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EVALUATION OF THE IRON STATUS IN NEPALESE LIVING IN SOUTHERN NEPAL

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ABSTRACT

This study examined serum protein and iron status of people aged 10 to 72 years living in the Itahari district (an industrial district, 40 males and 32 females) and in the Chitwan district (an agricultural district, 89 males and 82 females) in the Terai region of southern Nepal. The relationship between the results and food and nutrient intakes was also investigated. The mean values of weight were very low in both groups, which led to a low body mass index, 18-20. The mean values of serum total protein (TP) for the residents in the Chitwan district were higher than those of the Itahari ($p<0.05$) and in the latter, those for females were higher than males ($p<0.05$). Serum albumin (Alb) level did not differ significantly between the two groups and sexes. The mean values of serum iron (SI) were mostly within normal ranges, however those for Chitwan females were low. Unsaturated iron binding capacity (UIBC) and total iron binding capacity (TIBC) levels were much higher in the Chitwan than in the Itahari, therefore, the SI/TIBC ratio was lower in the former than in the latter and females in both groups also showed lower SI/TIBC ratio. These findings suggest that iron (Fe) intake for the Chitwan residents seems to be insufficient. The average amount of Fe intake in the Chitwan was lower, and about one-third of the residents, especially about half of the young women showed SI/TIBC ratios equal to or below 16%, offering support for the existence of iron deficiency. SI correlated negatively with UIBC. Serum TP and Alb associated with nutritional status correlated strongly with energy and protein rich food while Fe intake showed correlation with cereals, fish, meat and nutrients, except calcium. These findings indicate that the sufficient intake of food containing protein and energy can increase the level of Fe intake. Among legumes, black gram contained about 15 mg/100 g of Fe, showing that it could serve as a good food source of Fe because of its easy availability.

Keywords: Serum iron SI/TIBC ratio Serum proteins Food consumption Nepalese

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INTRODUCTION

Dietary surveys were carried out in an industrial district (Itahari district) in 1987 (1) and in an agricultural district (Chitwan district) in 1989 (2) in the Terai region of southern Nepal by the 24-hr dietary recall method of recording food consumption of the previous day. The majority of residents in the former district were industrial or commercial workers while in the latter, they were self-supporting but lived on a low income. The dietary patterns of the two districts were very simple and similar, but food consumption was greatly influenced by food habits, food availability and socioeconomic conditions. The average consumption of potatoes, milk and dairy products, legumes, and fats and oils in the former district was two times higher than in the latter, while the average amounts of colored vegetables and rice were much higher in the latter district (TABLE 1). As a result, calcium and iron intakes in the industrial district were higher while the intakes of vitamin A and C were lower. The average Fe intake in the agricultural district was 8 mg/day/person, which might be insufficient for the residents. Iron deficiency is still one of the most prevalent nutritional problems not only in many developing countries (3,4) but also in developed countries (5,6) in relation to anemia, which can be very serious for infants (4), young children (5,7-9) and pregnant women (10). There is little information concerning the iron status for Nepalese, therefore, this preliminary study was designed to assess the serum iron status for people living in the two districts and to examine the relationship among food and nutrient intakes and serum iron contents.

SUBJECTS AND METHODS

Fasting venous blood samples were obtained in the morning from apparently healthy subjects (10-72 years old, 40 males and 32 females in the Itahari district; 10-68 years old, 89 males and 82 females in the Chitwan district). Height and body weights were measured for all subjects, and body mass index (BMI) was calculated in weight/height^2 (kg/m^2).

Serum total protein (TP), albumin (Alb), iron (SI) and unsaturated iron binding capacity (UIBC) were measured by colorimetric method with clinical kits (TP by biuret reaction and Alb by bromocresol green eagent, Daiichi Chem. Co., Tokyo; SI and UIBC by nitoroso-PSAP method, Wako Pure Chem. Ind. Ltd., Osaka, Japan). Total iron binding capacity (TIBC) was calculated as the sum of SI and UIBC, and the SI/TIBC ratio (%) was calculated.

