Research Square

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Association between breakfast skipping and metabolic outcomes with sex, age, and work status stratification

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Abstract

Background

The association between breakfast skipping and abnormal metabolic outcome remains controversial. Large study with stratified data is needed.

Objective

The aim of the current study was to investigate the relationship between abnormal metabolic outcomes and breakfast skipping with sex, age, and work status stratification.

Methods

We used data from the Korea National Health and Nutrition Examination Surveys from 2013–2018. A total of 21,193 (9,022 men and 12,171 women) participants were included in the final analysis. The risk of the increased total number of metabolic outcomes linked to breakfast skipping was estimated using the Poisson regression analysis with sex, work status, and age stratification.

Results

A total of 11,952 (56.4%) participants consumed breakfast regularly. The prevalence of abnormal metabolic outcomes was higher among those with irregular breakfast consumption habits. In the irregular breakfast eating group, young men in the working population demonstrated a higher risk of metabolic syndrome after adjustment (odds ratio, 1.15; 95% confidence interval, 1.06–1.25). We found a similar association among middle-aged men in the working population (odds ratio, 1.11; 95% confidence interval, 1.05–1.19).

Conclusions

The risk of abnormal metabolic outcomes was significant in young men in the working population. Further studies are required to understand the association between specific working conditions (working hours or shift working) and breakfast intake status and the risk of metabolic outcomes

Introduction

Breakfast is the most important meal of the day because it helps the human body to start daily metabolism. Human body is regulated by the circadian rhythm. Circadian rhythm is influenced by the light–dark cycle, as well as by food uptake, which is the metabolic signal. Inversely, circadian regulation of metabolic genes affects metabolic outcomes of the human body, which signifies that feeding time and the circadian clock are tightly intertwined (1). Breakfast is important to jumpstart daily metabolism. A randomized clinical trial showed that breakfast skipping adversely affected circadian gene expression and correlated with increased postprandial glycemic response (2). The irregular consumption of breakfast can induce various health problems.

Many studies have reported on the association between breakfast skipping and health problems. A large, prospective study conducted in the US on middle-aged and older male health professionals in the US confirmed that eating breakfast was associated with a significantly lower risk of coronary heart disease (3). Some studies found that individuals who skipped breakfast had higher rates of mortality (4), higher serum cholesterol (5), and frequent health compromising behaviors (6) compared with regular breakfast eaters. In addition, other studies reported that breakfast intake had many beneficial effects such as improved satiety, reduced incidence of food cravings (7) and improved cognitive function and academic performance (8).

Breakfast skipping has a significant impact on body weight and metabolic outcomes. The relationship between breakfast skipping and high body mass index (BMI) has been widely reported in adolescent populations in Europe (9), Hong Kong (10), and Fiji (girls) (11). Similar associations were reported in the adult (12), middle-aged adult (13), and elderly (14) populations. Many studies reported that metabolic outcomes were associated with breakfast skipping; however, more evidence is required. The strength of association between breakfast habituation and metabolic outcomes varies according to the age group, sex, and ethnicity. For instance, a cross-sectional study on 5,316 American young adults showed that regular breakfast eaters were less likely to have elevated low-density lipoprotein cholesterol (LDL-C) levels and blood pressure and reduced serum high-density lipoprotein cholesterol (HDL-C) levels (15). In contrast, a study on 415 Korean adults confirmed that regular breakfast intake was associated with elevated triglyceride (TG) levels (16). Thus, studies on the association between breakfast skipping and metabolic syndrome remain conflicting, warranting further studies on this subject.

The present study was undertaken to (1) identify the relationship between breakfast skipping and metabolic outcomes in the Korean adult population and (2) demonstrate in detail the effect of breakfast skipping on metabolic outcomes according to age group, sex, and work status.

