Is It What They Eat or How Much They Eat That Matters More in Adults with Food Insecurity in a Wealthy-Country Context?

Min Gyeong Kang 1,†, Sung-Min Yook 2,† and Ji-Yun Hwang 3,*

1 Nutrition Education Major, Graduate School of Education, Sangmyung University, Seoul 03016, Korea; skekalsrud@naver.com
2 Department of Foodservice Management and Nutrition, Graduate School, Sangmyung University, Seoul 03016, Korea; smy522@naver.com
3 Major of Foodservice Management and Nutrition, Sangmyung University, Seoul 03016, Korea
* Correspondence: jiyunhk@smu.ac.kr; Tel.: +82-2-781-7521
† These authors contributed equally to this work.

Abstract: This study aimed to investigate whether dietary quantity and/or quality differ according to food security levels in the Korean adult population. Dietary adequacy and quality were evaluated by the Korean Dietary Reference Intake and the Korean Healthy Eating Index (KHEI) for adults, respectively, according to three food security levels, i.e., food security, low food security, and very low food security. A total of 7144 Korean adults (aged 19 to 64 years) were selected from cross-sectional data from the 2013–2015 Korean National Health and Nutrition Examination Surveys. The risk of inadequate nutrient intakes of protein (\(p_{\text{trend}} = 0.021\)) and phosphorus (\(p_{\text{trend}} = 0.002\)) increased according to food insecurity levels after adjustment for putative risk factors. The total KHEI scores (\(p < 0.001\)) as well as scores of having breakfast (\(p < 0.001\)) were lowest in the very low food security group. Among KHEI components, adults with food insecurity were less likely to get full scores from intakes of mixed grains (\(p_{\text{trend}} = 0.016\)), total fruit (\(p_{\text{trend}} = 0.039\)), fresh fruit (\(p_{\text{trend}} = 0.043\)), and breakfast (\(p_{\text{trend}} < 0.001\)). In addition, food-insecure adults were more likely to get zero scores from intakes of fresh fruit (\(p_{\text{trend}} = 0.002\)), milk and dairy products (\(p_{\text{trend}} = 0.049\)), breakfast (\(p_{\text{trend}} < 0.001\)), % of energy from sweets and beverages (\(p_{\text{trend}} = 0.002\)), and total energy (\(p_{\text{trend}} = 0.033\)). In conclusion, food security levels were associated with how much they ate, as well as what they ate, in adults in South Korea. These results implied that the diet adequacy as well as moderation and balance could be carefully treated with food assistance or nutrition intervention once nutritional adequacy has mostly been met. In addition, targeted intervention programs tailored to diverse contexts for improving food insecurity may prevent unintended consequences due to easy access to inexpensive obesogenic foods in adults with food insecurity.

Keywords: food insecurity; healthy eating index; dietary adequacy; dietary quality; adults

1. Introduction

Dietary quality has recently become the focus of extensive research interest, given the increased number of diet-related diseases and mortality in developed countries. A prolonged consumption of nutritionally unbalanced meals, such as high intake of sodium and low intakes of whole grains as well as fruits, has been reported to increase the risk of mortality and disability-adjusted life years in many countries [1].

The family members of households with food insecurity are more likely to cope with it by consuming cheap, palatable, high-fat, high-sodium, and high-sugar processed foods [2]. An inverse relationship between food insecurity and nutritional adequacy [3–13] and quality of meals [2,14–18] has been reported in several studies. Food insecurity has been also reported to be associated with eating habits and health behaviors [19,20], which affect physical and mental health [14,21–23] in Korea. Therefore, dietary inequality may exacerbate the impact of food insecurity.
Most previous studies have been conducted in low-income or vulnerable populations [2,3,7,15–18]. Given the fact that food security includes multiple aspects, such as availability, accessibility, and affordability of food, overall dietary quality in addition to nutritional adequacy needs to be evaluated across food security levels in the general adult populations. Furthermore, food insecurity has never been eradicated even in developed countries although abundance in food has been already achieved at the national level. However, information on levels of food security in relation to dietary quality in the general adult population, especially in the wealthy country context, is very limited.

A recent systematic review regarding assessment tools of dietary quality has suggested three aspects of dietary quality: the adequacy of nutrient intake, food variety or diversity, and moderation for intake of foods and food groups or energy and nutrients [24]. According to this previous study, evaluation of moderation among the three aspects was not often included in low- and middle-income countries whereas it has been developed and used in assessment tools such as the healthy eating index (HEI) in the high-income countries, such as the United States (US) [14,15,24–28]. Recently the Korean Healthy Eating Index (KHEI) for adults has been developed in our previous study [29] based on the Korea National Health and Nutrition Examination Survey (KNHANES) VI (2013–2015) and it is currently used in the KNHANES [30].

To the best of our knowledge, there is very little research on relationships between food security levels and overall dietary adequacy as well as quality in the general adult population in a developed-country context, and even no research in South Korea. Therefore, using a nationwide representative sample from the KNHANES, we investigate whether dietary quantity and/or quality differ according to food security levels in the population of general adults in a wealthy country context like South Korea.

2. Materials and Methods

2.1. Study Design and Subjects

The KNHANES study is an ongoing nationwide population-based cross-sectional study conducted by the Korea Disease Control and Prevention Agency (KDCA) since 1998. Non-institutionalized Koreans are randomly selected using a stratified and multi-stage clustered probability sampling method. Among 11,681 adults aged 19 to 64 years from the KNHANES VI study (2013–2015) with information on household food security levels and HEI data, 705 subjects with implausible daily energy intake (<800 kcal/day or >4000 kcal/day in men, <500 kcal/day or >3500 kcal/day in women; n = 705) [31] were excluded. Among the remaining 10,976 subjects, 226 pregnant or lactating women and 1587 with insufficient information on educational level, marital status, household income, height, weight, physical activity, smoking, alcohol drinking, and physical activity were excluded. A total of 7144 subjects were finally eligible for this analysis after further exclusion of 2019 subjects who recently changed their eating habits due to weight control or illness.

A written informed consent was obtained from all participants before the survey. The institutional review board (IRB) of the KDCA approved survey protocols (2013-07CON-03-4C, 2013-12EXP-03-5C, 2015-01-02-6C). Therefore, the additional IRB process was not needed for the current study.

2.2. Socio-Demographic Factors

Detailed data on socio-demographic factors and personal characteristics were collected including age, sex, number of household members, education level, marital status, household income level, smoking, alcohol drinking, level of physical activity, height, weight, and disease history. Education status was categorized as ≤elementary school graduate, middle school graduate, high school graduate, and ≥college graduate. Marital status was classified into three categories: married, never married, and separated, widowed, or divorced. Household income levels were classified as low, middle low, middle high, and high. Smoking behavior was classified as non-smoker, former smoker, smoking less than 20 cigarettes/day, and smoking ≥20 cigarettes/day. Alcohol drinking was categorized as
non-drinker, <1 drink/month, ≥1 drink–4 drinks/month, and ≥5 drinks/month. The level of physical activity was categorized into four categories: low, middle low, middle high, and high. Body mass index (BMI) was calculated as weight divided by height squared (kg/m²). Disease history included having hypertension, dyslipidemia, stroke, myocardial infarction (or angina), diabetes, cancer, kidney failure, or cirrhosis of the liver.

2.3. Household Food Security Measurement

In the KNHANES, household food security is measured using an 18-item questionnaire based on the US Household Food Security/Hunger Survey Module (US-HFSSM) since 2012 and is classified into four groups according to scores: food security (0–2 scores), mild food insecurity without hunger (3–7 scores for household with children; 3–5 for household without children), moderate food insecurity with hunger (8–12 for household with children; 6–8 scores for household without children), and severe food insecurity with hunger (13–18 scores for household with children; 9–10 scores for household without children) [32]. In this study, the levels of food security were reclassified as food security (high or marginal food security), low food security (mild food insecurity without hunger), and very low food security (moderate or severe food insecurity with hunger) due to low proportions of moderate and severe stages of food insecurity (0.48% and 0.06%, respectively).

