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Micronutrient intake among children in Puerto Rico: dietary and multivitamin-multimineral supplement sources

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Abstract

Background—Micronutrients are critical for healthy growth and development of children. Micronutrient intake from dietary sources is inadequate among some children and may be improved by use of multivitamin and multimineral (MVMM) supplements.

Objective—To assess micronutrient intake from dietary and MVMM supplement sources among 12-year-old children in Puerto Rico.

Methods—A representative sample of 732 children enrolled in an oral health study in Puerto Rico, who completed dietary and MVMM assessments through one 24-hr recall, were included in this analysis. Micronutrient intake sources were described and compared to the Dietary Reference Intakes (DRIs) using the Estimated Average Requirement when available (used Adequate Intake for vitamin K and pantothenic acid). Micronutrient profiles of MVMM users and non-users were compared using t-tests.

Results—Mean intakes of vitamins A, D, E, and K, pantothenic acid, calcium and magnesium from food and beverage sources were below the DRIs. From food and beverage sources, MVMM users had higher intakes of riboflavin and folate compared to non-users ($p < 0.05$). When MVMM supplements were taken into account, users had higher intake of all nutrients except vitamin K. With the help of MVMM, users increased intake of vitamins E, A, D, and pantothenic acid to IOM-recommended levels but calcium, magnesium and vitamin K remained below guidelines.

Conclusion—Micronutrient intake from diet was below the IOM-recommended levels in the total sample. MVMM use improved intake of selected micronutrients and facilitated meeting recommendations for some nutrients. Public health measures to improve micronutrient intake among children in Puerto Rico are needed.

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Keywords

children; dietary supplements; micronutrient intake; Puerto Rico; Hispanics

INTRODUCTION

Micronutrients are essential in children for healthy growth and development [1] but intake of micronutrients in industrialized countries [2] and among segments of the population, including some children [3], is poor. Multivitamin and multimineral (MVMM) dietary supplements help increase intake of micronutrients [4]. MVMMs are the most frequently used supplements among children and adults in the United States (US) [5–7]. According to the 1999–2002 National Health and Nutrition Examination Survey (NHANES), out of 31.8% of children (0–18 years of age) who use dietary supplements, 18.3% used MVMMs [6].

Few studies have examined adequacy of micronutrient intake and micronutrient sources in children in relation to the Dietary Reference Intakes (DRIs). A Canadian and a British study reported inadequacies in micronutrient intake in girls age 7–13 years having lower intakes of numerous micronutrients compared to boys [8,9]. Bailey et al., using 2003–2006 NHANES data, found micronutrient inadequacies in children older than 8 years, which were improved by use of dietary supplements for most, but not all, micronutrients (vitamin D and calcium remained low) [10]. Similarly, a study of 190 Hawaiian children age 6–13 years found that micronutrient adequacy from dietary sources was low, but improved with dietary supplements [11]. Lastly, among multi-ethnic (14% Hispanics) eighth-graders from the Third Child and Adolescent Trial for Cardiovascular Health study, dietary supplement users had significantly higher micronutrient intake than non-users [12]. Users also had intake levels above the DRIs for all micronutrients while non-users had intakes below the DRIs for folic acid, calcium, iron, and zinc.

Dietary patterns vary among race/ethnic groups in the US, including Hispanics [13] and considerable variability in micronutrient intake has been reported among adult Hispanics sub-groups [14]. Studies of children [10,12,15] and adults [15] have shown that Hispanics are less likely to use MVMM supplements compared to non-Hispanic whites, however samples have included mostly Mexican-Americans and adult Hispanics. In particular, there is a scarcity of data on micronutrient adequacy and micronutrient sources among Puerto Rican children. Given that Puerto Ricans experience the greatest health disparities of all Hispanic subgroups [16,17], especially in diet-related chronic diseases [18,19], understanding and improving micronutrient intake of Puerto Rican children is critical for embarking chronic disease prevention efforts.

