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Review

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Low-Carbohydrate Diets in Korea: Why Does It Matter, and What Is Next?

Kyungho Ha[1], YoonJu Song[2,*]

[1]*Department of Food Science and Nutrition, Jeju National University, Jeju;* [2]*Department of Food Science and Nutrition, The Catholic University of Korea, Bucheon, Korea*

In recent years, low-carbohydrate diets have become highly popular in Korea as a means to lose weight. People following this regime believe that fat and protein can be consumed in unlimited quantities, as long as carbohydrate intake is strictly restricted. However, low-carbohydrate diets are more complex than simply reducing carbohydrate intake. Meta-analyses of randomized controlled trials revealed that low-carbohydrate diets are at least as effective as low-fat diets in terms of weight loss, but their cardiovascular effects vary. Low-carbohydrate diets confer more beneficial effects on weight loss and lipid profiles such as triglycerides and high-density lipoprotein cholesterol but exhibited detrimental effects on lipid profiles such as total and low-density lipoprotein cholesterol. Korean diets are typically high in carbohydrates, where carbohydrate intake is in the range of 50%–80% of total energy. Within this range of carbohydrate intake, high carbohydrate intake was associated with an increased risk of elevated triglyceride and high-density lipoprotein cholesterol levels but with a reduced risk of elevated total and low-density lipoprotein-cholesterol levels. The optimal range of carbohydrate intake was depicted by a U-shaped relationship between carbohydrate intake and mortality, with 50%–60% of energy from carbohydrates having the lowest mortality risk. The distribution of macronutrients varied greatly according to age and sex groups in Korea. There is no single diet that can be recommended to all individuals, especially if focusing only on the quantity of macronutrients as opposed to their quality. The health benefits of low-carbohydrate or low-fat diets may depend on the source of protein and fat and the carbohydrate quality.

Key words: Low-carbohydrate diet, Low-fat diet, High-protein, Cardiometabolic risk factors, Obesity, Metabolic syndrome

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*Corresponding author
YoonJu Song

https://orcid.org/0000-0002-4764-5864

Department of Food Science and Nutrition, The Catholic University of Korea, 43 Jibong-ro, Bucheon 14662, Korea
Tel: +82-2-2164-4681
Fax: +82-2-2164-6583
E-mail: yjsong@catholic.ac.kr

INTRODUCTION

In recent years, low-carbohydrate (low-carb) diets have gained popularity as an alternative to conventional low-fat diets for weight loss. Among them, the Atkins diet has become one of the most successful low-carb diets, in which carbohydrate intake is strictly restricted, while protein and fat intake are unlimited; paradoxically, this promotes weight loss.[1,2] Numerous studies have since compared the effects of low-carb vs. low-fat diets. Meta-analyses of randomized controlled trials (RCTs) revealed that low-carb diets are at least as effective as low-fat diets in terms of weight loss, but their cardiovascular effects vary in diverse populations.[3-6]

Academic discussions regarding the effects of low-carb diets on short-term weight loss and health outcomes were already rife when television programs promoting low-carb, high-fat diets aired in Korea in 2016 and received huge public attention, triggering the low-carb diet trend in Korea. As a result, many people throughout Korea eat butter and pork belly without hesitation, believing that fat and protein can be consumed in unlimited quantities as long as carbohydrate consumption is restricted. However, low-carb diets are more complex than simply reducing carbohydrate intake.

The low-carb diet trend probably gained traction because of the ability to consume high amounts of fat while still achieving weight loss. The low-fat message has long been emphasized in the dietary guidelines of several countries, being a key factor in the prevention and management of obesity and cardiovascular disease. However, the fact that very low-fat diets accompany high carbohydrate intake and that excessive carbohydrate intake is associated with increased cardiometabolic risk factors has been overlooked. Similarly, very low-carb diets are associated with increased cardiometabolic risk factors. Several reports have found that very low-fat diets or very low-carb diets are not desirable, either in terms of overall nutritional status or in reducing cardiometabolic risk factors.[7,8]

Carbohydrate intakes differ according to dietary cultures. Korean diets are typically high in carbohydrates because they are often rice-based with several plant-based foods. A study comparing the diets of U.S. and Korean adults found that the average carbohydrate intake was 65% of energy in Korean adults and 50% in adults from the U.S.[9] In Korea, the recommended intake of dietary carbohydrates is higher than that of the U.S. The acceptable macronutrient distribution range (AMDR) of carbohydrates in Korea was 55%–70% until 2010 and was updated to 55%–65% in 2015.[10] The U.S. AMDR of dietary carbohydrates is 45%–60%.[11] This highlights differences in the notion of low-carb diets among different countries because carbohydrate intakes are population-specific.

Because the low-carb diet trend has only recently been introduced to Korea, few studies have investigated the extent to which carbohydrate intake should be reduced and fat and protein increased in Korean diets to prevent and manage obesity and cardiovascular disease. In this review, we compared the effects of low-carb diets and low-fat diets on cardiometabolic risk factors using recent meta-analyses. Furthermore, we summarized the associations between dietary carbohydrate intake and cardiometabolic risk factors in Korean populations and discussed the optimal carbohydrate intake and future directions for dietary research.

