Editorial
Others

Diabetes Metab J 2013;37:173-175
http://dx.doi.org/10.4093/dmj.2013.37.3.173
pISSN 2233-6079 · eISSN 2233-6087

dmj
DIABETES & METABOLISM JOURNAL

The Effects of Green Tea on Obesity and Type 2 Diabetes

Hyun Min Kim, Jaetaek Kim

Division of Endocrinology and Metabolism, Department of Internal Medicine, Chung-Ang University College of Medicine, Seoul, Korea

Obesity and type 2 diabetes are major public health issues worldwide, contributing to increased cardiovascular morbidity and mortality. The proportions of people with obesity and/or type 2 diabetes have increased and recently reaching epidemic levels in Asia [1]. Although pharmacologic modality is the mainstay treatment of diabetes, remedies using plants (e.g., garlic, psyllium, and green tea) have stimulated a new interest in research [2]. Green tea (*Camellia sinensis*) is one of the world's most popular beverages, especially in Asian countries including Korea, China, and Japan. Because of the high rate of green tea consumption in these populations, even small effects on an individual basis could have a large public health impact [3]. A population-based, prospective cohort study has shown that green tea consumption is associated with reduced mortality due to all causes and cardiovascular disease as well [4], and randomized controlled trials have indicated that green tea is effective in decreasing blood pressure, low density lipoprotein cholesterol, oxidative stress, and a marker of chronic inflammation [5].

Various studies have shown the beneficial effects of green tea, not only on cardiovascular diseases but also on obesity and type 2 diabetes itself [6,7]. In a retrospective cohort study performed in Japan, a 33% risk reduction of developing type 2 diabetes was found in subjects consuming six or more cups of green tea daily compared to those consuming less than 1 cup per week [6]. Wu et al. [7] reported that Taiwanese subjects who had habitually consumed tea for more than 10 years showed lower body fat composition and smaller waist circumference. Evidences from epidemiological studies suggest the possibility of green tea being a novel strategy for treatment or prevention of obesity and diabetes.

However, a limited number of clinical trials using green tea, green tea extracts (GTEs), or its main ingredient catechin have shown disappointing results in controlling hyperglycemia in type 2 diabetic patients or protecting the condition in healthy subjects. MacKenzie et al. [8] showed no significant difference in glucose control after 3 months of ingestion of decaffeinated GTE in type 2 diabetic patients in a double-blinded, placebo-controlled, randomized trial. Similarly, Nagao et al. [9] showed that plasma glucose levels and A1c did not improve after 12 weeks of supplementation with catechin in patients with type 2 diabetes [9]. However, they showed that the addition of catechin decreased A1c level and increased serum insulin level compared to the placebo group in a subgroup of patients who have been treated with insulin therapy. Also, Hsu et al. [10] showed no difference in glycemic control or lipid parameters after 16 weeks of green tea supplementation. Ryu et al. [11] showed that 4 weeks of green tea consumption did not affect inflammation, adiponectin levels, or insulin resistance in type 2 diabetic patients, and they suggested that those mechanisms were unlikely to explain the benefits in cardiovascular risk or mortality by tea consumption observed in epidemiological studies.

Despite these equivocal results, several mechanisms have

Corresponding author: Jaetaek Kim
Division of Endocrinology and Metabolism, Department of Internal Medicine, Chung-Ang University College of Medicine, 84 Heukseok-ro, Dongjak-gu, Seoul 156-861, Korea
E-mail: jtkim@cau.ac.kr

been proposed to explain the positive effect of green tea on glucose metabolism or obesity. Epigallocatechin gallate (EGCG), the most abundant form of catechin in green tea, has been known to be the main attributable factor of beneficial effects of green tea [12]. EGCG inhibits adipocyte proliferation and differentiation in 3T3-L1 cells [13], increases fat oxidation [14], and increases expression of GLUT-4 in adipose tissue of an animal model [15]. In human studies, clear increases in energy expenditure were documented [16]. Also, some suggested the protective function of EGCG for cytokine-induced β-cell destruction mediated by inhibition of nuclear factor-κB activation [17]. Recently, Tian et al. [18] showed that green tea polyphenols had antiobesity effect by up-regulating adiponectin levels in rats. They suggested that the involved mechanisms were the inhibition of Erk activation, alleviation of peroxisome proliferator-activated receptor γ (PPARγ) phosphorylation, and increases in the PPARγ expression [18]. Park et al. [19] revealed the ambivalent role of gallated catechin (GC) in green tea, including EGCG, in glucose tolerance. GC acutely reduces blood glucose levels mainly through its activities in the alimentary tract while increasing the glucose level when in the circulation by blocking normal glucose uptake into the tissues. They suggested the development of nonabsorbable derivatives of GC with only positive luminal effect as a prevention strategy of type 2 diabetes and obesity. As mentioned above, many researches are being performed to define the precise molecular mechanisms of green tea and ultimately, its clinical application in obesity and type 2 diabetes.

In this study, Bae and his colleagues [20] demonstrated the possibility of GTE as an antiobestic and/or antidiabetic agent when coadministered with another dietary supplement poly-γ-glutamic acid (γ-PGA) in *db/db* mice, potentially through the action of intestinal GTE. γ-PGA is a main constituent of the viscous material in Korean chungkookjang and Japanese natto. The study presents the results of nuclear magnetic resonance spectroscopy that γ-PGA can interact with EGCG, and this possible complex formation may delay the absorption of GCs to systemic circulation from the intestine, resulting in decreased blood glucose level. The protective effects of GTE+γ-PGA regimen on body weight gain and development of glucose intolerance were much better than treatment with either GTE or γ-PGA alone. Therefore, they suggest that GTE+γ-PGA treatment may be a promising preventative and therapeutic tool for obesity and type 2 diabetes. Future studies, especially in human, are warranted to confirm these benefits in patients with diabetes or healthy subjects, as well as to define the precise molecular mechanisms of action of green tea supplementation.