2.4. Nutrients Intake Measurement

Dietary intakes were measured by a single 24 h recall based on a weekday’s usual food intake from the participants via face-to-face interviews. Trained and highly skilled interviewers collected information on names of foods and dishes including recipes, brand names of processed foods including names of manufacturers, and amounts of food consumed. After converting all food intakes into each food ingredient intake, daily energy and 14 kinds of nutrients including vitamins and minerals intakes were calculated based on the 8th Korean Food Composition Table (KFCT) by the Rural Development Administration (RDA) of South Korea [33]. Currently, the standard KFCT includes over 3000 key food items frequently consumed in South Korea based on results of KNHANES, and every year about 350 raw and processed food items have been collected, analyzed, and evaluated for data quality under the Association of Official Analytical Chemists (AOAC), Codex Alimentarius (Codex), and Food and Agriculture Organization (FAO)/International Network of Food Data Systems (INFOODS) guidelines [34]. Fatty acid, cholesterol, and dietary fiber were calculated based on the database developed by the KDCA [33]. The adequacy of nutrient intake was assessed using the 2015 Korean Dietary Reference Intakes (KDRIs) [35]. In this study, the adequacy of energy intake was defined as an energy intake meeting 85–115% of the estimated energy requirement, taking into account about a 15% variation of energy intake within individuals based on the total daily energy intake [36]. Macronutrient intakes including carbohydrates, fats, n-3 fatty acids, n-6 fatty acids, and saturated fatty acids were compared according to the recommended percentages of total energy intake by the 2015 KDRIs. The adequate intake was defined as intakes equal to or above recommended nutrient intake (RNI) and below tolerable upper intake level (UL) for protein, vitamin A, vitamin C, thiamine, riboflavin, niacin, calcium, phosphorus, and iron, and was defined as intakes equal to or above the adequate intake (AI) for dietary fiber and potassium. Intakes of cholesterol and sodium were evaluated based on the intake goal.

2.5. Korean Healthy Eating Index (KHEI)

The KHEI is a standardized evaluation tool for overall quality of diet by scoring adherence to dietary guidelines for Koreans, which was developed based on data from the KNHANES [29,30]. The KHEI is composed of a total of 14 components (eight for adequacy, three for moderation, and three for balance) and the total score is calculated to be 0–100 points. Among eight adequacy components, five components are given 0–5 points (mixed grain intake, total fruit intake, fresh fruit intake, total vegetable intake, vegetable intake excluding kimchi and pickled vegetables), and 0–10 points for three components
(intakes of meat/fish/eggs/legumes, intakes of milk and dairy products, having breakfast). All three moderation components (% of energy from saturated fatty acid, sodium intake, % of energy from sweets and beverages) are given 0–10 points and all of the three balance components (% of energy from carbohydrate, % of energy from fat, energy intake) are given 0–5 points [29].

2.6. Statistical Analysis

The stratification variables and weights were considered in the statistical analysis due to the nature of the sampling frame of the KNHANES. Dates were expressed as means with standard error (SE) for continuous variables or number and weighted % for categorical variables. Differences among three groups (food security, low food security, very low food security) were evaluated using a general linear model (Tukey’s test of multiple comparison) or a chi-square test, as appropriate. Multivariable-adjusted logistic regression analysis was conducted to examine the odds ratio (OR) with 95% confidence interval (CI) for nutritional inadequacy and lack of dietary quality (<full score of KHEI components, zero score of KHEI components) across three food security groups. Models were first adjusted for age, sex, survey year, and total energy intake and second for these variables plus number of households, education, household income, marital status, and physical activity. Smoking and alcohol drinking were not included as confounders due to high relation to other confounding factors. The tendency (p trend) across the three groups was also evaluated after adjustment for potential confounders. All the analyses were performed using IBM SPSS Statistics 21 (IBM Co., Armonk, NY, USA). The significance level was considered as p-value < 0.05.

3. Results

3.1. Socio-Demographic Characteristics According to Food Security Status

Of the 7144 Korean adults examined, 6605 (92.5%) were considered to be food-secure, 452 (6.3%) were low food-secure, and 87 (1.2%) were very low food-secure (socio-demographic characteristics are presented in Table 1). As levels of food insecurity increased, household size (p = 0.004) and income (p < 0.001) decreased. Adults with food insecurity were more likely to be female (p = 0.047), less educated (p < 0.001), single (p < 0.001), drinker (p = 0.039), and less physically active (p = 0.010). However, age, smoking behavior, body mass index, and disease history did not differ significantly between the three groups.

Table 1. Socio-demographic characteristics of subjects according to household food security status.

| Characteristics          | Food Security (n = 6605) | Low Food Security (n = 452) | Very Low Food Security (n = 87) | p-Value |
|--------------------------|--------------------------|----------------------------|--------------------------------|---------|
| Age, years               | 41.3 ± 0.2               | 42.1 ± 0.7                 | 42.6 ± 1.7                     | 0.335   |
| Household size, n        | 3.3 ± 0.02 a             | 3.4 ± 0.08 a               | 2.9 ± 0.19 b                   | 0.004   |
| Body mass index, kg/m²   | 23.5 ± 0.1               | 23.6 ± 0.2                 | 23.6 ± 0.4                     | 0.812   |
| Female, n                | 3830 (58.0)              | 295 (65.3)                 | 49 (56.3)                      | 0.047   |
| Disease history          | 1406 (21.3)              | 114 (25.2)                 | 24 (27.6)                      | 0.249   |
| Education                |                          |                            |                                | <0.001  |
| ≤Elementary school graduate | 716 (10.8)               | 96 (21.2)                  | 25 (28.7)                      |         |
| Middle school graduate   | 640 (9.7)                | 65 (14.4)                  | 21 (24.1)                      |         |
| High school graduate     | 2620 (39.7)              | 198 (43.8)                 | 27 (31.0)                      |         |
| ≥College graduate        | 2629 (39.8)              | 93 (20.6)                  | 14 (16.1)                      |         |
Table 1. Cont.

| Characteristics          | Food Security (n = 6605) | Low Food Security (n = 452) | Very Low Food Security (n = 87) | p-Value |
|--------------------------|--------------------------|-----------------------------|-------------------------------|---------|
| Marital status           |                          |                             |                               |         |
| Married                  | 4875 (73.8)              | 284 (62.8)                  | 36 (41.4)                     | <0.001  |
| Never married            | 1310 (19.8)              | 88 (19.5)                   | 25 (28.7)                     |         |
| Separated, widowed, divorced | 420 (6.4)         | 80 (17.7)                   | 26 (29.9)                     |         |
| Household income         |                          |                             |                               |         |
| Low                      | 496 (7.5)                | 132 (29.2)                  | 47 (54.0)                     | <0.001  |
| Middle low               | 1590 (24.1)              | 197 (43.6)                  | 23 (26.4)                     |         |
| Middle high              | 2160 (32.7)              | 104 (23.0)                  | 16 (18.4)                     |         |
| High                     | 2359 (35.7)              | 19 (4.2)                    | 1 (1.1)                       |         |
| Smoking behavior         |                          |                             |                               | 0.346   |
| Nonsmoker                | 4108 (62.2)              | 273 (60.4)                  | 45 (51.7)                     |         |
| Former smoker            | 1121 (17.0)              | 63 (13.9)                   | 13 (14.9)                     |         |
| ≥20 cigarettes/day       | 854 (12.9)               | 76 (16.8)                   | 18 (20.7)                     |         |
| ≥20 cigarettes/day       | 522 (7.9)                | 40 (8.8)                    | 11 (12.6)                     |         |
| Alcohol drinking         |                          |                             |                               | 0.039   |
| Non-drinker              | 519 (7.9)                | 49 (10.8)                   | 8 (9.2)                       |         |
| ≥1 drink/month           | 2156 (32.6)              | 176 (38.9)                  | 32 (36.8)                     |         |
| ≥5 drinks/month          | 1915 (29.0)              | 114 (25.2)                  | 21 (24.1)                     |         |
| Physical Activity        |                          |                             |                               | 0.010   |
| Low                      | 2959 (44.8)              | 210 (46.5)                  | 50 (57.5)                     |         |
| Middle Low               | 1913 (29.0)              | 153 (33.8)                  | 19 (21.8)                     |         |
| Middle high              | 881 (13.3)               | 36 (8.0)                    | 10 (11.5)                     |         |
| High                     | 852 (12.9)               | 53 (11.7)                   | 8 (9.2)                       |         |

Different letters indicate the significant statistical difference, same letters indicate no significant difference (p < 0.05, Tukey’s test).

