BODY IRON RESERVES OF RURAL AND URBAN GUATEMALAN WOMEN OF REPRODUCTIVE AGE[1, 2]

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SUMMARY

Body iron reserves (using serum ferritin as an index), hematological status, and other indicators of iron nutrition were evaluated in three groups of non-pregnant nulliparous women with ages comprised between 14 and 29 years ($\bar{x}$ = 19 years). The first group (n = 33) included residents of the rural

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coastal area (< 750 m above sea level) (group RCG); the second (n = 32) from the rural highlands (751-1,500 m) (group RHG); and the third group (n = 104) from urban Guatemala City (1,500 m) (group UG). The women in the UG group belonged to the middle or high socioeconomic stratum. Median values in serum ferritin levels (ng/ml) for each group were: RCG = 11.5 (undetectable 50.6); RHG = 17.2 (1.9-83.1) and UG = 20.2 (3.9-56.7). The difference between RCG and UG was statistically significant ($P < 0.05$). The percentage of women with serum ferritin levels $\leqslant 9$ ng/ml (iron deficiency) was 45 in the RCG, 25 in the RHG and 12 in the UG group. In addition, the prevalence of subnormal hemoglobin levels (below $\bar{x} - 1$ SD) was 46o/o in the RCG, 12o/o in the RHG and 8o/o in the UG. There were no cases of subnormal blood folate levels. As results indicate, the women studied had low iron reserves, the rural coastal group being the most affected. They also evidenced the high prevalence of iron deficiency in the region and the need for public health actions to overcome this nutrition problem.

INTRODUCTION

Iron deficiency anemia continues to be an important nutrition problem throughout the world, particularly in the developing countries (1). One of the most vulnerable groups to this nutritional malady is that of women of reproductive age whose iron requirements are known to increase especially during pregnancy (2).

In addition to the well-recognized deleterious effect of anemia on physical work capacity (3, 4), it has been found that during pregnancy, anemia negatively affects the woman herself as well as the fetus (1, 5). They also experience a high incidence of abortion and premature delivery; and when anemia becomes severe, the likelihood of perinatal mortality is significantly increased (7). Human studies also suggest that maternal anemia negatively affects fetal growth rate and birth weight (8), hemoglobin mass (9), and the iron body reserves of the neonate (10).

In some developing regions of the world, the fulfillment of the woman's increased demand for iron is jeopardized by several factors such as a limited availability of dietary iron, poor environmental living conditions, and low socioeconomic level.

The purpose of the present study was to estimate the iron body reserves of nulliparous rural and urban Guatemalan women of reproductive age living under different geographic and socioeconomic conditions. It was borne in mind that at this stage of

life, stored iron represents the amount of iron reserves available for facing pregnancy and lactation.

METHODS

Three groups of Guatemalan women of reproductive age were studied, two from the rural and a third from the urban areas. One of the rural groups was comprised of 33 women resident of the so-called "coastal area" (communities of Masagua and El Milagro), located at an altitude of less than 750 m above sea level. The other was formed by 32 women resident of the so-called "Highland area" (communities of Santa Cruz Naranjo and Pueblo Nuevo Viñas), located between 751 and 1,500 m above sea level. The urban group was formed by 104 women resident of Guatemala City, at an altitude of 1,500 m above sea level. The women in this latter group belonged to a middle or high socioeconomic class, and were apparently well-nourished and in good health. All women were native Guatemalans and had lived in the communities studied for more than two years. Their ages were 14-29 years in the rural coastal group (mean, 18 years), 14-29 years in the rural highland group (mean, 19 years), and 16-25 years in the urban group (mean, 19 years). Furthermore, in order to eliminate factors that may positively or negatively influence iron nutriture, the women included in our study had to meet the following characteristics: a) be *nulligravidae;* b) never had spontaneous or induced abortion; c) be without present morbidity; d) no major surgery undergone during the previous 12 months; e) not taking iron supplements or consuming iron-fortified foods; f) had no hemorrhage, blood donations or blood transfusions in the 12 months prior to the investigation; g) not presently using intrauterine devices or taking oral contraceptives; and h) never had amenorrhea but experiencing instead regular menstrual cycles in terms of duration and intensity.