Methods

Data and study participants

We used data from the Korea National Health and Nutrition Examination Surveys (KNHANES) from 2013-2018. The KNHANES, which has been conducted every year since 1998 by the Korea Centers for Disease Control and Prevention, is a series of nationally representative, population-based surveys on the health and nutritional status of Korean citizens (17). The KNHANES database is publicly available on their website (http://knhanes.cdc.go.kr, available in Korean). More than 7,000 participants are selected each year by the stratified random sampling method. The data are collected by interviews, blood test, urine test, and physical examination in the examination vehicle. All participants agreed to provide their information. The total number of participants in the KNHANES from 2013-2018 was 47,217. We excluded the following participants: (1) those above 59 years of age or under 20 years of age (n=16,394); (2) those who refused to answer questions regarding their work status (n=5,063); and (3) those with missing information for metabolic outcomes, frequency of eating breakfast, education, and household income (n=4,567). After all the exclusions, the final number of participants included in this analysis was 21,193 (9,022 men and 12,171 women, Figure 1).

Status of breakfast

The frequency of breakfast consumption was assessed by a self-administered questionnaire. Participants were asked to report the average number of breakfasts consumed per week in the past year. Four categories were considered: 5-7/week, 3-4/week, 1-2/week, and 0/week. We then categorized the participants into two groups: (1) Regular breakfast eaters (those who ate breakfast almost every day, 5-7/week category); (2) Irregular breakfast eaters (those who ate breakfast rarely or never, 3-4/week, 1-2/week, and 0/week categories).

Classification and measurement of metabolic outcomes

Metabolic outcomes were assessed according to the National Cholesterol Education Program Adult Treatment Panel III criteria (18). Metabolic outcome profiles were composed of central obesity, raised blood pressure, raised fasting serum glucose, increased TG, and decreased HDL-C levels. Central obesity was defined as weight circumference exceeding 90 cm in men and 80 cm in women, in line with the Asian standard. Blood pressure was measured following the standard protocol using a mercury manometer (19). Patients were classified into the raised blood pressure group if they received any specific treatment for hypertension or if the systolic or diastolic blood pressures were ≥ 130 mmHg or ≥ 85 mmHg, respectively. We defined raised fasting glucose and increased TG levels in a similar manner and the cutoff values were 100 mg/dL and 150 mg/dL, respectively. We defined decreased HDL-C as levels of <40 mg/dL in men and <50 mg/dL in women. Serum glucose, TG, and HDL-C levels were measured on a Hitachi 7600-210 automatic analyzer (Hitachi, Japan) by using the hexokinase UV, enzymatic, and homogeneous enzymatic colorimetric methods, respectively. We defined metabolic syndrome as the presence of three or more abnormal metabolic outcomes.

Covariates

We considered work status, education, household income, smoking, and alcohol drinking as covariates. We defined workers as a paid working group to reduce heterogeneity of work characteristics. We classified education into three categories based on the highest level of education as (1) below middle school, (2) high school, and (3) university. Household income was divided into four quartiles. Smoking status was divided into three categories (current, former, and never). Alcohol drinking was classified into three categories (severe, moderate, and none).

Statistical analyses

All statistical analyses were performed using the Statistical Analysis System version 9.4 (SAS Institute, Cary, NC, USA). Chi-square tests were conducted to assess the differences in general characteristics based on regular breakfast intake. Student t-tests were conducted to compare the average of each measurement of metabolic outcomes and the total number of abnormal metabolic outcomes based on regular breakfast intake. To explore the association between the risk of increased total number of metabolic outcomes and regular breakfast intake, we used the Poisson regression analysis with adjustments for age, education level, income level, smoking, and alcohol drinking after sex, work status, and age stratification to estimate the odds ratio (OR) and 95% confidence intervals (CIs). The weighted prevalence of abnormal metabolic outcomes was calculated using the KNHANES population weighting with sex and age stratification.

Results

The baseline characteristics according to regular breakfast intake are presented in Table 1. The total number of participants was 21,193 (9,022 men and 12,171 women). The number (%) of participants who ate breakfast regularly was 11,952 (56.4%). No significant difference was observed in regular breakfast intake between men and women. The participants were stratified based on age as young (age, 20–39 years) and middle-aged (age, 40–59 years). The percentage of regular breakfast eaters among young participants (n = 2,775, 37.92%) was significantly lower than that among middle-aged participants (n = 9,177, 66.15%). Participants who received a high level of education tended to eat breakfast irregularly. In contrast, participants with a higher household income had regular breakfast eating habits.