3.2. Nutritional Adequacy According to Household Food Security Status

Korean adults with food insecurity were less likely to meet dietary guidelines recommended by the 2015 KDRIs for protein (p < 0.001), thiamin (p < 0.001), riboflavin (p = 0.009), niacin (p = 0.002), vitamin C (p = 0.003), calcium (p = 0.022), phosphorus (p < 0.001), potassium (p = 0.009), and iron (p = 0.009) (Table 2). The OR for inadequate nutrient intake increased in both low and very low food security groups, respectively, for protein (OR = 1.49, 95% CI = 1.19–1.85 for low food security; OR = 3.06, 95% CI = 1.84–5.08 for very low food security), thiamine (OR = 1.41, 95% CI = 1.05–1.90; OR = 2.61, 95% CI = 1.55–4.39), niacin (OR = 1.24, 95% CI = 1.00–1.54; OR = 2.26, 95% CI = 1.30–3.92), vitamin C (OR = 1.37, 95% CI = 1.07–1.74; OR = 2.17, 95% CI = 1.12–4.21), phosphorus (OR = 1.47, 95% CI = 1.15–1.88; OR = 4.10, 95% CI = 2.51–6.68), potassium (OR = 1.39, 95% CI = 1.08–1.78; OR = 2.38, 95% CI = 1.31–4.32). In addition, the OR for inadequate nutrient intake increased in adults with very low food security for riboflavin (OR = 1.99, 95% CI = 1.14–3.47), calcium (OR = 4.75, 95% CI = 1.48–15.25), and iron (OR = 2.02, 95% CI = 1.24–3.29). After adjusting for age, sex, survey year, and total energy intakes, the OR for inadequate nutrient intake remained significant for vitamin C (OR = 1.38, 95% CI = 1.07–1.78) in low food security and phosphorus (OR = 3.12, 95% CI = 1.07–9.12) in very low food security. However, these trends did not remain after further adjustment for household size, education, marital status, income levels, and physical activity. Except for protein (p trend = 0.021) and phosphorus (p trend = 0.002), the risk of inadequate nutrient intake did not increase according to food insecurity levels after adjustment for putative risk factors.
Table 2. Risk of nutritional inadequacy based on the KDRIs according to household food security status.

|                      | Mean    | Median   | 10th, 90th Percentile | % Meeting Guideline | OR (95% CI)| OR (95% CI)| OR (95% CI) | p Trend |
|----------------------|---------|----------|-----------------------|---------------------|------------|------------|------------|---------|
|                      |         |          |                       |                     | Model 1²   | Model 2³   | Model 3⁴   |         |
| **Total energy (kcal/day)** |         |          |                       |                     | 1.0        | 1.0        | 1.0        | 0.479   |
| Food security        | 2084    | 2012     | 1167, 3015            | 35.4 (32.7)         | 1.0        | 1.0        | 1.0        |         |
| Low food security    | 1960    | 1862     | 1088, 2925            | 31.6 (2.0)          | 1.13       | 0.90–1.44  | 0.90–1.44  | 1.03     |
| Very low food security | 1674  | 1593     | 884, 2428             | 24.1 (0.3)          | 1.37       | 0.84–2.29  | 0.84–2.29  | 1.20     |
|                       |         |          |                       |                     | p = 0.289  |            |            |         |
| **Carbohydrate (g/day)** |         |          |                       |                     |            |            |            | 0.202   |
| Food security        | 313     | 301      | 180, 455              | 27.9 (25.8)         | 1.0        | 1.0        | 1.0        |         |
| Low food security    | 300     | 293      | 163, 442              | 27.7 (1.7)          | 0.95       | 0.74–1.24  | 0.72–1.21  | 0.84     |
| Very low food security | 261  | 239      | 138, 415              | 24.1 (0.3)          | 1.00       | 0.57–1.74  | 0.57–1.66  | 0.84     |
|                       |         |          |                       |                     | p = 0.936  |            |            |         |
| **Fat (g/day)**      |         |          |                       |                     |            |            |            | 0.676   |
| Food security        | 47      | 42       | 15, 81                | 55.4 (51.2)         | 1.0        | 1.0        | 1.0        |         |
| Low food security    | 43      | 35       | 13, 77                | 53.1 (3.4)          | 1.05       | 0.82–1.33  | 0.79–1.29  | 0.87     |
| Very low food security | 33   | 29       | 8, 63                 | 43.7 (0.5)          | 1.52       | 0.94–2.48  | 0.87–2.24  | 1.11     |
|                       |         |          |                       |                     | p = 0.253  |            |            |         |
| **N-6 fatty acid (g/day)** |         |          |                       |                     |            |            |            | 0.753   |
| Food security        | 10.0    | 8.3      | 2.7, 18.1             | 41.9 (38.7)         | 1.0        | 1.0        | 1.0        |         |
| Low food security    | 9.0     | 7.0      | 2.4, 16.5             | 36.1 (2.3)          | 1.17       | 0.93–1.48  | 0.87–1.41  | 0.93     |
| Very low food security | 7.6  | 5.0      | 1.8, 15.9             | 34.5 (0.4)          | 1.36       | 0.80–2.29  | 0.68–1.89  | 0.87     |
|                       |         |          |                       |                     | p = 0.220  |            |            |         |
| **N-3 fatty acid (g/day)** |         |          |                       |                     |            |            |            | 0.938   |
| Food security        | 1.6     | 1.2      | 0.4, 3.2              | 48.3 (44.7)         | 1.0        | 1.0        | 1.0        |         |
| Low food security    | 1.5     | 1.0      | 0.3, 3.3              | 45.1 (2.9)          | 1.12       | 0.89–1.40  | 0.88–1.37  | 0.95     |
| Very low food security | 1.2  | 0.8      | 0.1, 2.4              | 40.2 (0.5)          | 1.28       | 0.73–2.27  | 0.68–2.08  | 0.930    |
|                       |         |          |                       |                     | p = 0.443  |            |            |         |
| **Saturated fat (g/day)** |         |          |                       |                     |            |            |            | 0.842   |
| Food security        | 14      | 12       | 4, 24                 | 72.2 (66.8)         | 1.0        | 1.0        | 1.0        |         |
| Low food security    | 13      | 10       | 3, 23                 | 72.3 (4.6)          | 0.96       | 0.76–1.22  | 0.81–1.34  | 1.13     |
| Very low food security | 9    | 8        | 2, 20                 | 74.7 (0.9)          | 0.79       | 0.40–1.54  | 0.44–1.95  | 1.05     |
|                       |         |          |                       |                     | p = 0.717  |            |            |         |
Table 2. Cont.

|                        | Mean | Median | 10th, 90th Percentile | % Meeting Guideline | Model 1 ² 95% CI | Model 2 ³ 95% CI | Model 3 ⁴ 95% CI | p Trend |
|------------------------|------|--------|------------------------|--------------------|------------------|------------------|------------------|---------|
| Dietary cholesterol (mg/day) |      |        |                        |                    |                  |                  |                  |         |
| Food security          | 262  | 208    | 37, 538                | 69.4 (64.2)        | 1.0              | 1.0              | 1.0              | 0.185   |
| Low food security      | 253  | 170    | 26, 590                | 70.6 (4.5)         | 0.90             | 0.70–1.15        | 1.04             | 0.79–1.36 |
| Very low food security | 202  | 96     | 8, 493                 | 80.5 (1.0)         | 0.73             | 0.41–1.31        | 1.20             | 0.66–2.20 |
| p = 0.405              |      |        |                        |                    |                  |                  |                  |         |
| Protein (g/day)        |      |        |                        |                    |                  |                  |                  | 0.021   |
| Food security          | 73   | 67     | 35, 111                | 64.8 (60.0)        | 1.0              | 1.0              | 1.0              |         |
| Low food security      | 66   | 62     | 29, 104                | 55.3 (3.5)         | 1.49 **          | 1.19–1.85        | 1.32             | 0.97–1.80 |
| Very low food security | 52   | 44     | 25, 93                 | 37.9 (0.5)         | 3.06 ***         | 1.84–5.08        | 1.72             | 0.72–4.10 |
| p = 0.149             |      |        |                        |                    |                  |                  |                  |         |
| Dietary fiber (g/day)  |      |        |                        |                    |                  |                  |                  | 0.744   |
| Food security          | 24   | 21     | 11, 40                 | 48.4 (44.7)        | 1.0              | 1.0              | 1.0              |         |
| Low food security      | 21   | 20     | 9, 37                  | 46.9 (3.0)         | 1.07             | 0.85–1.35        | 1.02             | 0.79–1.32 |
| Very low food security | 19   | 19     | 6, 35                  | 37.9 (0.5)         | 1.65             | 0.97–2.80        | 1.01             | 0.52–1.94 |
| p = 0.149             |      |        |                        |                    |                  |                  |                  |         |
| Vitamin A (µgRE/day)   |      |        |                        |                    |                  |                  |                  | 0.403   |
| Food security          | 729  | 536    | 196, 1333              | 33.8 (31.2)        | 1.0              | 1.0              | 1.0              |         |
| Low food security      | 734  | 486    | 165, 1390              | 31.6 (2.0)         | 0.99             | 0.77–1.28        | 0.932            | 0.71–1.22 |
| Very low food security | 662  | 408    | 109, 1422              | 24.1 (0.3)         | 1.24             | 0.71–2.18        | 0.855            | 0.47–1.55 |
| p = 0.752             |      |        |                        |                    |                  |                  |                  |         |
| Thiamin (mg/day)       |      |        |                        |                    |                  |                  |                  | 0.072   |
| Food security          | 2.1  | 1.9    | 1.0, 3.1               | 86.6 (80.0)        | 1.0              | 1.0              | 1.0              |         |
| Low food security      | 2.0  | 1.8    | 0.9, 3.0               | 81.9 (5.2)         | 1.41 *           | 1.05–1.90        | 1.12             | 0.80–1.57 |
| Very low food security | 1.6  | 1.4    | 0.7, 2.8               | 73.6 (0.9)         | 2.61 **          | 1.55–4.39        | 1.19             | 0.57–2.46 |
| p < 0.001             |      |        |                        |                    |                  |                  |                  |         |
| Riboflavin (mg/day)    |      |        |                        |                    |                  |                  |                  | 0.841   |
| Food security          | 1.4  | 1.3    | 0.6, 2.3               | 45.0 (41.6)        | 1.0              | 1.0              | 1.0              |         |
| Low food security      | 1.3  | 1.2    | 0.5, 2.0               | 40.0 (2.5)         | 1.24             | 0.98–1.55        | 1.06             | 0.81–1.40 |
| Very low food security | 1.1  | 0.8    | 0.3, 2.2               | 27.6 (0.3)         | 1.99 *           | 1.14–3.47        | 0.97             | 0.48–1.95 |
| p = 0.009             |      |        |                        |                    |                  |                  |                  |         |
Table 2. Cont.

