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Review

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Effects of Glycemic Index and Intake of Dietary Fiber on Serum HDL-Cholesterol Levels

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Abstract

We previously studied effects of glycemic index (GI) and intake of dietary fiber on serum high-density lipoprotein (HDL)-C levels to make "Dietary Reference Intakes for Japanese 2015", by using data obtained by clinical trials which evaluated effects of GI and intake of dietary fiber on HDL-C in Asian populations. We found that low GI and an increased intake of dietary fiber may be beneficially associated with HDL metabolism. Here we review meta-analyses on the effects of GI and intake of dietary fiber on serum HDL-C levels, to make "Dietary Reference Intake for Japanese 2020". A search was conducted by using PubMed, Embase and Google Scholar, and the search period was comprised up to May 2018. In spite of significant associations of low GI and dietary fiber intake with reduction of low-density lipoprotein (LDL)-C, we could not observe any significant influences of low GI and dietary fiber intake on HDL metabolism.

Keywords: Body weight; Dietary fiber; Glycemic index; High-density lipoprotein

Introduction

High-density lipoprotein (HDL) plays a role in reverse cholesterol transport from the peripheral tissues to liver, suppressing cholesterol accumulation in the peripheral tissue. Therefore, serum low HDL-cholesterol (HDL-C) level was strongly associated with development of atherosclerotic diseases [1, 2].

We previously studied effects of glycemic index (GI) and intake of dietary fiber on serum HDL-C levels to make "Dietary Reference Intakes for Japanese 2015", by using data obtained by clinical trials which evaluated effects of GI and intake of dietary fiber on HDL-C in Asian populations [3]. We found that low GI and an increased intake of dietary fiber may be beneficially associated with HDL metabolism [3]. Here we review meta-analyses on the effects of GI and intake of dietary fiber on serum HDL-C levels, to make "Dietary Reference Intake for Japanese 2020".

Methods

To make "Dietary Reference Intake for Japanese 2020", we searched meta-analyses of randomized controlled trials (RCTs). A search was conducted by using PubMed, Embase and Google Scholar, with the following keywords: glycemic index and HDL and meta-analysis or dietary fiber and HDL and meta-analysis. The search period was comprised up to May 2018.

Results

Effects of GI on HDL-C

Meta-analyses evaluated effects of GI on HDL-C were shown in Table 1. We found five meta-analyses which studied effects of GI on HDL-C [4-8]. All meta-analyses denied a significant effect of GI on HDL-C. However, three meta-analyses showed that compared with high GI, low GI reduced total cholesterol (TC) and low-density lipoprotein (LDL)-C [5-7]. Only one meta-analysis showed that low GI significantly reduced triglyceride (TG) [4]; however, other four studies challenged a significant effect of low GI on TG.

Effects of dietary fiber intake on HDL-C

Meta-analyses evaluated effects of dietary fiber intake on HDL-C were shown in Table 2. Eleven meta-analyses were eligible. In three meta-analyses, data on effects of dietary fiber intake on HDL-C were not available [9-11]. Seven meta-analyses reported that intake of dietary fiber is not significantly associated with changes in HDL-C. Two meta-analyses described that HDL-C was significantly reduced, but only by a small amount [12, 18].

Regarding other serum lipids, all meta-analyses demonstrated a significant reduction of LDL-C due to dietary fiber intake [9-19]. Three meta-analyses showed a significant reduc-

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Table 1. Meta-Analyses Evaluated Effects of Glycemic Index on HDL-C

