Obesity Research & Clinical Practice 14 (2020) 1–8

Contents lists available at ScienceDirect

Obesity Research & Clinical Practice

journal homepage: www.elsevier.com/locate/orcp

Review

Skipping breakfast is associated with overweight and obesity: A systematic review and meta-analysis

Xiumei Ma[a,b,c], Qing Chen[a,b,c], Yueli Pu[a,b,c], Man Guo[a,b,c], Zongzhe Jiang[a,b,c], Wei Huang[a,b,c], Yang Long[a,b,c], Yong Xu[a,b,c,*]

[a] Department of Diabetes and Endocrinology, Affiliated Hospital of Southwest Medical University, Luzhou, 646000, China
[b] Luzhou Key Laboratory of Cardiovascular and Metabolic Diseases, Affiliated Hospital of Southwest Medical University, Luzhou, Sichuan, 646000, China
[c] Collaborative Innovation Center for Prevention and Treatment of Cardiovascular Disease of Sichuan Province, Southwest Medical University, Luzhou, Sichuan 646000, China

ARTICLE INFO

Article history:
Received 27 September 2019
Received in revised form
15 November 2019
Accepted 30 December 2019

Keywords:
Skipping breakfast
Overweight
Obesity
Meta-analysis

ABSTRACT

Objective: In recent years, many original studies have shown that skipping breakfast has been associated with overweight and obesity; however, the results of different studies are inconsistent. Therefore, we conducted a systematic review and meta-analysis of observational studies to synthesize the associations between skipping breakfast and the risk of overweight/ obesity.
Methods: We did a systematic search using Pubmed, and Ovid searched up to August 2019. Observational studies (cohort studies and cross-sectional studies) reporting adjusted Odds Ratio or Risk Ratio estimates for the association between breakfast skipping and overweight/obesity (including abdominal obesity). Summary odds ratio (or Risk Ratio) and 95% confidence intervals calculated with a random-effects model.
Results: 45 observational studies (36 cross-sectional studies and 9 cohort studies) were included in this meta-analysis. In cross-sectional studies, The ORs of low frequency breakfast intake per week versus high frequency were 1.48 (95% CI 1.40–1.57; $I^2 = 54.0\%$; $P = 0.002$) for overweight/obesity, 1.31 (95% CI 1.17–1.47; $I^2 = 43.0\%$; $P = 0.15$) for abdominal obesity. In cohort studies, The RR of low-frequency breakfast intake per week versus high frequency was 1.44 (95% CI 1.25–1.66; $I^2 = 61\%$; $P = 0.009$) for overweight/obesity.
Conclusions: This meta-analysis confirmed that skipping breakfast is associated with overweight/obesity, and skipping breakfast increases the risk of overweight/obesity. The results of cohort studies and cross-sectional studies are consistent. There is no significant difference in these results among different ages, gender, regions, and economic conditions.

Contents

* Corresponding author.
E-mail address: xywyll@aliyun.com (Y. Xu).

https://doi.org/10.1016/j.orcp.2019.12.002
1871-403X/

Introduction

The number of overweight and obesity is increasing worldwide [1,2]. Obesity is considered to be one of the defining health and is recognized as the most prevalent form of malnutrition, which increases the incidence of obesity-related complications and the global burden of disease [3,4]. However, the etiology of obesity is likely multifactorial but not well understood. It was generally believed that genes and environment are involved in the occurrence and development of obesity [5]. A recent study has shown that energy imbalance can cause obesity through hypothalamic regulation, and dietary habits are closely related to energy balance [6].

"Breakfast is the most important meal of the day" [7] is a consensus in public. However, the definition of breakfast varies across studies. Here are two standard definitions [8] as follows: (1) Eat the first meal of the day before or at the beginning of the activity within 2 h of waking up, usually no later than 10 am, the calorie content is 20% to 35% of the total daily energy requirement. (2) The consumption of food or beverage (excluding water) between 5 and 9 am. However, with the change of life rhythm, the patterns of dietary behavior have changed over the past 40 years. Typical breakfast, lunch, and dinner meals are difficult to distinguish because skipping meals, notably skipping breakfast, have become more prevalent among school-age children, adolescents and working adults [9,10]. Nowadays, skipping breakfast has become a controversial public health issue. Many people believe that skipping breakfast can help with weight control. However, this behavior may increase in the prevalence of obesity and obesity-related complications [11–16], and regularly eating breakfast can reduce the risk of obesity effectively [17–19]. Recently, some studies have found no significant correlation between skipping breakfast and obesity [20–22]. What's more, some studies even indicate that skipping breakfast led to weight loss and eating breakfast may be harmful to health [23–26]. Accordingly, many studies have been performed during the past decades to explore the relationship between skipping breakfast and the risk of overweight/obesity. But the results of these studies are not consistent. Thus, the question of whether skipping breakfast was associated with obesity remained to be determined. On this basis, we performed the systematic review and meta-analysis of observational studies to systematically assess the association between breakfast skipping and the risk of obesity.

Methods

Search strategy

This meta-analysis was conducted following the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines [27]. We searched the PubMed and Ovid databases from their inception up to August 2019. The search terms were based on Medical Subheadings related to obesity (i.e. "obesity", "overweight", "abdominal obesity", "bodyweight", "body mass index") and skipping breakfast (i.e. "morning meal", "meal, morning", "morning meals", "meal timing", "omitting breakfast", "skipping meals", "eating habits", "eating pattern". We added a manual search using the reference lists of the relevant articles. The search was restricted to published English articles.

Eligibility and study selection

Two authors (XMM and QC) independently screened the titles, abstracts, and full texts of the identified studies to determine eligibility. Disagreements were resolved through consultation with the third author (YLP). The inclusion criteria for reviews were (1) an observational study using a cross-sectional or cohort design (had follow-up duration more than one year, (2) data on risk measures for overweight or obesity according to BMI criteria and corresponding confidence intervals (CIs) related to breakfast skipping or information sufficient to calculate them. A "breakfast skipping group" was defined as the lowest category of breakfast frequency in an individual study. The definition of skipping breakfast is to eat nothing between 5 and 9 am or only drinking something energy-containing or only eating something sweet, such as a bun, cookie or biscuit. Therefore, we included studies that defined breakfast-skippers as those who only sometimes ate breakfast as well as reviews in which breakfast-skippers never ate breakfast. Although the definition of overweight or obesity varied among studies, we included all studies that analyzed overweight or obesity as a dependent variable. The most updated article was selected if two or more items were published for the same observational study. Articles were excluded if they did not include original data; if they were editorials, letters, comments, or conference proceedings; or if they did not meet the inclusion criteria described above. The search was limited to human studies published in the English language.