| Nutrient (mg/day)      | Mean    | Median   | 10th, 90th Percentile | % Meeting Guideline | Model 1 OR 95% CI | Model 2 OR 95% CI | Model 3 OR 95% CI | p Trend |
|------------------------|---------|----------|-----------------------|---------------------|-------------------|-------------------|-------------------|---------|
| **Niacin (mg/day)**    |         |          |                       |                     |                   |                   |                   |         |
| Food security          | 17      | 15       | 8, 27                 | 48.0 (44.4)         | 1.0               | 1.0               | 1.0               | 0.406   |
| Low food security      | 15      | 14       | 7, 24                 | 43.1 (2.7)          | 1.24 *            | 1.00–1.54         | 1.10              | 0.88–1.37 |
| Very low food security | 12      | 11       | 5, 22                 | 28.7 (0.3)          | 2.26 **           | 1.30–3.92         | 1.32              | 0.71–2.47 |
| *p = 0.002            |         |          |                       |                     |                   |                   |                   |         |
| **Vitamin C (mg/day)** |         |          |                       |                     |                   |                   |                   | 0.080   |
| Food security          | 98      | 59       | 18, 235               | 33.9 (31.3)         | 1.0               | 1.0               | 1.0               |         |
| Low food security      | 84      | 50       | 15, 198               | 27.0 (1.7)          | 1.37 *            | 1.07–1.74         | 1.38 *            | 1.07–1.78 |
| Very low food security | 58      | 34       | 9, 136                | 21.8 (0.3)          | 2.17 *            | 1.12–4.21         | 1.80              | 0.87–3.71 |
| *p = 0.003            |         |          |                       |                     |                   |                   |                   |         |
| **Calcium (mg/day)**   |         |          |                       |                     |                   |                   |                   | 0.306   |
| Food security          | 498     | 442      | 215, 822              | 13.4 (12.4)         | 1.0               | 1.0               | 1.0               |         |
| Low food security      | 463     | 406      | 199, 765              | 11.1 (0.7)          | 1.19              | 0.83–1.69         | 1.09              | 0.75–1.57 |
| Very low food security | 368     | 378      | 127, 631              | 3.4 (0.0)           | 4.75 **           | 1.48–15.25        | 3.11              | 0.88–10.91 |
| *p = 0.023            |         |          |                       |                     |                   |                   |                   |         |
| **Phosphorus (mg/day)**|         |          |                       |                     |                   |                   |                   | 0.002   |
| Food security          | 1103    | 1047     | 568, 1655             | 80.4 (74.3)         | 1.0               | 1.0               | 1.0               |         |
| Low food security      | 1010    | 942      | 514, 1530             | 73.9 (4.7)          | 1.47 **           | 1.15–1.88         | 1.19              | 0.88–1.62 |
| Very low food security | 828     | 759      | 387, 1273             | 56.3 (0.7)          | 4.10 ***          | 2.51–6.68         | 3.12 *            | 1.07–9.12 |
| *p < 0.001            |         |          |                       |                     |                   |                   |                   |         |
| **Sodium (mg/day)**    |         |          |                       |                     |                   |                   |                   | 0.736   |
| Food security          | 4055    | 3608     | 1573, 6713            | 8.8(8.1)            | 1.0               | 1.0               | 1.0               |         |
| Low food security      | 3776    | 3384     | 1426, 6171            | 9.5(0.6)            | 1.07              | 0.73–1.56         | 1.31              | 0.89–1.94 |
| Very low food security | 3151    | 2747     | 1151, 5911            | 17.2(0.2)           | 0.61              | 0.31–1.21         | 1.03              | 0.52–2.05 |
| *p = 0.331            |         |          |                       |                     |                   |                   |                   |         |
| **Potassium (mg/day)** |         |          |                       |                     |                   |                   |                   | 0.278   |
| Food security          | 3072    | 2830     | 1534, 4772            | 30.2(27.9)          | 1.0               | 1.0               | 1.0               |         |
| Low food security      | 2708    | 2470     | 1304, 4322            | 24.6(1.6)           | 1.39 *            | 1.08–1.78         | 1.30              | 0.95–1.79 |
| Very low food security | 2251    | 2217     | 1015, 3696            | 17.2(0.2)           | 2.38 **           | 1.31–4.32         | 1.27              | 0.61–2.65 |
| *p = 0.009            |         |          |                       |                     |                   |                   |                   |         |
| Food security          | Mean | Median | 10th, 90th Percentile | % Meeting Guideline 1 | OR     | 95% CI | OR     | 95% CI | OR     | 95% CI | $p$ Trend |
|------------------------|------|--------|-----------------------|-----------------------|--------|--------|--------|--------|--------|--------|-----------|
| Iron (mg/day)          |      |        |                       |                       |        |        |        |        |        |        | 0.106     |
| Food security          | 17   | 15     | 8, 28                 | 72.1 (66.7)           | 1.0    |        | 1.0    |        | 1.0    |        |           |
| Low food security      | 16   | 14     | 7, 28                 | 69.5 (4.4)            | 1.16   | 0.92–1.46 | 0.98   | 0.75–1.28 | 0.90   | 0.68–1.19 |           |
| Very low food security | 14   | 12     | 5, 24                 | 59.8 (0.7)            | 2.02 **| 1.24–3.29 | 1.58   | 0.78–3.18 | 1.40   | 0.72–2.75 |           |

$KDRIs$, Dietary Reference Intakes for Koreans. $^1$ % meeting guideline: by food security group %. (by total %). $^2$ Model 1: unadjusted. $^3$ Model 2: adjusted for age, sex, survey year, total energy intake. $^4$ Model 3: adjusted for age, sex, survey year, total energy intake, household size, education, marital status, household income level, physical activity level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. 
3.3. Dietary Quality Measured by the KHEI According to Household Food Security Status

The total KHEI scores \((p < 0.001)\), as well as scores of having breakfast \((p < 0.001)\), were lowest in the very low food security group (Table 3) after controlling for confounding factors. Among KHEI components, adults with food insecurity were less likely to get full scores from intakes of mixed grains \((p \text{ trend} = 0.016)\), total fruit \((p \text{ trend} = 0.039)\), fresh fruit \((p \text{ trend} = 0.043)\), and breakfast \((p \text{ trend} < 0.001)\) and the OR for less than full scores of each KHEI component increased in adults with low food security \((\text{OR} = 1.39, 95\% \text{ CI} = 1.08–1.80 \text{ for having breakfast}; \text{OR} = 1.42, 95\% \text{ CI} = 1.02–1.98 \text{ for sodium intake})\) and those with very low food security \((\text{OR} = 2.59, 95\% \text{ CI} = 1.35–4.99 \text{ for having breakfast})\) (Table 4, Figure 1). In addition, food-insecure adults were more likely to get zero scores from intakes of fresh fruit \((p \text{ trend} = 0.020)\), milk and dairy products \((p \text{ trend} = 0.049)\), breakfast \((p \text{ trend} < 0.001)\), \% of energy from sweets and beverages \((p \text{ trend} = 0.002)\), and total energy \((p \text{ trend} = 0.033)\). The OR for zero scores of each KHEI component increased in adults with low food security \((\text{OR} = 1.48, 95\% \text{ CI} = 1.10–2.00 \text{ for having breakfast})\) and those with very low food security \((\text{OR} = 2.73, 95\% \text{ CI} = 1.32–5.65 \text{ for } \% \text{ of energy from sweets and beverages}; \text{OR} = 1.64, 95\% \text{ CI} = 1.04–2.57 \text{ for } \% \text{ of energy from carbohydrate}; \text{OR} = 1.93, 95\% \text{ CI} = 1.23–3.02 \text{ for } \% \text{ of energy from fat})\). However, the OR for zero scores of \% of energy from fat was lowest in adults with low food security \((\text{OR} = 0.72, 95\% \text{ CI} = 0.54–0.97)\).