A 10 ml blood sample was obtained from the antecubital vein of each woman under fasting conditions. In this sample, the following hematological and iron parameters were measured: a) hematocrit, hemoglobin and red cell count by standard methods using a cell counter; this information was used to calculate mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC); b) free erythrocyte protoporphyrins by the micro-method of Piomelli

(11, 12); c) whole blood folates by the microbiologic method using *Lactobacillus casei* (13); d) serum ferritin, to be used as index of iron stores by the method of Addison *et al.* (14) as modified by Miles *et al.* (15); e) serum iron, total iron binding capacity (TIBC) and per cent saturation of transferrin (%oST) according to Ramsay (16).

Data Analysis

The serum ferritin data were analyzed by both parametric and non-parametric statistics. Since the ferritin levels did not follow a normal distribution, in order to apply parametric analyses, they were treated logarithmically. Normality was attained by adding to each ferritin value the arbitrary number 50, and then obtaining their respective natural logarithm. Thus, means and standard deviations were obtained and comparisons between groups were made by paired "t" tests. The non-parametric analyses were performed by comparing the respective medians –first and fourth quartiles of the three groups– using paired Chi^2 tests. Furthermore, the percentage of women in each group with serum ferritin levels less than or equal to 9 ng/ml was also determined. This ferritin level corresponds approximately to 90 mg of iron reserves, and is the cut-off point below which women of this age are considered to be iron deficient (17, 18).

Since the communities studied were located at different altitudes, the hematological data were analyzed by comparing the results obtained with preestablished standards for the Central American region (19). For this purpose, the percentage of women in each group below the expected mean values minus one standard deviation was determined. According to Viteri, Tuna and Guzmán (19), this approach identifies individuals at risk, with a significant probability of having abnormally low values of hematological parameters and, thus, of belonging to an anemic population. We preferred to use this criterion instead of a given "normal" limit, because, as is widely known, the anemic and non-anemic populations overlap at the lower distribution level of hematological values in non-anemic populations. The prevalence of abnormal levels of iron biochemical parameters (other than ferritin) and blood folates was analyzed using the same procedure as for hematology, with the exception of protoporphyrins, which were compared with the mean value for free erythrocyte protophorphyrin observed in normal populations by Cook and Finch (20).

In the latter case, and also in regard to TIBC levels, the mean plus one standard deviation was used instead, as the cut-off point above which the percentages of abnormally high values of these parameters were determined.

RESULTS

Figure 1 shows the frequency distribution of serum ferritin levels. An important difference was the distribution of cases in the range of low serum ferritin levels. Values below 5 ng/ml of ferritin were: 2o/o in the urban group, 10o/o in the rural highland group and 34o/o in the rural coastal land group. High ferritin levels ($>$ 40 ng/ml) were approximately equal in the urban and rural highland groups. The percentage of cases in this category of ferritin levels, however, was lower in the coastal area group. Notice in this Figure that there was a shifting of the median value toward the left in the rural groups when compared with the urban, indicating a detriment of the overall iron status, from high values for urban to low values in the rural areas, particularly in the coastal region.

The arithmetic mean and median ferritin values for each group of women are presented in Table 1. Based on the logarithmic treatment of the data, it was found that, on the average, the urban group of women had a significantly higher difference when compared with the rural highland group. Furthermore, the median value was higher for the urban women than were the respective medians of the other two groups. As a whole, these differences were significant only between the urban and rural coastal groups ($P < 0.05$). When comparing the frequency of distribution of ferritin levels among different quartiles, however, the rural coastal land group had a significantly higher frequency of cases in the first quartile than those found in the same category for the rural highland and urban groups. In the coastal area, the serum ferritin values ranged from undetectable levels to 50.6 ng/ml.

