

HEMOGLOBIN, IRON, NUTRITION AND LIFE-STYLE AMONG ADOLESCENTS IN A COASTAL AND AN INLAND COMMUNITY IN NORTHERN NORWAY

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ABSTRACT

Background. Adolescents, influenced by modern youth culture, may have a diet containing too little iron and other vital nutrients.

Materials and methods. Adolescents from Finnmark county, situated well above the arctic circle in Norway, from a Sami culture, and from a coastal culture, were examined to study hemoglobin, iron stores, dietary composition, food habits and life-style. A short intervention with dietary instructions was made, followed by re-examination after one year.

Results. The inland adolescents had larger iron stores, higher dietary intake of meat and protein, and lower intake of sugar than coastal ones, in accordance with traditional Sami diets. All groups had too high intake of sugar and fat, and too low intake of vitamin D and fibre, compared to national recommendations. The adolescents hardly consumed fish. About 1/3 of them had a high dietary iron density, as well as higher concentrations of other dietary nutrients and a more health promoting life-style in general.

The short intervention did not have any effect on the magnitude of the iron stores, and only minor effects on food habits and life-style.

Conclusion. The adolescents from the Sami community still had a diet based on tradition. This was not found in the coastal community. The iron density in the diet may serve as an indicator of positive food habits and life-style in general. The modest effect of intervention, emphasizes the need for a creative, preventive medicine.

Keywords: Adolescents, nutrition, iron, lifestyle

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INTRODUCTION

International research has demonstrated that the diet of adolescents may be insufficient, especially concerning the iron content (1,2,3,4). The iron stores of the body may be too small, or even empty, particularly among menstruating girls.

Traditionally, the diets along the coast and in the inland of Finnmark county have differed, with a large consumption of seawater fish in the coastal communities and a substantial intake of meat, especially from reindeer, in the inland communities (5,6,7).

The present study was carried out to see if the traditional dietary patterns were maintained in a typical coastal community (Hammerfest) and a typical inland community (Kautokeino), to analyse the iron and nutritional statuses, to evaluate if the dietary iron content may be an indicator of a sufficient diet in general, to obtain an impression of the relationship between life-style and diet, and to evaluate the effectiveness of an intervention through school lessons aimed to improve dietary habits and life-style.

MATERIAL AND METHODS

Students (7th and 8th grade, 13 and 14 years old, n=232) in a coastal and an inland community in Finnmark county were examined with respect to hemoglobin concentration of the blood, serum ferritin (which correlates with the body iron stores), body weight and height, dietary habits, food composition and life-style.

The students from the inland community were mainly of Sami origin (> 85%), whereas the coastal students were defined mainly as Norwegian. The participation was voluntary, preceded by a written invitation to both the students and their parents. All the students gave a positive response.

Hemoglobin was analysed from whole blood with a Coulter T60 (modified cyanmethemoglobin method, Coulter Electronics, NY, USA) with an analytical coefficient of variation (CV) = 5% and analytical uncertainty of 10%. Serum was separated from blood samples by centrifugation and serum samples were frozen before analysis. S-ferritin was analysed by fluorescence immunoassay (FIA) (Baxter Stratus II immunoassay system), with a CV = 6% and analytical uncertainty of 12%. The CV of both assays was calculated by means of

internal controls (n=30). All the analyses were done in batch.

Dietary habits and composition, and life-style were analysed by means of a frequency questionnaire (91 questions, prepared in cooperation with the Research Centre for Health Promotion (HEMIL centre; senter for forskning om helsefremmende arbeid, miljø og livsstil), University of Bergen, Norway). The nutrient content was examined by a 3-day-food registration (standardised form, recorded Thursday - Saturday). The students had one hour of recording practice prior to the registration. The results were analysed at the Department of Nutritional Research, University of Oslo.

The study was approved by the Regional Board of Ethics.

Intervention

All students in 7th grade (n=117) were informed about the results of the hemoglobin and ferritin measurements of their own class. Thereafter five extra school lessons concerning these subjects were given by a trained clinical dietician, together with the usual teachers. Advice on general dietary habits and life-style was also emphasized.

After one year re-examination of hemoglobin, ferritin, dietary habits and composition, and life-style was carried out. The blood sampling and data collection were carried out in October, on both occasions.

Compliance

At the first examination (n=232, 7th and 8th grade, 13 and 14 years), 92% answered the frequency questionnaire, 80% participated in the blood sampling, height and weight measurements, and 47% completed the 3-day food registration.