Data extraction and quality assessment

Two authors (XMM and QC) extracted the following information from the included studies: first author name, publication year, country, area, economics, mean age and/or any range, number of participants (number of skippers, number of overweight/obesity), male ratio, measurement, diagnosis criteria of outcome, risk estimates (OR and/or adjusted OR) and corresponding 95% CI, and covariates adjusted in multivariate analysis. Interobserver agreement was assessed using Cohen's kappa, and any disagreements were resolved by discussion with the third author (YLP). Two authors (XMM and QC) independently performed quality assessments. The Newcastle-Ottawa Scale was applied for cohort studies. Studies with scores of 0–3, 4–6, and 7–9 were considered as low, moderate, and high quality, respectively.

Data synthesis and analysis

The OR/RR were calculated for overweight/obesity and abdominal obesity who skip breakfast versus those who regularly eat breakfast. Between-study heterogeneity was assessed by calculat-

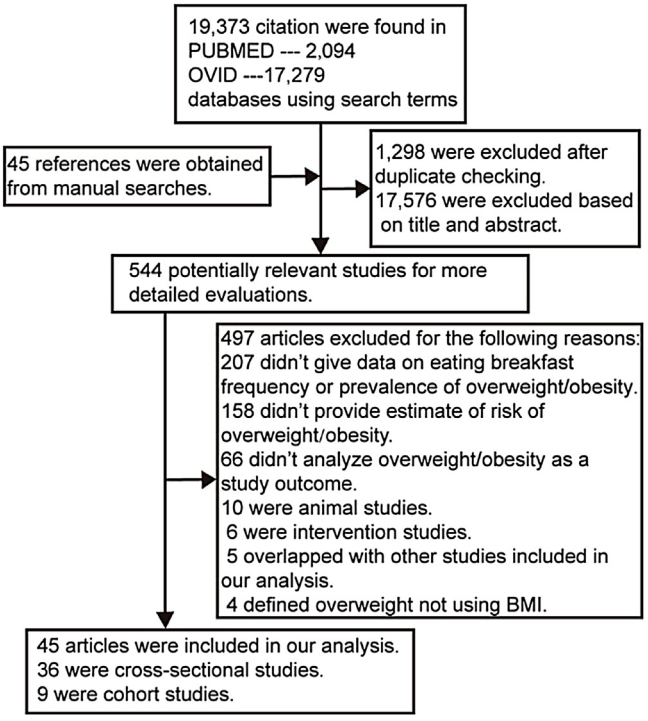

Fig. 1. Flowchart of meta-analysis.

ing the I^2 statistic, which is a quantitative measure of inconsistency across studies. Studies with an I^2 statistic of 25% to 50% were considered to have low heterogeneity, those with an I^2 statistic of 50% to 75% were believed to have moderate heterogeneity, and those with an I^2 statistic of >75% were supposed to have high heterogeneity. A random-effects model was used regardless of heterogeneity. Because participants' characteristics, breakfast frequency, the definition of outcomes, and other confounding factors were not consistent among studies. Data were analyzed using Revman 5.3 software and Stata 12.

Results

Literature search result

As presented in Fig. 1, the systematic search identified 19,373 articles, of which 1,298 were duplicates, and another 17,576 were considered as not- relevant based on title and abstract. After including 45 items obtained from the manual search, 554 studies were selected for full-text review. Finally, 45 studies, including 36 cross-sectional studies [18,28–62] and nine cohort studies [63–71], published between 2003 and 2019, were included in the meta-analysis. Interobserver agreement between the authors for study inclusion was outstanding ($\kappa = 0.95$).

Characteristics of included studies

The characteristics of the included studies are presented in Tables S1 & S2 (Supplementary material 1). Among the selected 45 studies, 9 was a cohort study (63–71), and the remaining 36 studies were cross-sectional studies or surveys (18, 28–62). Most of the studies were from Europe and Asia, of which 19 from Europe [32,35,38,40–43,46,47,53,57–61,64,68–70] and 18 from Asia [18,28–31,37,39,44,48–52,54,56,63,66,71], and the rest were from Africa [67], North America [45,55,62,65], South America [33] and Oceania [34,36]. The studies examined subjects of different ages: 33 studies enrolled children or adolescents [18,28,30,32–34,36–38,40,41,43,44,46–51,53–56,59–61,63,69,70],11 recruited adults of different ages [29,31,35,39,42,45,52,57,58,62], and 1 study did not mention age [71]. In most of the studies, only one study involved females only [51], and the remaining studies included both males and females. The definition of overweight or obesity varied among studies. 16 studies used the World Health Organization (WHO) definition [18,28,30,32,33,35,37,44,50,47–51,56,57,64,65,67,68], 20 the International Obesity Task Force definition [29,31,34,38,40,42,41–43,46–49,53,54,59,58–61,63,66,70,71] and 3 US Centers for Disease Control and Prevention (CDC) growth charts [36,41,55] and 6 studies used the study-specific definition of overweight or obesity [39,45,52,58,62,69]. In addition, 15 studies acknowledged the importance of potentially relevant confounding factors such as socioeconomic status (SES)—or its proxies (e.g., social class and occupation, income, education) [18,28,30,31,37,44–46,51,52,58,60,61,64,71], and physical activity [28,30,37,39,44–47,51,52,54,55,57,62,68], although these factors may have a substantial effect on weight [32]. In detail, most provided an adjusted OR for multiple confounding factors [18,28–35,37–39,42,44–47,52–55,57–64,66–68,71].