All results were expressed as mean $\pm$ SD. Student's t test was used to assess the statistical significance of the treatment difference. Pearson's correlation coefficients were computed to examine the relationship between the variables.

RESULTS

The mean values of height for males were significantly higher than those for females ($p<0.01$) in both groups, but there was no difference between the two groups (TABLE 2). The mean values of body weight for the Chitwan residents tended to be lower than those of the Itahari, especially those of females in the former were significantly lower ($p<0.01$). The mean levels of BMI were 20 for females in the Itahari district and around 18 for others.

The mean values of serum TP and Alb levels of the Itahari residents were 7.9 ± 0.6 and 4.5 ± 0.3 g/dl, respectively, while those of the Chitwan residents were 8.7 ± 0.6 and 4.6 ± 0.3 g/dl, respectively. The TP

TABLE 1.

Average Daily Food Consumption and Nutrient Intake of Persons Aged 10 to 72 Years.

	Itahari		Chitwan	
	Male (n=23)	Female (n=30)	Male (n=55)	Female (n=54)
Food group				
Cereals (g)	433±168	437±147	483±92*	433±115*
Rice (g)	378±172	374±159	464±80**	408±105**
Potatoes	115±57	98±83	67±91	53±82
Colored vegetables (g)	59±106	60±74	179±126	167±129
Milk & dairy products (g)	249±192	213±287	91±177	111±206
Fish (g)	13±34	7±22	13±31	13±33
Meat (g)	10±26	3±16	14±41	24±45
Fat & oils (g)	25±12	20±11	7±5	9±7
Nutrient intake				
Energy (kcal)	2427±572	2275±639	2340±526*	1930±457*
Carbohydrate (g)	419±117	410±124	449±96*	359±81*
Protein (g)	63.0±15.4	57.3±16.9	51.3±13.0	47.4±12.5
Fat (g)	50.0±18.4*	38.5±13.9*	23.0±9.8	26.1±13.8
Ca (mg)	612±272*	466±265*	412±228	395±237
Fe (mg)	13.1±4.3	11.9±4.2	8.5±3.4*	6.7±1.9*
Niacin (mg)	18.0±6.1	16.9±6.0	15.6±3.8**	14.2±3.5**
Vitamin C (mg)	101±87	79±54	120±59	114±63

Values are mean±SD. Significant differences between sexes in each group (*p<0.05, **p<0.01).

TABLE 2.

Physical Characteristics of Persons Aged 10 to72 Years.

	Itahari		Chitwan	
	Male (n=40)	Female (32)	Male (n=89)	Female (n=82)
Age (years)	27±17	24±11	27±13	27±11
Height (cm)	157±18*★	150±8*△	157±10#	149±6#★
Weight (kg)	46.8±16.1#	44.9±11.2★	44.8±10.0*	40.0±7.95*#★
Body mass index (kg/m^2)	18.3±4.1	19.7±4.1*#	17.7±2.3*	17.9±2.3#
Serum total protein (g/dl)	7.8±0.5*#☆	8.0±0.6*△▽	8.6±0.5#△	8.7±0.6☆▽
Serum albumin (g/dl)	4.5±0.3	4.5±0.3	4.7±0.3	4.6±0.3

Values are mean±SD.

Significant differences between the same superscript symbols (*,★,#,△,▽,☆ p<0.05).

level for the former was significantly lower than that of the latter (p<0.05), but the Alb level did not differ between the two groups. Significant differences were also observed between sexes in the Itahari residents with regard to levels of TP (p<0.05), which were higher in females (8.0±0.6 g/dl) than in males (7.8±0.5 g/dl) (TABLE 2). There was no difference between the two groups for the SI level, but UIBC and TIBC levels were much higher in the Chitwan residents than in the Itahari while the SI/TIBC ratio was lower in the former (TABLE 3). The SI level of Chitwan females (94±51 μ g/dl) was significantly lower than that of the males (102±41 μ g/dl) (p<0.05), while the UIBC of Itahari females (162±57 μ g/dl) was significantly higher than that of the males (133±48 μ g/dl) (p<0.05) (TABLE 3). The SI/TIBC ratio was higher in males than in females in both groups (p<0.05). The mean SI/TIBC ratio for the Chitwan aged 40-49 years male, 10-14 and 15-19 years females were 19.3±5.3, 19.6±11.0 and 18.5±12.3 μ g/dl, respectively which were very low among the subjects examined.

