The association between the timing of energy intake and the risk of overweight and obesity among Saudi female university students

Eman S. Alamri, MSc, PhD.

ABSTRACT

الأهداف : تهدف الدراسة الحالية إلى دراسة العلاقة الحالية بين وقت تناول السعرات الحرارية والاصابة بالسمنة وزيادة الوزن.

الطريقة: دراسة عرضية أجريت لعدد ٤٥٠ طالبة جامعية في جامعه تبوك، مدينة تبوك، في الفترة ما بين سبتمبر وديسمبر ٢٠١٨. وقد تم تقدير المتناول من الأغذية عن طريق استخدام سجلات الأغذية لمدة أربعة أيام شاملة إجازة نهاية الأسبوع. وقد تم اخذ قياس طول ووزن لحساب مؤشر كتلة الجسم.

النتائج: أظهرت النتائج وجود علاقة سلبية بين وقت تناول السعرات الحرارية في الصباح الباكر والاصابة بالسمنة او زيادة الوزن. ووجدت الدراسة علاقة عكسية بين الإصابة بالسمنة او زيادة الوزن مع تناول السعرات لحرارية في المساء.

الخاتمة: وجدت الدراسة ان تناول كميات كبيرة من السعرات الحرارية في وجبة العشاء مرتبط ارتباط إيجابي بمدى الإصابة بالسمنة أو زيادة الوزن، بينما تناول السعرات الحرارية في الصباح مرتبط ارتباط عسكي بمدى الإصابة بالسمنة أو زيادة الوزن.

Objectives: To investigate the relationship between the timing of energy intake and obesity.

Methods: A cross-sectional study was conducted between September 2018 and December 2018. A total of 450 Saudi female students from the University of Tabuk, Tabuk, Saudi Arabia were recruited. A 4-day dietary record was used to estimate the total energy intake per day and per meal. Height and weight were measured to calculate body mass index.

Results: The study showed a significant negative association between obesity and energy intake at breakfast (r = -0.70, $p<0.05$) and mid-morning (r = -0.53, $p<0.05$) as well as a significant positive association between obesity and energy intake at dinner (r = 0.85, $p<0.05$). Additionally, there was no significant difference between the obese and normal weight groups in the total energy intake per day or the total percentage of energy from fat, carbohydrate, and protein per day. However, the total energy intake for each meal and the percentage of energy from fat, carbohydrate, and protein per meal were significantly different between the groups.

Conclusion: The greater intake of energy at dinner was positively associated with obesity, while greater energy intake at breakfast were negatively associated with overweight and obesity.

Saudi Med J 2019; Vol. 40 (12): 1272-1277
doi: 10.15537/smj.2019.12.24686

From the Department of Nutrition and Food Science, Faculty of Home Economics, University of Tabuk, Tabuk, Kingdom of Saudi Arabia.

Received 12th May 2019. Accepted 28th October 2019.

Address correspondence and reprint request to: Dr Eman S. Alamri, Department of Nutrition and Food Science, Faculty of Home Economics, University of Tabuk, Tabuk, Kingdom of Saudi Arabia.
E-mail: ialamri@ut.edu.sa
ORCID ID: orcid.org/0000-0001-5113-0495

Obesity is one of the global health problems facing societies that has increased dramatically in recent years.[1] It was found that the prevalence of obesity was higher among women compared to men.[2] The Saudi National Health Survey found that there is a significant increase in the prevalence of overweight and obesity among the Saudi population aged 15 years and older, especially among women, and that the increase among women was significantly greater compared to the increase among men.[3] A study indicated that there is a significant increase in the trend of overweight and obesity among Saudi population.[4] Some cross-sectional study among Saudi female university students aged 19 years or older revealed that approximately third of them were overweight or obese.[5,6]

There are multiple factors that could cause overweight and obesity, such as family history of overweight and obesity, sociodemographic factors, portion size, physical activity, and marital status.[7-9] The Saudi National Health Survey found that the risk of obesity increased among Saudi women aged 15 years or older increased with age and incidence of hypertension found that the risk of obesity increased among Saudi women aged 15 years or older increased with age and incidence of hypertension.[3] Another study in Jeddah, Saudi Arabia, revealed that the number of servants, marital parity, and childbearing were significant predictors for obesity in women aged 11 years or older.[10] However, no study conducted in Saudi Arabia has evaluated the role of energy timing intake on weight status.