Table 3. Difference in means of KHEI item score according to household food security status.

|                          | Median 10th, 90th Percentile | Mean ± SE 1 | p-Value 1 |
|--------------------------|------------------------------|-------------|-----------|
| **Mixed grain intake**    |                              |             |           |
| Food security            | 1.7 0, 5.0 2.2 ± 0.04        | 0.153       |
| Low food security        | 1.0 0, 5.0 2.0 ± 0.13        |             |
| Very low food security   | 0 0, 5.0 1.8 ± 0.24          |             |
| **Total fruit intake**    |                              |             |           |
| Food security            | 1.6 0, 5.0 2.2 ± 0.04        | 0.195       |
| Low food security        | 0.3 0, 5.0 1.8 ± 0.11        |             |
| Very low food security   | 0 0, 5.0 1.4 ± 0.24          |             |
| **Fresh fruit intake**    |                              |             |           |
| Food security            | 2.1 0, 5.0 2.4 ± 0.04        | 0.081       |
| Low food security        | 0 0, 5.0 2.0 ± 0.13          |             |
| Very low food security   | 0 0, 5.0 1.4 ± 0.27          |             |
| **Total vegetable intake**|                             |             |           |
| Food security            | 3.9 1.5, 5.0 3.6 ± 0.02      | 0.822       |
| Low food security        | 3.5 1.3, 5.0 3.4 ± 0.09      |             |
| Very low food security   | 3.5 1.0, 5.0 3.2 ± 0.19      |             |
| Vegetable intake excluding kimchi and pickled vegetables |   |             |           |
| Food security            | 3.5 1.0, 5.0 3.3 ± 0.02      | 0.528       |
| Low food security        | 3.0 0.7, 5.0 3.1 ± 0.09      |             |
| Very low food security   | 3.0 0.3, 5.0 2.9 ± 0.23      |             |
| **Meat/fish/egg/legume intake** |                 |             |           |
| Food security            | 7.8 2.4, 10.0 7.1 ± 0.05    | 0.141       |
| Low food security        | 7.4 1.6, 10.0 6.7 ± 0.19    |             |
| Very low food security   | 5.3 0.4, 10.0 5.3 ± 0.43    |             |
| **Milk and dairy products intake** |                   |             |           |
| Food security            | 0 0, 10.0 3.3 ± 0.07        | 0.583       |
| Low food security        | 0 0, 10.0 2.8 ± 0.24        |             |
| Very low food security   | 0 0, 10.0 2.2 ± 0.48        |             |
| **Having breakfast**     |                              |             |           |
| Food security            | 6.5 0, 10.0 6.9 ± 0.07 a    | <0.001      |
| Low food security        | 6.1 0, 10.0 6.4 ± 0.25 ab   |             |
| Very low food security   | 4.5 0, 10.0 5.6 ± 0.53 b    |             |
Table 3. Cont.

|                                   | Median | 10th, 90th Percentile | Mean ± SE | p-Value |
|-----------------------------------|--------|------------------------|----------|---------|
| **% of energy from saturated fatty acid** |        |                        |          |         |
| Food security                     | 10.0   | 0, 10.0                | 7.8 ± 0.06 | 0.411   |
| Low food security                 | 9.9    | 0, 10.0                | 7.8 ± 0.19 |         |
| Very low food security            | 10.0   | 0, 10.0                | 8.1 ± 0.42 |         |
| **Sodium intake**                |        |                        |          |         |
| Food security                     | 6.4    | 0, 10.0                | 5.8 ± 0.05 | 0.650   |
| Low food security                 | 6.9    | 0.7, 10.0              | 6.2 ± 0.17 |         |
| Very low food security            | 8.2    | 1.3, 10.0              | 7.0 ± 0.37 |         |
| **% of energy from sweets and beverages** |        |                        |          |         |
| Food security                     | 10.0   | 6.0, 10.0              | 9.0 ± 0.04 | 0.080   |
| Low food security                 | 9.9    | 3.7, 10.0              | 8.8 ± 0.17 |         |
| Very low food security            | 9.7    | 0, 10.0                | 8.2 ± 0.37 |         |
| **% of energy from carbohydrate** |        |                        |          |         |
| Food security                     | 2.9    | 0, 5.0                 | 2.7 ± 0.03 | 0.110   |
| Low food security                 | 3.0    | 0, 5.0                 | 2.6 ± 0.12 |         |
| Very low food security            | 0.7    | 0, 5.0                 | 2.0 ± 0.25 |         |
| **% of energy from fat**          |        |                        |          |         |
| Food security                     | 5.0    | 0, 5.0                 | 3.5 ± 0.03 | 0.020   |
| Low food security                 | 5.0    | 0, 5.0                 | 3.6 ± 0.11 |         |
| Very low food security            | 4.1    | 0, 5.0                 | 2.8 ± 0.25 |         |
| **Total energy intake**           |        |                        |          |         |
| Food security                     | 5.0    | 0, 5.0                 | 3.4 ± 0.03 | 0.097   |
| Low food security                 | 5.0    | 0, 5.0                 | 3.2 ± 0.12 |         |
| Very low food security            | 3.8    | 0, 5.0                 | 2.7 ± 0.27 |         |
| **Total score**                   |        |                        |          | <0.001  |
| Food security                     | 63.9   | 47.4, 80.1             | 63.2 ± 0.22 |         |
| Low food security                 | 60.6   | 44.6, 77.8             | 60.3 ± 0.71 |         |
| Very low food security            | 55.4   | 37.2, 71.2             | 54.6 ± 1.66 |         |

KHEI, Korean Healthy Eating Index. Tukey’s test of multiple comparison and p-value were adjusted for age, sex, survey year, total energy intake, household size, education, marital status, household income level, physical activity level. Different letters in the same column indicate the significant statistical difference, same letters indicate no significant difference (p < 0.05, Tukey’s test).
Table 4. Dietary quality measured by the KHEI according to household food security status.

| Nutrient                          | % Full Score of KHEI | Less than Full Score | Zero Score |
|----------------------------------|----------------------|----------------------|------------|
|                                  | OR 95% CI            | OR 95% CI            | OR 95% CI  |
| **Model 1**                      | **Model 2**          | **Model 3**          | **Model 1**|
|                                  |                      |                      |            |
| **Mixed grain intake**           | (30.9)               |                      | (38.5)     |
| Food security                    | 31.1 (28.8)          | 1.0                  | 1.0        |
| Low food security                | 29.6 (1.9)           | 1.21                 | 0.93–1.57  |
| Very low food security           | 19.5 (0.2)           | 1.73                 | 0.92–3.24  |
| p = 0.093                       | p trend = 0.016      | p = 0.265            | p trend = 0.106 |
| **Model 2**                      |                      |                      |            |
| Total fruit intake               | (29.6)               |                      | (31.8)     |
| Food security                    | 30.2 (27.9)          | 1.0                  | 1.0        |
| Low food security                | 22.8 (1.4)           | 1.54 **              | 1.18–2.00  |
| Very low food security           | 19.5 (0.2)           |                      | 0.90–3.05  |
| p = 0.002                       | p trend = 0.039      | p = 0.001            | p trend = 0.059 |
| **Model 3**                      |                      |                      |            |
| Total vegetable intake           | (34.2)               |                      | (0.4)      |
| Food security                    | 34.5 (31.9)          | 1.0                  | 1.0        |
| Low food security                | 30.5 (1.9)           | 1.22                 | 0.97–1.55  |
| Very low food security           | 27.6 (0.3)           | 2.04 **              | 1.12–3.72  |
| p = 0.003                       | p trend = 0.043      | p = 0.001            | p trend = 0.020 |
| Vegetable intake excluding       | (31.1)               |                      | (1.4)      |
| kimchi and pickled vegetables    |                      |                      |            |
| Food security                    | 31.5 (29.1)          | 1.0                  | 1.0        |
| Low food security                | 25.2 (1.6)           | 1.34 *               | 1.03–1.73  |
| Very low food security           | 28.7 (0.3)           | 1.11                 | 0.62–1.99  |
| p = 0.094                       | p trend = 0.739      | p = 0.328            | p trend = 0.799 |
| Meat/fish/egg/legume intake      | (34.7)               |                      | (0.5)      |
| Food security                    | 35.3 (32.6)          | 1.0                  | 1.0        |
| Low food security                | 29.0 (1.8)           | 1.27                 | 1.00–1.61  |
| Very low food security           | 18.4 (0.2)           | 2.79 **              | 1.33–5.09  |
| p = 0.001                       | p trend = 0.123      | p = 0.001            | p trend = 0.054 |
| Milk and dairy products intake   | (23.7)               |                      | (59.0)     |
| Food security                    | 24.0 (22.2)          | 1.0                  | 1.0        |
| Low food security                | 20.8 (1.3)           | 1.20                 | 0.92–1.56  |
| Very low food security           | 19.5 (0.2)           | 1.64                 | 0.89–3.00  |
| p = 0.119                       | p trend = 0.491      | p = 0.002            | p trend = 0.049 |
|                                | % Full Score of KHEI 1 | Less than Full Score | % Zero Score of KHEI 2 | Zero Score |
|--------------------------------|------------------------|----------------------|------------------------|------------|
|                                | Model 1 3 OR 95% CI    | Model 2 4 OR 95% CI  | Model 3 5 OR 95% CI    | Model 1 3 OR 95% CI    |
| Having breakfast               | (60.9)                 | (14.6)               |                        |                        |
| Food security                  | 61.5 (56.9)            | 1.0                  | 1.0                    | 1.0                    |
| Low food security              | 56.2 (3.6)             | 1.23                 | 0.99–1.54              | 1.35 * 1.06–1.72       |
| Very low food security         | 41.4 (0.5)             | 2.06 *               | 1.17–3.63              | 2.35 ** 1.27–4.36      |
| p = 0.007                      |                        | p trend < 0.001      |                        |                        |
| % of energy from saturated fatty acid | (68.9)               | (10.4)               |                        |                        |
| Food security                  | 68.8 (63.6)            | 1.0                  | 1.0                    | 1.0                    |
| Low food security              | 69.7 (4.4)             | 0.95                 | 0.76–1.20              | 1.12 0.88–1.43         |
| Very low food security         | 67.8 (0.8)             | 0.95                 | 0.50–1.77              | 1.33 0.63–2.81         |
| p = 0.919                      |                        | p trend = 0.484      |                        |                        |
| Sodium intake                  | (18.1)                 | (11.2)               |                        |                        |
| Food security                  | 17.6 (16.3)            | 1.0                  | 1.0                    | 11.4 (10.5)            |
| Low food security              | 21.7 (1.4)             | 0.89                 | 0.68–1.17              | 1.19 0.87–1.62         |
| Very low food security         | 37.9 (0.5)             | 0.32 **              | 0.20–0.53              | 0.70 0.38–1.28         |
| p = 0.001                      |                        | p trend = 0.153      |                        |                        |
| % of energy from sweets and beverages | (79.6)               | (3.6)                |                        |                        |
| Food security                  | 79.8 (73.8)            | 1.0                  | 1.0                    | 3.3 (3.1)              |
| Low food security              | 77.9 (4.9)             | 1.01                 | 0.78–1.31              | 0.99 0.76–1.30         |
| Very low food security         | 70.1 (0.9)             | 1.60                 | 0.96–2.67              | 1.45 0.87–2.43         |
| p = 0.192                      |                        | p trend = 0.204      |                        |                        |
| % of energy from carbohydrate | (29.0)                 | (27.2)               |                        |                        |
| Food security                  | 29.3 (27.1)            | 1.0                  | 1.0                    | 26.8 (24.7)            |
| Low food security              | 25.7 (1.6)             | 1.20                 | 0.94–1.34              | 1.16 0.91–1.49         |
| Very low food security         | 24.1 (0.3)             | 1.21                 | 0.69–2.11              | 1.09 0.63–1.90         |
| p = 0.090                      |                        | p trend = 0.891      |                        |                        |
| % of energy from fat           | (55.3)                 | (18.6)               |                        |                        |
| Food security                  | 55.5 (51.4)            | 1.0                  | 1.0                    | 18.3 (16.9)            |
| Low food security              | 54.2 (3.4)             | 1.02                 | 0.80–1.29              | 0.99 0.78–1.26         |
| Very low food security         | 43.7 (0.5)             | 1.59                 | 0.98–2.59              | 1.50 0.94–2.40         |
| p = 0.178                      |                        | p trend = 0.772      |                        |                        |
Table 4. Cont.