Figure 2 shows the percentage of women in each group with ferritin levels equal to or less than 9 ng/ml. Based on this criterion, the prevalence of iron deficiency or depleted iron reserves was 12.5o/o in the urban, 25o/o in the rural highland and 45o/o in the rural coastal land groups. In other words, the prevalence of iron deficiency in the coastal area was nearly twice that in the rural

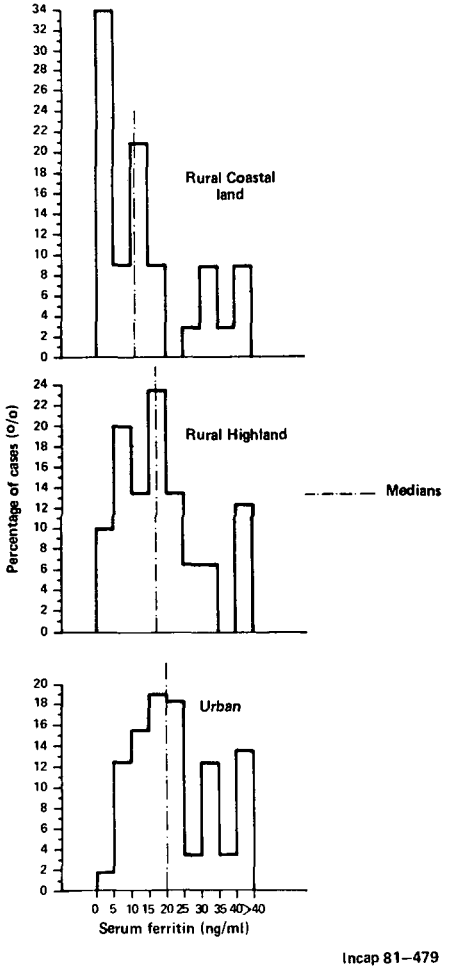

FIGURE 1

Distribution of cases by categories of serum ferritin levels in the different groups of women

TABLE 1

SERUM FERRITIN LEVELS IN THE DIFFERENT GROUPS OF WOMEN

Group	n	$\bar{x} \pm SD$	Median
Urban	104	$23.0 \pm 13.0^{a*}$	20.2^{a} (3.9 – 56.7)**
Rural highland	32	22.0 ± 19.0^{a}	17.2^{a} (1.9 – 83.1)
Rural coastal land	33	14.9 ± 14.3^{b}	11.5^{b} (0.0 – 50.6)

* Values with different superscript letters in vertical columns are significantly different ($P < 0.05$ or better).

** Range.

highland, and the prevalence in the latter group, in turn, was double that in the the urban group. These differences were all statistically significant ($P < 0.05$)..

The average age for each one of the groups of women was very similar. Nevertheless, since there was a difference in the age range of the urban group (16-25 years) as compared to the rural groups (14-29 years), the effect of age on serum ferritin levels was investigated. For the age range between 14 and 29 years old, comprising all the women in this study (n = 169), no significant correlation ($r = -0.0557$) was found between age and serum ferritin.

The percentage of women below the expected preestablished "normal" values of hematocrit and hemoglobin, as defined in the present study, is shown for each group in Table 2. The prevalence of cases below these cut-off points for both hematological parameters followed the same trend as did ferritin values, equal or less than 9 ng/ml. The prevalence of subnormal hemoglobin levels was 7.6o/o, 12.5o/o and 45.4o/o for the urban, rural highland and rural coastal land groups, respectively. The prevalences of subnormal hematocrit values were lower than those of hemoglobin in

