Acta Alimentaria, Vol. 32 (4), pp. 363–371 (2003)

NUTRITIONAL STATUS OF ELDERLY PATIENTS LIVING IN BUDAPEST

I. RURIK[a]*, E. GYÖMÖREI[b], L. BIRÓ[b], K. NAGY[b], A. REGÖLY-MÉREI[b] and M. ANTAL[b]

[a] Primary Care Office, H-1201 Budapest, Vörösmarty u. 5–7. Hungary
[b] National Institute of Food Hygiene and Nutrition, Fodor József National Center of Public Health, H-1097 Budapest, Gyáli út 3. Hungary

(Received: 20 January 2003; accepted: 20 May 2003)

The aim of this study was to evaluate the nutritional status of elderly belonging to one primary care office. Twenty-seven men and 26 women, all over 60 years, were involved.

Nutritional assessment, anthropometric measurements were performed, serum proteins, lipid and iron status and haematological parameters were determined.

Energy and protein intake was sufficient, but the distribution of energy with a high fat and low carbohydrate was inadequate. Iron, copper, calcium, retinol and folate intake was lower, whereas sodium, ascorbic acid and cobalamin intake was higher than the Hungarian recommendation. The prevalence of obesity characterized by body mass index or waist circumference was higher in women than in men. The percentage of pathological levels of lipid parameters was also higher in women. No iron deficient erythropoesis was detected, but high serum ferritin concentration as a marker of body iron store was determined in some cases.

General practitioners have possibilities to influence the nutritional habits of elderly, thereby reducing the incidence of obesity, cardiovascular diseases and stroke. Iron status of Hungarian elderly looks to be satisfactory, so supplementation without testing the iron status would be useless and harmful.

Keywords: elderly, energy, nutrient intake, anthropometry, lipid, iron, nutritional status

The elderly constitutes the fastest growing segment of the population all over the world, and this poses major health problems. Among the predictive factors of successful ageing, nutrition appears one of the major determinants because it may play a role in the ageing process and in the development of chronic diseases so common in the seniors. Because general practitioners have a very close connection with elderly persons, it would be desirable that in addition to health status they deal with the nutritional status as well.

The aim of this study was to investigate the nutritional status of an elderly population living free and belonging to a primary care office.

* To whom correspondence should be addressed.
Phone: +361-285-85-85; fax: +361-274-32-32; e-mail: rurik.dr@axelero.hu

1. Materials and methods

1.1. Study population

Twenty-seven elderly men (mean: 73.4 years) and 26 women (mean: 70.0 years) were recruited randomly from the primary care office in Pesterzsébet (a South-Budapest suburb) in the period from the beginning of February to the end of March 2002. Subjects were invited to the office and asked to participate in the study. Seniors were apparently in good health, the major registered health problems were hypertension (72%), heart disease (47%) and diabetes (25%). The study protocol was approved by the Regional Medical-Ethical Committee. Informal written consent was obtained from the study population.

1.2. Nutrient intake

Nutritional assessment was performed with a standardised dietary record (completed on 2 non-consecutive work days and Sunday) one week before blood sampling and checked in the course of dietetic interview (BÍRÓ, 2002). The data of the questionnaires were evaluated by means of a specially developed software programme, using the Hungarian nutrient database (ANTAL et al., 1997). The validity of the food intake data was estimated on the basis of basal metabolic rate /BMR/ (FAO/WHO/UNO, 1985). People with reported energy intake below 1.2×BMR were excluded.

1.3. Anthropometry

Anthropometric measurements were taken by trained nurses. Height and weight were measured in light under-clothes without shoes, using calibrated balance, and altimeter. Body mass index (BMI) was also calculated (kg m^{-2}). BMI between 25.00 and 29.99 kg m^{-2} was used to indicate grade 1 overweight and BMI between 30.0–39.99 as grade 2 overweight (WHO, 1995). Waist circumference (WC) was measured using a non-elastic plastic tape with the subject in upright position. The accepted normal upper level of waist circumference was 88 cm for women and 102 cm for men (LEAN et al., 1995).