Table 1
General characteristics of study participants

Characteristics	Regular breakfast		p-value
	Yes, n (%)	No, n (%)	
Total	11,952 (56.40)	9,241 (43.60)	
Sex			0.1100
Men	5,031 (55.76)	3,991 (44.24)	
Women	6,921 (56.86)	5,250 (43.14)	
Age (years)			< .0001
20–39	2,775 (37.92)	4,544 (62.08)	
40–59	9,177 (66.15)	4,697 (33.85)	
Education			< .0001
Middle school	3,671 (68.26)	1,707 (31.74)	
High school	3,878 (53.03)	3,435 (46.97)	
College or more	4,403 (51.79)	4,099 (48.21)	
Household income			< .0001
1st quartile	942 (53.43)	821 (46.57)	
2nd quartile	2,707 (54.30)	2,278 (45.70)	
3rd quartile	3,785 (55.09)	3,086 (44.91)	
4th quartile	4,518 (59.65)	3,056 (40.35)	
Smoking			< .0001
None	8,636 (59.59)	5,856 (40.41)	
Past	1,754 (57.36)	1,304 (42.64)	
Current	1,562 (42.88)	2,081 (57.12)	
Drinking			< .0001
None	4,122 (66.20)	2,105 (33.80)	
Moderate	6,743 (53.64)	5,829 (46.36)	
Severe	1,062 (44.96)	1,300 (55.04)	
Working			< .0001
No	7,042 (59.70)	4,754 (40.30)	

Characteristics	Regular breakfast		p-value
	Yes, n (%)	No, n (%)	
Yes	4,910 (52.25)	4,487 (47.75)	
Abdominal obesity			0.4420
No	9,601 (56.53)	7,384 (43.47)	
Yes	2,351 (55.87)	1,857 (44.13)	
Raised blood pressure			< .0001
No	8,955 (55.08)	7,303 (44.92)	
Yes	2,997 (60.73)	1,938 (39.27)	
Diabetes			< .0001
No	9,232 (55.66)	7,355 (44.34)	
Yes	2,720 (59.05)	1,886 (40.95)	
Increased TG			0.0095
No	8,697 (55.86)	6,871 (44.14)	
Yes	3,255 (57.87)	2,370 (42.13)	
Decreased HDL-C			0.0021
No	8,277 (55.71)	6,580 (44.29)	
Yes	3,675 (58.00)	2,661 (42.00)	
Metabolic syndrome			0.0001
No	9,717 (55.79)	7,701 (44.21)	
Yes	2,235 (59.21)	1,540 (40.79)	

Abdominal obesity: WC > 90 cm for men, WC > 80 cm for women (Asian modified)

Raised blood pressure: Systolic blood pressure ≥ 130 mmHg or Diastolic blood pressure ≥ 85 mmHg

Raised fasting plasma glucose: Plasma fasting glucose > 100 mg/dL or specific treatment for diabetes

Increased triglyceride (TG): Plasma triglyceride > 150 mg/dL or specific treatment for hyperlipidemia

Decreased high density lipoprotein cholesterol (HDL-C): Plasma HDL-C < 40 mg/dL for men, Plasma-HDL-C < 50 mg/dL for women

Metabolic syndrome: Three or more of the above traits (ATP III Criteria)

The percentage of irregular breakfast eaters is higher among individuals with unhealthy lifestyle habits. In our study, 57.12% of the current smokers ate breakfast irregularly, whereas 42.64% of the past smokers and 40.41% of the never-smokers ate irregularly. Furthermore, 55.04% of the heavy drinkers skipped breakfast, while 46.36% moderate drinkers and 33.80% non-drinkers skipped the meal. Compared with non-paid workers, paid workers have irregular breakfast eating habits. In our study, 47.75% of the paid workers did not eat breakfast regularly, whereas only 40.3% of the non-paid workers had an irregular pattern. Individuals with abnormal metabolic outcomes, except abdominal obesity, significantly tend to demonstrate regular breakfast eating habits. The specific metabolic outcomes stratified by working population are shown in Table 2. We considered the average value of each metabolic outcome according to the breakfast consumption status. Age was not stratified in the above analysis.