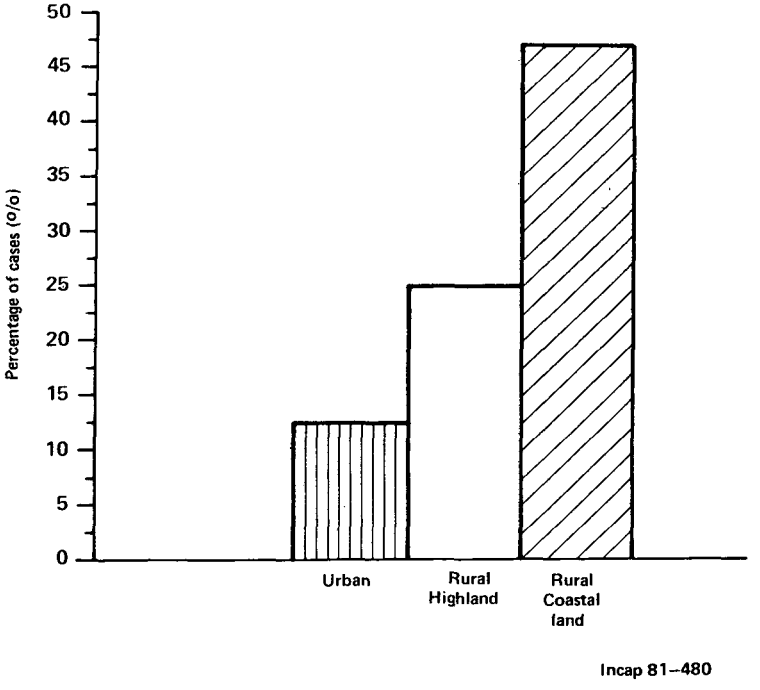

FIGURE 2

Percentage of women with serum ferritin levels $\leqslant$ 9 ng/ml.

each of the groups considered, but followed the same trend among the three groups. The prevalence of abnormal levels for the other hematological and iron parameters determined in this study is also presented in Table 2. None of the groups had subnormal blood folate levels. All the other hematologic indices and iron parameters however, revealed a clear indication of iron deficiency, especially in the rural groups.

TABLE 2

PREVALENCE OF "ABNORMAL" LEVELS OF HEMATOLOGICAL INDICES, IRON PARAMETERS AND BLOOD FOLATES ACCORDING TO PREESTABLISHED STANDARDS*

Parameters	Urban group (n: 104) %	Rural groups	
		Highland (n: 32) %	Coastal land (n: 33) %
Hemoglobin	7.6	12.5	45.4
Hematocrit	3.8	6.2	36.3
MCV	0.0	0.0	56.6
MCH	0.9	0.0	36.3
MCHC	2.9	3.1	21.2
RBC protoporphyrin	4.0	18.7	39.3
Serum iron	16.3	37.5	60.6
TIBC	0.0	6.2	12.1
% ST	25.9	40.6	66.6
Blood folates	0.0	0.0	0.0

* Viteri, Tuna and Guzmán (19), Cook and Pritchard (20) (protoporphyrin). See text for criterion.

DISCUSSION

As the results indicate many of the women studied, whatever their place of residence or socioeconomic status, had low iron body reserves. The low reserves of this mineral in women with the characteristics described in the present study may be attributed in part to the fact that several of them had just finished a period of rapid growth, and to the iron losses caused by menstruation. The loss of iron through the menstrual period has been estimated to be approximately 200 mg per year, or even more (21). In addition to these physiological factors, in many parts of the world, especially in rural areas, the dietary iron intake is limited and of poor biological availability. The lack of a significant correlation between age and serum ferritin levels also suggests that the differences in iron stores observed in the three groups studied were not related to the women's age distribution.

There are no other studies of this nature performed in Central America, therefore, no comparison can be made between our ferritin values and those likely to be found in other Central American areas. However, when comparing our results with those found in women of reproductive age in developed countries, the average ferritin values in any of the groups are lower than those reported for the developed world. Studies conducted by Cook *et al.* (18) and Halliday *et al.* (22) have shown that the average serum ferritin value for normal North American women of reproductive age is 34 ng/ml. An average value of 29 ng/ml has been reported by Seiler *et al.* (23) for the same region. In our findings, the highest average for serum ferritin was 23 ng/ml, which corresponded to the urban women of middle or high socioeconomic class. Furthermore, our highest individual ferritin value was 82 ng/ml, while the highest values found by Cook *et al.* (18), Halliday *et al.* (22) and Seiler *et al.* (23) were 125, 143 and 233 ng/ml, respectively. The lower iron reserves in our population, particularly in the rural area, are undoubtedly related in part to the habitual dietary patterns. The Guatemalan rural diets are mainly of vegetable origin and thus contain little heme iron and high amounts of inhibitors of iron absorption such as oxalates, phytates, tannins and fiber. On the other hand, developed countries normally consume various iron-fortified foods such as cereals and flours and greater quantities of foods having more biologically available iron.