At the second examination (n=117, 7th grade), 73% answered the frequency questionnaire, 71% participated in the blood sampling and 38% completed the 3-day food registration. The students that carried out the food registration at the first examination (7th and 8th grade, 13 and 14 years) were compared to those who did not, by means of the frequency questionnaire. There was no difference regarding intake of meat, fish, fruit, vegetables and alcohol, physical activity, or the regularity of lunch and dinner.

The group that completed the food registration consumed fewer daily sodas (7% vs. 26%), had a more regular daily breakfast (84% vs. 60%), and a smaller proportion smoked cigarettes on a daily basis (10% vs. 27%).

Statistical analysis

Statistical calculations were done using JMP statistical software (version 2.0, SAS). The Shapiro-Wilk W-test was utilised to examine the normal distribution of data. Otherwise, non-parametric tests were mainly used. Differences between groups were tested by means of Pearson's chi-square (nominal data) and the Wilcoxon rank sum test (interval and ordinal data). The covariation between continuous variables was examined by means of Pearson's product-moment correlation.

RESULTS

Weight, height, BMI (body mass index=kg/m²)

Table I (first examination) demonstrates that the boys (ages 13 -14 years) in the coastal community were significantly taller than the inland boys, while the BMI was significantly higher inland. Twelve percent (12%) of the inland boys had BMIs > 28 (borderline obese), while none of the coastal boys reached these levels. Three percent (3%) of the inland girls and 2% of the coastal girls had BMIs > 28. The coastal girls were taller than their inland counterparts.

During the following 12 months, a small increase in BMI was seen in all groups, but was only statistically significant among the boys (not shown).

Table I. Body height, body weight, and BMI in 13- and 14-year-old students in coastal and inland regions. Mean \pm SD.

	Boys		Girls	
	Coastal n=54	Inland n=43	Coastal n=56	Inland n=31
Height (cm)	161 \pm 9.1	157 \pm 9.5*	161 \pm 6.3	158 \pm 5.6*
Weight (kg)	50 \pm 8.6	53 \pm 16.1	53 \pm 8.8	51 \pm 10.1
BMI (kg/m ²)	19.4 \pm 2.0	21.6 \pm 4.8*	20.5 \pm 2.7	20.8 \pm 3.6

Inland vs. Coastal region: * p< 0.05

Hemoglobin and s-ferritin

Table II shows the levels of hemoglobin and serum ferritin at the first examination. No difference was seen between the coastal and inland groups concerning hemoglobin. Both boys and girls from inland had higher levels of ferritin compared to the coastal groups, but the difference was only statistically significant for the boys (p<0.05). The level of hemoglobin showed a non-significant increase in all groups

Table II. Hemoglobin and s-ferritin in 13- and 14-year-old students in coastal and inland regions. Median and 25-75 quartile.

	Boys		Girls	
	Coastal n=54	Inland n=43	Coastal n=56	Inland n=31
Hb (g/dl)	13.8	13.9	13.4	13.7
25-75 quartile	13.1-14.5	13.4-14.6	12.7-14.0	13.0-14.0
% < 12 g/dl	5.6	2.3	3.5	3.2
s-ferritin ($\mu\text{g/l}$)	23	34*	26	34
25 - 75 quartile	15-33	19-53	17-36	18-48

Inland vs. Coastal region: * $p < 0.02$

after one year (second examination, not shown). The ferritin values did not show any significant change. Table II also presents the portion (%) of students with levels below the proposed cut-off value indicating anemia and empty iron-stores. This proportion did not change significantly after the intervention (not shown).

Fifty percent (50%) of the coastal girls and 23% of the inland girls had had menarche before the first examination. The table does not distinguish between girls with and without menarche.

About 2/3 of the students with hemoglobin < 12 g/l, also had s-ferritin $< 10\mu\text{g/l}$, at both examinations. None of the students had s-ferritin $> 80 \mu\text{g/l}$.

Vitamins and minerals

The mean daily intake of vitamins and minerals is shown in table III.

The intake of vitamin D was 17-29 % and the intake of fibre 42-53 %

Table III. Daily intake of nutrients and energy in 13- and 14-year-old students in coastal and inland regions. Mean \pm SD.

