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Rice Consumption is associated with Better Nutrient Intake and Diet Quality in Children: National Health and Nutrition Examination Survey (NHANES) 2005-2010

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Abstract

The goal of this study was to determine the association of rice consumption with nutrient intake and diet quality in a nationally representative sample of US children. NHANES data were used to assess the association of rice consumption by children (2-18 yrs; N=8,367) with nutrient intake and diet quality. 24-hour dietary intakes were used to calculate usual intake (UI) of rice consumption, consumption categories were <0.25, ≥ 0.25 to <0.5, ≥ 0.5 to <1.0, and ≥ 1.0 ounce equivalent (oz eq) of UI of rice. Diet quality, covariate adjusted least square means ± SE, and, quartile trends across the rice consumption categories were examined. Significant positive trends ($p < 0.05$) (β coefficient across rice categories) were seen for adjusted intakes of vitamins A (48.3 µg RAE), B_{12} (0.3 µg) and D (0.41 µg), folate (54.1 µg DFE), magnesium (7.8 mg), iron (0.8 mg), protein (2.0 g), thiamin (0.07 mg), niacin (0.7 mg), zinc (0.5 mg), and sodium (38 mg). Significant inverse trends were seen for intakes of SFA (-1.1 g), added sugars (-0.9 tsp), and total sugars (-3.3 g). Significant ($p < 0.0001$) trends were seen in diet quality; diet quality scores increased 6.8 points between the lowest and the highest rice consumers. Significant positive trends ($p < 0.05$) (β coefficient across rice categories) were seen for component scores for total fruit (0.15), whole fruit (0.23), dark green and orange vegetables (0.29), total grains (0.06), and meat and beans (0.37). HEI-2005 component scores for SFA (0.48) and solid fats, alcohol, and added sugars (SoFAAS) (1.21) were higher but sodium scores (-0.16) were lower. Consumption of rice should be encouraged to improve nutrient intake and diet quality. Nutrition education can provide ways to reduce sodium added to rice dishes.

Keywords: Rice Consumption; NHANES; Children; Nutrient Intake; Diet Quality

Introduction

Two key recommendations in the 2010 Dietary Guidelines for Americans (DGA) focus on limiting the consumption of foods that contain refined grains and consuming at least half of all grains as whole grains. Thus, one is encouraged to increase whole grain intake by replacing refined grains, especially those containing solid fats, added sugars and sodium, with whole grains [1].

Refined grains, the overwhelming majority of which are enriched with iron, thiamin, riboflavin, niacin and folic acid, constitute the majority of grains consumed in the US. On average, Americans consume 6.3 oz eq of refined grains per day and less than 1 oz eq of whole grains [1,2]. At the 2,000 calorie level of the USDA Food Patterns, the recommended amount of refined grains is not more than 3 oz eq per day and 3 oz eq of whole grains [3]. Only 35% of people age 12 and older meet the total grain recommendation and only 4% met the whole grain recommendation [4].

In the United States (US) marketplace, consumers have a wide variety of grain-based food options. Unfortunately, the major food sources of refined grains are high in solid fats and added sugars [3]. For those 2 y and older, yeast breads (25.9%), pizza (11.4%), and grain-based desserts (9.9%) were the most commonly consumed refined grain products [3]. Rice and rice mixed dishes constituted only 4.4% of refined grain products consumed [3]. These data suggest that many refined grains are a part of dishes that are high in saturated fatty acids (SFA), solid fats, and sodium; however, this may not be the case for rice and most mixed dishes made from rice.

White rice is a refined grain that is a staple food in many parts of the world and is becoming more widely consumed in the US [5,6]. Brown rice is a whole grain but is less widely consumed than enriched, fortified white rice. Rice consumption has doubled in the US over the last 20 years [6]. Current intake of rice in the US is approximately 25 pounds per capita/year [7], with more than 70% being enriched, fortified white rice. This increase may be the result of an emphasis on healthy lifestyles, the rising demand for gluten-free foods, or continued introduction and domestic use of new rice-based products [8] .