Studies of weight loss and weight maintenance have mostly concentrated on the balance between caloric intake and caloric expenditure. However, the time of energy intake plays an important role in weight gain and weight maintenance.[11] A study by Garaulet[12] indicated that the feeding time especially for high-energy dense meals may have health consequences such as development of obesity. Recent data revealed that people who consumed breakfast consistently showed lower risk of weight gain compared to people who skipped breakfast. In addition, higher energy intake at lunch or dinner have increase the risk of an increased body mass index (BMI).[13] A review conducted by Almoosawi et al[14] suggested that eating late was related to overweight or obesity.

Another intervention study examined the effect of the timing of the main meal consumption on weight loss. The results revealed that the group that consumed high caloric food at breakfast lost significantly more weight compared to the other group that consumed high caloric food at dinner.[15] Interestingly, a study by Wang[16] indicated that food consumption at midday is correlated with a lower risk of overweight and obesity, while food intake in the evening is correlated with a higher risk. However, food consumption in the morning was not associated with overweight or obesity. Furthermore, a randomized controlled trial failed to support the idea on the positive relationship between breakfast consumption and body weight gain.[17] Recent review regarding the association between timing of energy intake and weight gain, showed inconsistent finding which require more studies.[18] Therefore, the current study will examine the impact of energy intake timing on weight status among Saudi female university students.

Disclosure. Author have no conflict of interests, and the work was not supported or funded by any drug company.

Methods. A cross-sectional study was conducted between September and December 2018. The study took place at the University of Tabuk, Tabuk, Saudi Arabia, among female students. The sample size was calculated by one of university statisticians. The following formula was used for calculation: $n = z^2\ p\ q/d^2$, where, n= the minimum sample size, z = standard score corresponding to a given confidence level, p = the proportion in the characteristics being measured, q = 1-p, d = sample error. The data were considered significant if the $p<0.05$ and power = 80%.

A minimum of 400 participants were required as calculated by the statistician. In total, 480 participants were recruited in case participants withdraw. The participants were recruited to the study through leaflets distributed at the university. The participants were required to complete a consent form to participate in this study. Any participant who were on a weight-loss regimen or had a medical condition that could influence their weight status were excluded from the study. Pregnant and breastfeeding participants were also excluded from the study. Ethical approval was obtained for the current study from the ethics committee at the University of Tabuk. The study was conducted according to the principles of Helsinki Declaration.

Screening questionnaire. The screening questionnaire was developed by the author. It was piloted on 30 students prior to the study to ensure clarity and estimate the time it took to complete the questionnaire as well as to obtain feedback from the participants, which could help to make alternations to the questionnaire. The questionnaire consisted of demographic information (for instance: participants' age, monthly household income, marital status, and ethnicity) and a section discussing the participants' health status and whether they were diagnosed with any particular disease that could influence their weight status.

Energy intake. This study used a 4-day dietary record to estimate the energy intake (Kcal) of participants and identify the timing of their energy intake. All participants were given a blank food diary and an instruction booklet on how to use the food diary. They were asked to write what and when they ate or drank in detail and whether they were inside or outside the house at the time of consumption. The author met each participant individually to ensure that the diary was written correctly. Portion size was estimated by using

spoons, cups, serving plates, and glasses. The average intake of energy was calculated based on the energy consumed in 4 consecutive days, including weekends, to avoid day-to-day variability.

Anthropometric measurements. Participant's measurements were taken by a trained research assistant. All participants' anthropometry was measured at a private place on the university campus according to the World Health Organization (WHO) protocol.[19] An electronic scale (Seca Ltd, Germany) was used to measure each participant's weight. For accuracy purposes, the scale was calibrated according to the manufacturer's guidelines. Weight was measured to the nearest 100 g. All participants were asked to take off their shoes and heavy clothes and to wear a minimal outer layer of clothing. The height of each of the participants was measured using a portable height measure (Seca 264, UK). It was measured to the nearest 0.5 cm. The BMI was calculated according to the WHO formula: body mass (kg)/height^2 (m^2) to classify the weight of the participants.