The purpose of this study was to assess micronutrient intake from dietary and MVMM supplement sources among 12-year-old children living in Puerto Rico (PR). We also examined MVMM supplement contribution to overall intake of micronutrients important for healthy child development. To our knowledge, this is the first study to examine micronutrient intake from dietary and MVMM sources among a representative sample of children in PR.

METHODS

Study design and participants

Data for the present study were drawn from the “island-wide” cross-sectional study “Oral Health Status, Knowledge and Attitudes of 12-Year Olds Residing in Puerto Rico, 2011”, that consisted of a sample of 1,550 12-year-old children enrolled in the academic year 2010–2011 (described elsewhere [20]). Briefly, a probabilistic random sample of all public and private schools (n=133) from the 11 health administrative regions of PR was used in the main study. For this analysis, a representative and similar subset sample was chosen to complete a 24-h dietary recall, by randomly selecting 50% of the participants within each school (n=800). The study was approved by the Institutional Review Board of the Medical Sciences campus at the University of Puerto Rico.

Measures

Assessments were conducted at the children’s respective schools by trained study personnel, and involved administration of a demographics survey, anthropometric measurements and dietary and MVMM assessments. Gender was self-reported. School region was grouped into three areas: metropolitan, coast, and mountain. School type was used as a proxy for social economic status (SES) [20,21]. Height and weight were measured following the NHANES procedures and BMI was calculated dividing weight (kilograms) by height (meters²). Participants were categorized according to the Center for Disease Control and Prevention age- and sex- specific Growth Charts as: underweight (BMI < 5th percentile), healthy weight (BMI 5th and <85th percentile), overweight (BMI 85th and <95th percentile), and obese (BMI 95th percentile) [22,23].

Dietary and MVMM supplement intake were assessed using a single 24-hr dietary recall, which was administered to 50% of children in each school (n=796), randomly selected from the larger sample. Consistent with the use of 24-hr dietary recalls for children age 8–9 years or older [24,25], the recalls were administered to the children without aid from parents or guardians. Children were prompted to list all foods and beverages consumed in the past 24 hours during breakfast, morning snack, lunch, afternoon snack, dinner, and night snack. They also were asked to indicate time and place of each meal as well as brands, preparation methods and items added to the meals. Children were assisted in estimating portion sizes by using a booklet with drawings and images of serving sizes including pictures of household serving utensils [26]. Use of dietary supplements was reported through a single (yes or no) question that asked “Did you take any supplement?” If the answer was yes, a follow up question asked the brand and dose of the product: “What is the brand and dose of the product?” Research data was entered into the Nutrition Data System for Research program (NDSR) (database version 2011, Nutrition Coordinating Center, University of Minnesota).

Statistical Analysis

From the total children recruited (n=796), 56 children that reported the use of other types of supplements (i.e., single vitamins, omega-3, and probiotics) were not included in the present analysis, as our main objective was to assess the contribution of MVMM to micronutrient intake. Furthermore, those with incomplete dietary assessments were not included (n=8).

Therefore, a total of 732 children had complete data for demographic, BMI and dietary and MVMM supplement data were included in this analysis. Only 3% of children were underweight, therefore they were grouped with children in the healthy weight category. Micronutrient intake from foods, beverages, and MVMM sources were obtained. We specifically examined: vitamins A, thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, folate, cobalamine, C, D, E, K, calcium, copper, iron, magnesium, and zinc, as these are common micronutrients present in MVMM supplements and are important nutrients for child development. Mean intake of micronutrients was calculated from foods and beverages for the overall sample and by gender. Subsequently, for each MVMM user, the contribution of the supplement to overall micronutrient intake was determined. Descriptive statistics were obtained for demographics including gender, school type, school region and BMI categories for the total sample and for MVMM users and non-users; Chi-square tests were conducted to examine differences across categorical variables. Mean micronutrient intake by gender and by MVMM dietary supplement use status (MVMM users vs. non-users) were contrasted using independent-samples T-test. Intake of the different micronutrients assessed was compared to the DRIs [27]. Analyses were conducted with SPSS Statistics program (Version 20). Statistical significance was set at $p < 0.05$.