Enriched, fortified white rice contributes more than 15 vitamins and minerals, including folate and other B-vitamins, iron, and zinc, to the diet; it is sodium and cholesterol free, and has only a trace of fat, with no SFA [9]. It has been argued that although some vitamins and minerals stripped from grains during the refining process are added back during the enrichment process (iron, thiamin, riboflavin, niacin, and folic acid), not all vitamins are replaced and dietary fiber is not replaced [1]. Brown rice is slightly higher in dietary fiber, magnesium, and phosphorus than enriched, fortified white rice, but brown rice is

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lower in B vitamins and iron since it is not enriched [9]. Thus, the effect of consuming rice on nutrient intake and diet quality, particularly in children, is unclear.

Fulgoni et al. [10], using data from the NHANES 1999-2004, showed that younger (2-13 years) and older (14-18 years) children who consumed rice had significantly higher total intakes of protein, dietary fiber, vitamin A and B_6, thiamin, niacin, folate, magnesium, iron, zinc, copper, sodium and potassium than non-consumers of rice. In contrast, rice consumers had lower intakes of total fat, specifically SFA and monounsaturated fatty acids than non-consumers of rice. These nutrient intake differences were reflected in higher consumption among rice consumers of total grains, total fruits, and legumes and lower consumption of added sugars and solid fat. In the older children, intake of calcium was lower in rice consumers, which was reflected in lower intakes of cheese and yogurt. These older NHANES data indicated that rice consumption was associated with better nutrient and food intake in children.

The effect of rice consumption on nutrient intake and diet quality using more recent nationally representative data is unknown. The objective of this study was to determine the association of rice consumption with nutrient intake and diet quality in a recent nationally representative sample of US children.

Subjects and Methods

Study population and analytic sample

Data from children 2-18 yrs. (n=8,367) participating in the NHANES 2005-2006, 2007-2008, and 2009-2010 were combined to increase the sample size [11]. Analyses included only individuals with complete and reliable dietary records as determined the National Center for Health Statistics staff and excluded females who were pregnant or lactating. This was a secondary data analysis which lacked personal identifiers; therefore, this study did not require institutional review [12].

Demographic information, including age, gender, race-ethnicity, poverty income ratio (PIR), physical activity levels, and smoking status (current smoker yes/no), used for covariates in the statistical analyses outlined below, was determined via interview [13].

Dietary analyses

Dietary intake was determined using two multiple pass 24-hour dietary recalls [14]. The first recall was in-person in the Mobile Examination Center and the second was conducted 3 to 10 days later via telephone [15]. The Food Commodity Intake Database (FCID) [16] was used to identify ingredients of survey foods that included rice [white (including flour) or brown rice]. The gram amount of rice consumed by NHANES 2005-2010 respondents was determined by applying the rice composition from FCID to the respondent's 24-hour recall dietary interview data. Usual intake (UI) was determined using the National Cancer Institute method [17]. The MyPyramid Equivalents Database (MPED) was used to translate the amounts of foods consumed into the number of equivalents for the seven MyPyramid major groups and the corresponding subgroups. Rice consumers were defined by UI of at least ¼ oz eq per day (<0.25 oz eq) and were further grouped into three rice consumption categories: ≥ 0.25 to <0.5, ≥ 0.5 to <1.0, and ≥ 1.0 oz eq of UI of rice. These rice consumption categories were more conservative estimates than those used in other studies [5,10] primarily due to our use of UI, which represents intake expected over time. For practical purposes, rice non-consumers were defined by a UI of less than ¼ oz eq (7.0875 grams) per day. Covariate-adjusted total nutrient intakes were determined using the 24-hour dietary recalls and focused on energy and nutrients to be managed in the diet (i.e., SFA, sodium, and added sugars) and nutrients of public health concern and those under-consumed by some groups (i.e., dietary fiber, vitamin D, folate, calcium, magnesium, iron, and potassium) [1]. Alcohol intake (g), which was used as a covariate in the statistical analyses, was also determined via the 24-hour dietary recalls.