Statistical analysis. The Statistical Package for Social Sciences for Windows, version 23 (IBM Corp, Armonk, NY, USA) was used to analyze the data in the present research. Pearson's correlation coefficients were used to find the relationship between BMI and and energy intake at the different eating occasions. The data was normally distributed, therefore, a t-test for an independent sample was used to calculate the significance of differences in the energy intake between individuals with normal weight versus individuals with overweight or obesity. Obesity was defined based on the WHO-BMI standard as follows: 1) underweight - defined as a BMI <18.5 k/m^2; 2) normal weight - as BMI 18.5-24.9 k/m^2; 3) overweight - 25-29.9 k/m^2; 4) obese - >30 k/m^2.

Results. The total number of female students who completed the study was 450 out of 480 (198 individuals with overweight or obesity and 252 individuals with normal weight). Thirty participants were excluded from the study (24 withdrew from the study, and 6 were on a weight-loss regimen). All of them were of Saudi ethnicity. The age of the participants ranged between 20 and 25 years, with a mean age of 22 years. The characteristics of the participants as summarized in **Table 1**.

No significant difference was found in total energy intake between the individuals with overweight or obesity and the individual with normal weight (**Table 2**). At breakfast and mid-morning, the total energy intake was significantly higher among the individual with normal weight compared to the individuals with overweight or obesity. On the other hand, the total energy intake at mid-afternoon and dinner was significantly higher among the individuals with overweight or obesity compared to the individual with normal weight.

The results showed a significant negative association between overweight and obesity with energy intake at breakfast (r = -0.70, p<0.05) and mid-morning (r = -0.53, p<0.05). However, a significant positive association was detected between overweight and obesity with energy intake at dinner (r = 0.85, p<0.05). There was no association between afternoon or mid-afternoon energy intake and obesity. The individual with normal weight consumed most of their energy at breakfast and mid-morning (38%). A similar percentage was consumed in the afternoon and mid-afternoon (37%). The lowest percentage of their energy intake was at dinner and in the late evening (25%). On the other hand, the individuals with overweight or obesity consumed the highest percentage of their daily energy intake at dinner and in the late evening (42%). However, their lowest daily energy intake was recorded at breakfast and mid-morning (22%). Their

Table 1 - Characteristics of the participants.

Variables	Normal weight group (n=252)	Obese and overweight group (n=198)
Weight (kg)	56	82
Height (cm)	160	161
Body mass index (kg/m^2)	22±1.2	33±2.3
Marital status	None	None
Monthly household income, SR		
<5000	10 (4)	13 (7)
5000-15 000	201(80)	120 (61)
>15 000	41(16)	65 (32)

Body mass index, height, and weight are expressed as the mean±SD. Values are presented as numbers and percentage (%).

Table 2 - Mean energy intake per day and mean energy intake for each meal of Saudi female university students.

Caloric intake (kcal)	Normal weight	Obese	*P*-value
Average total calories per day	1983±36	2009±33	0.06
Breakfast (4:00 to 9:00)	400±21*	300±26	0.02
Mid-morning (9:00 to 12:00)	350±28*	130±10	0.01
Lunch (12:00 to 4:00)	609±29	588±31	0.06
Mid-afternoon (4:00 to 7:00)	130±1*	155±8	0.04
Dinner (7:00 to 12:00)	354±16*	680±27	0.01
Late evening (12:00 to 4:00)	140±9	156±6	0.07

Data are expressed as mean ± SD. *The mean energy intake is significant at the p<0.05 level between the individuals with overweight or obesity compared to the individuals with normal weight

Table 3 - The percentage of energy intake from fat, protein, and carbohydrate of Saudi female university students.