| % Full Score of KHEI ¹ | Less than Full Score | % Zero Score of KHEI ² | Zero Score |
|------------------------|----------------------|------------------------|------------|
|                        | Model 1 ³ OR 95% CI  | Model 2 ⁴ OR 95% CI  | Model 3 ⁵ OR 95% CI  |
| Total energy intake    |                      |                        |                        |
| Food security          | 55.4 (51.3)          | 1.0 1.0                 | 21.3 (19.7)             |
| Low food security      | 52.4 (3.3)           | 1.11 0.90–1.38         | 1.12 0.90–1.38         |
| Very low food security | 43.7 (0.5)           | 1.47 0.92–2.36         | 1.49 0.93–2.39         |
| p = 0.178              |                      | p trend = 0.205        |                         |

|                        | Model 1 ³ OR 95% CI  | Model 2 ⁴ OR 95% CI  | Model 3 ⁵ OR 95% CI  |
| Total energy intake    |                      |                        |                        |
| Food security          | 55.4 (51.3)          | 1.0 1.0                 | 21.3 (19.7)             |
| Low food security      | 52.4 (3.3)           | 1.11 0.90–1.38         | 1.12 0.90–1.38         |
| Very low food security | 43.7 (0.5)           | 1.47 0.92–2.36         | 1.49 0.93–2.39         |
| p = 0.178              |                      | p trend = 0.205        |                         |

KHEI, Korean Healthy Eating Index. ¹ Percentage of people with the highest scores on KHEI items. ² Percentage of people with a score of zero on KHEI items. ¹,² By food security group % (by total %). ³ Model 1: unadjusted. ⁴ Model 2: adjusted for age, sex, survey year, total energy intake. ⁵ Model 3: adjusted for age, sex, survey year, total energy intake; household size, education, marital status, household income level, physical activity level. * p < 0.05, ** p < 0.01, *** p < 0.001.
Figure 1. The risk of less than full scores and zero scores according to household food security status. Results based on Model 3 in Table 4 adjusted for age, sex, survey year, total energy intake, household size, education, marital status, household income level, physical activity level. * $p < 0.05$, ** $p < 0.01$. Abbreviations: KHEI, Korean Healthy Eating Index.
4. Discussion

We found a strong and graded association between food security and nutritional adequacy and quality in a Korean adult population. The risk of inadequate nutrient intakes of protein and phosphorus increased as food security decreased. The total KHEI scores were lowest in the very low food security group. Among KHEI components, adults with food insecurity were less likely to get full scores from intakes of mixed grains, total fruit, fresh fruit, and breakfast. Moreover, food-insecure adults were more likely to get zero scores from intakes of fresh fruit, milk and dairy products, breakfast, % of energy from sweets and beverages, and total energy. This association appeared to be independent of other well-known risk factors for nutritional inadequacy and low dietary quality, such as age, sex, household size, education, marital status, household income levels, total energy intake, and physical activity. Our findings suggest that low food security may be an independent risk factor for nutritional inadequacy and lack of dietary quality in Korean adults.

Our result is consistent with previously reported findings [37–42]. Food insecurity was related to inadequate intake of vegetables, fruits, meats, and meat substitutes in adult women in northern Jordan [37]. An inverse association between food security and regular breakfast intake was also observed previously in a community-based survey of Korean adults [21]. Breakfast skipping reduced total energy intakes in US adults with food insecurity [36]. Household food insecurity was inversely associated with intakes of fruits and vegetables in the US [41] and Korean [39] adults. Moreover, an inverse association between levels of food security and intakes of milk and dairy products was also observed in adults in Korea [9] and women in northern Jordan [42]. The overall diet quality of adults with very low food security in our study was in line with previously reported studies [5,9,21,37–48], which showed reduced consumption of fruits and vegetables, increased consumption of sweets and beverages, and increased % of energy from carbohydrate and fat.

Nonetheless, some studies have also shown inconsistent results. In our study, no differences existed in nutrition adequacy as well as moderation intake of sodium and energy according to food security levels after controlling for confounders, although the tendency of getting zero scores from total energy intake increased as food security decreased. Consumption of sodium increased as total energy intake increased in the US adults with food insecurity [45]. These incompatible findings may be attributable to differences in dietary habits or ethnic differences. Furthermore, an inadequate iron intake was observed in the very low food security group in our study, but the risk of inadequacy did not exist after adjusting for confounding factors. Decreased hemoglobin levels and increased iron binding capacity were observed as food insecurity increased in Korean adults [49]. Persistent iron deficiency leads to hypocytosis or hypochromic anemia. Iron deficiency is also inversely associated with work efficiency, intellectual performance, and resistance to infection [50]. The best food sources of iron are meat, fish and shellfish, and poultry rich in heme irons, and the next best source foods are grains, beans, and dark green vegetables [35]. In our study, the total KHEI scores were lowest in the very low food security group, although no differences in each component except for breakfast intake existed across food security levels. In addition, no differences in overall KHEI scores were observed between adults with food security and low food security. Adequacy or sufficiency of food and nutrient intakes was mainly used to evaluate the quality of diet in the context of developing countries [51]. However, overall dietary quality needs to be carefully considered even though adequacy was almost met, especially in adults with very low food insecurity in the context of developed countries such as South Korea.