Diet quality was calculated using the Healthy Eating Index-2005 (HEI-2005) [18,19]. Food group standards and the development and evaluation of the HEI-2005 have been previously described [20,21]. The SAS code used to calculate HEI-2005 scores was downloaded from the Center for Nutrition Policy and Promotion website [22]. Briefly, HEI-2005 was designed to evaluate all of the major MyPyramid food groups and major subgroups and nutrients to manage in the diet. The twelve HEI-2005 components were summed for a total possible score of 100 points.

Statistical analyses

Sample-weighted data were used in all statistical analyses, and all analyses were performed using SUDAAN Release 11.0 (Research Triangle Institute, Research Triangle Park, NC) to adjust the variance for the complex sample design. For 2005-2010, a 6-year weight variable was created by assigning ⅓ of the 2-year weight for 2005-2006, 2007-2008, and 2009-2010 [11]. The sample-weighted percentages (and standard error of the percentages) of the demographics of subjects in rice groups were calculated using PROC CROSSTAB of SUDAAN. Least-square means (and the standard errors of the least-square means) were calculated using PROC REGRESS of SUDAAN. Covariates for least-square mean nutrient intakes were gender, age (years), race-ethnicity, poverty income ratio (PIR) grouped into three categories as (<1.25, 1.25–3.49, and >3.49), physical activity level (sedentary, moderate and vigorous), smoking status and alcohol intake (g/day) and energy (the latter was not included in analyses of energy intake). Similar covariates were used for HEI but not adjusted for energy intake as the HEI formula is based on 1000 calories. A p-for-trend across UI of rice was also determined. A p-value of <0.05 was considered significant.

Results

Demographics and lifestyle characteristics of the sample

The percentage of children 2-18 years (n=8,367) consuming greater than 0.25 oz eq of rice/day was 88% with the majority of rice consumers consuming ≥ 0.25 and <0.5 oz eq per day (67%). Non-consumers of rice were slightly younger, more likely female and non-Hispanic white, compared to children who consumed ≥ 1.0 oz eq of rice per day (Table 1).

Association between usual intake of rice consumption and diet quality

Significant ($p < 0.0001$) trends were seen in diet quality (Figure 1); diet quality scores increased 6.8 points between the non-consumers of rice and the highest rice consumers (≥ 1 oz eq). Significant positive trends ($p < 0.05$) (β coefficient across rice categories) were seen for component scores for total fruit (0.15), whole fruit (0.23), dark green and orange vegetables (0.29), total grains (0.06), and meat and beans (0.37). HEI-2005 component scores for SFA (0.48) and solid fats, alcohol, and added sugars (SoFAAS) (1.21) were higher, suggesting more favorable intake, but sodium scores (-0.16) were lower (Table 2).

Demographic Variables	All (n=8,367)		Usual Rice Intake (oz eq)							
			<0.25 (n=908, 11.5%)		≥ 0.25-<0.5 (n=5,541, 66.9%)		≥ 0.5-<1.0 (n=1,585, 17.9%)		≥ 1.0 (n=333, 3.7%)	
	Mean[2]	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Age, y	9.75	0.11	9.56[a]	0.23	9.85	0.13	9.27	0.19	10.84[a]	0.35
Gender, %										
Females	49.17	0.96	49.70[b]	2.11	50.59	1.25	51.24	1.94	11.38[b]	1.52
Ethnicity, %										
Whites, Non-Hispanic	61.06	2.09	63.51[b]	3.09	65.05	2.04	49.98	2.72	34.45[b]	4.82
Black, Non-Hispanic	13.77	1.18	14.62	2.08	13.09	1.24	16.20	1.63	11.69	2.00
Mexican-Americans	12.72	1.10	10.79	1.40	12.33	1.10	15.14	1.63	14.08	2.63
Poverty Income Ratio	2.56	0.06	2.67	0.10	2.56	0.07	2.50	0.08	2.55	0.18
Physical Activity—Intensity, %										
Sedentary	12.02	0.60	11.01	2.02	12.02	0.66	13.60	1.20	7.54	1.70
Light	20.74	0.80	19.93	1.98	20.60	0.89	22.23	1.44	18.44	2.81
Moderate-to-vigorous	67.24	0.94	69.05	2.81	67.38	1.00	64.18	1.71	74.02	3.05