CONFLICTS OF INTEREST

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

REFERENCES

1. Yoon KH, Lee JH, Kim JW, Cho JH, Choi YH, Ko SH, Zimmet P, Son HY. Epidemic obesity and type 2 diabetes in Asia. Lancet 2006;368:1681-8.
2. Bailey CJ, Day C. Traditional plant medicines as treatments for diabetes. Diabetes Care 1989;12:553-64.
3. Tomata Y, Kakizaki M, Nakaya N, Tsuboya T, Sone T, Kuriyama S, Hozawa A, Tsuji I. Green tea consumption and the risk of incident functional disability in elderly Japanese: the Ohsaki Cohort 2006 Study. Am J Clin Nutr 2012;95:732-9.
4. Kuriyama S, Shimazu T, Ohmori K, Kikuchi N, Nakaya N, Nishino Y, Tsubono Y, Tsuji I. Green tea consumption and mortality due to cardiovascular disease, cancer, and all causes in Japan: the Ohsaki study. JAMA 2006;296:1255-65.
5. Nantz MP, Rowe CA, Bukowski JF, Percival SS. Standardized capsule of Camellia sinensis lowers cardiovascular risk factors in a randomized, double-blind, placebo-controlled study. Nutrition 2009;25:147-54.
6. Iso H, Date C, Wakai K, Fukui M, Tamakoshi A; JACC Study Group. The relationship between green tea and total caffeine intake and risk for self-reported type 2 diabetes among Japanese adults. Ann Intern Med 2006;144:554-62.
7. Wu CH, Lu FH, Chang CS, Chang TC, Wang RH, Chang CJ. Relationship among habitual tea consumption, percent body fat, and body fat distribution. Obes Res 2003;11:1088-95.
8. Mackenzie T, Leary L, Brooks WB. The effect of an extract of green and black tea on glucose control in adults with type 2 diabetes mellitus: double-blind randomized study. Metabolism 2007;56:1340-4.
9. Nagao T, Meguro S, Hase T, Otsuka K, Komikado M, Tokimitsu I, Yamamoto T, Yamamoto K. A catechin-rich beverage improves obesity and blood glucose control in patients with type 2 diabetes. Obesity (Silver Spring) 2009;17:310-7.
10. Hsu CH, Liao YL, Lin SC, Tsai TH, Huang CJ, Chou P. Does supplementation with green tea extract improve insulin resis-

tance in obese type 2 diabetics? A randomized, double-blind, and placebo-controlled clinical trial. Altern Med Rev 2011;16:157-63.
11. Ryu OH, Lee J, Lee KW, Kim HY, Seo JA, Kim SG, Kim NH, Baik SH, Choi DS, Choi KM. Effects of green tea consumption on inflammation, insulin resistance and pulse wave velocity in type 2 diabetes patients. Diabetes Res Clin Pract 2006;71:356-8.
12. Higdon JV, Frei B. Tea catechins and polyphenols: health effects, metabolism, and antioxidant functions. Crit Rev Food Sci Nutr 2003;43:89-143.
13. Furuyashiki T, Nagayasu H, Aoki Y, Bessho H, Hashimoto T, Kanazawa K, Ashida H. Tea catechin suppresses adipocyte differentiation accompanied by down-regulation of PPARgamma2 and C/EBPalpha in 3T3-L1 cells. Biosci Biotechnol Biochem 2004;68:2353-9.
14. Klaus S, Pultz S, Thone-Reineke C, Wolfram S. Epigallocatechin gallate attenuates diet-induced obesity in mice by decreasing energy absorption and increasing fat oxidation. Int J Obes (Lond) 2005;29:615-23.
15. Wu LY, Juan CC, Hwang LS, Hsu YP, Ho PH, Ho LT. Green tea supplementation ameliorates insulin resistance and increases glucose transporter IV content in a fructose-fed rat model. Eur J Nutr 2004;43:116-24.
16. Rumpler W, Seale J, Clevidence B, Judd J, Wiley E, Yamamoto S, Komatsu T, Sawaki T, Ishikura Y, Hosoda K. Oolong tea increases metabolic rate and fat oxidation in men. J Nutr 2001;131:2848-52.
17. Han MK. Epigallocatechin gallate, a constituent of green tea, suppresses cytokine-induced pancreatic beta-cell damage. Exp Mol Med 2003;35:136-9.
18. Tian C, Ye X, Zhang R, Long J, Ren W, Ding S, Liao D, Jin X, Wu H, Xu S, Ying C. Green tea polyphenols reduced fat deposits in high fat-fed rats via erk1/2-PPARgamma-adiponectin pathway. PLoS One 2013;8:e53796.
19. Park JH, Jin JY, Baek WK, Park SH, Sung HY, Kim YK, Lee J, Song DK. Ambivalent role of gallated catechins in glucose tolerance in humans: a novel insight into non-absorbable gallated catechin-derived inhibitors of glucose absorption. J Physiol Pharmacol 2009;60:101-9.
20. Bae KC, Park JH, Na AY, Kim SJ, Ahn S, Kim SP, Oh BC, Cho HC, Kim YW, Song DK. Effect of green tea extract/poly-gamma-glutamic acid complex in obese type 2 diabetic mice. Diabetes Metab J 2013;37:196-206.