption (7). Specifically, Espelund et al. (7) found that ghrelin concentrations reached a peak around 1900, with a nadir occurring around 0400. In further support, leptin concentration increases overnight, reaching its nadir in the late afternoon (8). Because leptin is inversely associated with hunger, this provides some support for the notion that our physiology may be influencing these temporal differences in food consumption. This assertion is also supported by research that suggests that circadian rhythms play an important role in other health behavior-related activities. For example, Teo et al. (9) showed distinct differences in physical performance on the basis of circadian rhythms in core body temperature. This circadian rhythm-behavior relation is further supported by research that shows that physical activity behavioral manipulation can phase-shift an individual's circadian rhythm (10). Within the context of dietary behavior, whether circadian rhythms of dietary triggers drive an individual's desire to eat or skip breakfast, or whether the act of skipping breakfast phase-shifts these circadian rhythms of dietary and hunger triggers, is not explicitly clear (perhaps both play a contributing role). Clearly, this is an exciting and ripe area for future research, and we feel that this letter may help to spawn such necessary work.

The purpose of this letter is not to challenge the current literature but to suggest the potential importance of biological rhythms in the interpretation and approaches to breakfast consumption. In doing so, we may better understand the role of breakfast and design more effective interventions to promote breakfast consumption.

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## Reply to SL Buckner et al.

Dear Editor:

We thank Buckner et al. for their insightful comments on the developing evidence base with regard to breakfast consumption and health. Specifically, the authors emphasize the potential influence of biological rhythms in determining breakfast habits and whether breakfast consumption or skipping, in turn, affects these biological rhythms. We wholeheartedly agree that these are important questions that warrant further investigation.

The influence of circadian rhythmicity on all manner of physiologic responses has long been established. There is a large body of evidence that suggests that the circadian system affects metabolic pathways and that changes in nutritional status can, in turn, alter circadian rhythms (1). As highlighted by Buckner et al. in their letter, appetite regulatory hormone concentrations change throughout the day and the biological rhythm of hunger varies according to time of day. In our recent investigations published in this Journal we examined the effects of free-living, extended-morning, fasting/breakfast consumption interventions on all components of energy balance and associated health outcomes in lean (2) and obese (3) populations. These experiments had a strength of examining the impact of differing morning feeding patterns within the context of normal life in which numerous factors affecting food intake (both metabolic-homeostatic and cognitive-hedonic processes) are in play (4). However, because of the nature of these investigations, the role of biological rhythms was not a focus.

Nevertheless, as part of our wider program of work examining breakfast consumption (5), we were also keen to examine underlying physiologic processes after differing morning feeding patterns. In crossover laboratory experiments conducted in both lean (6) and obese (7) individuals, we compared extended-morning fasting with the consumption of a typical carbohydrate-rich breakfast. These studies shed light on the acute effects of different morning feeding patterns, with evidence of second-meal effects on insulin, greater anorectic hormone response (increased peptide tyrosine tyrosine and leptin in the afternoon), and a paradoxical lack of suppression of ghrelin after a lunch preceded by breakfast. We therefore showed that, against the backdrop of underlying circadian rhythms for these hormones, morning feeding pattern affects the concentrations of these hormones during the day. Although more research is required to further examine the metabolic-homeostatic responses to acute breakfast consumption and omission, it is hoped that this work goes some way toward

answering one of the questions posed by Buckner et al.: skipping breakfast does indeed acutely affect hormonal dietary triggers.

A second theme that the authors raise is the issue of whether circadian rhythms might be influencing an individual's propensity to eat or skip breakfast. This is an interesting and important question, but one that is surprisingly difficult to answer. Some recent investigations examined hormonal and metabolic responses to breakfast consumption/morning fasting in groups defined by their breakfast consumption habits (8, 9). Unfortunately, notwithstanding inherent difficulties in defining what constitutes a breakfast consumer or skipper, these studies were based on self-selected breakfast habits and therefore it is difficult to assess causality. For example, where differences are observed, it is not possible to untangle the effect of breakfast consumption per se from other factors that might be different between groups (breakfast consumers tend to exhibit healthy behaviors). In addition, there is no way of knowing whether appetitive responses observed contributed to, or are a product of, an individual's habitual morning feeding pattern. Further studies from our research program (5) aim to address if prolonged daily breakfast consumption/omission affects acute hormonal/metabolic and appetite responses on a given day. It is hoped that these results will give some insight into whether a randomly assigned daily morning feeding pattern results in entrainment of the appetitive regulatory system.

In conclusion, we agree with Buckner et al. that the roles of the circadian system in influencing dietary behaviors certainly warrant further study. However, it is also important to keep in mind that circadian rhythms are one of a number of factors that influence dietary behaviors. We would also caution that based on the current state of causal evidence relating to breakfast consumption (10), it is a little premature to be designing interventions to promote breakfast consumption for the general public. Much like our understanding of the role of circadian rhythmicity in breakfast consumption, our understanding of the influence of breakfast consumption on health still requires further development. In the future, with an accumulating understanding of the causal role of morning feeding on different elements of health, we might hope to be able to provide nuanced guidance for individuals to decide whether or not to eat breakfast.

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