[a]p< 0.01, [b]p < 0.0001
[1]Values are presented as means ± SE
[2]Mean values represent percentages for entire column except age

Table 1: Demographic and lifestyle characteristics of the children aged 2-18 years participating in the national health and nutrition. Examination Survey 2005-2010[1].

HEI-2005 Components2	Usual Rice Intake (oz eq)[1]										
	<0.25		≥ 0.25 - <0.5		≥ 0.5 - <1.0		≥ 1.0		Beta	SE	Quartile Trend P-value
	LSM	SE	LSM	SE	LSM	SE	LSM	SE			
Total fruit	2.43	0.11	2.55	0.05	2.76	0.10	2.81	0.16	0.15	0.07	0.0310
Whole fruit	1.80	0.12	2.01	0.06	2.26	0.10	2.45	0.16	0.23	0.06	0.0008
Total vegetable	2.57	0.08	2.05	0.04	2.30	0.07	2.45	0.15	-0.01	0.04	0.7579
Dark green and orange vegetables	0.57	0.07	0.56	0.03	1.01	0.07	1.37	0.16	0.29	0.05	<0.0001
Total grains	4.53	0.04	4.42	0.02	4.52	0.03	4.78	0.04	0.06	0.02	0.0020
Whole grains	0.94	0.06	0.90	0.04	0.94	0.05	0.90	0.10	0.001	0.04	0.9748
Milk	6.98	0.16	6.93	0.07	7.02	0.16	5.97	0.27	-0.13	0.08	0.1215
Meat and beans	6.32	0.19	6.68	0.07	7.07	0.12	7.39	0.23	0.37	0.08	<0.0001
Oils	5.39	0.16	5.40	0.06	5.40	0.15	5.48	0.31	0.01	0.09	0.8811
Saturated fatty acids[3]	5.61	0.16	5.05	0.07	5.94	0.11	7.17	0.24	0.48	0.09	<0.0001
Sodium3	3.93	0.14	4.35	0.08	3.96	0.14	3.35	0.26	-0.16	0.07	0.0229
Solid fats, alcohol, and added sugars (SoFAAS)[3]	9.21	0.26	8.53	0.15	10.52	0.23	13.01	0.45	1.21	0.14	<0.0001

[1]Values are presented as least-square means ± SE.
[2]Adjusted for gender, ethnicity, age, socioeconomic status (PIR 0-1.25, 1.25-3.5, >=3.25), physical activity level (sedentary, moderate, active), current smoking status, and alcohol consumption.
[3]Reversed scored – i.e., the higher the score, the lower the intake points.

Table 2: Association between usual rice intake and healthy eating index-2005[1] components in children.

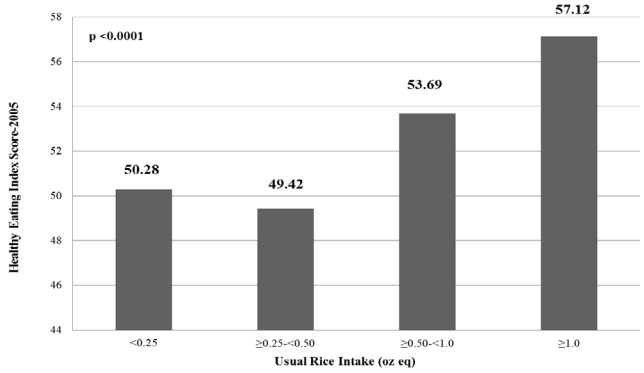

Figure 1: Usual rice intake and diet quality (HEI-2005), adjusted for gender, ethnicity, age, socioeconomic status (PIR 0-1.25, 1.25-3.5, >=3.25), physical activity (sedentary, moderate, active), smoking, and alcohol.

