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Nutrition intervention and adequate hygiene practices to improve iron status of vulnerable preschool Burkinabe children

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Abstract

Objective: To determine the impact of an intervention that combined an increase in dietary and bioavailable iron intakes and an improvement in hygiene behaviors on the iron status of preschool children from Burkina Faso.

Methods: Thirty-three orphans and vulnerable children from 11 families who were 1–6 y old, were non-anemic, or had mild to moderate anemia were enrolled in an 18-wk trial. Using the probability approach for planning diets in an assisted-living facility, bioavailable iron intake was increased from 0.4 to 0.9 mg/d by increasing the amounts of meat and citrus fruits and by adding iron-rich condiments to the diet, for an estimated cost of U.S. $0.59/mo. Hygiene behaviors were modified by implementing hand-washing before meals and by the use of individual plates for meals. Iron status indicators were measured twice and means at enrollment and after intervention were compared.

Results: After intervention, hemoglobin concentration increased from 98.7 to 103.8 g/L ($P = 0.006$). There was a decrease in total iron binding capacity (107 to 91 μmol/L, $P = 0.05$) and a marginal increase in transferrin saturation (13% to 17%, $P = 0.06$). Significant improvement was not observed for serum ferritin concentration or prevalence of depleted iron stores, likely due to the confounding effect of infection. Anemia and iron-deficiency anemia were decreased from 64% to 30% and from 61% to 30%, respectively.

Conclusion: Dietary modification associated with adequate hygiene behaviors could be a relevant strategy to control iron deficiency and anemia in areas where infection is a major health problem.

Keywords: Bioavailable iron; Dietary intervention; Hygiene behaviors; Infection; Iron-deficiency anemia; Preschool children

Introduction

In 1990, the World Summit for Children set goals for alleviating micronutrient deficiencies worldwide. Since that period, substantial efforts have been made and major advances have been achieved in the treatment and prevention of vitamin A and iodine deficiencies. However, for iron deficiency, there is no sign of progress. Indeed, iron-deficiency anemia still affects 40% to 60% of children in most developing countries, and the goal of reducing "by one-third the prevalence of iron-deficiency anemia among women and children by 2010" is unlikely to be met [1]. The health, behavioral, and economic liabilities of iron deficiency for young children are well known and include delayed cognitive functioning, poor immune function, and decreased physical performance and productivity [2].

The limited success in the prevention of iron deficiency and anemia is due to a multitude of factors such as limited implementation of effective interventions, ineffective communication, and the complex etiology of anemia [3,4]. Indeed, many causes of anemia have been identified and these causes vary among different countries. Four main strategies have been considered, alone or in combination, to overcome iron deficiency and anemia: 1) dietary enhancement, diversification associated with dietary education; 2) food fortification including biofortification; 3) iron supplementation;

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and 4) global public health measures. Dietary enhancement has many advantages over other strategies in relation to compliance, absence of adverse effects, sustainability, and improvement of other nutrient intakes. However, few studies have investigated the feasibility and effectiveness of such a strategy in developing countries. Results of intervention studies for preschool children that have been published are mitigated because of the confounding effects of infections [5,6].

Certain intervention trials have shown that providing adequate iron through iron supplementation or food fortification as a single measure would be insufficient to control iron-deficiency anemia in developing countries, where malaria and intestinal parasites occur commonly with multimicronutrient deficiencies [7,8]. Deworming and malaria control have been suggested as additional measures in such conditions [9]. Findings from community-based interventions have suggested that changing hygiene behaviors can lower childhood diarrhea and respiratory infections [10,11]. Therefore, we hypothesized that preventive measures aiming at reducing the risk of infections and improving dietary and bioavailable iron intakes could effectively improve iron status in countries such as Burkina Faso, where the etiology of anemia is multifactorial. To address this hypothesis, we designed a nutritional intervention that combined an increase in dietary and available iron intakes and an improvement of hygiene behaviors in vulnerable preschool children from rural Burkina.