Meal of the day	% Fat energy		*P*-value	% Protein energy		*P*-value	% Carbohydrate energy		*P*-value
	Normal weight	Obesity		Normal weight	Obesity		Normal weight	Obesity	
Breakfast	10	11	0.11	4	2	0.9	24	9	0.09
Lunch	15	9	0.06	7	6	0.13	15	21*	0.04
Dinner	8	14*	0.04	3	5*	0.3	14	23*	0.03
Total energy	33	34	0.15	14	13	0.16	53	52	0.15

*The percentage of energy intake is significantly higher at the $p<0.05$ level among the individuals with overweight or obesity compared to the individuals with normal weight.

daily energy consumption in the afternoon and mid-afternoon was 36%.

There was no significant difference in the percentage of total energy intake from fat, protein, and carbohydrate between the groups throughout the day (**Table 3**). However, the percentage of total energy intake from fat, protein and carbohydrate was significantly higher at dinner among the individuals with overweight or obesity compared to the individual with normal weight. At breakfast, the protein and carbohydrate energy intake percentage was significantly lower among the individuals with overweight or obesity compared to the individual with normal weight. At lunch, the fat energy intake percentage was significantly lower for the individuals with overweight or obesity, but their carbohydrate energy intake percentage was significantly higher compared to the individual with normal weight.

Discussion. The present study demonstrated a significant negative association between overweight and obesity with energy intake at breakfast and a significant positive association between overweight and obesity with energy intake at dinner. These results are in accordance with a previous intervention study, which found that the group that consumed high caloric food at breakfast lost significantly more weight compared to the other group that consumed high caloric food at dinner.[15] Another study demonstrated that higher energy intake at the evening meal was associated with risk of overweight and obesity, while energy consumption at breakfast did not lower the risk of obesity. However, the same study found that food consumption at midday is correlated with a lower risk of overweight and obesity.[16] This result contrasts with the results of the current research, which found no association between the midday meal and obesity. According to Tansey,[20] lower energy intake at midday was associated with higher BMI, and no significant association was found between other eating occasions and BMI. Another study revealed that a higher percentage of energy intake at midday can reduce the risk of overweight and obesity and no association was detected between weight gain and energy intake at the rest of the eating occasions.[21]

Furthermore, other studies focused on a single meal and investigated its impact on adults' weight gain. A study by Ozturk et al,[22] revealed that night eating was associated with weight gain of adults. Similar results were reported by other cross sectional studies.[23-27] On the other hand, other cross sectional studies showed no association between night eating and BMI.[28-32] Current review regarding the association between night eating and weight gain showed mixed results.[33] Recent meta-analysis revealed that it is difficult to draw conclusions on the influence of energy intake at dinner due to high heterogeneity.[34]

With regard to breakfast, several cross-sectional studies showed mixed results.[35,36] However, several studies have suggested that eating breakfast could reduce the risk of overweight and obesity.[17,37,38] One possible explanation for the relationship between breakfast energy intake and obesity is that breakfast skippers usually try to overcompensate for the lower morning energy intake by consuming larger amounts of high caloric food during the rest of the day.[39] This usually happens due to poor appetite control.[40]

The most interesting results in the present study were that there were no significant differences between the individuals with overweight or obesity and individuals with normal weight in the total energy intake per day. However, the total energy intake for each meal were significantly different between the groups. A randomized controlled trial conducted by Jakubowicz et al,[15] examine the effect of high energy intake at breakfast compared to high energy intake at dinner. The participants were divided into 2 groups with equal amount of energy intake per day (1400 kcal). The first group (breakfast group) consumed 700 kcal breakfast, 500 kcal lunch, and 200 kcal dinner; while the other group (dinner group) consumed 200 kcal breakfast, 500 kcal lunch, 700 kcal dinner for 12 weeks. The results showed that first group (breakfast group) lost significant weight than the second group (dinner group).[15] This shows that not only the total amount of

energy intake per day should be considered for weight control, but also the total amount of energy intake per meal and the time of consumption.

