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■ Original Article

Association between breakfast consumption frequency and chronic inflammation in Korean adult males: Korea National Health and Nutrition Examination Survey 2016–2018

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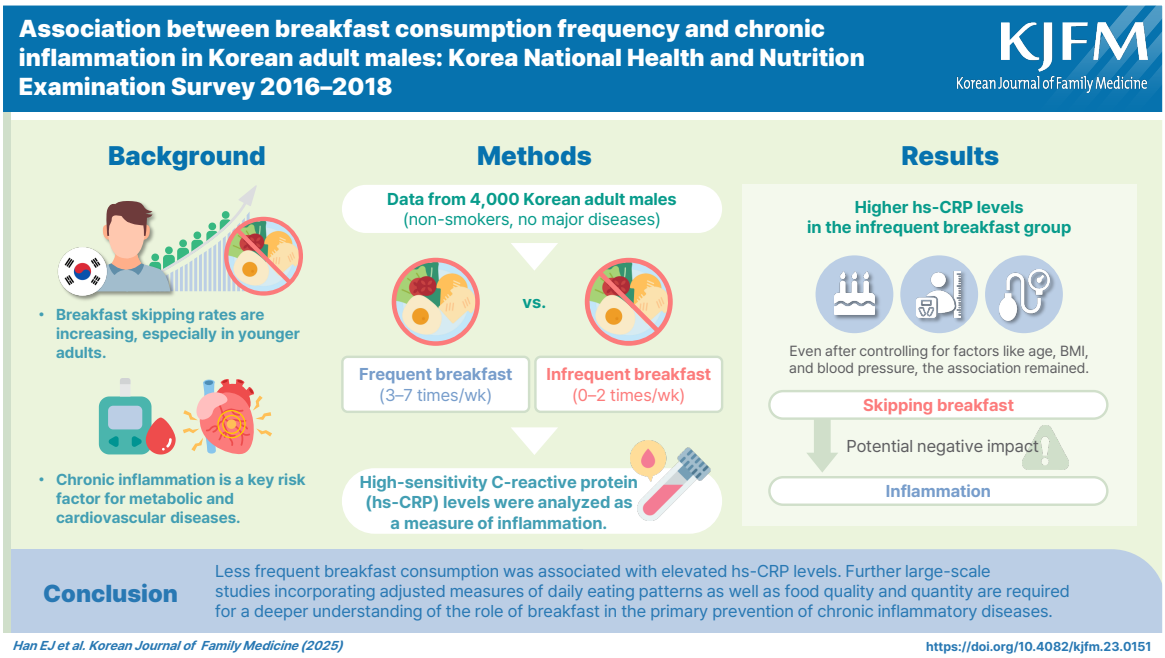

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Background: Skipping breakfast is associated with an increased risk of chronic inflammatory diseases. This study aimed to examine the association between breakfast-eating habits and inflammation, using high-sensitivity C-reactive protein (hs-CRP) as a marker.

Methods: A total of 4,000 Korean adult males with no history of myocardial infarction, angina, stroke, diabetes, rheumatoid arthritis, cancer, or current smoking were included. Data from the 2016–2018 Korea National Health and Nutrition Examination Survey were used for analysis. The frequency of breakfast consumption was assessed through a questionnaire item in the dietary survey section asking participants about their weekly breakfast consumption routines over the past year. Participants were categorized into two groups, namely "0–2 breakfasts per week" and "3–7 breakfasts per week"; hs-CRP concentrations were measured through blood tests.

Results: Comparing between the "infrequent breakfast consumption (0–2 breakfasts per week)" and "frequent breakfast consumption (3–7 breakfasts per week)" groups, the mean hs-CRP was found to be significantly higher in the "infrequent breakfast consumption" group, even after adjusting for age, body mass index, physical activity, alcohol consumption, systolic blood pressure, blood pressure medication, fasting blood glucose, and triglycerides (mean hs-CRP: frequent breakfast consumption, 1.36±0.09 mg/L; infrequent breakfast consumption, 1.17±0.05 mg/L; P-value=0.036).

Conclusion: Less frequent breakfast consumption was associated with elevated hs-CRP levels. Further large-scale studies incorporating adjusted measures of daily eating patterns as well as food quality and quantity are required for a deeper understanding of the role of breakfast in the primary prevention of chronic inflammatory diseases.