THE EFFECTS OF LOW-CARB AND LOW-FAT DIETS ON CARDIOMETABOLIC RISK FACTORS

Several RCTs have investigated the effects of low-carb diets on cardiometabolic risk factors, and the effects of low-carb diets and low-fat diets have been systemically evaluated in various meta-analyses (Table 1). The carbohydrate intake range used to define low-carb diets is inconsistent, varying between studies. Thus, the various definitions of low-carb diets must be considered when interpreting the findings. Low-carb diets can also be defined as high-fat diets. Schwingshackl and Hoffmann[5,12] defined high-fat diets as acquiring > 30% of energy from fats and low-fat diets as acquiring ≤ 30% energy from fats when they compared the effects of the two diets on cardiometabolic risk factors. Naude et al.[13] defined low-carb diets as obtaining < 45% of energy from carbohydrates and compared low-carb diets with balanced diets (energy intakes of 45%–65% carbohydrates, 25%–35% fats, and 10%–20% proteins). Diets in which carbohydrate intake is < 20% of energy, such as the Atkins diet, are sometimes referred to as "very low-carb diets."[4] The most recent meta-analysis defined low-carb diets as < 40% of energy from carbohydrates and low-fat diets as < 30% of energy from fats.[3]

Despite differences in how carbohydrate restriction is defined, recent studies suggest that low-carb diets confer more beneficial effects on short-term weight loss and lipid profiles such as triglycerides and high-density lipoprotein (HDL) cholesterol compared to low-fat diets while having no significant effects on blood pressure or fasting blood glucose. In a recent meta-analysis of 38 RCTs that lasted 6–12 months, participants on low-carb diets (< 40% of energy from carbohydrates) exhibited decreased body weight and triglycerides and increased HDL cholesterol compared to participants on low-fat diets.[3] Interventions with longer durations (6–24 months) and greater carbohydrate restrictions (Atkins diet or < 20% of energy) also reported similar findings.[4] When compared to long-term balanced isocaloric diets, low-carb diets were associated with increased HDL cholesterol but with no significant changes in weight loss or other lipid profiles.[13]

Detrimental effects of low-carb diets on total and low-density lipoprotein (LDL) cholesterol levels have also been reported. Participants assigned to low-carb diets exhibited increased LDL cholesterol levels after the intervention.[3,4] This may be related to the high fat contents of low-carb diets. In a meta-analysis comparing the effects of low-fat and high-fat diets, the weighted mean difference did not favor the high-fat diets for total cholesterol and LDL cholesterol levels, whereas it did favor the high-fat diets for triglyceride and HDL cholesterol levels.[5]

Low-carb diets seem to confer more benefits to people with abnormal glucose metabolisms. In 2014, Schwingshackl and Hoffmann[12] conducted a meta-analysis including 14 RCTs with durations of > 1 year and 1,753 pre-diabetic and diabetic adults; they

Table 1. The effects of low-carbohydrate diets on cardiometabolic risk factors in meta-analyses of RCTs

Author (year)	Review period, study design, subject	Intervention duration (mo)	Intervention	LC/HF diets vs. control diets, mean difference (95% CI)
Schwingshackl and Hoffmann (2013)[5]	Until Mar 2013, 32 RCTs, n = 8,862 (overweight and obese adults)	≥ 12	HF diets: > 30% fat LF diets: ≤ 30% fat	HF diets TG: –8.38 mg/dL (–13.50 to –3.25) HDL-C: +2.35 mg/dL (1.29 to 3.42) TC: +4.55 mg/dL (1.07 to 8.03) LDL-C: +3.11 mg/dL (1.71 to 4.51)
Schwingshackl and Hoffmann (2014)[12]*	Until Nov 2013, 14 RCTs, n = 1,753 (pre-diabetic and diabetic adults)	≥ 12	HF diets: > 30% fat (> 10% saturated fat) LF diets: ≤ 30% fat, 15% protein, and 55% carbohydrate	HF diets (total subjects) BW: –0.11 kg (–1.14 to 0.91) SBP: +0.59 mmHg (–2.18 to 3.36) DBP: –1.30 mmHg (–1.73 to –0.87) TG: –3.4 mg/dL (–4.1 to –2.5) HDL-C: +0.9 mg/dL (0.2 to 1.4) TC: +1.3 mg/dL (–1.8 to 4.1) LDL-C: +0.9 mg/dL (–1.8 to 3.6) FBG: –3.2 mg/dL (–9.4 to 2.7) HF diets (subjects with type 2 diabetes) BW: –0.47 kg (–1.85 to 0.92) SBP: –1.35 mmHg (–2.35 to –0.35) DBP: –1.35 mmHg (–1.79 to –0.92) TG: –3.2 mg/dL (–4.3 to –2.3) HDL-C: +0.7 mg/dL (0.0 to 1.4) TC: +1.4 mg/dL (–2.0 to 4.9) LDL-C: +0.7 mg/dL (–2.5 to 4.1) FBG: –7.4 mg/dL (–13.3 to –1.4)
Naude et al. (2014)[13]*	Until Mar 2014, 19 RCTs, n = 3,209 (overweight and obese adults)	12–24	LC diets: < 45% carbohydrate, high fat variant (with unlimited fat), high protein variant (with 25%–35% fat and > 20% protein) Balanced diets: 45%–65% carbohydrate, 25%–35% fat, and 10%–20% protein	LC diets for body weight (1–2 yr) High fat variant: –0.17 kg (–1.50 to 1.15) High protein variant: –1.38 kg (–3.21 to 0.45) LC diets (overall) BW: –0.48 kg (–1.44 to 0.49) SBP: –2.00 mmHg (–5.00 to 1,00) DBP: –0.03 mmHg (–1.68 to 1.62) TG: –1.1 mg/dL (–2.5 to 0.5) HDL-C: +0.7 mg/dL (0.2 to 1.4) TC: +1.1 mg/dL (–0.5 to 2.9) LDL-C: +1.3 mg/dL (–0.2 to 2.9)
Mansoor et al. (2016)[4]*	Until May 2015, 11 RCTs, n = 1,369 (healthy adults)	6–24	LC diets: Atkins diet (20–40 g/day of carbohydrate in the first phase with gradual increases) or < 20% carbohydrate LF diets: < 30% fat	LC diets BW: –2.17 kg (–3.36 to –0.99) SBP: –1.02 mmHg (–2.98 to 0.94) DBP: –1.01 mmHg (–2.75 to 0.74) TG: –4.7 mg/dL (–6.7 to –2.7) HDL-C: +2.5 mg/dL (1.6 to 3.4) TC: +4.7 mg/dL (–1.6 to 11.2) LDL-C: +2.9 mg/dL (0.0 to 5.9) FBG: –4.1 mg/dL (–0.9 to 1.4)
Chawla et al. (2020)[3]*	Until Sep 2019, 38 RCTs, n = 6,499 (adults without significant comorbidities)	6–12	LC diets: < 40% carbohydrate LF diets: < 30% fat	LC diets BW: –1.30 kg (–2.02 to –0.57) TG: –1.8 mg/dL (–2.9 to –0.7) HDL-C: +0.9 mg/dL (0.5 to 1.4) TC: +1.8 mg/dL (0.4 to 3.2) LDL-C: +1.3 mg/dL (0.4 to 2.2)

