COMMENTARY

A Global Perspective on White Rice Consumption and Risk of Type 2 Diabetes

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Preventive policies to improve diet and physical activity are urgently needed to stem the rising global burden of type 2 diabetes (1). In randomized trials, both high-carbohydrate diets (low in saturated fat and high in fiber), combined with physical activity and caloric restriction, and moderate-fat Mediterranean diets reduced diabetes risk (2). These findings suggest that diets with variable carbohydrate intakes are compatible with diabetes-prevention lifestyles but do not identify the optimal amount and type of dietary carbohydrates. Furthermore, the impact of high carbohydrate intakes in other parts of the world beyond the range studied in Western populations remains unclear.

Rice provides ~20% of the world's calorie intake (3). Of the 10 countries with the largest number of diabetes cases, 6 countries in Asia and South America have rice as the main staple food (4). Rice is predominantly consumed as white rice, a refined grain resulting from a milling process that removes the bran and germ and leaves the starchy endosperm. As a result, white rice is low in fiber, polyphenols, and micronutrients such as magnesium that may benefit glucose metabolism (5–7). White rice also has a high glycemic index (GI) and glycemic load (GL), reflecting high postprandial blood glucose levels (5). In several (8–10) but not all (9–11) prospective cohort studies in Asian countries, higher white rice consumption was associated with a higher risk of type 2 diabetes. Therefore, it is crucial to determine whether white rice consumption contributes to the development of type 2 diabetes, particularly in populations with high intake levels.

Bhavadharini et al. (12) evaluated the association between white rice consumption and diabetes risk in ~130,000 participants aged 35 to 70 years in the Prospective Urban Rural Epidemiology (PURE) cohort study. This study's unique feature is that it represents 21 countries in Asia, North and South America, Europe, and Africa. White rice consumption was classified according to the number of standard bowls (150 g) of rice consumed, ranging from less than one bowl per day to three or more bowls per day. Participants with high rice consumption had a very high intake of carbohydrate (71% of total energy) and low intakes of fat (15%), protein (12%), and fiber (11 g/day). During a mean of 9.5 years, ~6,000 incident cases of diabetes occurred. High white rice consumption was associated with a 20% higher diabetes risk (95% CI 3% to 41%) compared with low rice consumption. However, risk estimates differed by region, with a 65% higher risk for high versus low rice consumption in South Asia and no substantial association in China.

The PURE study is a large prospective cohort study using standardized methodology that facilitates comparing results for different world regions. However, the inclusion of many different countries also represents challenges for analyzing and interpreting the data. First, the differences in rice intakes for the various regions were so large that there was limited overlap in intake distributions. As a result, participants in low and high rice intake categories differed greatly in their risk factor profiles because they were mostly from different world regions. Also, the used categorization of rice consumption did not allow the evaluation of contrasts in rice intake that were most relevant for the distribution in different regions. Surprisingly, the highest rice intake category (median 900 g/day) was not associated with a higher diabetes risk than the second-highest category (395 g/day), which is not consistent with a dose-response relationship. A downside of the large number of countries included in the PURE study is that most countries' participant numbers were too small for independent analyses. Confounding factors may differ substantially by country, and country-specific analyses would have allowed for a more rigorous exploration and adjustment for confounders. In general, a more detailed evaluation of potential confounders such as intakes of alcohol,

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coffee, dairy, and red meat would have been desirable (6).

In line with the PURE study results for South Asia, higher refined grain consumption was strongly associated with higher diabetes risk in a South Indian cohort study (13). The lack of association between rice consumption and diabetes risk in China agrees with previous findings for Singapore Chinese and Japanese men (9,11) but not for women in Shanghai and Japan (8,9). Findings from populations with lower rice consumption levels have also been mixed (7,10). Thus, the available evidence raises the question of what may explain the variation in associations between white rice consumption and diabetes risk across different populations.

In lower-income rice-consuming populations in Asia, individuals commonly derive most of their dietary energy from white rice (14). In this context, high rice consumption will be associated with low consumption of many other food groups, resulting in an unbalanced diet lacking in fiber, micronutrients, polyunsaturated fatty acids, and healthy sources of protein (14). Such a dietary pattern is likely to be associated with a higher risk of type 2 diabetes (6), but this will not be solely due to white rice intake. Economic development in China has been associated with increasing dietary diversity, moving from the dominance of staple foods to increasing consumption of cooking oils, animal products, and vegetables (15). In recent decades, these dietary changes may have changed the dietary pattern associated with high rice consumption and its association with diabetes risk.

White rice typically has a high GI and GL, resulting in high postprandial blood glucose and insulin levels that have been postulated to reduce insulin sensitivity and β-cell function (16). In several prospective cohort studies, dietary GI and GL were directly associated with type 2 diabetes risk (17). Based on this mechanism, the impact of white rice is expected to be greater in populations with a high overall dietary GL and in ethnic groups that are more susceptible to insulin resistance, such as South Asians (18). Arsenic or other contaminants may also contribute to an adverse effect of rice consumption on diabetes risk. Rice can be a significant arsenic source (19), and arsenic intake has been associated with a higher risk of type 2 diabetes in several prospective studies (20). The arsenic content of rice varies by region depending on soil and water contamination (19), which could contribute to variation in rice's health effects.

An important issue is what foods are optimal alternatives for white rice to reduce diabetes incidence. Brown rice is higher in fiber and micronutrients than white rice (5), but it can be high-GI depending on the rice variety (high or low amylose) and preparation (21). One potential concern is that arsenic levels are higher in brown rice than white rice if grown in arsenic-rich areas (19). In U.S. cohorts, replacement of white rice with brown rice was associated with lower diabetes risk, although the risk reduction was greater for replacement with mixed whole grains (7). In a subgroup with the metabolic syndrome, parboiled brown rice consumption reduced HbA_{1c} levels compared with white rice in a crossover trial in India (22). Low-GI varieties of rice also warrant consideration, but results from trials in people without diabetes suggest that reducing carbohydrate intake through replacement with unsaturated fat is more likely to improve glucose metabolism than GI reduction (23,24).

The PURE study highlights that more research on the health impact of high-carbohydrate foods in different world regions is warranted (12). Such research should include prospective cohort studies that evaluate specific food substitutions (7,11) and longer-term randomized trials of various white rice alternatives. Currently, reducing white rice consumption to achieve a more balanced dietary pattern with a variety of whole grains, fruits, vegetables, legumes, nuts, and nontropical vegetable oils can be recommended to reduce the risk of type 2 diabetes and cardiovascular diseases (6,25).

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