	Boys		Girls		National recommendation	
	Coastal n=30	Inland n=16	Coastal n=36	Inland n=26	Boys	Girls
Vitamin A (μg)	707 \pm 510	720 \pm 373	926 \pm 885	555 \pm 198	1000	800
Vitamin D (μg)	2.9 \pm 2.4	2.0 \pm 0.8	1.7 \pm 1.0	2.0 \pm 1.0	10.0	10.0
Thiamin (mg)	1.2 \pm 0.4	1.3 \pm 0.5	0.9 \pm 0.3	1.0 \pm 0.4	1.4	1.1
Riboflavin (mg)	2.1 \pm 0.9	2.5 \pm 0.9	1.7 \pm 0.8	1.9 \pm 0.7	1.3	1.3
Vitamin C (mg)	66 \pm 53	74 \pm 63	53 \pm 24	45 \pm 29	60	60
Calcium (mg)	1390 \pm 650	1393 \pm 407	1141 \pm 511	1242 \pm 470	800	800
Iron (mg)	12.1 \pm 3.9	14.0 \pm 7.8	10.0 \pm 5.1	9.3 \pm 4.7	12	12-18
Magnesium (mg)	327 \pm 108	343 \pm 114	267 \pm 79	300 \pm 117	400	300
Dietary fibre (g)	15.5 \pm 5.8	14.7 \pm 5.8	14.3 \pm 4.5	14.0 \pm 7.8	35	27
Cholesterol (mg)	331 \pm 1549	312 \pm 116	242 \pm 123	248 \pm 141	350	350
Daily intake of energy (MJ)	10.6 \pm 2.6	9.7 \pm 2.6	8.6 \pm 2.4	8.3 \pm 3.1	9.9	8.4
Energy percent(%)						
Fat	32 \pm 4.9	34 \pm 7.3	30 \pm 5.4	33 \pm 4.5	< 30	< 30
Protein	14 \pm 2.6	17 \pm 4.4*	13 \pm 1.9	15 \pm 3.0*	10-15	10-15
Carbohydrate	52 \pm 5.3	48 \pm 7.6	55 \pm 5.8	51 \pm 4.9***	55-60	55-60
sugar	16 \pm 5.7	11 \pm 5.4**	17 \pm 6.5	12 \pm 5.5*	< 10	< 10

Inland vs. Coastal region:

* $p < 0.05$

** $p < 0.01$

*** $p < 0.005$

of the recommended levels (The National Board of Nutrition). The intake of iron was sufficient among the boys, while the girls' intake reached only about 80% of the national recommended amounts.

Energy

The intake of energy-delivering nutrients is also presented in table III. The total energy intake was at the of nationally recommended level. Both girls and boys from inland drew a higher portion of their energy from protein as compared to the coastal students. All groups had a higher intake of sugar (sucrose) than recommended, with the coastal groups having almost twice the recommended intake.

Life-style

Table IV shows that the majority (>80%) reported no daily physical activity, and about 30% of the boys and 20% of the girls reported physical activity 4-6 times a week. Physical activity at the level of "more than 4 times a week" was reported by 52% of the coastal boys and 38% of the inland boys, whereas 33% of the coastal girls and 20% of the inland girls reported likewise. The coastal group reported

Table IV. Life-style parameters, including intake of boiled fish and fried meat, in 13- and 14-year-old students in coastal and inland regions.

	Boys		Girls	
	Coastal n=69	Inland n=45	Coastal n=64	Inland n=35
Physical exercise (%)*				
every day	22	9	11	0
4-6 times a week	30	29	22	20
rarely/never	12	13	8	9
Smoking (%)				
every day	19	11	23	9
never	75	69	67	89
Alcohol (g/10MJ)**	0.8 ± 4.5	0.0	0.7 ± 3.0	0.0
Iron tablets (%)				
every day	10	4	8	9
rarely/never	86	82	86	91
Vitamin tablets (%)***				
every day	19	11	19	17
rarely/never	65	64	69	57
Boiled fish (%)	Coastal n=129		Inland n=89	
never/rarely	90		88	
1-3 times a week	6		12	
daily	4		0	
Fried meat (%)	n=133		n=79	
never/rarely	56		36	
1-3 times a week	43		63	
daily	1		1	

* Inducing shortness of breath, or sweating

** converted from reported intake of beer, wine and liquor (mean ± SD)

*** 75% of the girls and 71% of the boys reported taking vitamin tablets without iron

more physical activity than the inland students, in total.

With respect to smoking habits, about 20 % of the coastal adolescents (13 and 14 years old) and about 10% of the inland students report daily smoking. The majority (67-89%) reported no smoking at all.

The total reported alcohol intake was converted to grams/10 MJ, which is approximately equivalent to the intake expressed in grams/day. The inland students reported no intake at all, while the mean intake in the coastal groups was less than 1.0 gram/day, with a standard deviation (SD) of 3.0 (girls) and 4.5 g/10 MJ (boys).