Keywords: Breakfast Frequency; Chronic Inflammation; C-Reactive Protein; Cardiovascular Diseases; Metabolic Diseases

Introduction

The concentration of C-reactive protein (CRP) in blood is a marker of systemic inflammation and is elevated in acute infections, inflammatory responses, and aging [1]. In clinical practice, two methods are used to measure blood CRP levels: standard and high-sensitivity C-reactive protein (hs-CRP) assays. Standard clinical assays for CRP have a lower detection limit of 3–8 mg/L, which can be used to evaluate acute infections and trauma, whereas the hs-CRP assay is suitable for identifying low-grade inflammatory states because it can measure CRP within the normal range in healthy people [2]. An increase in blood hs-CRP concentrations from low levels has been used as a marker of atherosclerosis [3] and to stratify cardiovascular risk [4]. In addition, some studies have used hs-CRP levels to determine all-cause mortality [5]. In particular, high CRP levels are strongly associated with the progression of coronary heart disease in men but weakly associated in women [6]. Additionally, previous studies have reported a stronger association between elevated CRP levels and the incidence of metabolic syndrome and diabetes in men than in women [7].

Breakfast is widely recognized for its role in rebalancing energy levels, modulating appetite, and weight regulation [8]. Recent studies have demonstrated that breakfast consumption is associated with a reduced risk of atherosclerotic cardiovascular disease (ASCVD), diabetes, and metabolic syndrome [9,10]. Chronic low-grade inflammatory conditions have been found to disrupt metabolism, leading to an increased risk of conditions closely related to cardiovascular diseases (CVD), such as diabetes, hypertension, and obesity [11,12]. However, according to the 2012–2021 breakfast skipping rate trend by the Korea Centers for Disease Control and Prevention (currently, Korea Disease Control and Prevention Agency), the rate will be 31.7% in 2021, which is an 8.3% increase from 23.4% in 2012. Based on age, those in the ages of 19–29 years were the most likely to miss breakfast (53.0%), whereas those aged 65 years or older were the least likely (6.3%), indicating that younger people are more likely to miss breakfast. The prevalence of skipping breakfast among young people is worsening, with the highest prevalence among those aged 19–29 years at 53.0% and the lowest prevalence among those aged 65 years or older at 6.3% [13]. Although overseas studies have demonstrated an association between breakfast skipping and inflammation using markers such as hs-CRP and glycoprotein acetyls [14,15], no study has yet been conducted on this topic specifically in Korean males. The current study aimed to investigate the association between breakfast consumption frequency and inflammation, estimated via hs-CRP levels, in non-smoking adult males with no history of CVD, diabetes, rheumatoid arthritis, or cancer, using data from the Korean National Health Insurance Service.

Methods

Study subjects

The study utilized data from the 7th Korea National Health and Nutrition Examination Survey (2016–2018), focusing on adult males aged 19 years or older. Initially, the sample included 24,269 subjects. Exclusions were made for those under 19 years of age (n=4,880), females (n=10,831), individuals with a history of myocardial infarction, angina, stroke, diabetes, rheumatoid arthritis, or various cancers (stomach, liver, colon, breast, cervical, lung, thyroid, and other cancers) (n=2,335)—due to their potential to influence hs-CRP levels—and current smokers (n=513), who typically exhibit higher CRP levels [16]. After further excluding participants with missing health, screening, or nutritional survey data (n=1,710), the final analysis included 4,000 participants.

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The present study was approved by the Institutional Review Board (IRB) of Pusan National University Yangsan Hospital (IRB no., 55-2023-001). The requirement for informed consent from individual patients was omitted because of the retrospective design of this study.

Study variables

Independent variable: frequency of breakfast consumption

The frequency of breakfast consumption was assessed using the question, "How many times a week did you typically eat breakfast in the past year?" based on the dietary survey section of the Korea National Health and Nutrition Examination Survey. Participants who reported consuming breakfast "5–7 times a week" or "3–4 times a week" were classified as having "frequent breakfast consumption" while those who reported consuming breakfast "1–2 times a week" or "rarely (0 times a week)" were classified as having "infrequent breakfast consumption."

Dependent variable: hs-CRP

In this study, hs-CRP levels were obtained from blood tests conducted as part of the Korea National Health and Nutrition Examination Survey. The cutoff point was set at 0.5 mg/L, corresponding to an extremely low hs-CRP level, as obtained from a previous study [17].

