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Consumption of White Rice and Brown Rice and Urinary Inorganic Arsenic Concentration

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Keywords

NHANES; arsenic; brown rice; white rice

Existing data have suggested that rice intake was associated with elevated urinary excretion of total arsenic among pregnant women (1) and in a population in Bangladesh whose major staple food is rice (2). Moreover, evidence suggests that brown rice may contain more arsenic than white rice (3). In this research, we aimed to examine brown and white rice consumption in relation to urinary excretion of arsenic among U.S. adults.

The study population consisted of 6677 U.S. adults (≥20yr) in the 2003–2010 National Health and Nutrition Examination Survey (NHANES), who were randomly selected for urine arsenic analysis. Arsenic species were separated using high performance liquid chromatography. Because inorganic arsenic, i.e., arsenous acid and arsenic acid, had low detection rates (<5%), we derived inorganic arsenic excretion by subtracting most abundant organic arsenic, i.e., arsenobetaine, from the total arsenic concentration (4). We calculated average white rice and brown rice intake of these two nonconsecutive 24-hour recalls. The first recall was done during the in-person interview, and the second recall was conducted through a telephone interview 3–10 days later (5). In statistical analysis, we log-transformed excretion of arsenic and used generalized linear models to compare the urinary arsenic concentration in white-rice and brown-rice eaters. We took into account the sampling weights specifically for participants included in the arsenic assessments. We used SAS 9.3 (SAS Institute Inc., Cary, NC) to perform statistical analysis.

We observed that intakes of white and brown rice were both associated with higher total urinary arsenic concentrations, and the inorganic arsenic concentrations were not different

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between participants who primarily ate white rice versus those who ate brown rice: as shown in Figure 1 the geometric means±SE of inorganic arsenic were 7.93±0.24 μg/L for participants who did not eat rice (n=5443), 11.51±0.49 μg/L for those who ate < 1cup/d white rice only (n=562), and 13.06±0.56 μg/L for those who ate ≥ 1cup/d white rice only (n=505) (P_{trend}<0.001). For brown rice eaters, the means were 10.92±1.07 μg/L for those who ate < 1cup/d brown rice only (n=73) and 13.05±1.25 μg/L for those who ate ≥ 1cup/d brown rice only (n=67) (P_{trend}<0.001). There are only 27 participants who reported consuming both white rice and brown rice (mean total rice intake=2.14cup/d), and the geometric means±SE of their inorganic arsenic were 15.90±2.38 μg/L. Urine excretion of total arsenic and inorganic arsenic by participants' characteristics are presented in eTable 1 (link)

To our knowledge, the present study compared for the first time the two main types of rice, i.e., brown *vs* white rice, in terms of their contributions to inorganic arsenic exposures. Arsenic is primarily localized in outer layers of the grain (3). As a result, brown rice grains typically have higher arsenic levels than polished white rice (6). Jackson *et al.* recently reported a high inorganic arsenic concentrations in organic brown rice syrup (7). In the current study, however, we did not observe a difference in urinary excretion of inorganic arsenic between participants who primary ate brown rice and those who primarily ate white rice, although the number of brown rice eaters was relatively small. One explanation for this finding is that the two-day recalls may not be able to capture the long-term rice consumption. In addition, the outer layer part of rice grain, i.e., the pericarp and aleurone layer, which are removed during polishing process, makes up only a minor part of the grain (around 14%). Thus, at the same intake amount, the relative differences in arsenic concentrations between brown and white rice are less than those between bran *per se* and white rice (8).