Materials and methods

Participants

The study participants were orphans and vulnerable children from group foster homes in Guiloungou, a village located in central Burkina Faso, 40 km east of Ouagadougou, the capital city [12]. The inclusion criteria were an age 12–71 mo, no major illnesses, residing in the home for more than 1 mo, and a caregiver's consent. Criteria for exclusion were severe anemia (hemoglobin [Hb] $\leq$80 g/L), severe undernutrition (at least one z-score < -3), human immunodeficiency virus, and mental disability. In addition, children who formerly took iron/folic acid supplements within the previous 2 mo before enrollment were not included in the intervention, and the use of these supplements was discontinued for those participating in the study.

The study protocol was approved by the national ethics committee for health research of the Ministry of Health (Burkina Faso) and Laval University ethics committee for research (Canada). We did not include a control group because we believe that in Burkina Faso, where 92% of preschool children were anemic in 2003 [13], a placebo-controlled study is unethical due to the deleterious and irreversible effects of iron deficiency at this age [14]. An alternative could have been an iron-supplementation group. However, routine supplementation with iron and folic acid has been associated with higher rates of adverse events among children in infection-endemic areas [15].

Methods

Nutritional intervention

In this area of Burkina Faso, all family members eat together from a communal dish. Therefore, we used a group-eating approach with units of consumption (UCs) to estimate the nutrient intakes of children [16,17]. The food consumption of each family was weighed over 3 non-consecutive days. Individual intakes of each child were estimated by multiplying the overall consumption of its family by the ratio UCi/$\sum$UCs, where UCi is the unit of consumption of this child and $\sum$UCs is the sum of UCs of all individuals participating in the meal. The following UCs were used: UC = 1.0 for male particpants older than 14 y, UC = 0.8 for female participants older than 10 y, and UC = 0.3 + (0.05 $\times$ age [years]) for boys 14 y or younger and girls 10 y or younger [18]. At baseline, we used an iron-absorption rate of 3.5%, which represents the average from the World Health Organization/Food and Agriculture Organization (WHO/FAO) recommendation (5%) [19] and the bioavailability estimation (2%) for Moroccan preschool children from Zimmermann et al. [18]. After intervention, when amounts of iron-absorption enhancers were increased in the diet (meat factor 13 to 27 g/d and vitamin C 14 to 43 mg/d), we used a bioavailability of 5%.

The probability approach for planning diets for homogeneous groups in an assisted-living facility was used for dietary modification [20]. This approach includes 1) setting the specific nutritional goal (acceptable prevalence of inadequacy and the risk of excessive intake for the nutrient), 2) estimating the target usual intake distribution for the nutrient, 3) planning a menu (i.e., what foods to offer and how much) to achieve the target usual intake distribution, and 4) assessing the implementation of the plan.

We targeted bioavailable iron intake and set the prevalence of inadequacy to 10% (i.e., 10% with intakes below the estimated average requirement). Thus, intakes of bioavailable iron had to be increased by the amount required to reduce the proportion of inadequate intakes to 10%. Details of the calculation are presented in Table 1. As observed in Table 1, the target medium intakes of bioavailable iron in our subjects at baseline were estimated at 0.61 mg/d for

Table 1
Estimation of target median intake of bioavailable iron to obtain 10% prevalence of inadequacy in preschool children

Age groups	EAR (mg/d)	Intake at 10th percentile*	EAR intake at 10th percentile	Median intake† (mg/d)	Target median intake (mg/d)
1–3 y	0.54	0.28	0.26	0.35	0.61
4–8 y	0.74	0.37	0.37	0.44	0.81

EAR, estimated average requirement.

* Based on usual intake at the 10th percentile from the continuing survey of food intakes by individuals from 1994 to 1996 and using 18% bioavailability [41].

† Median intake of bioavailable iron estimated from our baseline data.