General characteristics

General characteristics of the study participants included age, body mass index (BMI), physical activity, alcohol consumption, systolic blood pressure, and hypertension treatment. BMI was calculated as weight (in kg) divided by the square of height (in m^2). Physical activity status was categorized as "none" or "yes" based on the participants' engagement in aerobic physical activity. Alcohol consumption status was categorized into "none" for "less than once a month" and "not at all in the past year," and "yes" for "at least once a month," based on the frequency of alcohol consumption over the past year. Blood pressure was measured as the final systolic blood pressure (2nd and 3rd mean), and hypertension treatment status was categorized as "none" or "yes." Fasting blood glucose and triglyceride levels were measured using an automated analyzer after a minimum fasting period of 12 hours.

Statistical analysis

The analyses were weighted to account for the demographic characteristics of the participants of the Korea National Health and Nutrition Examination Survey. Comparisons of anthropometric measurements, social factors, and blood test results based on breakfast consumption frequency were performed using t-tests and chi-square tests. A generalized linear model was analyzed while adjusting for confounding factors to assess the association between breakfast consumption frequency and hs-CRP levels. Logistic regression analysis was conducted to examine the association between breakfast consumption frequency and hs-CRP ≥0.5 mg/L, with the infrequent breakfast consumption group used as the reference category. A significance level of $P<0.05$ was adopted, and statistical analysis was performed using IBM SPSS ver. 27.0 (IBM Corp.).

Results

Participant characteristics related to frequency of breakfast consumption

A total of 4,000 participants were included in the analysis and categorized into two groups based on their breakfast consumption frequency (3 times a week). Most participants (82%) belonged to the frequent breakfast consumption group (3–7 breakfasts per week). The general characteristics of the infrequent breakfast consumption group (0–2 breakfasts per week; n=719) and the frequent breakfast consumption group (3–7 breakfasts per week; n=3,281) are presented in Table 1.

When analyzed according to breakfast consumption frequency, significant differences were observed in age, BMI, alcohol consumption, systolic blood pressure, history of hypertension treatment, and fasting blood glucose levels ($P<0.05$). Compared to the frequent breakfast

Table 1. Common characteristics based on breakfast consumption frequency

Characteristic	Infrequent breakfast consumption (0–2 breakfasts/wk)	Frequent breakfast consumption (3–7 breakfasts/wk)	P-value
Age (y)	35.74±0.46	50.99±0.41	<0.001
Body mass index (kg/m^2)	25.31±0.17	24.48±0.06	<0.001
Physical activity			
No	355 (46.8)	1,739 (46.9)	0.965
Yes	364 (53.2)	1,542 (53.1)	
Alcohol consumption			
No	93 (11.2)	747 (19.8)	<0.001
Yes	626 (88.8)	2,534 (80.2)	
Systolic blood pressure (mm Hg)	118.59±0.52	120.94±0.32	<0.001
Hypertension treatment			
No	654 (92.7)	2,288 (76.4)	<0.001
Yes	65 (7.5)	993 (23.6)	
Fasting blood glucose (mg/dL)	99.00±0.88	103.08±0.47	<0.001
Triglyceride (mg/dL)	154.04±4.47	145.18±2.63	0.076

Values are presented as mean±standard deviation or number (%).

consumption group, the infrequent breakfast consumption group was younger (35.74±0.46 years versus 50.99±0.41 years), had a higher percentage of individuals consuming alcohol at least once a month (88.8% versus 80.2%), and had a higher BMI (25.31±0.17 kg/m^2 versus 24.48±0.06 kg/m^2). On the other hand, the infrequent breakfast consumption group had lower systolic blood pressure (118.59±0.52 mm Hg versus 120.94±0.32 mm Hg) and fasting blood glucose levels (99.00±0.88 mg/dL versus 103.08±0.47 mg/dL), and a lower proportion of individuals taking medication for hypertension (7.3% versus 23.6%).

High-sensitivity C-reactive protein values based on frequency of breakfast consumption

To examine whether there were significant differences in the body's chronic inflammatory status based on the frequency of breakfast consumption, a generalized linear analysis was employed to determine the mean hs-CRP values (Table 2). In model 1, adjusting for age, BMI, physical activity, and alcohol consumption, the mean hs-CRP value was 1.37±0.09 mg/L for the infrequent breakfast consumption group and 1.18±0.05 mg/L for the frequent breakfast consumption group (P-value=0.032). In model 2, which further incorporated systolic blood pressure, blood pressure medication, fasting blood glucose, and triglyceride levels into model 1, the mean hs-CRP value remained higher in the infrequent breakfast consumption group (1.36±0.09 mg/L) than in the frequent breakfast consumption group (1.17±0.05 mg/L, P-value=0.036).