The results obtained in the study herein reported also show that even in the group of women belonging to the middle or high socioeconomic class, there was a 12% prevalence of iron deficiency as defined by serum ferritin levels. This finding points out the risk that women have of developing iron deficiency anemia during pregnancy. This is true particularly during the third trimester, as illustrated by the high prevalence of anemia (38.5%) found several years ago through a collaborative study of anemia which was carried out in Latin America (24). In this context, the present findings support the recommendation made by international agencies, such as WHO, in the sense that all pregnant women should receive iron supplementation as a public health measure in areas where anemia is highly prevalent (25).

The seriousness of the iron deficiency problem was greater in the coastal area group than in the rural highland and urban groups. There are no data in our study to explain specifically this marked difference. Nevertheless, evidence exists in the literature indicative that, although the overall iron intake in the coast is similar in

quantity to that in the highland, the diet in the coastal region contains less heme iron (26). In addition, it has been shown that in the coastal areas there is a higher prevalence of intestinal parasitic infestation, including hookworm (27).

The hematological data also indicate the existence of women at risk of being anemic in the three groups. The hematocrit and hemoglobin levels, however, were not as sensitive as ferritin for detecting iron deficiency, especially in the groups with lower prevalences. This illustrates the importance and high sensitivity of serum ferritin as a direct index of iron-nutritional status even before the development of anemia. Of the two classic hematologic parameters, however, hemoglobin was more sensitive than hematocrit. A similar observation has been reported in a recent publication (28).

As shown in Table 2, no deficiency of folates was found in any of the women indicating that the lack of this vitamin is not an etiological factor of anemia in the type of population studied, except as documented during pregnancy by others (24). In contrast, the hematological indices (MCV, MCH and MCHC) and all the other iron parameters measured, clearly indicate that the subnormal levels of hemoglobin and hematocrit observed are due primarily to a lack of iron. These observations are in agreement with the ferritin data, showing that iron deficiency is an important nutritional problem of the area. Public health actions should therefore be implemented to reduce its prevalence, particularly in coastal zones.

RESUMEN

RESERVAS CORPORALES DE HIERRO DE MUJERES GUATEMALTECAS DE EDAD REPRODUCTIVA, PERTENECIENTES A LAS AREAS RURAL Y URBANA

Las reservas corporales de hierro (usando ferritina como indicador), el estado hematológico y otros indicadores sanguíneos de la nutrición de hierro, fueron evaluados en tres grupos de mujeres nulíparas, no embarazadas, de 14 a 29 años de edad ($\bar{x}$ = 19 años). El primer grupo (n = 33) estuvo constituido por residentes del área rural de la costa (> 750 m sobre el nivel del mar) (Grupo GRC); el segundo (n = 32), por residentes del área rural del altiplano (751-1,500 m) (Grupo GRA); y el tercero (n = 104), por residentes de la ciudad de Guatemala (1,500 m) (Grupo urbano, GU). Las mujeres del grupo GU

pertenecían a la clase socioeconómica media o alta. Las medianas encontradas para los niveles de ferritina sérica (ng/ml) en cada grupo fueron: GRC = 11.5 (imperceptible — 50.6); GRA = 17.2 (1.9 — 83.1); y GU = 20.2 (3.9 — 56.7). La diferencia entre el grupo GRC y el GU fue estadísticamente significativa ($P < 0.05$). Los porcentajes de mujeres con niveles de ferritina sérica $\leqslant$ 9 ng/ml (deficiencia de hierro) fueron de 45 en el GRC, de 25 en el GRA, y de 12 en el GU. La prevalencia de niveles subnormales de hemoglobina (por debajo de $\bar{x} - 1$ DE) fue de 46% en el GRC, de 12% en el GRA, y de 8% en el GU. No se observaron niveles subnormales de folatos sanguíneos. Los resultados indican que las mujeres incluidas en el estudio poseen bajas reservas de hierro, siendo el grupo GRC el más afectado. Es evidente también la alta prevalencia de deficiencia de hierro en la región y la necesidad imperante de acciones de salud pública orientadas a resolver este problema.

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