

## Dietary Sodium Intake in Patients with Type 2 Diabetes Mellitus

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Excessive dietary sodium intake is a well-known risk factor of hypertension. A meta-analysis has shown that a reduction in dietary sodium intake can decrease high blood pressure [1], which is common in patients with diabetes. According to the Korean Diabetes Fact Sheet 2015, 62.5% of diabetics have hypertension [2]. Therefore, to effectively control diabetes and hypertension and to prevent other related complications, changes to patients' lifestyle, such as reducing dietary sodium intake, are needed. The Dietary Approaches to Stop Hypertension diet, which fixed the threshold for daily sodium intake to <2,400 mg, has been reported to benefit patients with type 2 diabetes mellitus (T2DM) [3]. For example, a meta-analysis showed that dietary salt restriction attenuates diabetic kidney disease [4]. The World Health Organization (WHO) [5] and Korean Diabetes Association [6] recommend a sodium intake of <2,000 mg/day. However, the benefits of low dietary sodium intake in patients with T2DM are still unclear, while some studies reported that reduced sodium intake resulted in albuminuria [7], cardiovascular diseases, and mortality [8].

Kang et al. [9] have contributed considerably to our understanding of the relationship between dietary sodium intake and diabetes. They analyzed data from the Korean National Health and Nutrition Examination Survey (2008 to 2010) and reported a correlation between dietary sodium intake and diabetes for 13,947 participants. They showed that the dietary sodium intake of all participants was higher than that recommended by the WHO, even if diabetics consumed less sodium compared to non-diabetics (4,910.2 mg/day vs. 5,188.2 mg/

day). In newly diagnosed diabetics, however, the dietary sodium intake was significantly higher than that of existing female diabetics and healthy individuals. In addition, higher dietary sodium intake was associated with an increased risk of hypercholesterolemia in diabetics, especially in males. The limitation of this study is that the data on dietary sodium intake were obtained by the 24-hour dietary recall method; however, given the number of participants, these findings are still significant.

Physician-prescribed lifestyle changes are needed to effectively control diabetes and hypertension. In agreement with the data from a study performed in the United States [10], these results reveal that patient education immediately after diagnosis might affect long-term dietary sodium intake habits. Although this study does not prove the existence of a causal relationship between sodium intake and diabetes, several studies indicate that high salt intake relates to obesity, a major risk factor of diabetes. A possible mechanism of high salt intake relates to obesity is that dietary salt is palatable, leading to greater food and sugar-sweetened beverage consumption, and thus increased calorie intake [11]. In addition, several reports demonstrate an association between sodium intake and obesity. Yoon and Oh [12] reported that high sodium intake increases the risk of obesity independently of calorie intake. Likewise, Ma et al. [13] reported that dietary salt intake is high in overweight and obese individuals, associated with a higher body fat mass after adjusting for age, sex, ethnicity, and calorie intake. These findings suggest that high dietary sodium in-

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take, independent of the calorie count, is a risk factor for obesity. Several studies also demonstrated an association between high dietary sodium intake and T2DM, as reported in an adult Finnish population [14]. Furthermore, Zhao et al. [15] illustrated that sodium intake regulates glucose homeostasis through peroxisome proliferator-activated receptor (PPAR)  $\delta$ /adiponectin/sodium-glucose transporter (SGLT) 2 pathway. High sodium intake increases adiponectin level through the activation of adipose PPAR $\delta$ , and the enhanced adiponectin downregulates renal SGLT2, resulting in natriuresis and glycosuria. However, this mechanism is impaired in diabetes [15]. These results indicate that a high salt intake leads to obesity and metabolic syndromes such as diabetes.

Regardless of the adverse effects of a high sodium diet, there are also concerns about the low range of sodium intake, because a low sodium intake can lead to adverse outcomes. The American Heart Association has set the recommended intake of sodium to 1,500 mg/day for diabetics [16]. However, several studies reported that low dietary sodium intake increases albuminuria and all-cause and cardiovascular mortality [7,8]. These results suggest that physicians should generally be cautious when recommending a daily sodium intake of 1,500 mg/day. Recently, Suckling et al. [17] reported a modest reduction in dietary sodium intake in patients with T2DM in accordance with WHO guidelines, resulting in a reduction of blood pressure and albuminuria without changing the fasting glucose and glycosylated hemoglobin levels. Although additional studies are needed to clarify this debate, these findings support the practice of physicians reducing dietary sodium intake to a recommended level in diabetics.

In summary, the sodium level is high in Korean diet, and dietary sodium intake is higher in newly diagnosed diabetics. The WHO has proposed a global action plan for the prevention and control of non-communicable diseases, and a reduction in dietary sodium intake by 30% is one of its goals [18]. Therefore, additional studies are needed to clarify the relationship between dietary sodium intake and diabetes. Patient education on the adverse effects of a high dietary sodium intake is also needed to prevent hypertension and diabetes.

## CONFLICTS OF INTEREST

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

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