*Units of blood lipid and fasting blood glucose levels in these studies were converted from mmol/L to mg/dL for comparison.
RCT, randomized controlled trial; LC, low-carbohydrate; HF, high-fat; CI, confidence interval; LF, low-fat; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; BW, body weight; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose.

found significant reductions in blood pressure, triglyceride levels, and fasting blood glucose levels in subjects with type 2 diabetes assigned to a high-fat diet.

Collectively, these findings suggest that low-carb diets have double-sided effects on cardiometabolic risk factors. Low-carb diets are more effective for weight loss and improving lipid profiles, including triglycerides and HDL cholesterol levels, compared to low-fat diets. However, these effects should be weighed against the potential deleterious effects of raised LDL and total cholesterol levels.

THE EFFECTS OF DIETARY CARBOHYDRATES ON CARDIOMETABOLIC RISK FACTORS IN THE KOREAN POPULATION

In recent decades, researchers have actively investigated the associations between dietary carbohydrate intake and cardiometabolic risk factors such as metabolic syndrome, dyslipidemia, and diabetes in the Korean population. Table 2 presents a summary of previous observational studies evaluating dietary carbohydrate intakes as percentages of total energy. Most studies evaluated carbohydrate intake as quantiles (e.g., quintiles, quartiles, tertiles),[7,9,14-19] whereas some studies categorized carbohydrate intakes into several specific ranges.[20-23]

Based on cross-sectional studies using data acquired by the Korea National Health and Nutrition Examination Survey (KNHANES), carbohydrate intake levels were 50%–56% of energy in the lowest quintile groups and 79%–83% of energy in the highest quintile groups among Korean adults.[9,15,17] When the highest and lowest quintile groups were compared, high carbohydrate intake was associated with an increased risk of metabolic syndrome in men[9,15] and women.[9] In addition, people with high carbohydrate intakes had an increased risk of elevated triglyceride levels[9,17,19] and lower HDL cholesterol levels,[9,14,17,19] whereas they had a reduced risk of elevated to-

Table 2. The associations between dietary carbohydrate and cardiometabolic risk factors in the Korean population

