# Dietary iron intake and iron status of young children

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**Aim.** To determine the prevalence of iron deficiency in healthy young children and whether there is an association between food habits and dietary iron intake and iron status.
**Methods.** 53 children aged 9-24 months were recruited into the study over a 12 month period from a general practice and Plunket child health clinics. Children with intercurrent infections were excluded. Iron status was determined from a full blood count and iron studies. Nutrient intake was assessed by a 24 hour food recall and dietary history questionnaire with nutrient analysis using the New Zealand Food Composition database from the New Zealand Institute of Crop and Food Research Ltd.
**Results.** 10 children (20%) were anaemic (haemoglobin <110g/L) and 7 children were iron deficient (serum ferritin <10μg/L). The daily mean iron intake was 5.1±3.1mg, which was 0.66 RDI for 9-12 months, and 0.80 for 12-24 months. There was no statistically significant relationship between iron status and food iron intake. Children in the top quintile for iron intake (mean 17.5 mg/day) consumed iron mainly from iron-fortified formula and baby food whereas the main source of iron in the lowest quintile (mean intake 2.0mg/day) was from a diverse range of foods including vegetables, bread and bakery goods, dairy products, breakfast cereals and fruit. In this group only one child consumed formula and three children consumed baby foods.
**Conclusion.** A high prevalence of anaemia and of iron deficiency was found amongst the otherwise healthy children in the sample, without their being a relationship between dietary iron intake and either haemoglobin or serum iron indices, except for ferritin.

**Key words: Anaemia, children, iron deficiency, iron intake, New Zealand**

## Introduction

Iron deficiency is a well recognised health problem amongst New Zealand children. Numerous studies over the past thirty years have documented its prevalence particularly amongst infants and young children living in underprivileged circumstances and the children of the Maori and Pacific Islanders[1-5]. The current prevalence of iron deficiency in otherwise healthy young children is not known.

The major goal in screening children for iron deficiency has been to identify iron deficiency anaemia. However anaemia is only a late manifestation of iron deficiency, and nutritional anaemia is uncommon. The significant consequences of iron deficiency relate to the deficiency in tissue iron, and current interest centres on the evidence that iron deficiency impairs psychomotor development and cognitive function[6,7]. These deficits are of particular concern because they may accompany iron deficiency without anaemia, and it is not known whether they are reversible.

There are many factors which contribute to the high prevalence of iron deficiency in children living in underprivileged circumstances: breastfeeding of short duration, lack of availability of iron fortified formula or foods, inadequate or inappropriate weaning foods and lack of medicinal iron for prevention of iron deficiency. In developed countries the availability of dietary iron can be restricted by the early introduction of cow's milk in infancy and by an excessive cow's milk intake in young children. Milk not only displaces iron-rich foods from the diet, but the high levels of protein, calcium and phosphorus form insoluble complexes with iron in the intestine[8,9]. Social and cultural feeding practices such as tea drinking, recognised to be a problem among Pacific Island children, may exacerbate the problem[10].

The assessment of food iron intake in relation to iron status has not been included in previous New Zealand studies. A study was therefore planned to assess the prevalence of iron deficiency in healthy young New Zealand children, and to determine its relationship to dietary habits in the weaning period, the type of transitional foods used, and the amount of iron in the diet.

## Methods

The subjects comprised 53 healthy children aged between 9 and 24 months living in Auckland. This was an opportunistic sample recruited by a paediatrician and the general practitioners at the Green Bay Medical Centre, West Auckland, and by a community paediatrician at child health (Plunket) clinics around Auckland. Subjects were recruited between August 1992 and August 1993. Criteria for recruitment were attendance for minor non-infectious condition, immunisation, or a well-child check. Children with intercurrent infections were excluded.