Table 2
Metabolic outcomes by regular breakfast

Characteristics	Regular breakfast		p-value
	Yes, mean (standard deviation)	No, mean (standard deviation)	
Total participants			
Men			
Abdominal circumference (cm)	82.53 (11.18)	83.83 (10.75)	0.0083
Systolic blood pressure (mmHg)	116.7 (13.71)	116.8 (12.67)	0.9456
Diastolic blood pressure (mmHg)	76.32 (11.53)	77.53 (10.89)	< .0001
Fasting glucose level (mg/dL)	99.74 (22.48)	98.05 (21.24)	0.0003
TG level (mg/dL)	149.6 (136.6)	156.8 (137.7)	0.0128
HDL-C level (mg/dL)	48.14 (10.87)	47.95 (10.85)	0.3939
Number of abnormal metabolic outcomes	1.44 (1.40)	1.45 (1.39)	0.8586
Women			
Abdominal circumference (cm)	75.69 (9.64)	75.30 (9.74)	0.0285
Systolic blood pressure (mmHg)	111.2 (14.77)	109.0 (13.26)	< .001
Diastolic blood pressure (mmHg)	72.47 (9.93)	72.15 (9.50)	0.0662
Fasting glucose level (mg/dL)	94.78 (18.12)	93.68 (18.21)	0.0010
TG level (mg/dL)	105.9 (79.51)	101.7 (73.87)	0.0028
HDL-C level (mg/dL)	55.06 (12.16)	56.30 (12.32)	< .0001
Number of abnormal metabolic outcomes	1.12 (1.24)	0.94 (1.16)	< .0001
Non-working population			
Men			
Abdominal circumference (cm)	80.18 (12.45)	81.96 (11.80)	< .0001
Systolic blood pressure (mmHg)	115.4 (13.50)	116.2 (12.98)	0.0306
Diastolic blood pressure (mmHg)	73.47 (12.15)	75.61 (11.40)	< .0001
Fasting glucose level (mg/dL)	98.98 (21.59)	97.84 (22.16)	0.0841
TG level (mg/dL)	136.7 (124.6)	148.0 (134.7)	0.0042

Characteristics	Regular breakfast		p-value
	Yes, mean (standard deviation)	No, mean (standard deviation)	
HDL-C level (mg/dL)	48.47 (10.91)	48.45 (10.79)	0.9474
Number of abnormal metabolic outcomes	1.28 (1.40)	1.31 (1.38)	0.5424
Women			
Abdominal circumference (cm)	75.19 (10.01)	75.41 (10.21)	0.3559
Systolic blood pressure (mmHg)	110.9 (14.70)	109.0 (13.32)	< .0001
Diastolic blood pressure (mmHg)	71.89 (10.08)	71.87 (9.64)	0.9338
Fasting glucose level (mg/dL)	94.58 (17.51)	94.20 (20.14)	0.4166
TG level (mg/dL)	107.7 (77.01)	104.2 (72.07)	0.0500
HDL-C level (mg/dL)	54.51 (11.95)	55.68 (12.25)	< .0001
Number of abnormal metabolic outcomes	1.13 (1.24)	0.99 (1.20)	< .0001
Working population			
Men			
Abdominal circumference (cm)	85.27 (8.74)	85.40 (9.50)	0.6219
Systolic blood pressure (mmHg)	118.3 (13.78)	117.2 (12.39)	0.0035
Diastolic blood pressure (mmHg)	79.65 (9.83)	79.14 (10.17)	0.0925
Fasting glucose level (mg/dL)	100.6 (23.46)	98.23 (20.43)	0.0003
TG level (mg/dL)	164.7 (148.0)	164.3 (139.7)	0.9257
HDL-C level (mg/dL)	47.77 (10.81)	47.53 (10.88)	0.4624
Number of abnormal metabolic outcomes	1.63 (1.38)	1.57 (1.39)	0.1188
Women			
Abdominal circumference (cm)	76.53 (8.93)	75.16 (9.11)	< .0001
Systolic blood pressure (mmHg)	111.7 (14.88)	108.9 (13.19)	< .0001
Diastolic blood pressure (mmHg)	73.45 (9.59)	72.49 (9.31)	0.0004
Fasting glucose level (mg/dL)	95.12 (19.10)	93.02 (15.40)	< .0001
TG level (mg/dL)	102.9 (83.46)	98.56 (75.99)	0.0580