RESULTS

In this sample of 732 12-year-old children living in PR, slightly over half (54.2%) were females and the majority was from public schools (78.6%) (Table 1). There was representation of children from the metropolitan (43.3%), coast (45.1%) and central (11.6%) regions of the island. Over half of the sample had a healthy weight (58.6%) while 18.5% were overweight and 22.9% were obese. Use of MVMM supplements was reported by 9.3% of the children. About 54% of MVMM users did not recall the brand of the product; therefore, we used the generic MVMM supplement from NDSR. There were no sex or school region differences between MVMM users and non-users. However, a greater proportion of MVMM users attended private schools (41.2% compared to non-users (19.4%; $P < 0.05$). Lastly, a greater proportion of MVMM users had a healthy weight compared to non-users (72.1% vs. 57.2%, respectively; $p < 0.05$).

Micronutrient intake from food and beverage sources in the total sample and by gender

Minerals—Mean intake of minerals from food and beverage sources is shown in Table 2. Intake of calcium and magnesium was below IOM-recommended levels overall and for boys and girls. Mean intake of copper, iron and zinc was above IOM-recommended levels overall and for boys and girls. Boys had significantly higher intakes of all 5 minerals than girls ($p < 0.05$).

Vitamins—Mean intake of vitamins from food and beverage sources are shown in Table 2. Mean intake of thiamin, niacin, riboflavin, pyridoxine, cobalamine, and vitamin C were above the IOM-recommended levels. Folate intake was at the IOM-recommended level overall and among boys, but was slightly below the recommended level for girls. Mean intake of pantothenic acid, and vitamins A, E, K, and D were below IOM-recommended

levels. Boys had significantly higher intake of thiamin, niacin, riboflavin, pyridoxine, pantothenic acid, and folate ($p<0.05$) compared to girls.

Micronutrient intake among MVMM supplement users and non-users

Minerals—Mineral intake from diet and MVMM supplements are shown in Figures 1A and 1B. From food and beverage sources only, MVMM users had higher intake of magnesium compared to non-users ($p=0.06$). When taking into account nutrient contribution from MVMM supplements, users had significantly higher intakes of all minerals assessed compared to non-users ($p<0.05$). Mean intake of calcium and magnesium were below IOM-recommended levels while intakes of copper, iron and zinc were above recommended levels.

Vitamins—Mean intake levels of water-soluble vitamins from diet and MVMM supplements are shown in Figures 2A–2C. From food and beverage sources only, MVMM users had significantly higher intakes of riboflavin and folate compared to non-users ($p<0.05$). When taking into account nutrient contribution from MVMM supplements, users had significantly higher intakes of all vitamins compared to non-users ($p<0.05$). Non-users and MVMM users met the recommended levels of all these vitamins from food and beverage sources, except pantothenic acid, which was met by users with the help of MVMM supplements. Therefore, MVMMs contributed to intake of these vitamins beyond these recommendations.

Figures 3A and 3B show intake levels of lipo-soluble vitamins from diet and MVMM supplements combined. From food and beverage sources only, intakes of these vitamins were similar between non-users and MVMM users. When taking into account nutrient contribution from MVMM supplements, users had significantly higher mean intake of vitamins E, A and D than non-users ($p<0.05$) but vitamin K intake was similar between groups. MVMMs contributed to meet IOM-recommended levels for vitamins E, D, and A, but not for vitamin K.

DISCUSSION

To our knowledge, this is the first study to examine micronutrient intake from food, beverage and MVMM sources among a representative sample of 12-year-old children living in PR. Puerto Ricans bear a considerable burden of health disparities compared to other Hispanic groups and to the overall US population [16–19]. Selected micronutrients are associated with a variety of chronic health conditions [28] and thus understanding overall micronutrient intake at an age where children are rapidly developing may provide insights for intervention targets that could reduce health disparities among Puerto Ricans.