Skipping breakfast and overweight/obesity (36 cross-sectional studies)

Thirty-five cross-sectional studies investigated the relationship between skipping breakfast and overweight/obesity. The summary odds ratio for low versus high-frequency breakfast eating per week was 1.48 (95% CI 1.40–1.56; $I^2 = 54.0\%$; $P < 0.0001$) for overweight and obesity (Fig. 2). According to Fig. 2, skipping breakfast is associated with overweight and even obesity. To explore the origin of the heterogeneity, we performed subgroup analyses across several key study characteristics to examine the effect of the attributes on study results (Table S3 in Supplementary material 1). A positive association between skipping breakfast and prevalence of overweight/obesity was consistently observed throughout all subgroups of the specified study characteristics. No significant difference in the strength of the association of breakfast skipping with overweight or obesity was observed according to whether study participants lived in Asia, Europe, Oceania, North or South America, or whether the researched countries were developed countries or developing countries. And the strength of the association between breakfast skipping and overweight/obesity did not differ between child/adolescents and adults/the elderly. Moreover, study-specific adjustments for covariates did not influence the study result. Besides, four of the 36 cross-sectional studies included reported the association between skipping breakfast and abdominal obesity. According to Fig. 3, the summary odds ratio for low versus high-frequency breakfast eating per week was 1.31 (95% CI 1.17–1.47; $I^2 = 43.0\%$; $P = 0.15$).

Sensitivity analysis and publication bias

To test the stability of the results, we carried out sensitivity analysis. First of all, we use fixed effect model and random effect model to calculate respectively. The results (Figs. S1 and S2 in Supplementary material 2) show that whether we use random effect model (OR 1.48 95% CI 1.40–1.57) or fixed-effect model (OR 1.44 95% CI 1.40–1.49), there is no significant impact on the results of combined effect. And, we identify and correct funnel asymmetry caused by publication bias by using pruning and complementing method. According to the results of the diagram (Fig. S3 in Supplementary material 2), 10 additional studies are needed. We selected OR as the effective index and use fixed effect model and random effect model respectively for shear compensation analysis. The point estimation and 95% confidence interval estimation results of the combined

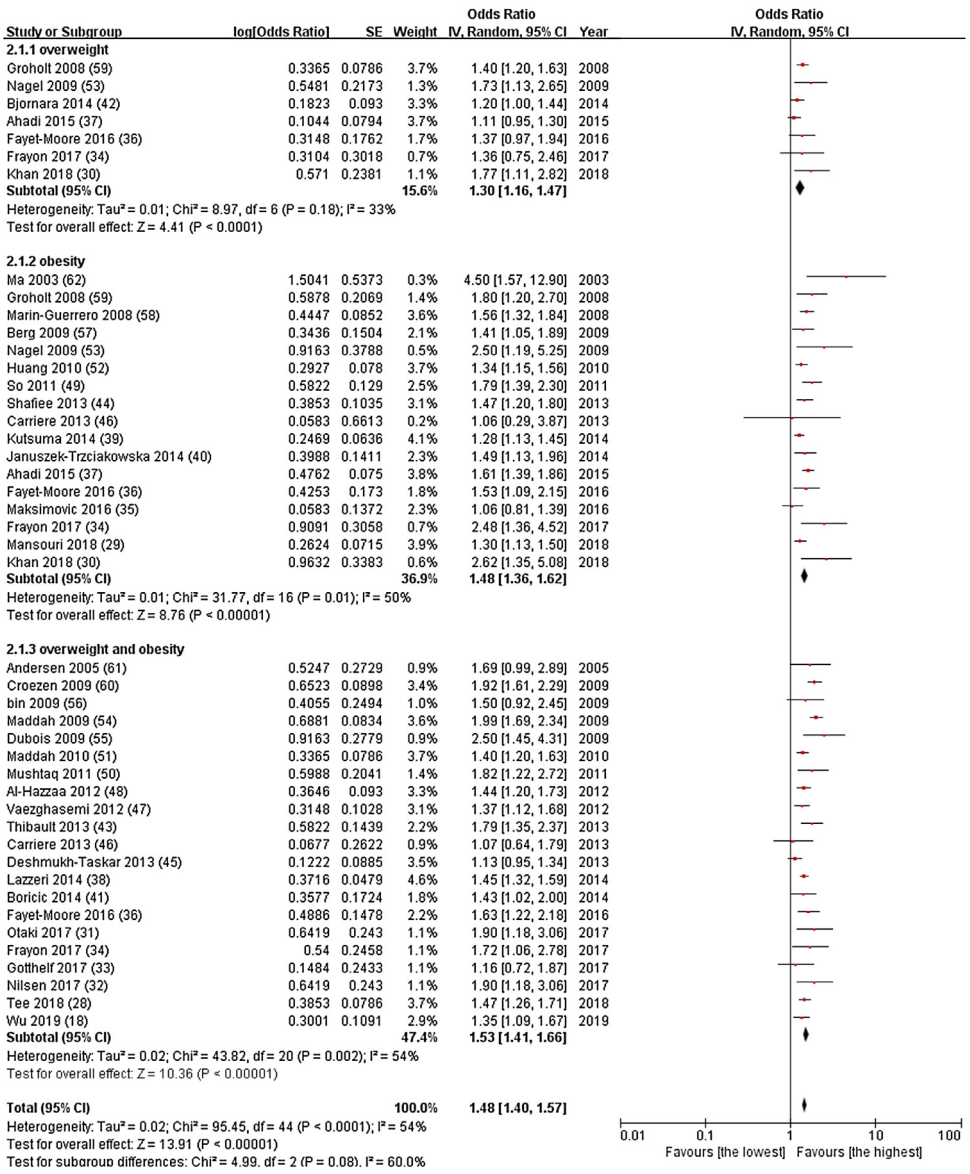

Fig. 2. Forest plot of odds ratios (ORs) of overweight/obesity for the lowest frequency breakfast eating per week vs. the highest.