Association between usual intake of rice consumption and nutrient intakes

There was no association between energy intakes across the rice consumption categories (Table 3). Significant positive trends (p <0.05) (β coefficient across rice categories) were seen for adjusted intakes of vitamin A (48.3 μg RAE), vitamin D (0.41 μg), folate (54.1 μg DFE), magnesium (7.8 mg), iron (0.8 mg), protein (2.0 g), vitamin B_{12} (0.3 μg), thiamin (0.07mg), niacin (0.7 mg), and zinc (0.5 mg). Significant inverse trends were seen in intakes of SFA (-1.1 g), added sugars (-0.9 tsp), and total sugars (-3.3 g).

Discussion

These data indicate that in rice consumers there was better diet quality and nutrient intake than seen in non-rice consumers. These findings are very consistent with studies using earlier NHANES data on children and adults [5,10] and a more recent study on adults [23].

Nutrients	Usual Rice Intake (oz eq) 1								Beta	SE	Quartile Trend P-value
	<0.25		≥ 0.25 - <0.5		≥ 0.5 - <1.0		≥ 1.0				
	LSM	SE	LSM	SE	LSM	SE	LSM	SE			
Nutrients to be Managed in the Diet[2]											
Energy (kcal)3	2104	36.6	1886	16.0	1955	34.7	2258	83.6	13.4	25.2	0.597
Saturated fatty acids (g)	24.2	0.36	26.0	0.17	24.1	0.24	19.9	0.71	-1.08	0.21	<0.0001
Sodium (mg)	3118	56.2	2988	23.2	3080	42.4	3545	161	78.7	38.3	0.045
Added sugars (tsp eq)	19.3	0.65	19.7	0.29	18.5	0.38	15.9	1.26	-0.92	0.32	0.0055
Nutrients of Public Health Concern or Under-Consumed[2]											
Dietary fiber (g)	14.4	0.33	12.4	0.15	13.6	0.23	13.9	0.55	0.01	0.19	0.938
Vitamin D (D2 + D3) (mcg)	5.45	0.19	5.53	0.10	6.49	0.22	5.70	0.37	0.41	0.11	0.0008
Vitamin A (mcg RAE) Folate, DFE (mcg)	564 534	17.7 16.8	569 481	8.59 7.74	675 599	11.5 14.3	617 658	49.2 20.1	48.3 54.1	9.81 7.05	<0.0001 <0.0001
Calcium (mg)	1003	27.1	1018	11.0	1031	16.7	889	49.0	-10.25	13.7	0.458
Magnesium (mg)	234	4.51	223	1.91	239	2.31	259	6.15	7.84	2.08	0.0005
Iron (mg)	14.3	0.43	13.4	0.13	15.5	0.26	15.7	0.41	0.82	0.13	<0.0001
Potassium (mg)	2243	36.8	2127	18.3	2254	31.1	2286	68.8	34.2	19.0	0.078
Other Nutrients of Interest[2]											
Protein (g)	66.7	0.98	67.8	0.48	69.9	0.75	73.7	2.04	2.04	0.47	<0.0001
Total sugars (g)	132	3.03	131	1.20	129	1.87	116	4.84	-3.31	1.46	0.0277
Cholesterol (mg)	199	8.29	221	4.20	210	3.93	235	11.9	5.04	3.41	0.146
Vitamin B_{12} (mcg)	4.60	0.14	4.91	0.08	5.56	0.13	4.68	0.23	0.30	0.06	<0.0001
Riboflavin (mg)	2.06	0.04	2.01	0.02	2.20	0.03	1.86	0.06	0.03	0.02	0.103
Thiamin (mg)	1.57	0.03	1.48	0.02	1.65	0.02	1.71	0.05	0.07	0.01	<0.0001
Niacin (mg)	21.9	0.49	20.3	0.26	22.6	0.35	22.9	0.63	0.72	0.20	0.0007
Zinc (mg)	10.24	0.21	10.05	0.11	11.1	0.20	11.3	0.40	0.54	0.12	<0.0001