Author (year)	Study design, dataset	Subject	Dietary assessment instrument	Dietary carbohydrate (% of energy)	Primary outcome	Effect size (95% CI)* (vs. Ref)
Kim et al. (2008)[14]	Cross-sectional, Yangpyeong	910 Adults aged ≥20 yr	FFQ (121 items)	Quintiles (Ref: Q1)† Men: 58%, 67.5%, and 74.5% Women: 61.6%, 68.7%, and 74.2%	MetS and its components (WC, BP, HDL-C, TG, FBG)	Men NS Women MetS for Q5: 2.05 (0.92–4.56); *P* for trend=0.03 HDL-C for Q5: 3.54 (1.69–7.40)
Park et al. (2010)[20]	Cross-sectional, 2005 KNHANES	3,771 Adults aged 20–69 yr (1,536 men and 2,235 women)	24-hr recall	Specific ranges <55%, 55%–70% (Ref), and >70%	Obesity, BP, TG, TC, HDL-C, LDL-C, FBG	Men <55%: NS TC for >70%: 0.59 (0.35–0.99) Women HDL-C for >70%: 1.54 (1.26–1.87) FBG for <55%: 1.74 (0.36–8.32) FBG for >70%: 2.53 (1.35–4.73)
Song et al. (2014)[15]	Cross-sectional, 2007–2009 KNHANES	6,845 Adults aged 30–65 yr (2,631 men and 4,214 women)	24-hr recall	Quintiles (Ref: Q1) Men: 54.5%, 62.4%, 67.5%, 72.3%, and 78.7% Women: 56.2%, 65.1%, 70.4%, 75.2%, and 81.6%	MetS	Men Q5: 1.46 (1.07–2.01) Women NS
Song et al. (2017)[17]	Cross-sectional, 2008–2012 KNHANES	14,301 Adults aged ≥30 yr (5,715 men and 8,586 women)	24-hr recall	Quintiles (Ref: Q1) Men: 51.1%, 62.1%, 68.1%, 73.4%, and 80.9% Women: 53.6%, 64.7%, 70.4%, 75.8%, and 82.7%	Dyslipidemia (TC, HDL-C, LDL-C, TG)	Men HDL-C for Q5: 1.38 (1.08–1.77) LDL-C for Q5: 0.75 (0.59–0.96) TG for Q5: 1.37 (1.07–1.76) Women TC for Q5: 0.77 (0.63–0.94) HDL-C for Q5: 1.52 (1.25–1.86) LDL-C for Q5: 0.88 (0.71–1.09); *P* for trend=0.039 TG for Q5: 1.37 (1.07–1.74)

(*Continued to the next page*)

Table 2. Continued

Author (year)	Study design, dataset	Subject	Dietary assessment instrument	Dietary carbohydrate (% of energy)	Primary outcome	Effect size (95% CI)* (vs. Ref)
Ha et al. (2018)[9]	Cross-sectional, 2007–2012 KNHANES	20,515 Adults aged ≥19 yr (8,236 men and 12,279 women)	24-hr recall	Quintiles (Ref: Q1) Men: 50.1%, 61.4%, 67.3%, 72.8%, and 80.7% Women: 51.6%, 63.3%, 69.4%, 75.0%, and 82.3%	MetS and its components (WC, BP, HDL-C, TG, FBG)	Men MetS for Q5: 1.32 (1.01–1.73) HDL-C for Q5: 1.31 (1.06–1.62) TG for Q5: 1.32 (1.07–1.63) Women MetS for Q5: 1.31 (1.01–1.69) HDL-C for Q5: 1.45 (1.21–1.74) TG for Q5: 1.26 (1.00–1.58)
Kwon et al. (2018)[18]	Cross-sectional, 2008–2011 KNHANES	15,582 Adults aged 20–64 yr (6,732 men and 8,845 women)	24-hr recall	Tertiles (Ref: T1) Men: ≤61.0%, 61.0%–70.1%, and ≥70.1% Women: ≤63.5%, 63.5%–72.8%, and ≥72.8%	MetS	Men T3: 1.35 (1.08–1.68) Women T3: 1.27 (1.03–1.56)
Lee et al. (2018)[21]	Cross-sectional, 2013–2015 KNHANES	13,106 Adults aged ≥20 yr (5,966 men and 7,140 women)	24-hr recall	Specific ranges <55% (Ref), 55%–60%, 60–65%, 65%–70%, 70%–75%, 75–80%, and >80%	MetS and its components (WC, BP, HDL-C, TG, FBG)	Men FBG for 60%–65%: 1.30 (1.00–1.70) FBG for 70%–75%: 1.27 (1.00–1.60) TG for 60%–65%: 1.27 (1.00–1.61) TG for >80%: 1.41 (1.03–1.92) MetS for 70%–75%: 1.44 (1.08–1.93) Women HDL-C for 75%–80%: 1.27 (1.00–1.61) HDL-C for >80%: 1.38 (1.06–1.80)
Sho et al. (2020)[22]	Cross-sectional, 2016–2017 KNHANES	7,566 Adults aged 19–64 yr	24-hr recall	Specific ranges <45%, 45%–50%, 50%–55%, 55%–60%, 60%–65% (Ref), 65%–70%, 70%–75%, and ≥75%	MetS and its components (WC, BP, HDL-C, TG, FBG)	BP for <45%: 1.48 (1.10–2.00) BP for 70%–75%: 1.25 (1.00–1.55) HDL-C for ≥75%: 1.37 (1.10–1.70)
Shin et al. (2021)[19]	Cross-sectional, HEXA study	93,870 Adults	FFQ (106 items)	Quintiles of high-GI carbohydrate (g) (Ref: Q1)[†] Men: 62.6%, 72.0%, 79.8% Women: 63.3%, 72.5%, and 80.4%	Dyslipidemia (TC, HDL-C, LDL-C, TG)	Men HDL-C for Q5: 1.27 (1.09–1.48) TG for Q5: 1.50 (1.24–1.82) LDL-C for Q5: 0.67 (0.57–0.79) TC for Q5: 0.70 (0.60–0.81) Women HDL-C for Q5: 1.51 (1.31–1.74) TG for Q5: 1.73 (1.54–1.93) LDL-C for Q5: 0.66 (0.58–0.74) TC for Q5: 0.67 (0.61–0.75)
Cho et al. (2017)[16]	Longitudinal, KoGES, 2-year follow-up	5,565 Adults aged 49–69 yr	FFQ (103 items)	Quartiles (Ref: Q4) 34%–66%, 67%–70%, 71%–75%, and 76%–89%	Incidence of MetS and its components	MetS for Q1: 0.97 (0.77–1.23) MetS for Q2: 0.77 (0.61–0.97) HDL-C for Q1: 0.81 (0.66–0.99)
Ha et al. (2019)[7]	Longitudinal, KoGES, 12-year follow-up	5,595 Adults aged 40–69 yr (2,684 men and 2,911 women)	FFQ (103 items)	Quartiles (Ref: Q1) Men: 64.7%, 69.8%, 73.7%, and 78.0% Women: 66.3%, 71.8%, 75.6%, and 80.4%	Type 2 diabetes incidence	Men Q3: 1.40 (1.02–1.93) Q4: 1.54 (1.03–2.30) Women Q3: 1.09 (0.75–1.57) Q4: 1.69 (1.08–2.67)
Kwon et al. (2020)[23]	Longitudinal, 2007–2015 KNHANES	42,192 Adults aged ≥19 yr	24-hr recall	Specific ranges <50%, 50%–60% (Ref), and ≥60%	All-cause mortality	<50%: 1.31 (1.03–1.67) ≥60%: 1.32 (1.12–1.57)