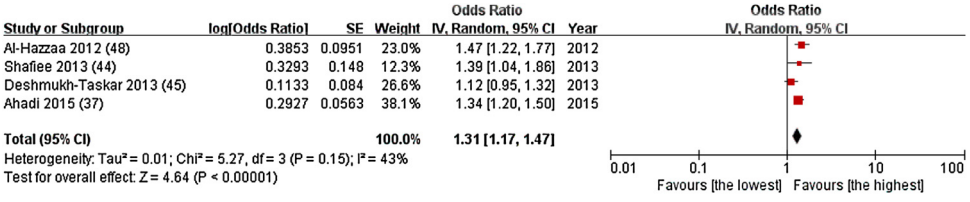

Fig. 3. Forest plot of odds ratios (ORs) of abdominal obesity for the lowest frequency breakfast eating per week vs. the highest.

effect amount are shown in the table (Table S4 in Supplementary material 2). The results show that the point estimation and 95% confidence interval of the combined effect amount have no significant change before and after the shear compensation, suggesting that the conclusion of this meta-analysis is stable. Then, we examine the impact of individual studies on the total combined effect (influence analysis), and the results (Fig. S4 in Supplementary material 2) showed that each study included has little impact on the overall combined effect. Finally, publication bias analysis showed that there was no significant publication bias (Fig. S5 in Supplementary material 2).

Skipping breakfast and overweight/obesity (9 cohort studies)

Nine cohorts (4 prospective cohort studies and 5 retrospective cohort studies) investigated the relationship between skipping breakfast and overweight/obesity. The quality of each cohort study included was assessed independently using the Newcastle-Ottawa scale (NOS) (Table S5 in Supplementary material 1). The results showed that each study scored no less than 6 points and was therefore considered to be of medium-to-high quality. The follow-up period for each study was not less than one year, and the longest was 20 years. In a random-effects meta-analysis of the 9 studies,

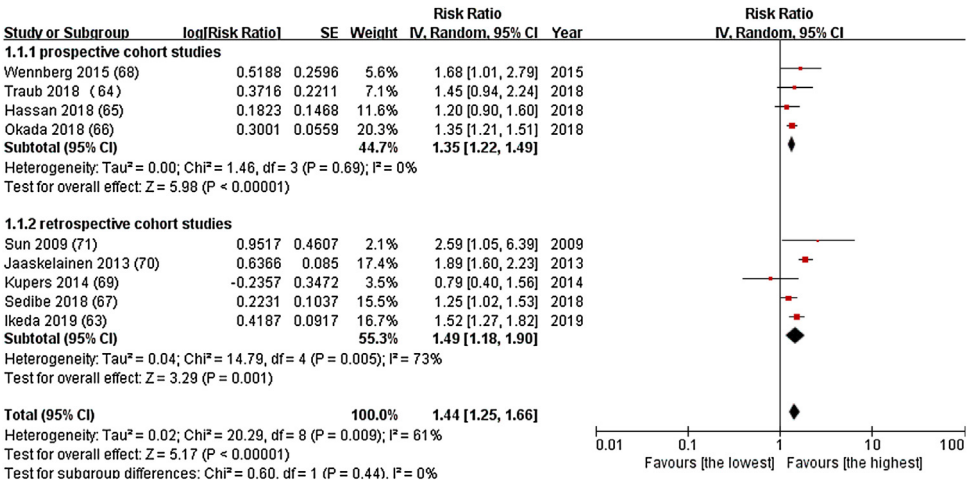

Fig. 4. Forest plot of risk ratios (RRs) for the lowest frequency breakfast eating per week vs. the highest and the risk of overweight/obesity.

we observed that at the end of the trials, participants who skipped breakfast had a higher risk of overweight/obesity than those ate breakfast. The summary Risk Ratio for the lowest frequency breakfast eating per week versus the highest was 1.44 (95% CI 1.25–1.66; $I^2 = 61\%$; P = 0.009) for overweight/obesity (Fig. 4). No significant difference in the strength of the association of breakfast skipping with overweight or obesity was observed according to whether prospective cohort studies or retrospective cohort studies. The funnel diagram (Fig. S5 in Supplementary material 2) is symmetrical, suggesting no significant publication bias.

Discussion

This systematic review and meta-analysis included both cohort studies and cross-sectional studies examining weight change in consuming or skipping breakfast found skipping breakfast increases the risk of overweight/obesity and abdominal obesity. The results of cohort studies and cross-sectional studies are consistent. There was no significant difference in these results among different age groups, gender groups, regions, and economic conditions. Although previous articles have reported the correlation between breakfast and obesity, this article still has its unique features. First, it includes the largest sample size of the population. Furthermore, cross-sectional and cohort studies were included. Therefore, in studying the relationship between breakfast and obesity, we can also prove the causal relationship.

This result extended those of a previous report examining the association between skipping breakfast and obesity [72]. That study was conducted in 2011 and included cross-sectional surveys from 1994 to 2011, and the authors reported that skipping breakfast corresponded with a 1.75-times increase in the risk of obesity compared with those who regularly ate breakfast. However, contrary to the conclusion, another meta-analysis of randomized controlled trials examining weight change in adults consuming or skipping breakfast found no evidence to support the notion that breakfast consumption promotes weight loss or that skipping breakfast leads to weight gain [73]. As the quality of the included studies was mostly low, the findings should be interpreted with caution. The present meta-analysis included original articles of observational studies (cross-sectional and cohort studies were also included) from 2003 to 2019. Our research found that skipping breakfast increased the risk of overweight/obesity by 48% in cross-sectional studies and 44% in cohort studies. Second, we also analyzed the meta-analysis of the correlation between breakfast and abdominal obesity. We found that skipping breakfast increased the risk of abdominal obesity by 31% in cross-sectional studies. Finally, we found there was no significant difference in these results among different age, gender, regions, and economic conditions.

These data suggest that the association between skipping breakfast and overweight and obesity is global, regardless of differences in cultural and economic backgrounds among countries in which studies were performed, although this association has not been confirmed in some African countries because of lack of research in those regions. In Western countries, school breakfast programs are rather common. Many districts have implemented Breakfast in the Classroom (BIC), offering breakfast directly to students at the start of the school day, to increase the frequency of breakfasts. Although some opponents caution BIC has harmful effects on child weight, studies showed that breakfast does not increase obesity. Ochoa-Aviles et al. conducted a cluster randomized controlled trial of school-based intervention improved dietary intake outcomes and found that students who regularly ate breakfast had lower waist circumference [74]. Vik et al. also confirmed that having regular family breakfast was inversely associated with overweight [75]. Blondin et al. conducted an updated review of the literature and suggested that a possible, protective role for breakfast consumption in preventing excess adiposity during childhood and adolescence [76]. Current research is mainly concentrated in Asia and the Pacific, so we can further expand the scope of the study.