In one study, an unusual timing of food intake was associated with weight gain.[12] Another study indicated that restriction of feeding times, especially during the night, can prevent obesity without reduction of caloric intake.[41] Furthermore, timed feeding can reverse the harmful influence of a high-fat diet.[42] Changing the habitual times of food intake can lead to negative consequences on body health. For example, an experimental study in humans who work night-shifts showed a decline in leptin concentrations, which can lead to obesity due to its ability to control appetite, and an increase in glucose and insulin levels and arterial pressure.[43]

Circadian rhythm has a large impact on human biological activity.[44] Evidence has demonstrated that circadian clocks are sensitive to the timing of food consumption.[45] The circadian rhythm has a large impact on the mobilization and accumulation of fat since several genes that are available in adipose tissue and that can lead to obesity are influenced by a circadian rhythm.[46] Furthermore, the circadian clock can influence hunger and hormonal secretion.[47] Therefore, timing of energy intake plays a crucial role in circadian rhythms regulation as it could alter circadian clocks, which could lead to weight gain and dysregulation of metabolism.[46]

There are some strengths in the current study, namely: the height and weight were measured by a trained research assistant, which is considered more accurate than self-reported. In addition, the dietary data were revised by the researcher to check the accuracy of the dietary data. However, the main limitations were difficulty of estimating energy intake and using a cross sectional design as well as the sampling was not a random. Also, lack of control for possible confounding factors such as physical activity level and data were collected from female at only one university, therefore, may not be representative of all to the Saudi Arabian population. There were few research carried out on this topic and findings are still inconsistent, therefore, more study are required especially randomized controlled trail to get a conclusive results.

In conclusion, the present results showed that greater energy intake in the morning and mid-morning was correlated with a lower risk of overweight and obesity, while greater energy intake in the evening was associated with a higher risk of overweight and obesity. In addition, the total energy intake for each meal and the percentage of energy from fat, carbohydrate and protein per meal were significantly different between the individual with overweight or obesity and individual with normal weight. Thus, the timing of energy intake play an important role in the incidence of overweight and obesity.

Acknowledgment. *The author gratefully acknowledge all participants for their cooperation and their patience. Also, the author would like to thank MDPI (https://www.mdpi.com/authors/english)for English language editing.*

References

1. World Health Organization. Obesity and overweight. [Cited 2019 May 9]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
2. NCD Risk Factor Collaboration. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. ***Lancet*** 2016; 387: 1377-1396.
3. Saudi Ministry of Health. Saudi Health Interview Survey Results. 2013. [Updated 2019. Cited 2019 May 9]. Available form: http://www.healthdata.org/ksa/projects/saudi-health-interview-survey
4. Alqarni S. A review of prevalence of obesity in Saudi Arabia. ***J Obes Eat Disord*** 2016; 2: 2.
5. Elsoadaa S. Overweight and obesity among Saudi female population. ***J Ameri Sci*** 2013; 9: 853-857.
6. Manan A, Alhakbany D, Hana A. Alzamil B, Wajude A. Alabdullatif A et al. Lifestyle habits in relation to overweight and obesity among Saudi women attending Health Science Colleges. ***J Epid Global Health*** 2018; 8: 13-19.
7. Williams EP, Mesidor M, Winters K, Dubbert PM, Wyatt SB. Overweight and obesity: prevalence, consequences, and causes of a growing public health problem. ***Cur Obes Rep*** 2015; 4: 363-370.
8. Al-Kadi A, Malik AM, Mansour AE. Rising incidence of obesity in Saudi residents. A threatening challenge for the surgeons. ***Int J Health Sci*** 2018; 12: 45-49.
9. Aljabri K, Bokhari S, Alshareef M, Khan M, Aljabri B. Overweight and obesity in Saudi women of childbearing age. ***Endocrinol Metabo Res*** 2018; 3: 53-62.
10. Alharbi M, Jackson R. Factors associated with obesity among Saudi women of reproductive age in Jeddah City. ***J Obes Overweig*** 2017; 3: 106.
11. Aparicio E, Rodríguez R, Aranceta-Bartrina J, Gil J , González-Gross G, Serra-Majem L, et al. Differences in meal patterns and timing with regard to central obesity in the ANIBES ('Anthropometric data, macronutrients and micronutrients intake, practice of physical activity, socioeconomic data and lifestyles in Spain') Study. ***Public Health Nutr*** 2017; 20: 2364-2373.
12. Garaulet M, Gómez-Abellán P. Timing of food intake and obesity: a novel association. ***Physiol Behav*** 2014; 134: 44-50.
13. Kahleova H, Lloren J, Mashchak A, Hill M, Fraser G. Meal frequency and timing are associated with changes in body mass index in adventist health study 2. ***J Nutr*** 2017; 147: 1722–1728.
14. Almoosawi S, Vingeliene S, Karagounis LG, Pot GK. Chrono-nutrition: A review of current evidence from observational studies on global trends in time-of-day of energy intake and its