Several mechanisms for the effects of food insecurity on lack of dietary adequacy and quality have been proposed. Breakfast skipping increased as food insecurity increased in our study. Lack of knowledge related to diet was known to cause breakfast skipping that leads to insufficient daily energy consumption in households with food [43]. Insufficient daily energy intake, but increased percentages of energy from fat, were due to breakfast skipping in women with household food insecurity [5,47]. Our results suggest that adults with low or very low food security were more likely to get energy from sweets and
beverages and were less likely to have fresh fruit and milk and dairy products as shown in previously reported results, showing an inverse association between income levels and intakes of energy from unhealthy desserts such as sugars and sweetened beverages [46]. There exists geographical or regional disparity in food security, so called food deserts. Especially in underprivileged metropolitan areas, excessive supply of high energy-dense foods in households with food insecurity may be attributable to easy access to cheaper, more delicious, and easier to prepare foods than healthy foods [44]. Therefore, policies and programs for food security are thought to be difficult due to the nature of multifaceted aspects of food insecurity, such as income or educational levels, family composition, social safety net, unemployment, and social isolation [46,52–58]. Despite global economic growth, problems related to food insecurity are not easily resolved. A fundamental solution with a thoroughly designed and tailored approach to promote food security from a macroscopic point of view is needed in order to minimize disparity in diet and health.

Our study had several limitations that should be addressed in future studies. We observed an association between food security and dietary adequacy and quality only in a cross-sectional setting. Therefore, we were not able to determine whether food security level is a cause or consequence of dietary adequacy and quality. Further research is needed to evaluate the causality between levels of food security and dietary adequacy and quality. Furthermore, although the majority of putative risk factors for dietary adequacy and quality were included in the analysis, there may exist potentially unmeasured confounding factors due to the food environment, food assistance, or other correlated factors of having low income. For example, levels of food security as well as dietary adequacy and quality may be influenced by food support, which was not considered in the study. Future research that includes a wide range of environmental and social factors needs to be conducted. Nonetheless, our study had several advantages. Our study used nationally representative data from 2013–2015 KNHANES. Moreover, the KHEI developed for Korean adults was used to evaluate overall dietary quality [29]. Furthermore, household food security was measured using the most accurate tool of the full 18 items based on the US-HFSSM.

5. Conclusions

In conclusion, our results suggest that food security levels were associated with how much they ate, as well what they ate, in adults in South Korea. These results implied that the diet adequacy, as well as moderation and balance, could be carefully treated with food assistance or nutrition intervention once nutritional adequacy has mostly been met. In addition, targeted intervention programs tailored to diverse contexts for improving food insecurity may prevent unintended consequences due to easy access to inexpensive obesogenic foods in adults with food insecurity. Especially, the current era of COVID-19 may exacerbate household food insecurity as reported previously in the US [59]. Therefore, further study needs to examine whether the COVID-19 pandemic may worsen existing disparities and whether timely programs such as food assistance may mitigate food insecurity in the Korean population.

Author Contributions: Conceptualization, J.-Y.H. and M.G.K.; methodology J.-Y.H.; software, M.G.K. and S.-M.Y.; validation, J.-Y.H., M.G.K. and S.-M.Y.; formal analysis, M.G.K. and S.-M.Y.; data curation, M.G.K. and S.-M.Y.; writing—original draft preparation, M.G.K.; writing—review and editing, J.-Y.H. and S.-M.Y.; visualization, M.G.K. and S.-M.Y.; supervision, J.-Y.H.; project administration, M.G.K.; funding acquisition, J.-Y.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by a 2019 research grant from Sangmyung University.

Institutional Review Board Statement: The institutional review board (IRB) of the Korea Disease Control and Prevention Agency (KDCA) approved survey protocols (2013-07CON-03-4C, 2013-12EXP-03-5C, 2015-01-02-6C) for the survey. Ethical review and approval were waived for this study, due to using secondary data which did not include personal information.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.
Data Availability Statement: The data are available from the Korean National Health and Nutrition Examination Survey (KNHANES) website.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. GBD 2017 Diet Collaborators; Afshin, A.; Sur, P.J.; Fay, K.A.; Cornaby, L.; Ferrara, G.; Salama, J.S.; Mullany, E.C.; Abate, K.H.; Abbafati, C.; et al. Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. Lancet 2019, 393, 1958–1972. [CrossRef]

2. Leung, C.W.; Epel, E.S.; Ritchie, L.D.; Crawford, P.B.; Laraia, B.A. Food insecurity is inversely associated with diet quality of lower-income adults. J. Acad. Nutr. Diet. 2014, 114, 1943–1953. [CrossRef]

3. Kim, H.R. Nutrition transition and shifting diet linked noncommunicable diseases and policy issues. Health Welf Policy Forum 2013, 198, 27–37.

4. Guthrie, J.F.; Nord, M. Federal activities to monitor food security. J. Acad. Nutr. Diet. 2002, 102, 904–906. [CrossRef]

5. Champagne, C.M.; Casey, P.H.; Connell, C.L.; Stuff, J.E.; Gossett, J.M.; Harsha, D.W.; McCabe-Sellers, B.; Robbins, J.M.; Simpson, P.M.; Weber, J.L.; et al. Poverty and food intake in rural America: Diet quality is lower in food insecure adults in the Mississippi Delta. J. Am. Diet. Assoc. 2007, 107, 1886–1894. [CrossRef] [PubMed]

6. Pei, C.S.; Appannah, G.; Sulaiman, N. Household food insecurity, diet quality, and weight status among indigenous women (Mah Meri) in Peninsular Malaysia. Nutr. Res. Pract. 2018, 12, 135–142. [CrossRef] [PubMed]

7. Rodríguez, L.A.; Mundo-Rosas, V.; Méndez-Gómez-Humarán, I.; Pérez-Escamilla, R.; Shamah-Levy, T. Dietary quality and household food insecurity among Mexican children and adolescents. Matern. Child Nutr. 2017, 13, e12372. [CrossRef] [PubMed]

8. Huet, C.; Rosol, R.; Egeland, G.M. The prevalence of food insecurity is high and the diet quality poor in Inuit communities. J. Nutr. 2012, 142, 541–547. [CrossRef] [PubMed]

9. Tarasuk, V.S.; Beaton, G.H. Women’s dietary intakes in the context of household food insecurity. J. Nutr. 1999, 129, 672–679. [CrossRef]

10. Kirkpatrick, S.I.; Tarasuk, V. Food insecurity is associated with nutrient inadequacies among Canadian adults and adolescents. J. Nutr. 2008, 138, 604–612. [CrossRef]

11. Mclaughlin, C.; Tarasuk, V.; Kreiger, N. An examination of at-home food preparation activity among low-income, food-insecure women. J. Am. Diet. Assoc. 2003, 103, 1506–1512. [CrossRef]

12. Olson, C.M. Symposium: Advances in Measuring Food Insecurity and Hunger in the US Introduction. J. Nutr. 1999, 129 (Suppl. 2S), 504S–505S. [CrossRef]

13. Yang, Y.J. Socio-demographic characteristics, nutrient intakes and mental health status of older Korean adults depending on household food security: Based on the 2008-2010 Korean National Health and Nutrition Examination Survey. Korean J. Commun. Nutr. 2015, 20, 30–40. [CrossRef]

14. Jun, S.; Hong, E.; Joung, H. Flavonoid intake according to food security in Korean adults: Based on the Korea National Health and Nutrition Examination Survey 2007–2012. J. Nutr. Health 2015, 48, 507–518. [CrossRef]

15. Lane, G.; Nisbet, C.; Vatanparast, H. Food Insecurity and Nutritional Risk among Canadian Newcomer Children in Saskatchewan. Nutrients 2019, 11, 1744. [CrossRef]

16. Kim, H.J.; Oh, K. Household food insecurity and dietary intake in Korea: Results from the 2012 Korea National Health and Nutrition Examination Survey. Public Health Nutr. 2015, 18, 3317–3325. [CrossRef]

17. Shim, J.S.; Oh, K.W.; Nam, C.M. Association of Household Food Security with Dietary Intake; Based on the Third (2005) Korea National Health and Nutrition Examination Survey (KNHANES III). J. Nutr. Health 2008, 41, 174–183.

18. Lim, H.S.; Park, Y.H.; Lee, H.H.; Kim, T.H.; Kim, S.K. Comparison of calcium intake status by region and socioeconomic status in Korea: The 2011-2013 Korea National Health and Nutrition Examination Survey. J. Bone Metab. 2015, 22, 119–126. [CrossRef]

19. Hur, I.; Jang, M.J.; Oh, K. Food and nutrient intakes according to income in Korean men and women. Osong Public Health Res. Perspect. 2011, 2, 192–197. [CrossRef]

20. Shim, J.E.; Yoon, J.; Lee, K.; Kwon, S. Evaluation of dietary intake of Korean school-aged children from low-income families by comparing with the Korean food guide: Analysis of the data from the 2001 National Health and Nutrition Survey. Korean J. Nutr. 2009, 42, 691–701. [CrossRef]

21. Chun, I.; Ryu, S.Y.; Park, J.; Ro, H.K.; Han, M.A. Associations between food insecurity and healthy behaviors among Korean adults. Nutr. Res. Pract. 2015, 9, 425–432. [CrossRef]

22. Lee, S.E.; Song, Y.J.; Kim, Y.; Choe, J.; Paik, H.Y. Household food insufficiency is associated with dietary intake in Korean adults. Public Health Nutr. 2016, 19, 1112–1121. [CrossRef]