The majority of the students did not take vitamins or minerals as dietary supplements, with the inland boys reporting the lowest intake frequency.

Meat and fish

The consumption of meat (fried, meat balls, stew, hot dogs) was higher among the inland groups than among the coastal students ($p < 0.001$ for boys and $p < 0.04$ for girls), while the intake of fish did not differ (table IV). About 90% of the students in both communities answered that they rarely, or never, consumed boiled fish. The intake of fried fish was slightly higher (not shown).

Iron intake and dietary habits

Table V shows daily iron intake, depending on whether the student confirmed, or did not confirm, certain statements relating to dietary habits and life-style. The table demonstrates that the iron intake is higher in adolescents who have meals and physical activity on a regular basis.

Table V. Iron intake (mg/day, mean value) by 13- and 14-year-old students in coastal and inland regions according to whether the test-person confirms, or does not confirm, various statements.

Statement	Confirms		Does not confirm	
	n	Iron intake	n	Iron intake
Breakfast every day	82	11.4	15	8.7
Lunch every day	52	11.4	45	10.4
Dinner every day	72	11.7	25	8.8*
Supper every day	57	12.0	40	9.4*
Snacks every week	39	10.2	58	11.5
Physical exercise 4-6 times a week	37	13.4	60	9.5**
Smoking minimum once a week	11	10.8	86	11

* $p < 0.01$

** $p < 0.001$

Table VI. Intake of various nutrients by 13- and 14-year-old adolescents with high (> 12 mg/10MJ) and low (<10 mg/MJ) dietary iron density in coastal and inland regions. Mean value.

	High iron density n=35	Low iron density n=39
Energy from fat (%)	31.3	32.8
Energy from sugar (%)	11.9	17.3
Intake per 10 MJ:		
Protein (g)	96	79***
animal protein (g)	67	52***
Fat (g)	83	87
Carbohydrates (g)	307	314
starch (g)	169	152*
sugar (g)	71	103***
Dietary fibres (g)	17	14***
Cholesterol (mg)	346	264***
Vitamin A (µg)	1165	579**
Vitamin D (µg)	2	2
Thiamin (mg)	1.3	1.0***
Riboflavin (mg)	2.6	1.8***
Vitamin C (mg)	69	55
Magnesium (mg)	355	310***
Calcium (mg)	1410	1343

* p < 0.05

** p < 0.01

*** p < 0.001

Dietary iron density and intake of nutrients

The intakes of various dietary nutrients, depending upon the iron density in the diet (high and low iron density) are presented in table VI. Students with a high iron density in their diet, also had a significantly higher intake of protein, starch, cholesterol, thiamin and magnesium, and less intake of sugar (sucrose).

Thirty-six percent (36%) of the students who completed the 3-day food registration, had low dietary iron density (< 10 mg/10MJ), 32% had average high iron density (10-12mg/10MJ) and 32% had high iron density (> 12mg/10MJ).

Effect of intervention

The students of 7th grade had five extra school lectures focusing on iron metabolism, as well as general dietary and life-style advice. At the second examination, after the intervention, more students reported an intake of boiled potatoes (“minimum 3 times a week”: 54% before and 66% after), a more frequent consumption of bread after school (“minimum 4 times a week”: 46% before and 55% after), and a higher proportion judged themselves as being able to prepare a healthy meal for their friends (71% before and 91% after).

No changes were seen regarding hemoglobin, s-ferritin, the intake of fruit, orange-juice, sodas, snacks, or iron as dietary additions, the frequencies of breakfast, dinner and supper, physical activity, or smoking.

DISCUSSION

The present study focused on adolescents of 13-15 years, their intake of dietary iron and iron-stores, as well as their intake of nutrients in general, dietary habits and life-style.

The general validity of the findings relative to blood testing and the frequency questionnaire is considered satisfactory, with compliances of 80-92%, while the validity of the findings from the 3-day food registration may be limited, due to the fact that less than 50% of the students completed this item.

Weight, height, BMI. The lower body height of the inland students is in accordance with their Sami heritage, as is the larger BMI, which is also found in the adult population (8). Whether the increased BMI in the Sami population is related to an increased risk of cardiovascular disease as in Caucasians, is not clear. Mortality from cardiovascular disease as a whole has been reported to be lower in the inland areas of Finnmark than in the coastal areas (8).