TABLE 3.
Serum Iron (SI) Levels of Persons Aged 10 to 72 Years.

Sex (age)	Subjects* (n)	SI (μ g/dl)	UIBC* (μ g/dl)	TIBC* (μ g/dl)	SI/TIBC ratio (%)
Itahari					
Male					
10-14	9	98±23	155±28	253±33	38.8±8.0
15-19	4	123±51	184±37	307±48	39.1±13.7
20-29	11	107±33	128±37	236±50	45.7±13.1
30-39	8	166±56	100±67	265±35	63.6±23.0
40-49	3	139±49	136±18	276±49	49.2±10.8
50-72	5	112±53	123±29	234±63	46.2±14.5
All	40	119±49	133±48*	252±45	47.0±17.0*
Female					
10-14	5	119±42	177±39	296±85	41.1±10.5
15-19	7	114±44	164±73	278±60	42.8±16.3
20-29	9 (1)	90±27	150±64	240±57	39.7±13.1
30-39	7	82±30	167±26	249±40	32.6±12.3
40-49	3 (1)	123±64	187±25	310±94	36.7±14.5
50	1	89	165	254	35.1
All	32 (2)	102±41	162±57*	264±63	39.4±13.7*
Chitwan					
Male					
10-14	17 (5)	90±31	324±54	415±48	21.9±7.3
15-19	15 (5)	100±36	364±78	464±59	22.1±9.0
20-29	26 (4)	134±49	304±100	437±71	31.8±12.7
30-39	12 (2)	119±35	324±100	442±71	28.3±11.4
40-49	9 (4)	87±30	362±67	450±82	19.3±5.3
50-68	10 (4)	117±85	319±162	432±96	31.0±28.2
All	89(24)	111±47*	328±96	439±69	26.4±13.9*
Female					
10-14	15 (7)	82±42	354±91	436±67	19.6±11.0
15-19	16 (8)	85±46	400±94	485±61	18.5±12.3
20-29	23 (10)	95±69	387±155	482±122	21.8±16.1
30-39	12 (3)	101±40	323±76	424±52	24.6±11.1
40-49	6 (1)	118±33	274±97	392±75	31.7±11.8
50-60	10(3)	100±42	333±93	432±68	24.0±10.7
All	82 (32)	94±51*	359±115	453±88	22.2±13.0*

*( )Numbers expressed equal or below 16% of SI/TIBC ratio.
*Abbreviations: UIBC, unsaturated iron binding capacity; TIBC, total iron binding capacity.
Significant differences between sexes in each group (*p<0.05).

The frequency distribution pattern of the SI/TIBC ratio for Itahari residents differed greatly from that for the Chitwan (FIG. 1). For the SI/TIBC ratio, the proportion of 20~55% of normal ranges in the Itahari district was much higher than that in the Chitwan district (75% in the former vs. 57% in the latter). The proportions of equal to or below 16% (abnormal levels) (11) and 17~19% of the SI/TIBC ratio in the Itahari were 3 and 5%, respectively, while those of Chitwan were 33 and 8%, respectively, which accounted for 40% of the residents.

TABLE 4 shows the correlation coefficients for the serum parameters examined. These values were