Although the current meta-analysis based on cross-sectional studies only showed an association between skipping breakfast and obesity and could not reveal cause-effect relationships. In our meta-analysis, based on nine cohort studies, we found that skipping breakfast increased the risk of overweight/obesity. There have been reports of plausible findings suggesting reasons that skipping breakfast leads to the development of obesity. First, breakfast skipping is associated with changes in appetite and decreased satiety, which may lead to subsequent overeating and impaired insulin sensitivity. In contrast, eating breakfast is useful for regulating appetite, and it can also improve blood sugar response and increase insulin sensitivity in the next meal. Breakfast can break the prolonged overnight fast immediately. However, the longer the fasting time, the higher the concentration of ghrelin (peptide hormone that stimulates hunger), which can mimic fasting to enhance human hedonic, orbitofrontal cortex, and hippocampal responses to food [77]. Chowdhury et al. conducted a randomized controlled trial and demonstrated that in obese adults, daily breakfast leads to more significant physical activity during the morning, whereas morning fasting results in partial dietary compensation (i.e. higher energy intake) later in the day [78]. Besides, another randomized, cross-over trial reported that the adverse effects of skipping breakfast, including more elevated insulin and free fatty acid levels after

lunch, increased hunger, and reduced satiety [79]. Second, from the metabolic aspect, skipping breakfast may lead to obesity through genes, hormones, etc. A randomized clinical trial conducted by *professor Daniela Jakubowicz* clarified the effect of breakfast on the expression of clock genes, and the clock gene could regulate the glucose level of healthy individuals and diabetics after a meal, that is insulin reaction. He showed that skipping breakfast increased postprandial hyperglycemia after lunch and dinner in association with lower iGLP-1 and impaired insulin response [80], and omission of breakfast also altered the expression of genes involved in the circadian clock and metabolism (*Per1*, *Cry1*, *Rorα*, *Sirt1*, and *Clock*), which affected circadian hormone secretion and increased postprandial glycemia [81]. Also, a clinical trial indicates that individuals who skip breakfast are associated with stress-independent over-activity in the hypothalamic-pituitary-adrenal (HPA) axis contribute to disrupted cortisol rhythms [82].

The first major limitation of this study is that it cannot resolve the frequency-effect correlation between breakfast and obesity index. However, our findings are supported by several studies. For example, Sun et al. [71] demonstrated that compared with people who almost daily eat breakfast, people who rarely eat have a higher risk of obesity. Similar results were reported by Shafiee [44], Tee [28] and Croezen [60]. However, more prospective studies are needed to ascertain the relationship between breakfast skipping and future obesity risk. A second major limitation is different adjusted factors, such as the differences among studies in physical activity, ethnicity, dietary energy content, types of items typically consumed at breakfast, and cultural and socio-economical background for skipping breakfast, which might influence the association between breakfast skipping and the prevalence of obesity. Thirdly, other factors of breakfast, such as the type of breakfast, the definition of breakfast, and even the eating time, may have an impact on the correlation between breakfast and obesity, but this paper lacks the analysis of these factors. Forth, the frequency of having breakfast among breakfast skippers varied between and within studies. For example, the report in which breakfast skipping was regarded as a dichotomous variable could have weakened the association with the prevalence of obesity or overweight, although the possibility was not statistically significant. Finally, because EMBASE and Web of Science are not reviewed when retrieving databases, there may be bias caused by incomplete retrieval.

In conclusion, results from this study confirmed the association between breakfast skipping and increased risk of overweight/obesity. This meta-analysis indicates that breakfast is critical for the risk of obesity. Therefore, promoting eating breakfast regular in all population is a useful recommendation to reduce the risk of overweight/obesity in primary prevention. For future studies, we suggest that trials should be fully adjusted for dietary factors and physical activities. We also recommend that the dose-response relationship between breakfast quantity and body mass index (BMI) should be further investigated. Finally, more observational and interventional studies are needed to identify the underlying mechanisms that link skipping breakfast with overweight/obesity.

Conflict of interest

We declare that there is no conflict of financial and commercial interest that could be perceived as prejudicing the impartiality of this study.

Ethical statement

The article was not plagiarized and had not previously been published in other journals.

Funding

This work was supported by the Program of National natural science foundation of China (NO. 81800741).

Acknowledgments

Thanks for all the authors of included papers. We declare that we have no conflict with finical and commercial interest. Xiumei Ma and Yong Xu participated in the study conception and design. Xiumei Ma and Qing Chen acquired reports of trials and extracted data. Xiumei Ma, Qing Chen, and Yueli Pu performed data analyses. Man Guo and Wei Huang checked for statistical consistency. Xiumei Ma, Qing Chen, and Yueli Pu contributed to data interpretation and drafted the manuscript. Yang Long and Yong Xu critically reviewed the manuscript. Xiumei Ma, Qing Chen and Yong Xu contributed to the discussion, are guarantors of this work, have full access to all data in the study, and take responsibility for the integrity and accuracy of the data analysis. All authors approved the final version of this manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.orcp.2019.12.002.