The age range of children was evenly distributed between the age groups 9-12, 13-16, 17-20 and 21-24 months. There were slightly more females than males. The standard deviation score (SDS) for weight for males was

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-0.23, for females 0.08. The mean age of mothers in the sample was 29.4 ± 7.7years, slightly older than the mean age of mothers recorded in the Plunket National Child Health Study (NCHS) of 27.7 years[11] and in the December 1990 National Census of 27.2 years[12] (Table 2). There were fewer single mothers and Pacific Island and Maori mothers in the sample compared to mothers in the Plunket NCHS (Table 1). Based on the Elley-lrving Socio-Economic Index[13] there were fewer fathers in socioeconomic groups 1 and 2, and groups 5 and 6 in the sample compared to fathers in the Plunket NCHS (Table 1).

**Table 1.** Demographic characteristics of study group.

| | Years | n | Sample | Plunket[a] | Census[b] |
|---|---|---|---|---|---|
| **Maternal Age** | 20-24 | 5 | 9 | 21.2 | 23.2 |
| | 25-29 | 15 | 28 | 34.7 | 35.3 |
| | 30-34 | 14 | 26 | 27.9 | 24.6 |
| | 35-39 | 16 | 30 | 8.6 | 7.5 |
| | 40-44 | 3 | 7 | .9 | 1.0 |
| **Family Status (Living arrangements)** | | | | | |
| Alone with child | | 2 | 4 | 12 | na |
| With partner and child | | 14 | 26 | | na |
| With partner and children | | 35 | 66 | | na |
| Other | | 2 | 4 | 88 | na |
| **Socioeconomic status: Elley-lrving socio-economic index[C].** | | | | | |
| | 1 | 5 | 11 | | 7.5 |
| | 2 | 5 | 11 | 31 | 11.0 |
| | 3 | 17 | 37 | 51 | 23.0 |
| | 4 | 12 | 26 | | 33.0 |
| | 5 | 6 | 13 | 18 | 17.0 |
| | 6 | 1 | 2 | | 8.5 |
| **Ethnicity** | | | | | |
| Non Maori non Pacific Islander | | 47 | 89 | 82.3 | 86.9 |
| Maori | | 5 | 9 | 12.0 | 9.5 |
| Pacific Islander | | 1 | 2 | 5.7 | 3.6 |

a. Alison LH 1993; b. New Zealand Government Department of Statistics 1991; c. Elley WB, Irving JC 1985

Parents of eligible children were handed an information leaflet inviting participation in a screening test for iron deficiency in their child. Included was a brief description of the blood test and food intake questionnaire. Those who agreed to take part were advised that the principal investigator would contact them to arrange a home visit to administer the food intake questionnaire after the blood test had been taken. No dietary advice was given at this time.

Blood samples were taken at commercial laboratories. Nurses with experience in venepuncture took 5mL samples from each child. These were analysed at the central Auckland base of Diagnostic Laboratory .

The blood indices measured were serum ferritin, serum iron, total iron-binding capacity, transferrin saturation, haemoglobin (Hb), mean cell volume, mean cell haemoglobin, white blood count, neutrophils and lymphocytes.

Computer analyses of the results were forwarded within 24 hours to the requesting doctor who checked the results for any anomalies and these were not disclosed to the principal investigator until dietary intake data was obtained. Iron deficiency was defined by serum ferritin less than 10μg/L and anaemia was defined by haemoglobin less than 110g/L[14-16].

Food intake data were obtained by a qualified dietitian unaware of the child's iron status using the 24-hour recall method and a dietary history questionnaire. Food models, food photographs, and measuring devices were used to help the parent identify serving sizes of food consumed. Information about the child's milk feeding history and unstructured questioning to determine consumption of iron containing foods was recorded. Nutrient intake was analysed using the New Zealand Food Composition Database (NZ Institute of Crop and Food Research Ltd). The data from the 24-hour food recall was analysed by the programme Diet Cruncher: Diet Analysis software (R. Marshall. Nutricomp. Dunedin,1993). This uses the database from Foodfiles, the New Zealand Food Composition Database from NZ Institute of Crop and Food Research Ltd.

The results were analysed using univariate and multiple regression analysis through the SAS statistical package[17].