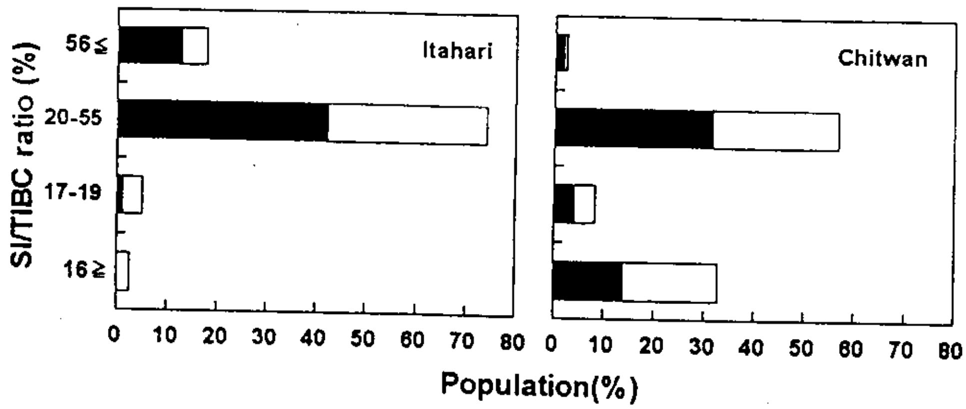

FIG. 1: Frequency Distribution Pattern of the SI/TIBC Ratio of the Subjects in Itahari (n=72) and Chitwan (n=171) districts, males (■) and females (□).

TABLE 4.

Correlation between Various Parameters Measured for Nepalese.

Parameter	Age	TP	Alb	SI	UIBC	TIBC	SI/TIBC
Age		–	0.03	0.08	−0.06	–	−0.10
Total protein (TP)	−0.06		0.56***	0.13	0.13	0.22	−0.13
Albumin (Alb)	−0.20*	0.62***		0.14	0.10	0.20	−0.14
Iron (SI)	0.11	−0.15	0.14		−0.40***	0.43***	0.39***
UIBC[a]	−0.12	0.35***	0.08	−0.72***		0.65***	−0.60***
TIBC[a]	−0.10	0.37***	0.21*	−0.34***	0.90***		−0.20
SI/TIBC ratio (SI/TIBC)	0.16	−0.26**	0.33***	0.94***	−0.86***	−0.57***	

*$p<0.05$, **$p<0.01$, ***$p<0.001$.

[a]Abbreviations: UIBC, unsaturated iron binding capacity; TIBC, total iron binding capacity.

Upper right: Itahari (n=72); lower left: Chitwan (n=171).

not influenced by age except Alb. There were significant positive correlations between TP and Alb (r = 0.62 for Chitwan and r = 0.56 for Itahari, $p<0.001$ for both groups, respectively) and between UIBC and TIBC (r = 0.94 for Chitwan and r = 0.65 for Itahari, $p<0.001$ for both groups, respectively), and a negative correlation between SI and UIBC (r = −0.72 for Chitwan and r = −0.40 for Itahari, $p<0.001$ for both groups, respectively). Significant correlations were found only in the Chitwan residents between TP and UIBC (r = 0.35, $p<0.001$), TP and TIBC (r = 0.37, $p<0.001$), TP and the SI/TIBC ratio (r = −0.26, $p<0.01$), Alb and TIBC (r = 0.21, $p<0.05$), Alb and the SI/TIBC ratio (r = 0.33, $p<0.001$), TIBC and the SI/TIBC ratio (r = −0.57, $p<0.001$). We found a positive correlation between SI and TIBC in the Itahari residents (r = 0.43, $p<0.001$) but a negative one in the Chitwan (r = −0.34, $p<0.001$). TABLE 5 shows the correlation between nutrient intake and serum parameters of the Chitwan residents. Fe nutrient correlated with cereals, fish, meat and the amounts of nutrient intake except Ca (TABLE 5). However, SI showed correlation only with cereals, rice and fat, and TIBC only with cereals and rice. TP correlated with fish, meat and protein, while Alb with milk and dairy products, meat, protein, Fe and niacin.

DISCUSSION

Generally, the food consumption and the average energy intake seemed to be adequate for residents of both districts as a whole (TABLE 1) although those of protein, Ca and Fe were lower in the Chitwan compared with those of other reports (24.4-26.2, 23-26 years, Samoan men) (13) (19.9-22.6 and 18.7-22.1, 10-21 years old for males and females, Australia, respectively) (14). These might be explained by the energy expenditure being greater than energy intake.

TABLE 5.
Correlation among Nutrient Intake and Serum Contents (Chitwan).