*Effect sizes are expressed as odds ratios for all cross-sectional studies and Cho et al. (2017)[16], as relative risks for Ha et al. (2019)[7], and as hazard ratios for Kwon et al. (2020)[23];
[†]These studies presented values for the first, third, and fifth quintiles only.
CI, confidence interval; Ref, reference group; FFQ, food frequency questionnaire; MetS, metabolic syndrome; WC, waist circumference; BP, blood pressure; HDL-C, high-density lipoprotein cholesterol; TG, triglycerides; FBG, elevated fasting blood glucose; NS, not significant; KNHANES, Korea National Health and Nutrition Examination Survey; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HEXA, Health Examinees; GI, glycemic index; KoGES, Korean Genome and Epidemiology Study.

tal and LDL cholesterol levels.[17,19]

Several cross-sectional studies examining specific ranges of dietary carbohydrates found similar associations.[20-22] Lee et al.[21] categorized 13,106 adults aged 20 years or older into seven groups based on their carbohydrate intake, ranging from < 55% to > 80% of energy from carbohydrates. Then they examined associations of each group with metabolic syndrome, using the < 55% of energy group as reference. Women in the two highest carbohydrate intake groups had an increased risk of low HDL cholesterol levels, and men in the 70%–75% of energy group had a 44% higher risk of metabolic syndrome. Furthermore, in men, a higher risk of elevated fasting blood glucose and triglyceride levels was present in the 60%–75% of energy groups and 60%–65% and > 80% of energy groups, respectively. These findings support those of previous meta-analyses, which suggested that low-carb diets were effective at improving triglyceride and HDL cholesterol levels, but not at improving total and LDL cholesterol levels.

The groups that appeared to be associated with cardiometabolic risk factors were not just the very high-carbohydrate (high-carb) intake group.[20,22] Park et al.[20] found that women in the < 55% of energy from carbohydrates group had an increased risk of diabetes and low HDL cholesterol levels compared to those in the 55%–70% group. A recent study using the 2016–2017 KNHANES data observed that adults in both the < 45% and 70%–75% groups had a higher risk of elevated blood pressure than those in the 60%–65% group.[22]

The associations between dietary carbohydrates and cardiometabolic risk factors have also been examined in longitudinally.[7,16,23] A prospective cohort study with 12-year follow-ups found that middle-aged men and women in the highest quartile of carbohydrate intake (approximately 80% of energy from carbohydrates) had 1.5- and 1.7-times higher risks of incident type 2 diabetes, respectively, compared to those in the lowest quartile (65%–66% of energy).[7] The study found a very low fat intake was also associated with an increased risk for type 2 diabetes. Another longitudinal study reported that the 2-year incidence of metabolic syndrome was lower in individuals who acquired 67%–70% of energy from carbohydrates compared to the 76%–89% of energy from carbohydrates group.[16] Recently, Kwon et al.[23] examined associations between dietary carbohydrate intake and all-cause mortality by linking the 2007–2015 KNHANES data with the national death index, which was followed up until 2017. They found a U-shaped association between all-cause mortality and dietary carbohydrate intake, with a minimal risk at 50%–60%.

Overall, the carbohydrate intake of Korean adults ranged from 50%–80% of energy, which was clearly higher than that of U.S. adults (35%–65% of energy).[9] For Korean adults, a very high carbohydrate intake (> 70% of energy) was associated with a higher risk of metabolic syndrome and type 2 diabetes, but also with a lower risk of elevated total and LDL cholesterol levels, compared to those acquiring 50%–60% of energy from carbohydrates.