**Results**

From the total sample of 53 children tested, the ferritin level was not available for one child nor Hb from three. The median serum ferritin level was 23μg/L, mean 31.67 ± 27.9μg/L. The median Hb was 119.5g/L, mean 116.46 ± 9.67g/L. There were no differences in mean values across the age range of sub-samples at 9-12, 13-16, 17-20 and 21-24 months. Ten children (20%) had a Hb < 110g/L, and 7 had a serum ferritin < 10μg/L.

Breastfeeding was initiated in 94% of the sample, and this continued in 77% of infants at 9 weeks and in 22% at one year. Cow's milk was introduced at a mean age of 11 months, being the main type of milk drink by 19 months.

The daily mean iron intake was 5.1 ± 3.1mg, which was 0.66 RDI for 9-12 months, and 0.80 for 12-24 months. There was an increase in daily energy and macronutrient intake with age (Table 2).

**Table 2.** Mean (± SD) Daily Energy and Nutrient Intake by Age Group, Combined Sexes

| Age (months) | 9-12 | | 13-16 | | 17-20 | | 21-24 | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Energy (kJ) | 3625 | 650 | 4190 | 1259 | 4325 | 1531 | 4549 | 932 |
| Protein (g) | 27.6 | 8.4 | 31.6 | 10.3 | 38.7 | 16.3 | 41 | 12.2 |
| Fat (g) | 32.4 | 11.0 | 37.9 | 14.7 | 38.1 | 17.2 | 44.0 | 17.2 |
| Carbohydrate (g) | 121 | 37 | 139.5 | 59 | 141. | 451 | 139.8 | 32.5 |
| Fibre (g) | 8.3 | 5.4 | 7.8 | 4.3 | 7.3 | 4.8 | 10.1 | 5 |
| Vitamin C (mg) | 76 | 55 | 94 | 58 | 72 | 70 | 60 | 36 |
| Iron (mg) | 6.2 | 4.4 | 5.1 | 3.4 | 4.5 | 3.1 | 4.8 | 1.9 |

There was no statistically significant relationship between iron status and food iron intake. Using serum ferritin and Hb as the dependent variables, multiple regression analysis showed no statistically significant relationship between breastfeeding at 3 months, cow's milk feeding at 9 months, daily protein, vitamin C or iron intake.

The 10 children in the top quintile for dietary iron intake (mean 17.5mg) consumed iron from different types of food compared to children in the lowest quintile (mean 2.0mg). Children taking cow's milk as a main milk were over-represented in those in the lowest quintile. In the high iron intake group there were only two children aged 11 and 17 months taking cow's milk as a primary milk drink (50mL and 350mL respectively). In the low iron group there were seven children (mean age 17 months) taking a mean intake of 530mL. Those with the higher iron intake were predominantly formula fed with most of their iron coming from formula and commercial baby food. The 6 major food sources of iron in the study group (which contributed >5% of iron) were baby food, formulae, fast foods (fried fish, chicken and burgers), eggs, meat and breakfast cereals. There was no difference in haemoglobin levels between children with high iron intakes (mean Hb 115g/L) and low iron intakes (mean Hb 118g/L). The mean serum ferritin for children with high iron intakes was higher at 53mcg/L compared to 27mcg/L for children with low iron intakes ($p < 0.05$).

Eleven percent of mothers gave tea to their children, but the sample size prevented any conclusion being drawn from its potential effect as an inhibitor of iron absorption.

**Discussion.**

The results of this study show that iron deficiency with or without anaemia is common amongst otherwise healthy children towards the end of infancy and through the second year of life. Although there were marked differences in dietary iron intake according to food choices there was no relationship between dietary intake of iron and iron status.

The validity of results of dietary intake depend on the accuracy of the 24 hour food intake data. Potential errors include both qualitative and quantitative recording errors, memory distortions or under or over-estimation of food items since estimates of portion sizes by food models is not as accurate as weighing or measuring[18,19].

These findings are similar to other studies in which no association between nutrient intake and iron status has been demonstrated[20-22]. The arbitrary cut off points for haematological indices in young children, and the subtle dietary differences over a period of time, cannot be appreciated or quantified over a single day's observations but the present study combined 24 hour recall and dietary history data for a more representative example of food and nutrient intakes for each child. A longitudinal study would permit analysis of the differences in dietary intake during infancy and weaning and associated iron status.