1.4. Laboratory measurements

After taking fasting blood samples, laboratory parameters were determined in the sera: total protein and albumin with colorimetric methods using Roche Diagnostics tests, prealbumin with immuno-turbidimetric assay using Randox kit; triglyceride (Tg), total cholesterol (T-C), HDL-cholesterol (HDL-C) and LDL-cholesterol (LDL-C) concentrations were measured using Roche Diagnostics tests. Iron, unsaturated iron-binding capacity (UIBC) and ferritin were assayed with Roche Diagnostics tests. Total iron binding capacity (TIBC) was calculated automatically by the equipment, transferrin saturation (TS) was calculated [serum iron (μmol l^{-1})×100/TIBC (μmol l^{-1})]. All analyses were determined in a Cobas Mira Plus Chemistry Analyser.

Zinc-protoporphyrin (ZPP) was measured by haematofluorometry (AVIV, ZP 206D, New-Jersey, USA). Haematological parameters [haematocrit (Ht), haemoglobin (Hb), white blood cell (WBC) and red blood cell (RBC) counts, mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC)] were determined in a Cobas Minos Vet Roche Haematology (Basel, Switzerland) instrument.

1.5. Statistical analysis

The statistical analysis was performed with the SPSS 9.0 for Windows. Means and standard deviations (SD) are presented. Differences between the two groups were analysed by one way analysis of variance (ANOVA) followed by Student's *t*-test (significant value $P<0.05$).

2. Results and discussion

After validation of food questionnaire, the results of 24 men and 20 women were evaluated. Daily energy intake was somewhat higher in men than in women, but the energy distribution pattern did not show significant difference between sexes. The total carbohydrate energy percentage was below the accepted value (55% en). Protein intake in average was more than 1 g kg^{-1} body weight in both sexes. More than half of the protein derived from animal sources. Lipid represented 38.4 and 39.2% en of the total energy for men and women, respectively, which is very high. Intakes for saturated fatty acids (SFAs) and cholesterol were also higher than the recommended values: 10% en and 300 mg/day, respectively (Table 1).

Iron, copper, calcium, retinol and folate intake was below, whereas intakes for sodium, ascorbic acid and cobalamin were higher than the Hungarian recommendation in both men and women (Table 2).

One man (4%) and 4 women (15%) were in grade 2 overweight category, namely obese according to the BMI. Nine men (37%) and 22 women (85%) were ranged in the obese category on the basis of data for waist circumference (Table 3).

There were no significant differences between men and women regarding the biochemical and haematological variables, which were all in the reference range. The level of prealbumin indicated protein malnutrition in one man and in two women. The average values of serum lipid parameters tended to be higher in men than in women, however, these differences were not significant. The prevalence of high Tg, T-C and LDL-C was much higher in women than in men. The percent of subjects with anaemic blood parameters are also presented. Only one man had ferritin level in the anaemic range which means that iron depletion was detected only in one person (Table 4).

Table 1. Daily energy and macronutrient intake and energy distribution pattern in apparently healthy elderly people

	Men (n=24)		Women (n=20)	
	Mean	±SD	Mean	±SD
Energy (MJ)	9.75[a]	1.817	8.78[a]	1.288
Carbohydrate (g)	260.9	66.8	232.9	39.5
% of energy	45.3	6.8	44.8	5.2
Sugar % of energy	6.6	5.6	6.5	4.4
Protein (g)	82.1	15.9	78.1	15.6
% of energy	14.2	2.1	15.0	2.3
Animal protein (g)	46.6	13.5	47.4	13.8
% of energy	8.0	2.1	9.0	2.2
Plant protein (g)	35.5	7.2	30.7	4.2
% of energy	6.1	1.0	5.9	0.7
Fat (g)	100.0	26.1	91.6	19.6
% of energy	38.4	6.3	39.2	4.7
Saturated fat (g)	31.2	8.8	29.4	8.0
% of energy	12.0	2.5	12.5	2.4
Monounsaturated fat (g)	33.0	10.4	29.5	7.9
% of energy	12.6	3.1	12.6	2.6
Polyunsaturated fat (g)	22.6	8.7	20.6	7.6
% of energy	8.7	2.8	8.9	3.0
Cholesterol (mg)	344.6	126.1	329.0	126.3
Fiber (g)	23.5	5.6	22.8	4.5
Alcohol (g)	6.1	9.9	2.2	3.7
% of energy	1.8	2.9	0.8	1.4
Caffeine (mg)	54.5	51.9	90.8	92.6