THE OPTIMAL CARBOHYDRATE INTAKE: THE LONG-TERM EFFECT ON MORTALITY

Although numerous studies have reported the effects of low-carb diets on weight loss and/or cardiometabolic risk factors, there is still a lack of consensus as to whether low-carb diets should be recommended due to concerns about their long-term efficacy. In fact, the differences in weight loss between low-carb diets and low-fat diets were nonsignificant beyond 12 months.[3]

Recently, because a long-term health outcome such as mortality is not practical in clinical trials, the long-term effects of carbohydrate restriction on mortality have been investigated using cohort data. The large-scale Prospective Urban Rural Epidemiology (PURE) study examined carbohydrate intake and mortality.[24] The study collected data from participants in 18 countries over five continents with various socioeconomic factors; socioeconomic factors are related to nutritional status. Nutritional excess is more common in European and North American countries, whereas undernutrition is of greater concern in other regions. This has led to a broader range of carbohydrate intakes than in other studies. They found that the highest quintile of carbohydrate intake (77.2% of energy) was associated with a 28% increased risk of total mortality compared to the lowest quintile of carbohydrate intake (46.4% of energy) but not with the risk of cardiovascular disease or mortality.[24] In addition, total fat and saturated fat intakes were not significantly associated with risks of myocardial infarction or cardiovascular disease mortality.

Moreover, the Atherosclerosis Risk in Communities (ARIC) study reported that obtaining 50%–55% of energy from carbohydrates was associated with the lowest risk of mortality.[25] They also conducted a meta-analysis of seven multinational prospective studies and found a U-shaped association between dietary carbohydrates and mortality, in which either low carbohydrate intake (<40% of energy) or high carbohydrate intake (>70% of energy) were associated with greater mortality risk than moderate carbohydrate intake (50%–60% of energy).[25] The left side of the U-shaped curve represented the North American and European cohorts, while the right side represented Asian and multinational cohorts.[25] This indicates that a moderate carbohydrate intake seems optimal in terms of minimizing the risk of mortality. In addition, Asian countries should focus on reducing carbohydrate intake, whereas North American and European countries should focus on increasing carbohydrate intakes to achieve the optimal dietary carbohydrate consumption.

WHAT ARE THE CURRENT INTAKE LEVELS OF MACRONUTRIENTS IN KOREA?

According to the secular trend of macronutrient intake in Korea over the past decade, the proportion of adults with high-carb diet (≥70%) has decreased from 41.4% in 2010 to 23.5% in 2019, whereas that of adults with low-carb diet (<50%) has increased from 8.8% in 2010 to 17.0% in 2019 (Fig. 1).

Although the trend of high-carb diets is decreasing, the average intake of carbohydrates, proteins, and fats among Korean adults aged 19 years or older is 62.5%, 15.6%, and 21.9%, respectively, according to the most recent 2019 KNHANES data. The average intake shows that Korean adults typically consume high-carb, low-fat diets. In addition, the distribution of macronutrients as percentages of energy intake varied greatly according to age and sex groups (Fig. 2). The proportion of adults with very low-carb intake (<45% of energy) by age group in men were 15.4% for 19–29 years, 12.6% for 30–49 years, 3.3% for 50–64 years, 2.7% for 65–74 years, and 0.9% for the 75 years or more. The percentages of men with very high-carb intake (>80% of energy) by age group were 1.5% for 19–29 years, 1.3% for 30–49 years, 5.6% for 50–64 years, 12.4% for 65–74 years, and 15.9% for 75 years or more. Similar patterns were observed in women. These findings suggest that younger adults were more likely to have low-carb diets, whereas older adults were more likely to have high-carb diets.

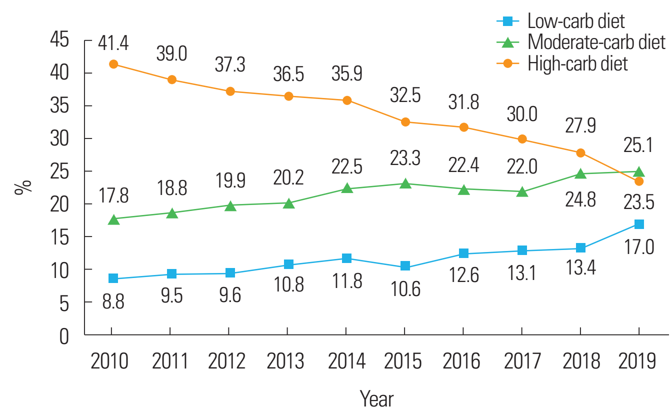

Figure 1. The secular trends in the age-standardized proportion of low-carbohydrate (carb), moderate-carbohydrate, and high-carbohydrate diets in Korean adults are shown. Data were obtained from the 2010–2019 Korea National Health and Nutrition Examination Survey (n=61,410). Low-carb, moderate-carb, and high-carb diets were defined as <50%, 50%–60%, and ≥70% of energy from carbohydrate, respectively.

Alongside the decreased carbohydrate intake among younger adults, higher protein and total fat intakes were also present in younger populations. The proportion of adults with high protein intakes (>20% of energy) in the 19–29 years group was 26.4% in men and 19.3% in women, compared to 8.0% in men and 4.9% in women aged 75 years or more. The increasing total fat intake in younger people may be concerning, particularly if this is the case for saturated fats. The proportions of adults with high saturated fat intakes (>10% of energy) aged 19–29 years were 30.9% in men and 37.4% in women, compared to 2.0% in men and 6.9% in women aged 75 years or more. The differences in macronutrient distributions between sex and age groups suggest that dietary patterns are rapidly transitioning in Korea and that one type of diet cannot be recommended to all.