Characteristics	Regular breakfast		p-value
	Yes, mean (standard deviation)	No, mean (standard deviation)	
HDL-C level (mg/dL)	56.00 (12.44)	57.09 (12.36)	0.0021
Number of abnormal metabolic outcomes	1.10 (1.24)	0.87 (1.11)	< .0001
TG: Triglyceride			
HDL-C: High density lipoprotein-cholesterol			

The weighted prevalence of the total number of abnormal metabolic outcomes is shown in Fig. 2. The percentage of participants without abnormal metabolic outcomes was higher among those who consumed breakfast regularly. The weighted prevalence of abnormal metabolic outcomes was higher among those who consumed breakfast irregularly. The difference was significant in the population of young men.

The association between metabolic syndrome and irregular breakfast consumption after adjusting age, education, household income, smoking status, and alcohol drinking status is presented in Table 3. Poisson regression analysis revealed that an irregular breakfast eating pattern increased the risk of metabolic syndrome among men in the working population. Work status was found to be an important variable that affected the strength of association between irregular breakfast intake and abnormal metabolic outcomes. Stratification based on the work status revealed that the strength of association was stronger among men in the working population (OR, 1.13, 1.08–1.19) than among men in the non-working population (OR, 1.08, 1.02–1.14). Stratification based on age revealed that irregular breakfast consumption showed a significant association with metabolic syndrome. Young men in the working population with irregular breakfast eating habits had a higher risk of metabolic syndrome after adjustment (OR, 1.15; 95% CI, 1.06–1.25). We found a similar association among middle-aged men in the working population (OR, 1.11; 95% CI, 1.05–1.19). No significant association was observed in women and non-workers.

Table 3
The association between abnormal metabolic outcomes and irregular breakfast based on the Poisson regression analysis

	Odds Ratio (95% Confidence Interval)
Total participants	
Men	
Regular breakfast	1.00 (Reference)
Irregular breakfast	**1.11 (1.07–1.15)**
Women	
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.02 (0.98–1.06)
Non-working population	
Men	
Regular breakfast	1.00 (Reference)
Irregular breakfast	**1.08 (1.02–1.14)**
Women	
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.04 (0.99–1.09)
Working population	
Men	
Regular breakfast	1.00 (Reference)
Irregular breakfast	**1.13 (1.08–1.19)**
Women	
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.00 (0.94–1.06)
Non-working population	
Young men	
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.10 (0.98–1.24)
Middle-aged men	

	Odds Ratio (95% Confidence Interval)
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.06 (0.99–1.13)
Young women	
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.10 (0.99–1.22)
Middle-aged women	
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.04 (0.98–1.09)
Working population	
Young men	
Regular breakfast	1.00 (Reference)
Irregular breakfast	**1.15 (1.06–1.25)**
Middle-aged men	
Regular breakfast	1.00 (Reference)
Irregular breakfast	**1.11 (1.05–1.19)**
Young women	
Regular breakfast	1.00 (Reference)
Irregular breakfast	1.07 (0.96–1.20)
Middle-aged women	
Regular breakfast	1.00 (Reference)
Irregular breakfast	0.97 (0.91–1.04)

All models are adjusted for age, education level, income level, smoking, and alcohol drinking.

Values in bold indicate statistical significance

Young population: 20–39 years old

Middle-aged population: 40–59 years old

Discussion

We conducted the current study to understand the association between regular breakfast intake and metabolic outcomes with sex, work status, and age group stratification. The results of this study showed that irregular breakfast intake (< 5 times per week) was closely linked to an increased risk of abnormal metabolic outcomes, especially in young men in the working population.

These results are consistent with a previous study that used the KNHANES data and showed that breakfast consumption patterns were associated with a risk of metabolic syndrome (20). Furthermore, our results are compatible with a review article, which reported that daily breakfast eaters were less likely to have Cardiovascular disease risk factors, including elevated serum LDL-C levels, low serum HDL-C levels, and elevated blood pressure (21).