References

[1] Roberto CA, Swinburn B, Hawkes C, Huang TT, Costa SA, Ashe M, et al. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking. Lancet 2015;385(9985):2400–9.
[2] Afshin A, Forouzanfar MH, Reitsma MB, Sur P, Estep K, Lee A, et al. Health effects of overweight and obesity in 195 countries over 25 years. N Engl J Med 2017;377(1):13–27.
[3] Finucane MM, Stevens GA, Cowan MJ, Danaei G, Lin JK, Paciorek CJ, et al. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. Lancet 2011;377(9765):557–67.
[4] Wang YC, McPherson K, Marsh T, Gortmaker SL, Brown M. Health and economic burden of the projected obesity trends in the USA and the UK. Lancet 2011;378(9793):815–25.
[5] Casazza K, Brown A, Astrup A, Bertz F, Baum C, Brown MB, et al. Weighing the evidence of common beliefs in obesity research. Crit Rev Food Sci Nutr 2015;55(14):2014–53.
[6] Zhang X, Zhang G, Zhang H, Karin M, Bai H, Cai D. Hypothalamic IKKbeta/NF-kappaB and ER stress link overnutrition to energy imbalance and obesity. Cell 2008;135(1):61–73.
[7] O'Neil CE, Byrd-Bredbenner C, Hayes D, Jana L, Klinger SE, Stephenson-Martin S. The role of breakfast in health: definition and criteria for a quality breakfast. J Acad Nutr Diet 2014;114(12 Suppl):S8–s26.
[8] Feeley A, Musenge E, Pettifor JM, Norris SA. Changes in dietary habits and eating practices in adolescents living in urban South Africa: the birth to twenty cohort. Nutrition 2012;28(7–8):e1–6.
[9] Greenwood JL, Stanford JB. Preventing or improving obesity by addressing specific eating patterns. J Am Board Fam Med 2008;21(2):135–40.
[10] Howden JA, Chong YH, Leung SF, Rabuco LB, Sakamoto M, Tchai BS, et al. Breakfast practices in the Asian region. Asia Pac J Clin Nutr 1993;2(2):77–84.
[11] Giovannini M, Agostoni C, Shamir R. Symposium overview: do we all eat breakfast and is it important? Crit Rev Food Sci Nutr 2010;50(2):97–9.
[12] Goyal R, Julka S. Impact of breakfast skipping on the health status of the population. Indian J Endocrinol Metab 2014;18(5):683–7.
[13] Kent LM, Worsley A. Breakfast size is related to body mass index for men, but not women. Nutr Res 2010;30(4):240–5.
[14] McCrory MA, Campbell WW. Effects of eating frequency, snacking, and breakfast skipping on energy regulation: symposium overview. J Nutr 2011;141(1):144–7.
[15] Timlin MT, Pereira MA. Breakfast frequency and quality in the etiology of adult obesity and chronic diseases. Nutr Rev 2007;65(6 Pt 1):268–81.
[16] Thomas EA, Higgins J, Bessesen DH, McNair B, Cornier MA. Usual breakfast eating habits affect response to breakfast skipping in overweight women. Obesity (Silver Spring) 2015;23(4):750–9.
[17] Blondin SA, Anzman-Frasca S, Djang HC, Economos CD. Breakfast consumption and adiposity among children and adolescents: an updated review of the literature. Pediatr obesity 2016;11:333–48.