association with obesity. ***Proc Nutr Soc*** 2016; 75: 487-500.
15. Jakubowicz D, Barnea M, Wainstein J. High caloric intake at breakfast vs. dinner differentially influences weight loss of overweight and obese women. ***Obesity*** 2013; 21: 2504-2512.
16. Wang J, Patterson R, Ang A. Timing of energy intake during the day is associated with risk of obesity in adults. ***J Hum Nutr Diet*** 2014; 27: 255-262.
17. Dhurandhar E, Dawson J, Alcorn A, Larsen L, Thomas E, Cardel M et al. The effectiveness of breakfast recommendations on weight loss: A randomized controlled trial. ***Am J Clin Nutr*** 2014; 100: 507-513.
18. Antonio P, Grant T, Antonino B, Tatiana M. The influence of meal frequency and timing on health in humans: the role of fasting. ***Nutrients*** 2019; 11: E719.
19. World Health Organization. Guide to physical measurements. [Cited 2019 May 9]. Available from: https://www.who.int/ncds/surveillance/steps/Section%204%20Step%202%20Physical%20Measurements.pdf
20. Tansey R, Donald H. The timing of energy intake and its link to obesity, 2016. [Updated 2019. Cited 2019 April 8]. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/8179531281EBBFE578E75411535C10AF/S0029665115004450a.pdf/timing_of_energy_intake_and_its_link_to_obesity.pdf
21. Hermenegildo Y, López-García E, García-Esquinas E, Pérez-Tasigchana RF, Rodríguez-Artalejo F, Guallar-Castillón P. Distribution of energy intake throughout the day and weight gain: a population-based cohort study in Spain. ***British J Nutr*** 2016; 115: 2003-2010.
22. Öztürk G, Eğici MT, Toprak D, Erdoğan AM, Hamidiye S, Etfal Training and Reseach Hospital, et al. Relationship between night eating disorders and obesity. ***Ankara Med J*** 2018; 18: 117-122.
23. Gallant A, Drapeau V, Allison KC, Tremblay A, Lambert M, O'Loughlin J, et al. Night eating behavior and metabolic heath in mothers and fathers enrolled in the QUALITY cohort study. ***Eat Behav*** 2014; 15: 186-191.
24. Meule A, Allison K, Brähler E, de Zwaan M. The association between night eating and body mass depends on age. ***Eat Behav*** 2014; 15: 683-685.
25. Meule A, Allison K, Platte P. Emotional eating moderates the relationship of night eating with binge eating and body mass. ***Eur Eat Disord Rev*** 2014; 22: 147-151.
26. Nolan L, Geliebter A. "Food addiction" is associated with night eating severity. ***Appetite*** 2016; 98: 89-94.
27. Yeh S, Brown R. Disordered eating partly mediates the relationship between poor sleep quality and high body mass index. ***Eat Behav*** 2014; 15: 291-297.
28. Gallant A, Lundgren J, O'Loughlin J, Allison K, Tremblay A, Henderson M, et al. Night-eating symptoms and 2-year weight change in parents enrolled in the QUALITY cohort. ***Int J Obes*** 2015; 39: 1161-1165.
29. Aloi M, Rania M, de Fazio P, Vinai P, Tagliabue A, Allison KCS-GC. Validation of the Italian version of the Night Eating Questionnaire (I-NEQ). ***J Psychopathol*** 2017; 23: 137-144.
30. He J, Ji F, Zhang X, Fan X. Psychometric properties and gender invariance of the simplified Chinese version of Night Eating Questionnaire in a large sample of mainland Chinese college students. ***Eat Weight Disord*** 2019; 24: 57-66.