Values are reported as mean. SD: standard deviation.
[a]: Significant difference between men and women: $P<0.05$

Table 2. Daily micronutrients intake in apparently healthy elderly people

Nutrient	Men (n=24)			Women (n=20)		
	Mean	±SD	RDA in Hungary	Mean	±SD	RDA in Hungary
Iron (mg)	10.0	1.7	12	9.3	1.4	15.0
Copper (mg)	1.0	0.4	1.40	0.9	0.2	1.40
Calcium (mg)	686.8	203.1	1000	722.0	244.1	1000
Sodium (g)	5.82	1.29	2.00	5.69	0.99	2.00
Retinol equivalent (mg)	0.70	0.40	1.00	0.70	0.40	0.80
Ascorbic acid (mg)	99.3	52.0	60.0	112.6	58.2	60.0
Folate (μg)	128.4	46.0	200.0	127.5	37.0	200.0
Pyridoxine (mg)	1.63	0.46	2.20	1.64	0.37	2.00
Cobalamin (μg)	2.7	1.9	2.00	2.7	2.1	2.00

Values are reported as mean. SD: standard deviation.
RDA: recommended daily allowance

Table 3. Gender differences in anthropometric characteristics of apparently healthy elderly people

	Men (n=27)		Women (n=26)	
	Mean n (%)	±SD	Mean n (%)	±SD
Age (yrs)	73.4	5.43	70.0	4.07
Weight (kg)	75.3[a]	9.19	67.4[a]	9.68
Height (cm)	170.2[b]	5.61	159.9[b]	5.48
Body mass index (kg m^{-2})	26.1	3.17	26.4	3.50
<18.5	1 (4%)		0	
≥25.0–29.9	18 (68%)		12 (46%)	
≥30	1 (4%)		4 (15%)	
Waist circumference (cm)	102.9	8.41	99.5	8.59
>102 cm men	10 (37%)			
>88 cm women			22 (85%)	

Values are reported as mean. SD: standard deviation.
Significance: [a] $P<0.01$, [b] $P<0.001$

In our study 3 men (11%) and 6 women (23%) underreported their energy intake. Similar finding (7.6% for men, 16.2% for women) was observed in the elderly German population (LÜHRMANN et al., 2001). It is accepted that the usual range of PAL (physical activity level) in the healthy elderly is between 1.5–1.8 for elderly in industrialized countries (BEAUFRÈRE et al., 2000). Taking into account the BMR with a 1.5 PAL value, the average energy requirements would be 9.2±1.43 MJ for men, and 8.2±0.64 MJ for women in this study. These values are in agreement with the reported energy intake. However, the energy intakes were characterized with a low carbohydrate and a high lipid content, which promotes obesity (KENNEDY et al., 2001; ROLLS & HILL, 1998). The protein intake was sufficient, considering the recent recommendation (0.9–1.1 g kg^{-1}/day) (BEAUFRÈRE et al., 2000). Micronutrients intake with the exception of sodium, ascorbic acid, and cobalamin was lower than the Hungarian RDA and those values assessed for Spanish elderly (ORTEGA et al., 1995). The high prevalence of hypertension (72%) in our population can partly be attributed to the excess sodium intake.

The average BMI values for men and women were similar to those found in the Gothenburg Study referred by WHO (1995) for the comparable age groups. However, we could not find significant difference between sexes as it was found in ILSA study (PREISSINOTTO et al., 2002). Moreover, the prevalence of obesity (BMI>30 kg m^{-2}) was much lower (4% vs. 15% for men, and 15% vs. 28% for women) in our population. This result could be assigned to the smaller sample size. Nevertheless, we also found a higher incidence of obesity in women than in men. Recently, WC has been recommended as a better indicator than BMI of abdominal and overall fatness especially in elderly (SEIDELL & VISSCHER, 2000). The obesity characterised with WC also showed a higher percentage in women.