[18] Wu CH, Lin CY, Hsieh YP, Strong C, Meshki C, Lin YC, et al. Dietary behaviors mediate the association between food insecurity and obesity among socioeconomically disadvantaged youth. Appetite 2019;132:275–81.
[19] Betts JA, Richardson JD, Chowdhury EA, Holman GD, Tsintzas K, Thompson D. The causal role of breakfast in energy balance and health: a randomized controlled trial in lean adults. Am J Clin Nutr 2014;100(2):539–47.
[20] van Nassau F, Singh AS, Cerin E, Salmon J, van Mechelen W, Brug J, Chinapaw MJ. The Dutch Obesity Intervention in Teenagers (DOiT) cluster controlled implementation trial: intervention effects and mediators and moderators of adiposity and energy balance-related behaviours. Int J Behav Nutr Phys Act 2014;(11):158.
[21] Sudharsanan N, Romano S, Cunningham SA. School Breakfast Receipt and Obesity among American Fifth- and Eighth-Graders. J Acad Nutr Diet 2016;116:599-607.e3.
[22] Dhurandhar EJ. True, true, unrelated? A review of recent evidence for a causal influence of breakfast on obesity. Curr Opin Endocrinol Diabetes Obes 2016;23(5):384–8.
[23] Kahleova H, Lloren JI, Mashchak A, Hill M, Fraser GE. Meal frequency and timing are associated with changes in body mass index in adventist health study 2. J Nutr 2017;147(9):1722–8.
[24] Geliebter A, Astbury NM, Aviram-Friedman R, Yahav E, Hashim S. Skipping breakfast leads to weight loss but also elevated cholesterol compared with consuming daily breakfasts of oat porridge or frosted cornflakes in overweight individuals: a randomised controlled trial. J Nutr Sci 2014;3:e56.
[25] LeCheminant GM, LeCheminant JD, Tucker LA, Bailey BW. A randomized controlled trial to study the effects of breakfast on energy intake, physical activity, and body fat in women who are nonhabitual breakfast eaters. Appetite 2017;112:44–51.
[26] LeCheminant GM, LeCheminant JD, Tucker LA, Bailey BW. A randomized controlled trial to study the effects of breakfast on energy intake, physical activity, and body fat in women who are nonhabitual breakfast eaters. Appetite 2017;112:44–51.
[27] Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis of Observational Studies in Epidemiology (MOOSE) group. JAMA 2000;283(15):2008–12.
[28] Tee ES, Nurliyana AR, Norimah AK, Mohamed H, Tan SY, Appukutty M, et al. Breakfast consumption among Malaysian primary and secondary school children and relationship with body weight status - findings from the MyBreakfast Study. Asia Pac J Clin Nutr 2018;27(2):421–32.
[29] Mansouri M, Hasani-Ranjbar S, Yaghubi H, Rahmani J, Tabrizi YM, Keshtkar A, et al. Breakfast consumption pattern and its association with overweight and obesity among university students: a population-based study. Eat Weight Disord 2018, http://dx.doi.org/10.1007/s40519-018-0609-8.
[30] Khan A, Khan SR, Burton NW. Missing breakfast is associated with overweight and obesity in Bangladeshi adolescents. Acta Paediatr 2018;08(1):178–9.
[31] Otaki N, Obayashi K, Saeki K, Kitagawa M, Tone N, Kurumatani N. Relationship between breakfast skipping and obesity among elderly: cross-sectional analysis of the HEIJO-KYO study. J Nutr Health Aging 2017;21(5):501–4.
[32] Nilsen BB, Yngve A, Monteagudo C, Tellstrom R, Scander H, Werner B. Reported habitual intake of breakfast and selected foods in relation to overweight status among seven- to nine-year-old Swedish children. Scand J Public Health 2017;45(8):886–94.
[33] Gotthelf SJ, Tempestti CP. Breakfast, nutritional status, and socioeconomic outcome measures among primary school students from the City of Salta: a cross-sectional study. Arch Argent Pediatr 2017;115(5):424–31.
[34] Frayon S, Cherrier S, Cavaloc Y, Touitou A, Zongo P, Wattelez G, et al. Nutrition behaviors and sociodemographic factors associated with overweight in the multi-ethnic adolescents of New Caledonia. Ethn Health 2017:1–17.
[35] Maksimovic MZ, Gudelj Rakic JM, Vlajinac HD, Vasiljevic ND, Marinkovic JM. Relationship between health behaviour and body mass index in the Serbian adult population: data from National Health Survey 2013. Int J Public Health 2016;61(1):57–68.
[36] Fayet-Moore F, Kim J, Sritharan N, Petocz P. Impact of breakfast skipping and breakfast choice on the nutrient intake and body mass index of Australian children. Nutrients 2016;8(8).
[37] Ahadi Z, Qorbani M, Kelishadi R, Ardalan G, Motlagh ME, Asayesh H, et al. Association between breakfast intake with anthropometric measurements, blood pressure and food consumption behaviors among Iranian children and adolescents: the CASPIAN-IV study. Public Health 2015;129(6):740–7.
[38] Lazzeri G, Giacchi MV, Spinelli A, Pammolli A, Dalmasso P, Nardone P, et al. Overweight among students aged 11-15 years and its relationship with breakfast, area of residence and parents' education: results from the Italian HBSC 2010 cross-sectional study. Nutr J 2014;13:69.
[39] Kutsuma A, Nakajima K, Suwa K. Potential association between breakfast skipping and concomitant late-night-dinner eating with metabolic syndrome and proteinuria in the Japanese population. Scientifica 2014;2014:253581.
[40] Januszek-Trzciakowska A, Malecka-Tendera E, Klimek K, Matusik P. Obesity risk factors in a representative group of Polish prepubertal children. Arch Med Sci 2014;10(5):880–5.
[41] Boricic K, Simic S, Vasiljevic N, Marinkovic J. Risk factors associated with overweight among adolescents in Serbia. Zdr Varst 2014;53(4):283–93.
[42] Bjornara HB, Vik FN, Brug J, Manios Y, De Bourdeaudhuij I, Jan N, et al. The association of breakfast skipping and television viewing at breakfast with weight status among parents of 10-12-year-olds in eight European countries; the ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) cross-sectional study. Public Health Nutr 2014;17(4):906–14.
[43] Thibault H, Carriere C, Langevin C, Kossi Deti E, Barberger-Gateau P, Maurice S. Prevalence and factors associated with overweight and obesity in French primary-school children. Public Health Nutr 2013;16(2):193–201.
[44] Shafiee G, Kelishadi R, Qorbani M, Motlagh ME, Taheri M, Ardalan G, et al. Association of breakfast intake with cardiometabolic risk factors. J Pediatr 2013;89(6):575–82.
[45] Deshmukh-Taskar P, Nicklas TA, Radcliffe JD, O'Neil CE, Liu Y. The relationship of breakfast skipping and type of breakfast consumed with overweight/obesity, abdominal obesity, other cardiometabolic risk factors and the metabolic syndrome in young adults. The National Health and Nutrition Examination Survey (NHANES): 1999-2006. Public Health Nutr 2013;16(11):2073–82.
[46] Carriere C, Langevin C, Lamireau T, Maurice S, Thibault H. Dietary behaviors as associated factors for overweight and obesity in a sample of adolescents from Aquitaine, France. J Physiol Biochem 2013;69(1):111–8.
[47] Vaezghasemi M, Lindkvist M, Ivarsson A, Eurenius E. Overweight and lifestyle among 13-15 year olds: a cross-sectional study in northern Sweden. Scand J Public Health 2012;40(3):221–8.
[48] Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Musaiger AO. Lifestyle factors associated with overweight and obesity among Saudi adolescents. BMC Public Health 2012;12:354.
[49] So HK, Nelson EA, Li AM, Guldan GS, Yin J, Ng PC, et al. Breakfast frequency inversely associated with BMI and body fatness in Hong Kong Chinese children aged 9-18 years. Br J Nutr 2011;106(5):742–51.
[50] Mushtaq MU, Gull S, Mushtaq K, Shahid U, Shad MA, Akram J. Dietary behaviors, physical activity and sedentary lifestyle associated with overweight and obesity, and their socio-demographic correlates, among Pakistani primary school children. Int J Behav Nutr Phys Act 2011;8:130.
[51] Maddah M, Nikooyeh B. Factors associated with overweight in children in Rasht, Iran: gender, maternal education, skipping breakfast and parental obesity. Public Health Nutr 2010;13(2):196–200.
[52] Huang CJ, Hu HT, Fan YC, Liao YM, Tsai PS. Associations of breakfast skipping with obesity and health-related quality of life: evidence from a national survey in Taiwan. Int J Obes 2010;34(4):720–5.
[53] Nagel G, Wabitsch M, Galm C, Berg S, Brandstetter S, Fritz M, et al. Determinants of obesity in the Ulm research on metabolism, exercise and lifestyle in children (URMEL-ICE). Eur J Pediatr 2009;168(10):1259–67.
[54] Maddah M. Risk factors for overweight in urban and rural school girls in Iran: skipping breakfast and early menarche. Int J Cardiol 2009;136(2):235–8.
[55] Dubois L, Girard M, Potvin Kent M, Farmer A, Tatone-Tokuda F. Breakfast skipping is associated with differences in meal patterns, macronutrient intakes and overweight among pre-school children. Public Health Nutr 2009;12(1):19–28.
[56] bin Zaal AA, Musaiger AO, D'Souza R. Dietary habits associated with obesity among adolescents in Dubai, United Arab Emirates. Nutr Hosp 2009;24(4):437–44.
[57] Berg C, Lappas G, Wolk A, Strandhagen E, Toren K, Rosengren A, et al. Eating patterns and portion size associated with obesity in a Swedish population. Appetite 2009;52(1):21–6.
[58] Marin-Guerrero AC, Gutierrez-Fisac JL, Guallar-Castillon P, Banegas JR, Rodriguez-Artalejo F. Eating behaviours and obesity in the adult population of Spain. Br J Nutr 2008;100(5):1142–8.
[59] Groholt EK, Stigum H, Nordhagen R. Overweight and obesity among adolescents in Norway: cultural and socio-economic differences. J Public Health (Oxf) 2008;30(3):258–65.
[60] Croezen S, Visscher TLS, Ter Bogt NCW, et al. Skipping breakfast, alcohol consumption and physical inactivity as risk factors for overweight and obesity in adolescents: results of the E-MOVO project. Eur J Clin Nutr 2007;63(3):405–412.
[61] Andersen LF, Lillegaard IT, Overby N, Lytle L, Klepp KI, Johansson L. Overweight and obesity among Norwegian school children: changes from 1993 to 2000. Scand J Public Health 2005;33(2):99–106.
[62] Ma Y, Bertone ER, Stanek 3rd EJ, Reed GW, Hebert JR, Cohen NL, et al. Association between eating patterns and obesity in a free-living US adult population. Am J Epidemiol 2003;158(1):85–92.
[63] Ikeda N, Nishi N. First incidence and associated factors of overweight and obesity from preschool to primary school: longitudinal analysis of a national cohort in Japan. Int J Obes 2019;43(4):751–60.
[64] Traub M, Lauer R, Kesztyus T, Wartha O, Steinacker JM, Kesztyus D. Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren. BMC Public Health 2018;18(1):363.
[65] Hassan BK, Cunha DB, da Veiga GV, Pereira RA, Sichieri R. Changes in breakfast frequency and composition during adolescence: the Adolescent Nutritional Assessment Longitudinal Study, a cohort from Brazil. PLoS One 2018;13(7):e0200587.
[66] Okada C, Tabuchi T, Iso H. Association between skipping breakfast in parents and children and childhood overweight/obesity among children: a nationwide 10.5-year prospective study in Japan. Int J Obes 2018;42(10):1724–32.
[67] Sedibe MH, Pisa PT, Feeley AB, Pedro TM, Kahn K, Norris SA. Dietary habits and eating practices and their association with overweight and obesity in rural and urban black south African adolescents. Nutrients 2018;10(2).
[68] Wennberg M, Gustafsson PE, Wennberg P, Hammarstrom A. Poor breakfast habits in adolescence predict the metabolic syndrome in adulthood. Public Health Nutr 2015;18(1):122–9.