There was no significant association between breakfast skipping and abnormal metabolic outcomes in women. A Japanese longitudinal cohort study on factory employees showed that the average frequency of breakfast skipping was not associated with BMI and waist circumference in women (22). Our results are consistent with those of the aforementioned study. There are several explanations for this result. Postmenopausal status is known to be associated with abnormal metabolic outcomes. In middle-aged women, postmenopausal status has been reported to affect the outcome (23). One study reported lower BMI and appearance-related satisfaction among young Korean university women students compared with European and American students (24). This could increase the risk of eating disorders in young women, which might affect the result.

Another cross-sectional study using the KNHANES data reported a different result and stated that the risk of abnormal metabolic outcomes increased in both men and women (25). However, the definition of breakfast skipping in the study was different from that of our study. A breakfast skipper was defined as a subject who had skipped breakfast 1 day or 2 days before the survey. This definition has a limitation in the overall representation of breakfast consumption. From 2013, the KNHANES changed the question regarding breakfast consumption habit from “Did you skip breakfast before 1 day or 2 days?” to “What is the average frequency of breakfast consumption per week for the past 1 year?” We considered the latter question in this study.

Herein, we have proposed several mechanisms to explain the association between abnormal metabolic outcomes and breakfast skipping. Breakfast is the very first meal of the day, which kick-starts the daily metabolism of the human body. Energy consumption will be lower than the energy requirement if breakfast is skipped before going to work. Food deprivation state is known to cause reduction in the basal metabolic rate (BMR) via compensatory metabolism (26). The reduction in the BMR leads to the consumption of excess calories, ultimately leading to weight gain.

The time of consumption of a meal affects the postprandial increase in energy expenditure and blood glucose levels. A randomized repeated-measures study showed that skipping breakfast was compensated by consuming big meals at lunch. In addition, the study found that breakfast skipping increased the overall 24 hour average blood glucose levels (27). Another study found that breakfast skipping was associated with higher Hemoglobin A1c values, which indicate poorer glycemic control (28).

A longitudinal study showed that breakfast skippers had high levels of fasting insulin (29). Poor glycemic control is associated with high levels of glucose, insulin resistance, and high levels of fasting insulin. Insulin is known to stimulate hydroxy-methyl-glutaryl Co-A reductase activity, which has a crucial role in the biosynthesis of cholesterol and lipids. Through these mechanisms, skipping breakfast might lead to raised fasting glucose, increased blood pressure, high levels of serum TG, and low levels of HDL-C.

The current study observed a more significant relationship between breakfast skipping and abnormal metabolic outcomes in working men than in women in all other groups. A previous study indicated that men in the working group, compared with women in the same group, had a higher risk of metabolic syndrome associated with the working condition (30). Another study reported a significantly increased risk of metabolic syndrome in working men compared with working women (31). Results of the current study further support the idea of the working male population being vulnerable to metabolic syndrome.

To the best of our knowledge, our study is the first and largest sample-sized study to explore the association between abnormal metabolic outcomes and breakfast skipping in the Korean population. Only few studies have investigated the effect of work status on the association between breakfast skipping and abnormal metabolic outcomes. Our research indicated that the detrimental effect of breakfast skipping was evident in the working Korean male population, especially in young adults. Educating young male workers regarding the benefits of eating breakfast could be a great way to prevent further metabolic diseases.

The present study identified the relationship between breakfast skipping and the risk of metabolic syndrome and proposed a novel hypothesis to explain the variable strength of association according to the stratifications. We considered stratifications, such as age and work status, that had not been used in previous studies. Work status is an important factor that affects daily metabolism. The different strength of association according to work status implies that daily activity or stress levels might be an effect modifier of the association between breakfast skipping and abnormal metabolic outcomes.