Table 4. Biochemical and haematological variables in apparently healthy elderly people

Biomarkers threshold limit of normal range (men, women if different)		Men (n=27) mean ± SD out of normal range n (percent)	Women (n=26)
Total Protein		74.5 ± 3.08	73.8 ± 3.87
	<64 g l^{-1}	0	0
Albumin	<25 g l^{-1}	46.3 ± 2.07	46.5 ± 2.88
		0	0
Prealbumin	<20 g l^{-1}	30.6 ± 6.92	28.0 ± 4.62
		1 (3.7%)	2 (7.7%)
Triglyceride	>2.3 mmol l^{-1}	1.6 ± 0.72	2.1 ± 1.02
		3 (11.1%)	8 (30.8%)
Total Cholesterol	>6.2 mmol l^{-1}	5.9 ± 0.85	6.4 ± 1.20
		8 (30%)	14 (53.8%)
LDL-Cholesterol	>4.4 mmol l^{-1}	3.8 ± 0.78	4.0 ± 1.03
		4 (14.8%)	8 (30.8%)
HDL-Cholesterol	<1.0 mmol l^{-1} men	1.5 ± 0.51	1.4 ± 0.37
	<1.1 mmol l^{-1} women	4 (14.8%)	3 (11.5%)
White blood cell		7.2 ± 2.81	6.3 ± 1.61
	>10×10^9 l^{-1}	3 (11.1%)	1 (3.8%)
Red blood cell	<4.3×10^{12} l^{-1} men	4.9 ± 0.56	4.8 ± 0.43
	<3.8×10^{12} l^{-1} women	2 (7.4%)	1 (3.8%)
Haematocrit ($l\,l^{-1}$)	<0.39 men	0.41 ± 0.039	0.39 ± 0,033
	<0.35 women	10 (37%)	2 (7.7%)
Haemoglobin	<130^{12} l^{-1} men	150 ± 15.2	142 ± 12.0
	<120^{12} l^{-1} women	2 (7.4%)	1 (3.8%)
MCV		83.9 ± 4.34	82.7 ± 4.04
	Microcytosis: <80 fl	4 (14.8%)	6 (23.1%)
	Macrocytosis: >100 fl	0	0
MCHC	<320 g l^{-1}	363 ± 10.0	362 ± 7.3
		0	0
Iron	<11 μmol l^{-1} men;	17.3 ± 6.17	16.2 ± 4.94
	<9 μmol l^{-1} women	4 (14.8%)	1 (3.8%)
TIBC	>81 μmol l^{-1}	61.8 ± 7.74	60.2 ± 7.60
		0	0
Transferrin saturation		28.1 ± 10.19	27.4 ± 9.30
	<16%	4 (14.8%)	3 (11.5%)
Ferritin		101.4 [a] (12-614)	94.4 [a] (30-495)
	<20 ng ml^{-1}	1 (3.7%)	0
	>200 ng ml^{-1}	4 (14.8%)	1 (3.8%)
ZPP		54.5 ± 11.58	58.2 ± 9.95
	>70 μmol ZPP mol $Haem^{-1}$	3 (11.1%)	4 (15.4%)

[a] Geometric mean and range.
MCV: Mean corpuscular volume, MCHC: Mean corpuscular haemoglobin concentration

Only prealbumin level was slightly under the desirable range in one man and two women. Prealbumin is the best serum analytic available to reflect short-term protein-energy malnutrition (INGELBLEEK & YOUNG, 1994). The half-life of prealbumin is 2 days, and rapid response to lowered energy intake occurs within a period as short as

3 days. The anthropometric values, energy and protein intakes evaluated by the average of 3 separate days within a week were in the acceptable range in these seniors. So, these low prealbumin concentrations might be the consequence of a transitional short episode of protein-energy malnutrition.