31. Hood M, Reutrakul S, Crowley S. Night eating in patients with type 2 diabetes. Associations with glycemic control, eating patterns, sleep, and mood. ***Appetite*** 2014; 79: 91-96.
32. Kim O, Kim M, Lee J, Jung H. Night-eating syndrome and the severity of self-reported depressive symptoms from the Korea nurses' health study: analysis of propensity score matching and ordinal regression. ***Public Health*** 2016; 141: 80-87.
33. Maija B, Bruzas A, Kelly C, Allison M. A review of the relationship between Night Eating Syndrome and body mass index. ***Curr Obes Reports*** 2019; 8: 145-155.
34. Fong M, Caterson, I, Madigan C. Are large dinners associated with excess weight, and does eating a smaller dinner achieve greater weight loss? A systematic review and meta-analysis. ***Br J Nutr*** 2017; 118: 616-628.
35. Daradkeh G, Al Muhannadi A, Chandra P, Fadlalla A, Moudi Al Hajr, Al Muhannad H. Breakfast skipping as a risk correlate of overweight, obesity and central obesity among adolescents in the State of Qatar· ***EC Nutrition*** 2016; 3: 757-765.
36. Isgin K, Bellikci-Koyu E, Akyol-Mutlu E, Nergiz-Unal R, Ayaz A, Buyuktuncer Z. Breakfast skipping linked to the risk of obesity in school-aged children. ***J Acad Nut Diet*** 2017; 117: A19.
37. Zilberter T, Zilberter E. Breakfast: to skip or not to skip? ***Front Public Health*** 2014. 2014; 2: 59.
38. Nas A, Mirza N, Hägele F, Kahlhöfer M, Keller J, Rising R, et al. Impact of breakfast skipping compared with dinner skipping on regulation of energy balance and metabolic risk. ***Am J Cli Nutr*** 2017; 105: 1351-1361.
39. Scheer FA, Hilton M, Mantzoros CS, Shea SA. Adverse metabolic and cardiovascular consequences of circadian misalignment. ***Proc Natl Acad Sci*** 2009; 106: 4453-4458.
40. Timlin M, Pereira M. Breakfast frequency and quality in the etiology of adult obesity and chronic diseases. ***Nutr Rev*** 2007; 65: 268 -281.
41. Longo VD, Panda S. Fasting, circadian rhythms, and time-restricted feeding in healthy lifespan. ***Cell Meta*** 2016; 23: 1048-1059.
42. Chaix A, Zarrinpar A, Miu P, Panda S. Time-restricted feeding is a preventative and therapeutic intervention against diverse nutritional challenges. ***Cell Meta*** 2014; 20: 991-1005.
43. Bandin C, Scheer F, Luque A, Ávila-Gandía V, Zamora S, Madrid JA, et al. Meal timing affects glucose tolerance, substrate oxidation and circadian-related variables: a randomized, crossover trial. ***Int J Obes*** 2014; 39: 828-833.
44. Keith C. Summa, Fred W. Turek. Chronobiology and obesity: interactions between circadian rhythms and energy regulation. ***Adv Nutr*** 2014; 5: 312S-319S.
45. Wehrens S, Christou S, Isherwood C, Middleton B, Gibbs M, Archer S et al. Meal timing regulates the human circadian system. ***Curr Biol*** 2017; 27: 1768-1775.
46. Poggiogalle E, Jamshed H, Peterson C. Circadian regulation of glucose, lipid, and energy metabolism in humans. ***Metabolism*** 2018; 84; 11-27.
47. Roenneberg T, Merrow M. The circadian clock and human health. ***Current Bio*** 2016; 26: R432-R443.