In this representative sample of 12-year-old children in PR, micronutrient intake from food and beverage sources was lower than recommended levels for 7 (calcium, magnesium, pantothenic acid, and vitamins A, D, E, and K) of the 17 micronutrients evaluated. Intake of other nutrients (copper, iron, zinc, thiamin, niacin, riboflavin, pyridoxine, cobalamine, and vitamin C) was above the IOM-recommended levels, except folate among girls, which was somewhat lower than the recommended level. When compared to 6–11 year old children from the US [29], intake of calcium, magnesium, iron, vitamin C, thiamin, riboflavin, niacin,

pyridoxine, and cobalamine were lower in this sample. We also found that MVMM users had significantly higher intakes of riboflavin and folate and marginally significant higher intake of magnesium compared to non-users from food and beverage sources. Although Bailey et al. did not observed differences in micronutrient intake from food and beverage sources between users and non-users, they reported that non-users had higher nutrient inadequacy for calcium, magnesium, phosphorous, and vitamins A and C than users [10]. However, a study in 14-year-old children reported that dietary supplement users had significantly higher intake of 16 of the 20 micronutrients analyzed from food sources [12]. This higher micronutrient intake in users could be related to a healthier dietary pattern associated with dietary supplement use.

Intake of micronutrients that exceed the IOM recommended levels, as indicated by the Tolerable Upper Intake Level (UL), have been reported in children [10,11,30] and adults [30,31] when evaluating contribution of dietary supplements. In particular, this has been observed for iron, zinc, folic acid, copper, niacin and vitamins A and C [10,11,30]. In our sample, only intake of niacin exceeded the UL (20 mg/d) in MVMM users (25 mg/d). The UL for niacin only applies to synthetic sources of the micronutrient including supplements and fortified foods [32]. The main risk associated with this excessive intake is flushing and to a less extent hepatotoxicity. However, the established UL for children is extrapolated from that of adults and the majority of the adverse effects are reported because of high doses of niacin used for medical treatment [32].

There were gender differences in the intake of some micronutrients from dietary sources, with boys having higher intakes of calcium, copper, iron, magnesium, zinc, thiamin, riboflavin, niacin, pyridoxine, pantothenic acid, and folate than girls. This finding is consistent with two other studies conducted in Canada and England [8,9]. The higher intake of these micronutrients could be related to the overall higher dietary intake among boys in this age range [8,9,33].

Our findings support that MMVM use has the potential to improve micronutrient intake among children with nutrient-poor diets as MVMM users had significantly higher intakes of all micronutrients examined in this study compared to non-users, except for vitamin K. Our findings are consistent with a study that observed higher intake of most examined micronutrients in children aged 2–18 years [34] and a study that reported similar findings for 14 year olds [12]. In the present study, recommendations for pantothenic acid and vitamins A, D, and E were met only because of MVMM use. Nonetheless, intake of calcium, magnesium, and vitamin K, essential micronutrients for bone mass accretion which begins to peak during puberty [35], was still below the recommendations even among MVMM users. At least one previous study found that MVMM use failed to improve intake levels for vitamin K [34]. This could be explained by the low amounts of vitamin K added to MVMM supplements. In our sample, foods and beverages sources supplied users with 43.5 mg/d while MVMM supplements supplied an extra 1 mg/d. Similarly, MVMM supplements have low amounts of calcium and in our study, it only supplied an extra 56 mg/d.