In summary, we found that consumption of white and brown rice showed similar associations with inorganic arsenic in urine. Data from prospective studies with larger sample size of rice eaters are needed to verify our findings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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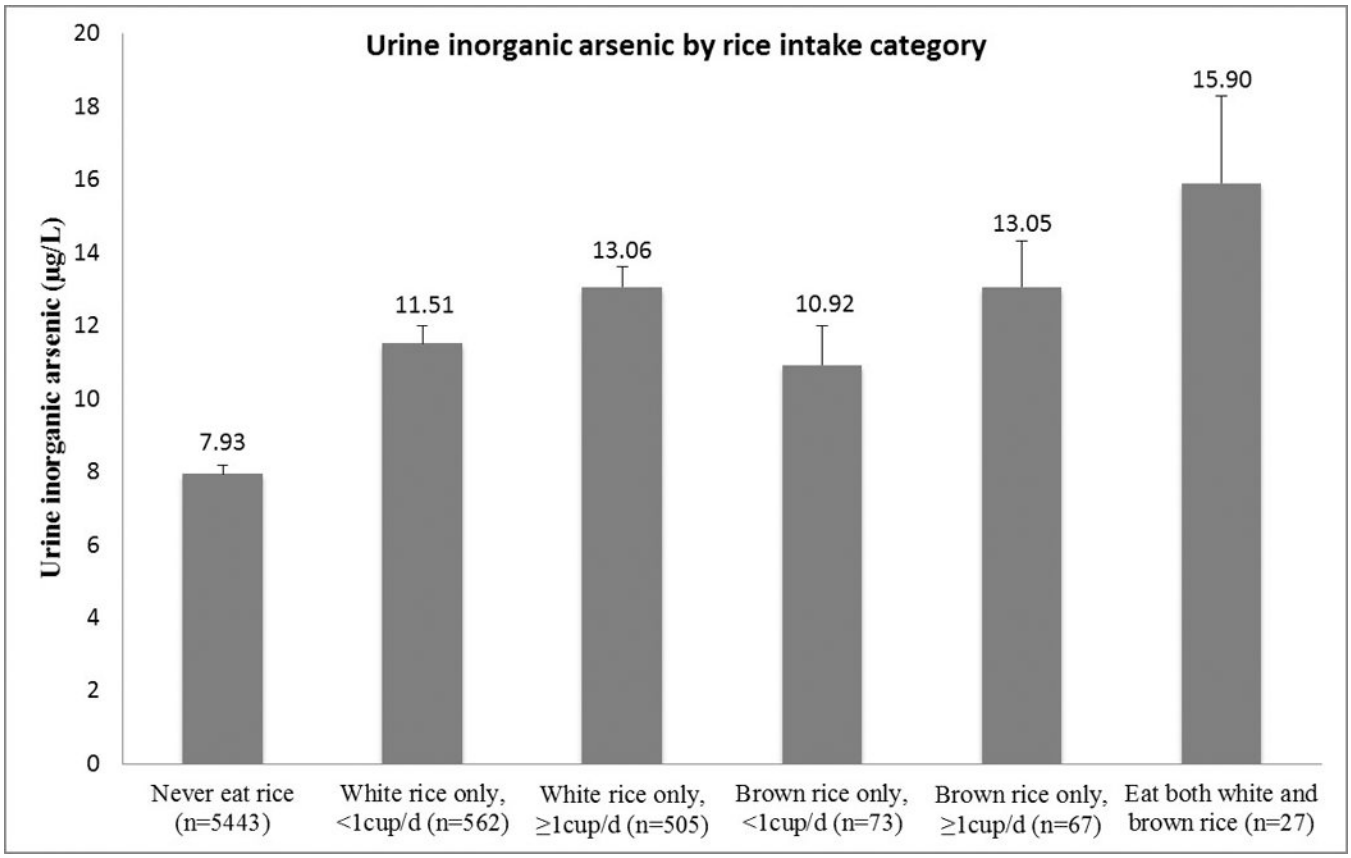

Figure 1. Urinary concentration of inorganic arsenic by category of rice consumption

Data are geometric means (in μg/L), adjusted for age (years), gender (male/female), race/ethnicity (white/black/Mexican American/others), body mass index (kg/m^2), education (less than high school/high school/higher than high school), smoking status (never smoked/former smoker/current smoker) and urine creatinine level (mg/dL). Sample size in each category: Never eat rice (n=5443); White rice only, <1cup/d (n=562); White rice only, ≥1cup/d (n=505); Brown rice only, <1cup/d (n=73); Brown rice only, ≥1cup/d (n=67); Eat both white and brown rice (n=27).