Odds ratio for high high-sensitivity C-reactive protein by frequency of breakfast consumption

Logistic regression analysis was conducted to examine the odds ratio (OR) of having hs-CRP >0.5 mg/L, based on breakfast consumption frequency. In model 1 analysis, adjusted for age, BMI, physical activity, and alcohol consumption, the OR of having hs-CRP >0.5 mg/L was significantly higher in the infrequent breakfast consumption group than in the frequent breakfast consumption group (OR, 1.34; 95% confidence interval [CI], 1.09–1.66; P=0.007). This association remained consistent in model 2, which further adjusted for blood pressure, hypertension treatment, fasting blood glucose, and triglycerides over model 1 (OR, 1.31; 95% CI, 1.06–1.62; P=0.013) (Table 3).

Table 2. Adjusted means of high-sensitivity C-reactive protein concentrations based on breakfast consumption frequency

	Infrequent breakfast consumption (0–2 breakfasts/wk)	Frequent breakfast consumption (3–7 breakfasts/wk)	P-value
Crude	1.27±0.08	1.17±0.04	0.229
Model 1	1.37±0.09	1.18±0.04	0.032
Model 2	1.36±0.09	1.17±0.04	0.036

Values are presented as mean±standard deviation. Model 1: adjusted for age, BMI, physical activity, and alcohol consumption. Model 2: adjusted for age, BMI, physical activity, and alcohol consumption, systolic blood pressure, hypertension treatment, fasting blood glucose, and triglyceride.
BMI, body mass index.

Discussion

This study aimed to examine the association between breakfast consumption frequency and hs-CRP levels in non-smoking adult men without a history of cancer, rheumatoid arthritis, CVD, or diabetes using data from the 2016, 2017, and 2018 Korea National Health and Nutrition Examination Surveys. This study demonstrated that infrequent breakfast consumption was significantly associated with higher hs-CRP levels compared to frequent breakfast consumption (P<0.05) even after adjusting for age, BMI, physical activity, alcohol consumption, systolic blood pressure, hypertension treatment, fasting blood glucose, and triglycerides.

Consistent with our results, previous studies exploring the association between breakfast consumption frequency and inflammation reported similar findings. A cross-sectional study involving 70,092 Chinese adults investigated the association between breakfast consumption and chronic inflammation using hs-CRP levels. The adjusted OR for the "no-breakfast" group, compared to the "breakfast everyday" group, was 1.86 (95% CI, 1.73–2.00) for hs-CRP ≥1.0 mg/L and 1.27 (95% CI, 1.15–1.40) for hs-CRP ≥3.0 mg/L. The "no-breakfast" group exhibited increased odds ratio of having elevated CRP levels (P for trend <0.001 for both) [15]. Furthermore, a cross-sectional study conducted as part of the Cancer Prevention Study-3 Diet Assessment Substudy involving 644 participants analyzed the association between breakfast consumption and inflammation using glycoprotein acetyl. The study found that the group consuming breakfast 5 days a week had higher glycoprotein acetyl values compared to the group consuming breakfast 6 days a week (β, 0.21; 95% CI, 0.03–0.40) [8].

Frequently skipping breakfast is associated with an increased risk of being overweight and obese [18]. Consistent with these findings, we observed a higher BMI in the infrequent breakfast consumption group. Previous studies have consistently shown that skipping break-

Table 3. OR and 95% CI for hs-CRP across all breakfast frequency groups

	hs-CRP (ref: ≤0.5)	Breakfast frequency (ref: frequent breakfast consumption)	OR (95% CI)	P-value
Crude	>0.5	Infrequent breakfast consumption	1.15 (0.95–1.39)	0.142
Model 1	>0.5	Infrequent breakfast consumption	1.34 (1.09–1.66)	0.007
Model 2	>0.5	Infrequent breakfast consumption	1.31 (1.06–1.62)	0.013

Model 1: adjusted for age, BMI, physical activity, and alcohol consumption. Model 2: adjusted for age, BMI, physical activity, and alcohol consumption, systolic blood pressure, hypertension treatment, fasting blood glucose, and triglyceride.
OR, odds ratio; CI, confidence interval; hs-CRP, high-sensitivity C-reactive protein; Ref, reference; BMI, body mass index.

fast is linked to adverse metabolic outcomes, including elevated total cholesterol, triglycerides, fasting blood glucose, and hypertension [19-21], all of which are recognized as risk factors for CVD. Moreover, numerous studies have demonstrated a strong association between skipping breakfast and an increased risk of ASCVD, metabolic syndrome, CVD, total stroke, and cerebral hemorrhage [9].