Authors	Assessed studies	Subjects studied	Effects on HDL-C	Effects on other lipids
Schwingshackl L, et al [4]	Meta-analyses were performed for each parameter to assess pooled effect in terms of WMD between the post-intervention of the low GI diets and the respective high GI counterparts	9 studies enrolling 1065 children or adolescents	HDL-C under investigation was not affected by either low or high GI	Compared to diets providing a high GI, low GI protocols resulted in significantly more pronounced decreases in serum TG (-15.14 mg/dL, 95% CI: -26.26 to -4.00)
Fleming P, et al [5]	RCTs on the effect of low-GI diets on serum lipid levels	4 studies	There was no significant effect on HDL-C levels	Low-GI diets were shown to have a significant effect on decreasing TC and LDL-C over a short time span (5 - 12 weeks). There was no significant effect on TG levels
Goff LM, et al [6]	RCTs comparing low- with high GI diets over at least 4 weeks	28 RCTs (1,272 participants; studies ranged from 6 to 155 participants)	There was no effect on HDL-C (MD: -0.03 mmol/L, 95% CI: -0.06 - 0.00)	Low GI diets significantly reduced TC (-0.13 mmol/L, 95% CI: -0.22 to -0.04, P = 0.004) and LDL-C (-0.16 mmol/L, 95% CI: -0.24 to -0.08, P < 0.0001) compared with high GI diets independently of weight loss. There was no effect on TG (MD 0.01 mmol/L, 95% CI: -0.06 to 0.08)
Kelly S, et al [7]	RCTs that assess the relationship between the consumption of low GI diets over a minimum of 4 weeks and the effects on coronary heart disease and on risk factors for coronary heart disease	15 RCTs	There is no evidence that low GI diets have an effect on HDL-C	Meta-analysis detected limited and weak evidence of a relationship between low GI diets and slightly lower TC, compared with higher GI diets. There is no evidence that low GI diets have an effect on LDL-C and TG
Opperman AM, et al [8]	RCTs with a crossover or parallel design, investigating the effect of low GI versus high GI diets on markers for carbohydrate and lipid metabolism	16 studies (10 crossover design and 6 parallel design, n = 396)	No change was observed in HDL-C	Low GI diets significantly reduced TC by -0.33 (95 % CI: -0.47 to -0.18) mmol/L (P < 0.0001) and tended to reduce LDL-C in type 2 diabetic subjects by -0.15 (95% CI: -0.31 to -0.00) mmol/L (P = 0.06) compared with high GI diets. No change was observed in TG

CI, confidence interval; GI, glycemic index; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density-cholesterol; MD, mean difference; RCT, randomized controlled trial; TC, total cholesterol; TG, triglyceride; WMD, weighted mean difference.

tion of non-HDL-C by intake of dietary fiber [9-11]. Only two meta-analyses reported that dietary fiber intake reduced serum TG [13, 17]; however, six studies challenged a significant influence of dietary fiber intake on serum TG levels [12, 14-16, 19].

Discussion

To make "Dietary Reference Intakes for Japanese 2015", we mainly adopted clinical studies performed in Japanese or Asian populations. Regarding effects of GI on HDL-C, we adopted and used three cross-sectional studies performed in Korea and Japan. Odds ratios for having low HDL-C in the highest quintile was 1.54 (CI: 1.17 - 2.03) for glycemic load (GL) which is calculated indirectly as GI times the weight of available carbohydrate, in Korean men as compared with the second quintile as a reference [20]. In the cross-sectional study on the association between dietary GI and GL and metabolic risk factors in healthy Japanese women (n = 1,354), dietary GL was independently negatively correlated with HDL-C [21]. In the study investigating the correlation between dietary GI, GL and cardiovascular risk factors in 32 Japanese women aged 52.5 ± 7.2 years old, the highest concentration of HDL-C was observed in the lowest GI tertile ($P < 0.01$), and the highest concentration of HDL-C was observed in the lowest GL tertile ($P < 0.05$) [22].

However, to make "Dietary Reference Intakes for Japanese 2020", we mainly adopted meta-analyses which have high evidence level. In spite of the existence of a significant association between low GI and reduction of LDL-C, the present study failed to show a significant effect of GI on HDL-C.