	TP	Alb	SI	TIBC	Fe intake
Food intake					
Cereals	0.07	0.06	-0.32**	0.21*	0.23*
Rice	0.13	0.11	-0.30**	0.25*	0.13
Colored vegetable	-0.01	0.05	0.02	0.16	-0.14
Milk & dairy products	-0.07	-0.26*	-0.19	0.04	-0.08
Fish	0.23*	0.17	0.01	-0.11	0.23*
Meat	0.26*	0.22*	-0.10	0.19	0.39***
Nutrient intake					
Energy	0.14	0.20	-0.03	0.05	0.77***
Carbohydrate	0.10	0.19	-0.02	0.05	0.71***
Protein	0.22*	0.23*	-0.11	0.06	0.79***
Fat	0.19	0.04	-0.28**	0.10	0.29**
Ca	-	-0.05	-0.09	0.13	0.17
Fe	0.09	0.22*	0.16	-0.08	1.00
Niacin	0.20	0.24*	-0.13	0.18	0.62***
Vitamin C	-0.04	-	0.12	0.07	0.22*

*p<0.05, ** p<0.01, ***p<0.001.
n=93 (44 males and 49 females).

The mean TP level for the Chitwan district was higher than those of children in Brazil (7.5 g/dl for 7 years old or less) (15) and Thailand (7.4 g/dl for 4-6 years old) (16). The average serum iron (SI) level did not differ significantly between the two groups and were mostly within normal ranges (109 ± 27 μ g/dl for males and 95 ± 22 μ g/dl for females) (17), however, UIBC and TIBC were markedly higher in the Chitwan district. We found that the mean UIBC and TIBC levels for young Japanese (n=103) were 173 ± 62 and 285 ± 47 μ g/dl, respectively (unpublished data). Judging from these results, Chitwan residents seemed to be insufficient for Fe intake which agreed with the results of lower Fe intake of the Chitwan residents (only about 60% of the Fe intake of the Itahari residents). This also supports the result of about one-third of the residents and especially about a half of the females the 10- and 20- year groups in the Chitwan district showing SI/TIBC ratio of equal to or below 16% (abnormal levels) (11) in this study, while only two persons showed such low SI/TIBC ratio in the Itahari district (TABLE 3). However, understanding the more precise iron status for the people will be require further investigation.

Age correlated negatively with Alb, which coincided with the report by Baumgartner et al (18). The strong correlations between Fe intake and energy intake, and between Fe intake and protein intake found in this study were also reported by Kurosaki (19). It is well known that serum TP and Alb levels are associated with the nutritional status of the people. These indicate that adequate amounts of food containing protein and energy are needed and the sufficient intake of such food can increase the level of Fe intake. Although the data are not shown, UIBC and the SI/TIBC ratio showed the same correlation among food groups and nutrients as TIBC and SI, respectively.

It is unknown that correlation between TP and UIBC, TP and TIBC, TP and the SI/TIBC ratio, Alb and TIBC, Alb and the SI/TIBC ratio were found in the Chitwan district but not in the Itahari. The negative correlation between SI and TIBC in the Chitwan was due to high level of TIBC in this district compared with in the Itahari. Fe intake correlated strongly with fish and meat, however, the amounts and frequency of fish and meat intake in this study were very low (TABLE 5). Although rice did not show correlation with Fe intake, rice consumption was very high and rice could be easily obtained by the people. About 400 g of half-polished rice contains about 3 mg of Fe calculated from food table of Japan, serving as a good source. One of iron rich food is black gram, which contains about 15 mg/100 g of Fe (unpublished data) and soups using many kinds of legumes (beans, peas and lentils) are very common dish. But, the phytic acid in rice and legumes inhibits Fe absorption by the body (20-22), and moreover, absorption of nonheme Fe contained in plant food is lower compared with heme Fe. On the other hand, potential iron bioavailability improves with vitamin C (23-24) and vitamin C intake seemed to be adequate for the people in this study. Parasitic infection also causes the iron-deficiency (25). We did not examined it in these areas, but 3.8 to 10.7 % of those in Kathmandu had hookworm infection (26,27). Parasitic infection should be prevented and supplementary foods should be added to improve local diet and nutritional status.

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