[69] Kupers LK, de Pijper JJ, Sauer PJ, Stolk RP, Corpeleijn E. Skipping breakfast and overweight in 2- and 5-year-old Dutch children-the GECKO Drenthe cohort. Int J Obes 2014;38(4):569–71.
[70] Jaaskelainen A, Schwab U, Kolehmainen M, Pirkola J, Jarvelin MR, Laitinen J. Associations of meal frequency and breakfast with obesity and metabolic syndrome traits in adolescents of Northern Finland Birth Cohort 1986. Nutr Metab Cardiovasc Dis 2013;23(10):1002–9.
[71] Sun Y, Sekine M, Kagamimori S. Lifestyle and overweight among Japanese adolescents: the Toyama birth cohort study. J Epidemiol 2009;19(6):303–10.
[72] Horikawa C, Kodama S, Yachi Y, Heianza Y, Hirasawa R, Ibe Y, et al. Skipping breakfast and prevalence of overweight and obesity in Asian and Pacific regions: a meta-analysis. Prev Med 2011;53(4-5):260–7.
[73] Sievert K, Hussain SM, Page MJ, Wang Y, Hughes HJ, Malek M, et al. Effect of breakfast on weight and energy intake: systematic review and meta-analysis of randomised controlled trials. BMJ 2019;364:l42.
[74] Ochoa-Aviles A, Verstraeten R, Huybregts L, Andrade S, Van Camp J, Donoso S, et al. A school-based intervention improved dietary intake outcomes and reduced waist circumference in adolescents: a cluster randomized controlled trial. Nutr J 2017;16(1):79.
[75] Vik FN, Te Velde SJ, Van Lippevelde W, Manios Y, Kovacs E, Jan N, et al. Regular family breakfast was associated with children's overweight and parental education: results from the ENERGY cross-sectional study. Prev Med 2016;91:197–203.
[76] Blondin SA, Anzman-Frasca S, Djang HC, Economos CD. Breakfast consumption and adiposity among children and adolescents: an updated review of the literature. Pediatr Obes 2016;11(5):333–48.
[77] Onnerfalt J, Erlanson-Albertsson C, Montelius C, Thorngren-Jerneck K. Obese children aged 4-6 displayed decreased fasting and postprandial ghrelin levels in response to a test meal. Acta Paediatr 2018;107(3):523–8.
[78] Chowdhury EA, Richardson JD, Holman GD, Tsintzas K, Thompson D, Betts JA. The causal role of breakfast in energy balance and health: a randomized controlled trial in obese adults. Am J Clin Nutr 2016;103(3):747–56.
[79] Adamska-Patruno E, Billing-Marczak K, Orlowski M, Gorska M, Krotkiewski M, Kretowski A. A synergistic formulation of plant extracts decreases postprandial glucose and insulin peaks: results from two randomized, controlled, cross-over studies using real-world meals. Nutrients 2018;10(8).
[80] Jakubowicz D, Wainstein J, Ahren B, Landau Z, Bar-Dayan Y, Froy O. Fasting until noon triggers increased postprandial hyperglycemia and impaired insulin response after lunch and dinner in individuals with type 2 diabetes: a randomized clinical trial. Diabetes Care 2015;38(10):1820–6.
[81] Jakubowicz D, Wainstein J, Landau Z, Raz I, Ahren B, Chapnik N, et al. Influences of breakfast on clock gene expression and postprandial glycemia in healthy individuals and individuals with diabetes: a randomized clinical trial. Diabetes Care 2017;40(11):1573–9.
[82] Witbracht M, Keim NL, Forester S, Widaman A, Laugero K. Female breakfast skippers display a disrupted cortisol rhythm and elevated blood pressure. Physiol Behav 2015;140:215–21.