Several clinical trials to study effects of dietary fiber on HDL-C were performed in Asian populations. Zhang et al investigated the impact of oat consumption on cholesterol levels in Chinese adults with mild-to-moderate hypercholesterolemia [23]. Dietary fiber intake increased significantly in the oat group compared to the control group. HDL-C decreased significantly in the control group versus the oat group. Singh

Table 2. Meta-Analyses Evaluated Effects of Dietary Fiber Intake on HDL-C

Authors	Assessed studies	Subjects studied	Effects on HDL-C	Effects on other lipids
Ho HVT, et al [9]	RCTs with a follow-up of ≥ 3 weeks that assessed the effect of konjac glucomannan (KJM) on LDL-C, non-HDL-C or apolipoprotein B	12 studies (n = 370), 8 in adults and 4 in children	NA	KJM significantly lowered LDL-C (MD: -0.35 mmol/L; 95% CI: -0.46 to -0.25 mmol/L) and non-HDL-C (MD: -0.32 mmol/L; 95% CI: -0.46 to -0.19 mmol/L).Data from six trials suggested no impact of KJM on apolipoprotein B
Ho HV, et al [10]	RCTs of ≥ 3-week duration assessing the effect of diets enriched with barley β-glucan compared with controlled diets on LDL-C, non-HDL-C or apoB	14 trials (n = 615)	NA	A median dose of 6.5 and 6.9 g/day of barley β-glucan for a median duration of 4 weeks significantly reduced LDL-C (MD: -0.25 mmol/L (95% CI: -0.30 to -0.20)) and non-HDL-C (MD: -0.31 mmol/L (95% CI: -0.39 to -0.23)), respectively, with no significant changes to apoB levels, compared with control diets
Ho HV, et al [11]	RCTs investigating the cholesterol-lowering potential of oat β-glucan on LDL-C, non-HDL-C and apoB	58 trials (n = 3,974)	NA	A median dose of 3.5 g/day of oat β-glucan significantly lowered LDL-C (-0.19; 95% CI: -0.23 to -0.14 mmol/L, P < 0.00001), non-HDL-C (-0.20; 95% CI: -0.26 to -0.15 mmol/L, P < 0.00001) and apoB (-0.03; 95% CI: -0.05 to -0.02 g/L, P < 0.0001) compared with control interventions
Hartley L, et al [12]	RCTs that assessed the effects of dietary fiber compared with no intervention or a minimal intervention on CVD and related risk factors	23 RCTs (1,513 participants)	There was a very small but statistically significant decrease rather than increase in HDL-C with increased fiber intake (MD: -0.03 mmol/L, 95% CI: -0.06 to -0.01)	There is a significant beneficial effect of increased fiber on TC (MD: -0.23 mmol/L, 95% CI -0.40 to -0.06), and LDL-C (MD: -0.14 mmol/L, 95% CI: -0.22 to -0.06) but not on TG (MD: 0.00 mmol/L, 95% CI: -0.04 - 0.05)
Hollænder PL, et al [13]	RCTs compared whole-grain foods with a non-whole-grain control in adults	6,069 articles	No effect of whole-grain foods on HDL-C was seen	Whole-grain intake lowered LDL-C (WMD: -0.09 mmol/L; 95% CI: -0.15 to -0.03 mmol/L; P < 0.01) and TC (WMD: -0.12 mmol/L; 95% CI: -0.19 to -0.05 mmol/L; P < 0.001) compared with the control. Whole-grain foods tended to lower TG compared with the control (WMD: -0.04 mmol/L; 95% CI: -0.08 - 0.01 mmol/L; P = 0.10)
Zhu X, et al [14]	RCTs that investigated the effects of beta-glucan consumption in hypercholesterolemic subjects	17 eligible RCTs with 916 subjects	There were no significant differences in HDL-C	Beta-glucan consumption in hypercholesterolemic population significantly lowered TC (MD: -0.26 mmol/L; 95% CI: -0.33 to -0.18; P < 0.00001) and LDL-C (MD: -0.21 mmol/L; 95% CI, -0.27 to -0.14; P < 0.00001). There were no significant differences in TG
Onakpoya IJ, et al [15]	RCTs examining the effectiveness of polyglycoplex (PGX), a novel functional fiber, on body weight and metabolic parameters	4 RCTs with a total of 217 participants	There was no significant difference between PGX and placebo for HDL-C	Significant reductions were noted for TC and LDL-C. There was no significant difference between PGX and placebo for TG
Whitehead A, et al [16]	RCTs comparing ≥ 3 g oat β-glucan (OBG)/d with an appropriate control.	28 RCTs	There was no significant effect of OBG on HDL-C	OBG in doses of ≥ 3 g/day reduced LDL-C and TC relative to control by 0.25 mmol/L (95% CI: 0.20 - 0.30; P < 0.0001) and 0.30 mmol/L (95% CI: 0.24 - 0.35; P < 0.0001), respectively. There was no significant effect of OBG on TG