Despite the potential benefits of MVMM supplementation, a very small proportion of children in this sample reported MVMM use. Although few studies are available for

comparisons, the prevalence of MVMM supplement use in this sample is lower than other groups [6,30,36]. A study that examined 1999–2000 NHANES data in 10,136 children reported that 18.3% use MVMM supplements [6]. In other international studies, MVMM supplement use among children has been higher. For example, 28.4% of 6,131 10–12 year old children in the 2007–2009 Korean National Health and Nutrition Examination Survey reported using MVMM supplements [36]. Similarly, MVMM use in Canadian 9–13 years olds was reported at 25.0% (n=34,381) [30].

In the present study, most children that reported supplement use attended private schools, a proxy for high SES in this population. Similar, MVMM use among children and adolescents in the US [6,34] and in Korea [36] increases with increasing family income. One reason for this could be related to the cost of MVMM. It has been estimated that the use of dietary supplements may cost \$20–\$40 per year [37]. Therefore, families from low SES may not be able to afford such practice.

In agreement with previous studies [6,34,36], we observed that a greater proportion of MVMM users in our sample were categorized as healthy weight. This finding is consistent with reports that MVMM users tend to engage in other healthy behaviors, including eating healthier diets [12,34,38,39] and physical activity [34,40].

Our study has some strengths and limitations worth acknowledging. A study limitation is that dietary and MVMM assessments relied on the self-report of 12-year-old children. As seen in this study slightly over half of the participants did not recall the brand of the supplement. Some brands have similar content of vitamins and minerals however; we noticed at least 2 brands that had higher content of some vitamins (i.e. vitamin A and E), while others had no content of calcium, magnesium and vitamin K. However, 24-hr dietary recalls have been shown to be valid instrument for dietary assessment in children over 10 years of age in many studies [41]. Another assessment-related limitation is that a single 24-hour dietary recall was used and therefore usual intake cannot be assumed, as intra- and inter-person variability could not be determined. Therefore, nutrient adequacy of the diet could not be calculated. A strength of this study is that the study focuses on Puerto Ricans, a population with well-documented health disparities in diet-related chronic diseases. Also, the sample is representative of 12-year-old children living in PR and this is the first study to report micronutrient intake and sources among this children.

In conclusion, in this sample of 12-year-old children living in Puerto Rico intake of a number of micronutrients was below the recommended levels on average, implying that a high proportion of children are not meeting the guidelines. Micronutrient intake levels of calcium, magnesium, pantothenic acid, and vitamins A, D, E, and K from food and beverage sources were below IOM-recommended levels, most of which were significantly improved with MVMM supplement use. However, intake of important micronutrients for bone mass accretion, specifically calcium, magnesium, and vitamin K, were below the recommended level even with supplement use. Therefore, public health measures to improve micronutrient intake from diet and educate on proper use of dietary supplements in children in PR are needed.

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Figure 1. Intake of minerals in MVMM users compared to non-users in the total sample
 A. Mean intakes of calcium and magnesium; B. Mean intakes of copper, iron, and zinc. Dashed line represents the Estimated Average Requirement (EAR) for each nutrient. The EAR for iron differs by gender (5.9 for boys and 5.7 mg/d for girls); the dashed line represents the midpoint of the two guidelines (5.8 mg/d). ‡Significantly higher intake compared to non-users in the total sample from food and beverage sources only by T-test ($p < 0.05$). *Significantly higher intake compared to non-users in the total sample when MVMM supplements are added by T-test ($p < 0.05$).

Figure 2. Intake of hidro-soluble vitamins in MVMM users compared to non-users in the total sample

A. Mean intakes of thiamin, niacin, riboflavin, pyridoxine, and pantothenic acid. B. Mean intakes of folate and cobalamine. C. Mean intake of vitamin C. The dashed line represents the EAR for each nutrient except for pantothenic acid (Adequate intake (AI)). †Significantly higher intake compared to non-users in the total sample form food and beverage sources only by T-test ($p < 0.05$). *Significantly higher intake compared to non-users in the total sample when MVMM supplements are added by T-test ($p < 0.05$).