Macronutrient intakes were similar to previous published studies of children of similar age[23]. The daily mean iron intake was 0.66 of the RDI for children aged 9-12 months and 0.80 of the RDI for children 12-24 months. This was similar to the daily intake of iron in Swedish children aged 12 months, which was found to be 0.80 of the RDI[24]. In Australian children aged between 6 months and 3 years the mean daily iron intake was 0.66 of the RDI for children under 12 months from low income families and 0.59 of the RDI for children of the same age from higher income families[25]. This difference was due to a higher intake of iron rich cereals in children from low income families.

Other studies have shown that infants fed cow's milk have lower intakes of iron and are more likely to have impaired iron status than formula fed infants, even with the addition of fortified weaning foods[26-28]. In this study, children who drank cow's milk had a lower iron intake compared to formula fed children, but there were no differences in iron status between the feeding groups. This may have been due to the small sample size.

Children in the highest quintile for dietary iron intake consumed iron from different types of food compared to children in the lowest quintile. For example, of the children in the high iron quintile there were only two children taking cow's milk as a main milk drink. They also had a higher vitamin C intake (153mg) compared to those in the low intake quintile (66mg) and their largest contribution of iron intake was from baby food and infant formula (80%). In the low iron intake group there were only three children who consumed baby foods and only one child consumed infant formula.

Establishing strategies for meeting the iron needs of young children requires knowledge of the iron content and the bioavailability of iron in various foods. Although the iron in breast milk is well absorbed, little iron is present. Most of the iron in the infant's diet consists of iron added in the commercial manufacture of infant foods, especially iron fortified formulas and infant cereals. Independent of gastrointestinal losses, infants fed cow's milk in the first half year of life remain at risk of iron depletion even when supplementary iron containing foods are used. Cow's milk contains low concentrations of iron, and studies in infants show that its absorption is poor[29]. There is a high concentration of calcium and phosphorus in cow's milk, more than double the level in breast milk and iron forms an insoluble complex with these minerals.

In conclusion, these results show that although iron deficiency and anaemia are common amongst otherwise healthy young children, and that dietary intake is highly dependent on transitional food choices, the relationship between iron deficiency and a low intake is obscure in this study group. With our current state of knowledge, this points out the importance of testing the effects of intervention or supplementation to determine what public health strategies may be needed to reduce the prevalence of iron deficiency.

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## 摘要

目的：确定健康儿童缺铁症的发病率以及饮食习惯和饮食摄入铁与铁营养状况之间的关系。

方法：作者在十二个月的时间里研究了 53 名九至二十四个月的婴儿。其中不包括目前已受感染的婴儿。母亲的种族亦记录在案，其中有五名为毛利族母亲(9%)，一名为来自太平洋群岛的母亲。其余均为非毛利，非太平洋群岛母亲。血液中铁的分析决定了铁营养状况。营养摄取通过 24 小时食物记录和饮食历史问答来测定，并运用了 New Zealand Institute of Crop and Food Research Ltd.的新西兰食品成分资料库进行营养分析。

结果：10 名儿童(2%)患有贫血（血红蛋白<110g/L)，7 名儿童患有缺铁症（血清铁蛋白<10ug/L)。每日铁摄入量为 5.1±3.1 毫克，即 9-12 月的儿童为 0.66RDI，12-24 月的儿童为 0.80. 从统计上看，铁营养状况和食物铁摄入之间并没有必然的联系。铁摄入量最多的儿童(17.5 毫克/天）主要从婴儿牛奶和婴儿食品摄取铁质。而铁摄入量最少的儿童则是从不同食物，包括蔬菜，面包，乳制品，早餐麦片和水果中摄取铁质。在这组儿童中只有一名儿童服用婴儿牛奶，三名儿童服用婴儿食品。

结论：在其他方面均健康的儿童中发现了贫血的高发病率，食物摄入和铁营养状况之间并无关联。



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