WHAT IS NEXT AFTER THE LOW-CARB DIET TREND IN KOREA?

Many people in Korea are now aware of the undesirable effects of a very high-carb intake, even if it is accompanied by a low fat intake. As a result, many people are reducing their intake of carbohydrates. However, not everyone following a low-carb diet succeeds at losing weight. One explanation for this could be that the quality

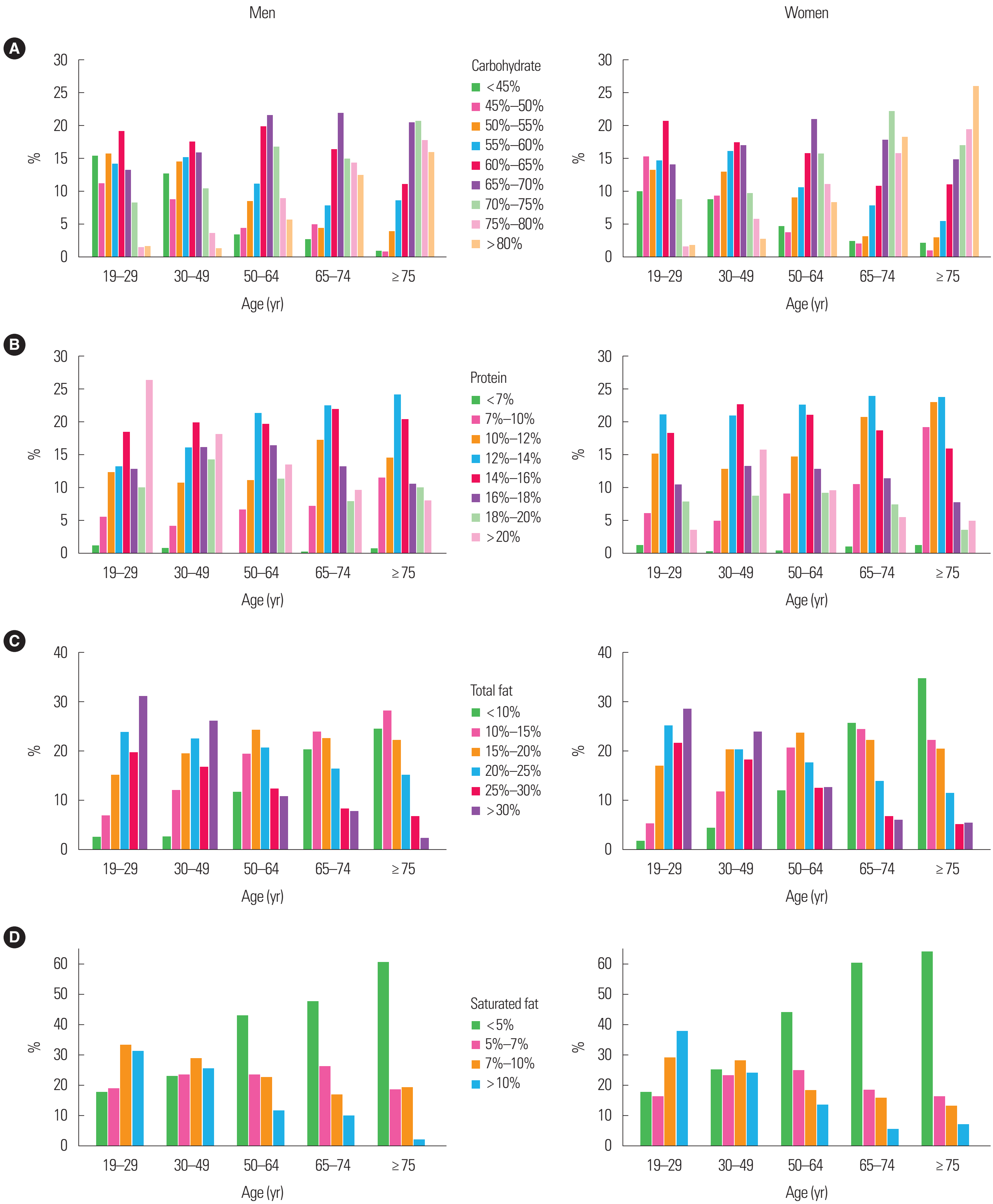

Figure 2. Distribution of Korean adults according to percentages of energy intake from (A) carbohydrate, (B) protein, (C) total fat, and (D) saturated fat by sex and age group (2,495 men and 3,277 women). Data were obtained from the 2019 Korea National Health and Nutrition Examination Survey.

of the carbohydrates, fats, and proteins are more important than their quantity. In long-standing controversies regarding low-carb and low-fat diets, several recent studies have suggested that the health benefits of low-carb or low-fat diets may depend on the food sources of proteins and fats and the quality of carbohydrates. Shan et al.[26] reported that overall low-carb and low-fat diets were not associated with total mortality in 37,233 adults from the U.S., but a healthy low-carb or low-fat diet was associated with lower total mortality, where high-quality carbohydrates were defined as carbohydrates from whole grains, whole fruit, legumes, and non-starchy vegetables, and healthy proteins and fats were defined as plant proteins and unsaturated fat. Seidelmann et al.[25] reported that increased consumption of animal-based proteins and fats as replacements for carbohydrates was significantly associated with an increased risk of mortality, while consuming plant-based proteins and fats instead was significantly associated with a decreased risk of morality.