Our study has several limitations. First, we used a self-administered questionnaire to acquire information about breakfast consumption, which could involve a recall bias. However, even highly cited interventional or randomized controlled trials (3) have considered self-reporting of consumption habits by the participants. Thus, it may be considered that recall bias could be present in our study, as well as in other studies. Moreover, the large sample size in our study could have reduced the effect of the bias because the expected bias might be similar among all individuals. In addition, our questionnaire was designed to include the 1-year average frequency to appropriately reflect the long-term dietary habits of the participants. Second, considering the cross-sectional design of our study, more caution must be exercised to establish a causal relationship. A longitudinal interventional study is needed to definitively unveil the exact mechanism. Thirdly, although we stratified participants based on work status, we did not examine the specific working conditions such as shift work, long working hours, manual work, and clerical work. Further analysis based on working conditions is required to determine whether breakfast skipping is an important risk factor for abnormal metabolic outcomes in the working population.

Finally, since the energy requirement for work was not quantified in this study, we could not directly compare the morning energy expenditure between the working and non-working populations. Further detailed studies are required to reveal the relationship between early morning working, breakfast skipping, and the risk of abnormal metabolic outcomes.

Although breakfast is considered the most important meal of the day, the percentage of regular breakfast eaters among young adults was only 37.92%. The trend is in progress, accelerating the risk of metabolic outcomes among young adults. The risk is accentuated in the working population of young men, and further studies are required to clarify the association between specific working conditions (working hours or shift working), breakfast habituation, and the risk of metabolic outcomes.

Conclusion

Our study showed that breakfast skipping is associated with abnormal metabolic outcomes in Korean population of men, and provided novel ideas to explain the mechanism through which breakfast skipping affects metabolic outcomes.

Abbreviations

KNHANES
Korea National Health and Nutrition Examination Survey
BMI
Body mass index
LDL-C
Low-density lipoprotein cholesterol
HDL-C
High-density lipoprotein cholesterol
TG
Triglyceride
BMR
Basal metabolic rate

Declarations

Ethics approval and consent to participate

Data were anonymized prior to release to the authors from the KNHANES. All participants in the survey signed an informed consent form. The Institutional Review Board (IRB) of the Gil Medical Center, Gachon University, approved the current study (IRB number: GCIRB2020-147).

Consent for publication

Not applicable.

Availability of data and material

The KNHANES are an open data to public and all researchers can use it for approved research by registering and applying at https://knhanes.cdc.go.kr/knhanes/eng/index.do

Competing interests

The authors declare that they have no competing interests

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Not applicable.

Authors' contributions

JH and WL conceived and designed the study, analyzed and interpreted the data, and drafted and reviewed manuscript. WJC and SH conducted the analyses and drafted and reviewed the manuscript. SKK interpreted the data and drafted and reviewed the manuscript. All authors read and approved the final manuscript.