In the current study, the frequent breakfast consumption group exhibited higher systolic blood pressure, prevalence of hypertension, and fasting blood glucose levels. These findings may be attributed to the higher average age of the frequent breakfast consumption group than that of the infrequent breakfast consumption group, since age is a well-known risk factor for chronic and metabolic diseases, such as hypertension and diabetes. In line with our results, a study conducted by the International Breakfast Research Initiative reported a U-shaped relationship between age and breakfast consumption frequency, with higher breakfast consumption observed in children and elderly individuals. These findings are consistent with the results of our study [22].

In this study, we hypothesized that several mechanisms underlie the association between skipping breakfast and chronic inflammation. First, skipping breakfast may contribute to an increase in postprandial glucose levels after lunch and dinner, potentially leading to overeating and higher peak glucose levels, resulting in glucose variability [20]. Hyperglycemia and glucose variability are speculated to induce oxidative stress, which subsequently triggers inflammation [23]. Second, meal timing and frequency affect circadian rhythms, which are also known to be associated with inflammatory pathways and can contribute to the development of inflammation [24,25]. Third, skipping breakfast can disrupt the hepatic circadian clock, leading to fluctuations in lipid metabolism, such as elevated triglyceride and reduced HDL-cholesterol levels [26]. Triglycerides, cholesterol, and glucose are all involved in the metabolic pathway of nuclear factor (NF)-κB, a transcription factor implicated in inflammation [27]. Hence, skipping breakfast could possibly promote inflammation through the activation of NF-κB. Finally, breakfast consumption has been shown to contribute significantly to the intake of thiamine, riboflavin, and folate [15]. Deficiencies of these essential nutrients are associated with inflammation [28,29].

A limitation of this study is that it was conducted only in Korea and did not include multiple ethnicities. Future studies should investigate the relationship between breakfast consumption and hs-CRP levels across different ethnicities. Second, the frequency of breakfast consumption was divided into two groups with a cut-off of 3 times a week and not broken down further. Third, it did not consider work patterns, such as shift work, which can affect breakfast behavior. Fourth, it did not identify the presence or absence of lunch and dinner; as a result, eating patterns, such as how many meals they have per day, could not be analyzed further. Fifth, the diet quality, such as the type of food consumed during breakfast, was not assessed. Sixth, we did not identify or adjust for sleep parameters, such as snoring, sleep duration, and insomnia, which are known to influence breakfast behavior and are associated with CVD risk [30]. Seventh, because the information was captured by self-report questionnaires, we were not able to accurately identify and exclude the participants' acute infection status, which may have affected their hs-CRP levels at the time. Nevertheless, this study has the strength of being the first large-scale study to examine the relationship between breakfast consumption and inflammation in the Korean population. In addition, the study was conducted in healthy adult men who were non-smokers and did not have a history of diseases that could cause elevated CRP levels (cancer, rheumatoid arthritis, CVD, and diabetes), suggesting that breakfast habits can affect inflammation even in healthy individuals. Finally, previous studies had used hs-CRP cut-offs of 1 mg/L and 3 mg/L to identify the associations [15], whereas the current study used 0.5 mg/L to identify associations based on very low risk of CVD [17]. Therefore, this study confirmed that even if the cutoff hs-CRP level is set at 0.5 mg/L, the trend is consistent with previous findings [15] and can be used as an indicator for active educational materials for the primary prevention of CVD in people who tend to progressively show an increase in hs-CRP values, even at very low levels.

This study provides evidence of an association between breakfast consumption and chronic inflammation in healthy Korean adult men. However, further large-scale studies conducted in Korea that consider adjusted measures of daily eating patterns, as well as the quality and quantity of food, are warranted to enhance our understanding of this area.

Article Information

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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