For Korean populations, diets comprising approximately 50% of energy from carbohydrates can be regarded as low-carb diets. According to the most recent 2020 Dietary Reference Intakes for Koreans (KDRIs), the recommendation for macronutrient distribution in adults is 55%–65% dietary carbohydrate, 15%–30% dietary fat, and 7%–20% dietary protein, which is the same level as the previous KDRIs.[10] With regard to dietary carbohydrates, the estimated average requirement and recommended nutrient intake have been newly established as 100 g/day, 130 g/day, respectively, based on the evidence of 100 g glucose daily used in the brain in 2020 KDRIs.

Furthermore, high-protein diets are becoming more popular as individuals attempt to consume more protein than fat in place of carbohydrates. High-protein diets, in which protein intake is increased by 25% of energy, can be effective for weight loss and weight maintenance.[27,28] In a study of Korean adults, the effects of moderate-carbohydrate (MC) diets (50%–60% of energy from carbohydrates) and high-carbohydrate (HC) diets ($\geq$70% of energy from carbohydrates) were compared in individuals who consumed more plant protein (P) or animal protein (A). Compared to the MCP diet group, the odds ratios of metabolic syndrome in men were 1.51 (95% confidence interval [CI], 1.02–2.22) for the MCA diet group, and 1.73 (95% CI, 1.16–2.59) for the HCP diet group, and 2.42 (95% CI, 1.41–4.15) for the HCA diet group; a stronger association between diet and metabolic syndrome was found in younger adults (19–49 years).[29] However, the average protein intakes in the MCP and MCA diet groups were 14.2% and 18.1%, which are low compared to studies of high-protein diets in Western population. High-protein diets are difficult to implement in Korea, especially diets based on plant proteins. More investigations into healthy high-protein diets with moderate carbohydrate intakes in Korean populations should be conducted.

Despite the controversies discussed above, low-fat diets are still effective for weight management in Korea. However, the quality of carbohydrates in low-fat diets should be emphasized. Higher intakes of dietary fiber and whole grains are more strongly associated with several non-communicable disease outcomes compared to measures of glycemic index or glycemic load in a dose-response manner.[30] In addition, a study examining dietary fiber intake in Korean adults revealed that total fiber and fruit fiber intake were inversely associated with metabolic syndrome in men.[31] This was further supported by the finding that whole fruit consumption had positive effects on obesity and metabolic syndrome in men. Another study investigating the consumption of refined grains in Korean adults found that high consumption of refined grains or white rice was associated with an increased risk of metabolic syndrome in women.[15] Taken together, these studies suggest that improving dietary carbohydrate quality, such as by consuming whole grains and whole fruits, is more important in improving health outcomes than is altering the carbohydrate quantity. Moreover, they indicate that healthy low-carb diets can be achieved by focusing on consuming plant proteins, and healthy low-fat diets can be achieved by focusing on carbohydrate quality.

CONCLUSION

In summary, several meta-analyses revealed that low-carb diets are effective for short-term weight loss and improving lipid profiles, including triglycerides and HDL cholesterol levels, particularly among people with abnormal glucose metabolism. However, the positive effects of low-carb diets should be weighed against the potential deteriorative effects of raised LDL and total cholesterol levels.

Korean diets are typically classed as high-carb diets because the carbohydrate intake range of Korean adults is 50%–80% of energy. Within this range of carbohydrate intake, very high-carb diets (>70%

of energy) were associated with increased risks of metabolic syndrome or type 2 diabetes with decreased risks of dyslipidemia (e.g., elevated total and LDL cholesterol levels) compared to those who followed low-carb diets (<50% of energy). This is in line with findings from meta-analyses of RCTs.

The optimal range of carbohydrate intake was depicted by a U-shaped relationship between carbohydrate intake and mortality, with 50%–60% of energy from carbohydrates having the lowest mortality risk. The carbohydrate intake compromising approximately 50% of energy from carbohydrates can be regarded as low-carb diets in Korea. As the distribution of macronutrients varies greatly according to age and sex groups, one type of diet cannot be recommended to all. The sources and quality of proteins, fats, and carbohydrates may greatly influence the health benefits of low-carb or low-fat diets. Further studies are needed to explore the effects of long-term, sustainable diets comprising various food sources in Korea.

CONFLICTS OF INTEREST

YoonJu Song has been the Editor of the Journal of Obesity & Metabolic Syndrome; however, she was not involved in the peer reviewer selection, evaluation, or decision process of this article. Otherwise, no other potential conflicts of interest relevant to this article are reported.

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AUTHOR CONTRIBUTIONS

Study concept and design: YS; analysis and interpretation of data: all authors; drafting of the manuscript: all authors; critical revision of the manuscript: all authors; statistical analysis: KH; obtained funding: YS; administrative, technical, or material support: YS; and study supervision: YS.

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