Table 2. Meta-Analyses Evaluated Effects of Dietary Fiber Intake on HDL-C - *(continued)*

Authors	Assessed studies	Subjects studied	Effects on HDL-C	Effects on other lipids
Talati R, et al [17]	RCTs of barley that reported efficacy data on at least 1 lipid endpoint	8 trials (n = 391 patients) of 4 - 12 weeks' duration evaluating the lipid-reducing effects of barley	The use of barley did not significantly alter HDL-C	The use of barley significantly lowered TC (WMD: -13.38 mg/dL; 95% CI: -18.46 to -8.31 mg/dL), LDL-C (WMD: -10.02 mg/dL; 95% CI: -14.03 to -6.00 mg/dL) and TG (WMD, -11.83 mg/dL; 95% CI: -20.12 to -3.55 mg/dL)
Wei ZH, et al [18]	This meta-analysis was primarily conducted to address the dose-response relationship between psyllium and serum cholesterol level and time-dependent effect of psyllium in mild-to-moderate hypercholesterolemic subjects	21 RCTS, which enrolled a total of 1,030 and 687 subjects receiving psyllium or placebo, respectively, were included in the meta-analysis. The dose of psyllium was between 3.0 and 20.4 g/day and intervention period was more than 2 weeks	HDL-C was significantly reduced, but only by a small amount (0.0353 mmol/L, 95% CI: 0.0003 - 0.0514).	Compared with placebo, psyllium lowered serum TC by 0.375 mmol/L (95% CI: 0.257 - 0.494 mmol/L), and LDL-C by 0.278 mmol/L (95% CI: 0.213 - 0.312 mmol/L). A significant dose-response relationship was found between doses (3 - 20.4 g/day) and TC or LDL-C changes. There was a time effect of psyllium on TC and LDL-C. There was no significant effect on TG
Brown L, et al [19]	RCTs which were performed to quantify the cholesterol-lowering effect of major dietary fibers.	67 RCTs	HDL-C was not significantly influenced by soluble fiber	Soluble fiber (2 - 10 g/day) was associated with small but significant decreases in TC (-0.045 mmol/L/soluble fiber (g); 95% CI: -0.054 to -0.035) and LDL-C (-0.057 mmol/L/soluble fiber (g); 95% CI: -0.070 to -0.044). TG was not significantly influenced by soluble fiber

BMI, body mass index; CI, confidence interval; CVD, cardiovascular disease; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density-cholesterol; MD, mean difference; NA, not available; RCT, randomized controlled trial; TC, total cholesterol; TG, triglyceride; WMD, weighted mean difference.

et al performed a RCT to examine the effects of a soluble fiber and a potassium-rich diet containing daily 0.5 - 1.0 kg of guava intake in patients with essential hypertension [24]. In their study, increased intake of soluble dietary fiber was associated with an insignificant increase in HDL-C (4.6%) [24]. In the study performed in China, a total of 110 elderly people with hyperlipidemia were randomly assigned to the experimental group who consumed an ordinary diet plus foods containing refined konjac meal, and the control group who consumed only the ordinary diet for 45 days [25]. At the end of the trial, HDL-C significantly elevated ($P < 0.01$) in the experimental group.

The present study showed a significant association between dietary fiber intake and reduction of LDL-C; however, it did not demonstrate a significant influence on HDL-C.

Conclusions

In spite of significant associations of low GI and dietary fiber intake with reduction of LDL-C, we could not observe any significant influences of low GI and dietary fiber intake on HDL metabolism.

Conflict of Interest

The authors declare that they have no competing interests.

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