23. Chung, H.K.; Kim, O.Y.; Kwak, S.Y.; Cho, Y.; Lee, K.W.; Shin, M.J. Household food insecurity is associated with adverse mental health indicators and lower quality of life among Koreans: Results from the Korea National Health and Nutrition Examination Survey 2012–2013. Nutrients 2016, 8, 819. [CrossRef]

24. Oh, S.Y.; Hong, M.J. Food insecurity is associated with dietary intake and body size of Korean children from low-income families in urban areas. Eur. J. Clin. Nutr. 2003, 57, 1598–1604. [CrossRef]

25. Kwon, S.O.; Oh, S.Y. Associations of household food insecurity with socioeconomic measures, health status and nutrient intake in low income elderly. J. Nutr. Health 2007, 40, 762–768.
26. Lee, K.; Yoo, H.S. Association of food insecurity and depression in Korean adults. JKAIS 2016, 17, 62–71.
27. Kim, K.; Kim, M.K.; Shin, Y.J. Household food insecurity and its characteristics in Korea. Health Soc. Welf. Rev. 2009, 29, 268–292.
28. Trijsburg, L.; Talsma, E.F.; De Vries, J.H.; Kennedy, G.; Kuijsten, A.; Brouwer, I.D. Diet quality indices for research in low- and middle-income countries: A systematic review. Nutr. Rev. 2019, 77, 515–540. [CrossRef]
29. Guenther, P.M.; Reedy, J.; Krebs-Smith, S.M.; Reeve, B.B.; Basiotes, F.P. Development and Evaluation of the Healthy Eating Index-2005; Technical Report; Department of Agriculture, Center for Nutrition Policy and Promotion: Alexandria, VA, USA, 2007.
30. Krebs-Smith, S.M.; Pannucci, T.E.; Subar, A.F.; Kirkpatrick, S.L.; Lerman, J.L.; Tooze, J.A.; Wilson, M.M.; Reedy, J. Update of the healthy eating index: HEI-2015. J. Acad. Nutr. Diet. 2018, 118, 1591–1602. [CrossRef]
31. Woodruff, S.J.; Hanning, R.M. Development and implications of a revised Canadian healthy eating index (HEIC-2009). Public Health Nutr. 2010, 13, 820–825. [CrossRef]
32. Hiza, H.A.; Casavale, K.O.; Guenther, P.M.; Davis, C.A. Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. J. Acad. Nutr. Diet. 2013, 113, 297–306. [CrossRef]
33. Korea Centers for Disease Control and Prevention. Nutrition and Health Status of Korean Adults: The Sixth Korea National Health and Nutrition Examination Survey (KNHANES VI-3); Korea Centers for Disease Control and Prevention: Osong, Korea, 2016.
34. English site for Food Composition Database. Available online: http://koreanfood.rda.go.kr/eng/dfctFoodSrchEng/main (accessed on 25 February 2021).
35. Yook, S.M.; Park, S.; Moon, H.K.; Kim, K.; Shim, J.E.; Hwang, J.Y. Development of the Korea national health and nutrition examination survey data. J. Nutr. Health 2015, 48, 419–428. [CrossRef]
36. Yun, S.; Oh, K. Development and status of Korea Healthy Eating Index for adults based on the Korea National Health and Nutrition Examination Survey. Public Health Wkly Rep. 2018, 11, 1764–1772.
37. Banna, J.C.; McCrory, M.A.; Fialkowski, M.K.; Boushey, C. Examining the feasibility of using self-reported energy intake data: Considerations for method selection. Front. Nutr. 2017, 4, 45. [CrossRef]
38. Korea Centers for Disease Control and Prevention. The Sixth Korea National Health and Nutrition Examination Survey (KNHANES VI-3); Korea Centers for Disease Control and Prevention: Osong, Korea, 2019.
39. The Ministry of Health and Welfare. The Korean Nutrition Society. Dietary Reference Intakes for Koreans 2015; The Ministry of Health and Welfare: Sejong, Korea, 2015.
40. Tugault-Lafleur, C.N.; Black, J.L.; Barr, S.I. A systematic review of methods to assess children’s diets in the school context. Adv. Nutr. 2017, 8, 63–79. [CrossRef]
41. Lynch, S.R. Why nutritional iron deficiency persists as a worldwide problem. J. Nutr. 2011, 141, 763S–768S. [CrossRef]
42. Workicho, A.; Belachew, T.; Feyissa, G.T.; Wondafrash, B.; Lachat, C.; Verstraeten, R.; Kolsteren, P. Household dietary diversity and Animal Source Food consumption in Ethiopia: Evidence from the 2011 Welfare Monitoring Survey. BMC Public Health 2016, 16, 1192. [CrossRef]
43. Lee, Y.S.; Kim, T.H. Household food insecurity and breakfast skipping: Their association with depressive symptoms. Psychiatry Res. 2019, 271, 83–88. [CrossRef]
44. Crews, D.C.; Kuczinarski, M.F.; Grubbs, V.; Hedgeman, E.; Shahinian, V.B.; Evans, M.K.; Zonderman, A.B.; Burrows, N.R.; Williams, D.E.; Saran, R.; et al. Effect of food insecurity on chronic kidney disease in lower-income Americans. Am. J. Nephrol. 2010, 31, 83–97. [CrossRef]
45. Kim, D.W.; Lee, M.S.; Na, B.J.; Hong, J.Y. Health-related dietary behaviors and lifestyle factors associated with sodium hyper- ingestion in Korean adults. JKAIS 2013, 14, 3326–3337.
46. Kim, J.H.; Lim, G.E.; Kang, S.; Lee, K.; Park, T.J.; Kim, J. The relationship between daily sodium intake and obesity in Korean adults. Korean J. Health Promot. 2015, 15, 175–184. [CrossRef]
47. Kim, N.; Kim, G.U.; Kim, H. Comparative Study of Dietary Patterns by Living Arrangements: The Korea National Health and Nutrition Examination Survey. J. Environ. Res. Public Health 2017, 12, 2371. [CrossRef] [PubMed]
48. Shim, J.E.; Paik, H.Y.; Moon, H.K. Breakfast consumption pattern, diet quality and health outcomes in adults from 2001 National Health and Nutrition Survey. J. Nutr. Health 2007, 40, 451.
49. Tarasuk, V.S. Household food insecurity with hunger is associated with women’s food intakes, health and household circumstances. J. Nutr. 2001, 131, 2670–2676. [CrossRef] [PubMed]
50. Lee, S.H.; Chung, S.J.; Choi, K.R. Relationship between nutrient intake and biochemical index with breakfast eating in Korean adults: Analysis of data from the 2007 National Health and Nutrition Survey. Korean J. Food Cult. 2011, 26, 94–99.
51. Gunderson, C.; Kreider, B.; Pepper, J. The economics of food insecurity in the United States. Appl. Econ. Perspect. Policy 2011, 33, 281–303. [CrossRef]
52. Lee, J.; Shin, A. Vegetable and fruit intake in one person household: The Korean National Health and Nutrition Examination Survey (2010–2012). J. Nutr. Health 2015, 48, 269–276. [CrossRef]
53. Kendall, A.; Olson, C.M.; Frongillo, E.A., Jr. Relationship of hunger and food insecurity to food availability and consumption. J. Am. Diet. Assoc. 1996, 96, 1019–1024. [CrossRef]
54. Bawadi, H.A.; Tayyem, R.P.; Dwyair, A.N.; Al-Akour, N. Prevalence of food insecurity among women in northern Jordan. J. Health Popul. Nutr. 2012, 30, 49. [CrossRef]
55. Taylor, C.A.; Spees, C.K.; Markworth, A.M.; Watowicz, R.P.; Clark, J.K.; Hooker, N.H. Differences in US adult dietary patterns by food security status. J. Consum. Aff. 2017, 51, 549–565. [CrossRef]
56. Lee, J.S.; Kim, H.Y.; Hwang, J.Y.; Kwon, S.; Chung, H.R.; Kwak, T.K.; Kang, M.H.; Choi, Y.S. Development of Nutrition Quotient for Korean adults: Item selection and validation of factor structure. *J. Nutr. Health* **2018**, *51*, 340–356. [CrossRef]
57. Jang, H.B.; Park, J.Y.; Lee, H.J.; Kang, J.H.; Park, K.H.; Song, J. Association between parental socioeconomic level, overweight, and eating habits with diet quality in Korean sixth grade school children. *Korean J. Nutr.* **2011**, *44*, 416–427. [CrossRef]
58. Alaimo, K.; Briefel, R.R.; Frongillo, E.A., Jr.; Olson, C.M. Food insufficiency exists in the United States: Results from the third National Health and Nutrition Examination Survey (NHANES III). *Am. J. Public Health* **1998**, *88*, 419–426. [CrossRef] [PubMed]
59. Wolfson, J.A.; Leung, C.W. Food insecurity and COVID-19: Disparities in early effects for US adults. *Nutrients* **2020**, *12*, 1648. [CrossRef] [PubMed]