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Figures

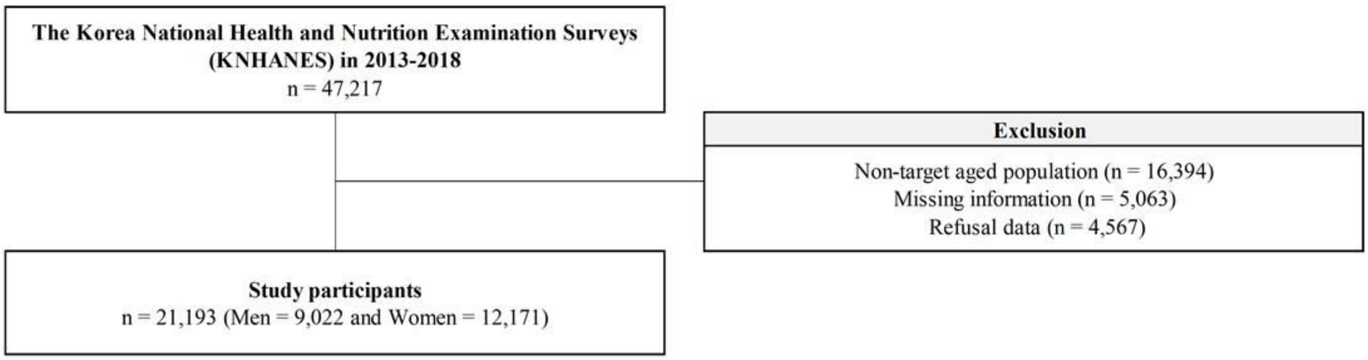

Figure 1

Schematic diagram depicting study population

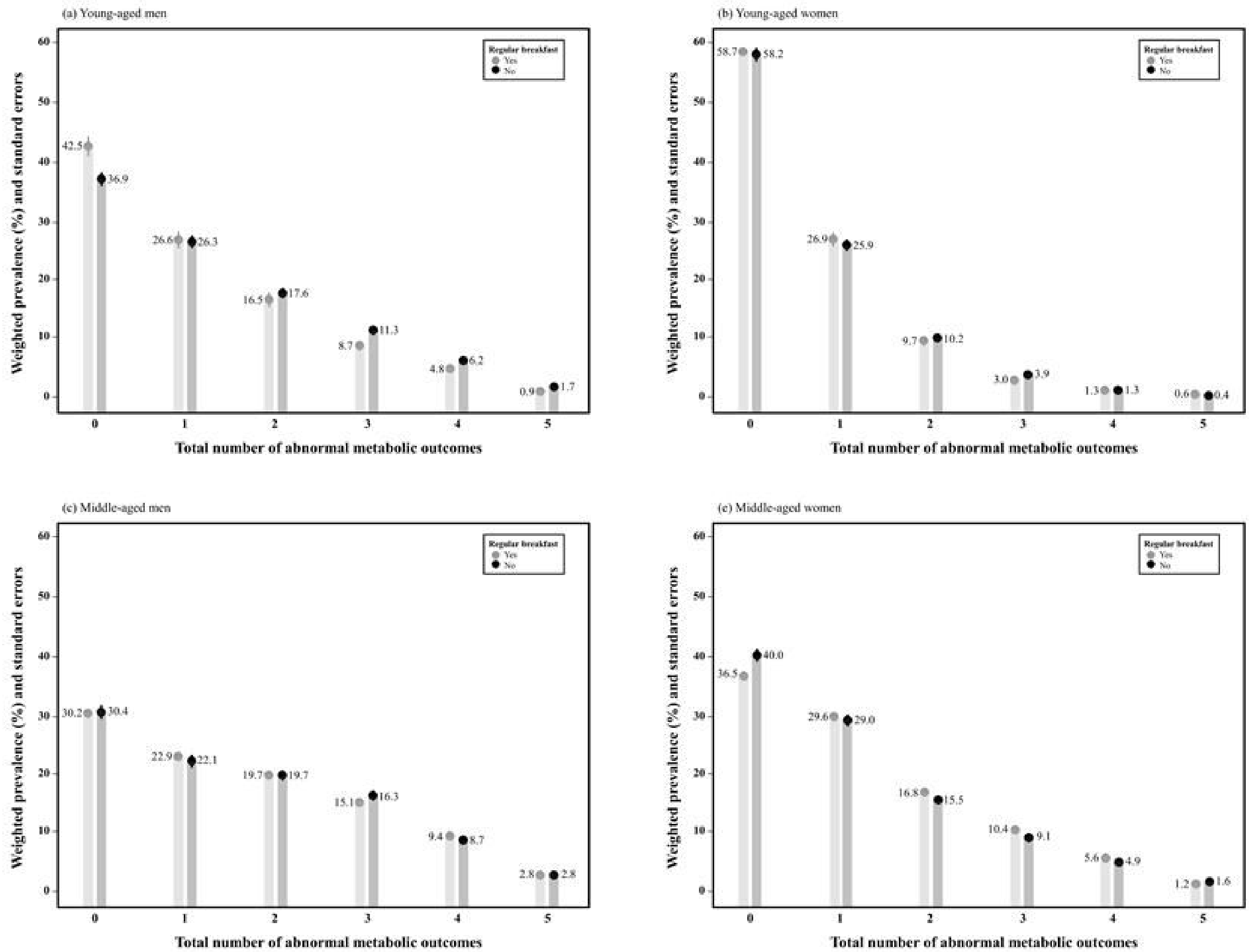

Figure 2

Weighted prevalence and standard errors of total number of metabolic outcomes according to age and sex