[1]Values are presented as least square means ± SE
[2]Adjusted for gender, ethnicity, age, socioeconomic status (PIR 0-1.25, 1.25-3.5, >=3.25), physical activity level (sedentary, moderate, active), current smoking status, alcohol consumption, and energy intake
[3]Adjusted for gender, ethnicity, age, socioeconomic status (PIR 0-1.25, 1.25-3.5, >=3.25), physical activity level (sedentary, moderate, active), current smoking status, and alcohol consumption

Table 3: Association between usual rice intake and nutrient intake in children.

The consistency of the association of rice consumption with higher intakes of vitamin D, folate, magnesium, iron, protein, vitamin B_{12}, thiamin, niacin, and zinc is positive for the diet of American children. The increase in nutrient intake among rice consumers may reflect the increase in diet quality, specifically the component scores for total fruit, whole fruit, dark green and orange vegetables, total grains, and meat and beans. SFAs, solid fats, and added sugars were lower with increased rice consumption. These nutrients were identified by the 2010 DGA as nutrients/foods to limit in the diet [1].

The finding that rice consumers had greater intakes of meat and beans, specifically legumes [10], may in part be due to rice being consumed as a rice-and-bean mixed dish, a popular combination among Hispanics [24] and Southerners [25]. Given that the 2010 DGA [1] recommend an increase in bean consumption to help meet the current recommendations for dietary fiber, potassium, and magnesium, recommending rice consumption may be a viable strategy to help American consume more beans/legumes in their diet. It was encouraging to see that rice consumers had higher intakes of dark green and orange vegetables because vegetable consumption is very low in children [1]. Incorporating rice into vegetable dishes may be one way to get more vegetables into the diets of children.

Despite the potential of rice dishes in getting some Americans closer to meeting recommended intake of vegetables, sodium intake was higher in the rice consumption groups. The highest rice consumption group consumed 427 mg more sodium than the non-consumers of rice. Since rice is sodium-free, this suggests that some rice products may be processed with added sodium or that consumers season rice dishes with salt or adds high-sodium ingredients. Potassium intake was also higher among rice consumers, suggesting that the increased intake of fruits, vegetables, and beans may be helping to balance the sodium intake with higher intakes of potassium.

Although findings from this study are consistent with earlier findings [5,10], results should be interpreted with caution. Differences in methodologies used (i.e., definitions for determining and categorizing rice consumers; food group definitions; and years of the studies) need to be considered when interpreting the results. However, our data confirm that rice consumption is associated with positive improvements in the diet. It is important to note that these results are from a cross-sectional epidemiologic study, and as such, one cannot draw conclusions about cause and effect.

Another limitation is the arbitrary definition used to define rice consumers. In this study, and previous studies [5,10], there was an assumption that consumers were homogenous such that rice consumers had similar rice consumption patterns. However, a study conducted with adults identified six rice consumption patterns using additional cluster analysis [23]. The highest consumption of rice occurred with meat mixtures and vegetables/legumes. Examination of individual food codes showed that examples of meat mixtures consumed with rice included chicken/beef with or without gravy/sauce; fried rice with meat; and soup with meat. Several of these meat mixtures included vegetables. Several other mixtures included ethnic foods like red beans

and rice; shrimp creole; gumbo; jambalaya; chicken chow mein; burrito; or quesadilla. Spanish rice was also a popular rice dish. Data from this study suggest that rice consumption patterns vary considerably. A similar study is needed to look at rice consumption patterns in children. Arbitrary definitions of dietary exposures may be too simplistic of an approach to understanding the relationship between individual foods and overall dietary intakes and diet quality. More studies are needed to better understand the nutritional impact of specific foods in the diet in addition to the assessment of food-based patterns.

Conclusion

Consumption of rice by children in our study was associated with higher nutrient intakes and better overall diet quality and should be encouraged. Since sodium intakes were also higher, recipes with less sodium and nutrition education should be developed to reduce sodium added to rice dishes.

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