Figure 3. Intake of lipo-soluble vitamins in MVMM users compared to non-users in the total sample

A. Mean intakes of vitamins E and K and; B. Mean intake of vitamin A and D. The dashed line represents the EAR for each nutrient except for vitamin K (AI). EAR for vitamin A differs by gender (445 for boys and 420 mg/d for girls); the dashed line represents the midpoint of the two guidelines (433 mg/d). ‡Significantly higher intake compared to non-users in the total sample from food and beverage sources only by T-test ($p < 0.05$).

*Significantly higher intake compared to non-users in the total sample when MVMM supplements are added by T-test ($p < 0.05$).

Table 1

Sample characteristic by MVMM supplement use status.

Characteristic	Total Sample N=732	Non-Users N=664 (90.7%)	MVMM Users N=68 (9.3%)	P value
Sex				
Male	335 (45.8)	307 (46.2)	28 (41.2)	0.425
Female	397 (54.2)	357 (53.8)	40 (58.8)	
School Type[*]				
Public	575 (78.6)	535 (80.6)	40 (58.8)	<0.0001
Private	157 (21.4)	129 (19.4)	28 (41.2)	
Region				
Metropolitan	317 (43.3)	284 (42.8)	33 (48.5)	0.326
Coast	330 (45.1)	305 (45.9)	25 (36.8)	
Central	85 (11.6)	75 (11.3)	10 (14.7)	
BMI^{*I}				
Underweight/Healthy weight	426 (58.5)	377 (57.2)	49 (72.1)	0.049
Overweight	135 (18.5)	125 (18.9)	10 (14.7)	
Obese	167 (23.0)	158 (23.9)	9 (13.2)	

* Significant differences between MVMM users and non-users by Chi-Square analysis (p<0.05).

^I BMI data are missing for 4 MVMM non-users; healthy weight category includes 23 participants that were underweight.

Table 2

Mean intake of micronutrient in the total sample and by gender.

Micronutrient	Total Sample N=732	Boys N=335 (45.8%)	Girls N=397 (54.2%)	P value ¹	IOM Guidelines (EAR or AD) ²
<i>Minerals</i>					
Calcium (mg)	618±341	657±359	585±322	0.004	1100
Magnesium (mg)	158±62.2	166±62.8	152±61.0	0.002	200
Copper (mg)	0.76±0.35	0.81±0.38	0.76±0.33	0.002	0.540
Iron (mg)	9.95±4.16	10.45±4.21	9.54±4.08	0.003	5.9M/5.7F
Zinc (mg)	7.94±3.74	8.32±3.87	7.62±3.60	0.011	7.0
<i>Vitamins</i>					
Thiamin (mg)	1.27±0.55	1.35±0.57	1.23±0.52	0.0001	0.7
Niacin (mg)	15.6±7.3	16.7±7.8	14.7±6.7	0.0001	9.0
Riboflavin (mg)	1.38±0.62	1.45±0.64	1.32±0.61	0.004	0.8
Pyridoxine (mg)	1.24±0.63	1.31±0.62	1.19±0.62	0.006	0.8
Pantothenic Acid (mg)	3.37±1.49	3.58±1.54	3.30±1.43	0.001	4.0
Folate (mcg)	249±125	259±121	241±128	0.046	250
Cobalamine (mcg)	3.23±2.97	3.33±2.37	3.15±3.40	0.431	1.5
Vitamin A (mcg)	346±317	363±332	331±303	0.172	445M/420F
Vitamin C (mg)	88.8±236	96.0±305	82.7±157	0.446	39.0
Vitamin E (mg)	4.41±2.75	4.53±2.80	4.31±2.71	0.290	9.0
Vitamin K (mg)	39.7±23.8	39.6±22.4	39.8±24.9	0.903	60.0
Vitamin D (mcg)	4.41±3.24	4.66±3.21	4.20±3.26	0.055	10.0

¹ T-test (p<0.05).² Reported IOM guidelines for all micronutrients are EAR except for pantothenic acid and vitamin K (AD). M: Males; F: females.