Hemoglobin and iron. The higher consumption of meat may explain the higher s-ferritin levels and iron stores of the inland students. This is in accordance with the dietary traditions (5,6,8). The results from the energy intake contributed by proteins support this assumption. On the other hand, the difference in the proportion of girls in the two groups with respect to menarche and menstrual bleeding will also contribute, in the same direction, to the difference in s-ferritin.

Concerning the indications of a too low daily iron intake among the girls, under-reporting cannot be excluded, since very few had empty iron-stores, although too low intakes of iron are well known from other reports (1,9).

Few of the adolescents had empty iron-stores and anemia (s-ferritin < 10 µg/l and hemoglobin < 12 g/l). The cut-off limit of empty iron-stores is debated (9,10), but this does not affect the fact that only a minor proportion of the students had values representing empty stores.

Still, in the general population this group will probably constitute a substantial number of subjects, who should be addressed to improve their iron status. This must be on an individual basis, to avoid over-dosage with iron and the risk of developing hemochromatosis.

Nutrients, vitamins, minerals. The findings are mainly based on

the 3-day food registration. From the results of the frequency questionnaire, it seems that the group that completed the food registration consisted of the most highly motivated subjects, who probably have the most health-promoting life-style.

In this group the intake of nutrients in general was sufficient, except for vitamin D and dietary fibres. Insufficient intake of vitamin D has also been found both in the south of Norway and in Sweden (1,2). The intake of vitamin D is related to the consumption of fish and, in particular, fat-containing sea-water fish.

A few decades ago, the general knowledge of the population concerning the necessity for a sufficient intake of vitamin D and sea-water fish was good. Low intake of vitamin D, especially combined with scarce sunlight, may affect the metabolism of bone minerals, and form the basis for pathological development.

Sufficient intake of fibre is necessary for normal bowel function.

The high intake of sugar, particularly among the coastal adolescents, may contribute to the development of a metabolic syndrome and type II diabetes. High levels of blood sugar cause elevated levels of glycated blood proteins, and juvenile atheromatosis is correlated to increased levels of glycated hemoglobin (11).

Fish. The reported intake of fish was very low compared to the intake among adults in the same communities (the coastal community: 55% consumed boiled fish five times, or more, per month, versus 38% in the inland area)(7). A too large intake of fat and sugar, combined with a very small consumption of fish, may adversely affect blood lipids and the blood vessel walls, resulting in arteriosclerosis (12).

Life-style. It is probably fair to characterise the majority of the adolescents of the present study as physical inactive (physical activity less than four times a week). Even among adults, this level is too low (13). It is also worrying that about 1/5 of students, 13 and 14 years old, reported daily smoking. This is equal to what is found among 15-year-old students elsewhere (14). Cigarette smoking further increases the development of arteriosclerosis, affects lung function, and is a general negative health factor.

The consumption of alcohol was generally low, with the coastal group having a higher intake. The registration was carried out during the weekend, and is probably not representative for the whole week. The large standard deviations show that the consumption was unequally distributed among the participants, with a rather substan-

tial difference between the highest and lowest intakes. The inland students reported no intake at all, which is in accordance with recent findings (Spein, A.R.; Seminar om Samisk Helseforskning (Congress on Health Research in the Sami Region), Karasjok, November 2001).

The results demonstrate that the group which had a healthy lifestyle (about 1/3), including regular meals, less intake of snacks and more physical activity, also had a more favourable intake of nutrients (more dietary iron, proteins, fibre, vitamin A, thiamin, riboflavin and magnesium, and less dietary sugar). This is consistent with findings elsewhere (2,14,15). The group with a low dietary iron density should probably be addressed from a preventive point of view.

Intervention. The effect was modest, which was not surprising. More fundamental changes probably require both a more creative and a more extensive intervention program.

Conclusion. The study showed that, in the adolescents of the coastal and inland communities, the hemoglobin and s-ferritin levels were generally sufficient, the intake of dietary sugar and fat was too high, and that the intake of vitamin D and fibre was too low. The inland group had a higher intake of proteins from meat and a lower intake of sugar compared to the coastal students. They also had larger iron stores. The traditional inland dietary pattern seemed to be maintained to a certain degree.

None of the adolescent groups consumed boiled fish, and the intake of fish was generally low. This implies that the coastal adolescents did not follow the traditional dietary habits.

About 1/3 of the group completing the food registration, had a high dietary iron density, which was associated with a favourable diet and life-style in general.

A small number of students had empty iron-stores. Intervention through school did not increase this percentage, and had only a modest effect otherwise.

The results call for more active and creative preventive measures.

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