Serum lipid parameters except HDL-C tended to be lower in men than in women. Similar observation was seen in other studies (JOHNSON et al., 1993; STRANDBERG et al., 1992). Moreover the level of serum Tg, T-C and LDL-C was in the pathological range in 8 (30.8%), 14 (53.8%) and 8 (30.8%) women and in 3 (11.1%), 8 (30%) and 4 (14.8%) men, respectively. On the contrary, the HDL-C concentration was in the pathological range for 3 women (11.5%) and for 4 men (15.1%). Waist circumference correlates with abdominal visceral adipose tissue and considered as a potentially atherogenic risk factor (LEAN et al., 1995; SEIDELL et al., 2001). According to our results, 22 women (85%) and only 10 men (37%) had their waist circumference in the high risk group, and the prevalence of obesity indicated by BMI was almost four times higher in women than in men. So both the lipid parameters and anthropometric measurements revealed worse health status connected with cardiovascular risk in elderly women than in men. According to the Third Report of the NCEP EXPERT PANEL (2001), elevated LDL-C and low HDL-C levels are predictive factors for CVD in old age, too. Among others the first steps of prevention are to change nutritional habits and lifestyle practices including the reduction of total fat and saturated fatty acids intake and the weight control. Unfortunately, in our population studied both bad dietary habits and obesity were observed. So, general practitioners have to influence elderly to live in a healthier manner, even if it is a very difficult task in these ages.

According to the WHO Group of Experts Nutritional Anaemia's (1972) criteria (Hb <130 g l^{-1} for men; <120 g l^{-1} for women), the prevalence of anaemia was 7.4% (2 men) and 3.8% (one woman) in free living elderly men and women, respectively. These data are in good agreement with those found by OLIVARES and co-workers (2000). In our study protein energy and B_{12} vitamin intakes were sufficient. Although folate intake was low, no macrocytosis was detected in any subject, excluding the occurrence of pernicious or folic acid deficient anaemia. Nevertheless, we have to mention that haemoglobin concentration did not decrease dramatically and values were close to the cut off points (129, 128 and 112 g l^{-1}). The most common nutritional anaemia is caused by iron deficiency (KASDAN, 1996). In our cases only one person had low ferritin level but iron deficient erythropoesis or anemia did not occur. Ferritin, an acute phase protein, is elevated in inflammatory or infectious diseases. In these cases a higher cut off point is recommended to assess iron deficiency (AHLUWALIA et al., 1995). Our seniors were apparently healthy when they entered the study. Oxidative stress is hypothesised to play an important role in the pathogenesis of several chronic diseases such as cardiovascular disease. It is believed that iron might be involved in these processes by catalysing the oxidation of low density lipoprotein cholesterol. According to SALONEN and co-workers (1992), the critical level of serum ferritin as a marker of the saturation of body iron store is at or above 200 μg l^{-1}, when there is a higher risk of acute myocardial infarct (AMI). Moreover, the combination of high iron levels and high

serum LDL-cholesterol was associated with a higher risk of AMI. Although there are ample studies (BAYKAN et al., 2001; SEMPOS & LOOKAR, 2001; SULLIVAN, 2001; WHITTAKER & CHANDERBHAN, 2001; SOCHASKI et al., 2002) for and against this phenomenon, the question concerning the relationship between iron status and AMI remains to be elucidated. Since in our study the concentration of serum ferritin was in the reference range, despite the fact that the elderly did not take any kind of iron pills, we propose that generally elderly subjects do not need iron supplementation. This fact raises the responsibility of health practitioners when they suggest iron supplementation without assessing the iron status of elderly people.

3. Conclusion

The primary care physicians and also the nurses are in the closest connection with the patient. The elderly are the most frequent visitors of each primary care office, they need the largest amount of medicine, and they should be considered the target population of primary care. Advice in daily way of life, in nutrition, in life style practices are strongly needed, though some of them are neglected. We strongly believe, supposed by recent and partly cited evaluations, that it is never too late to change bad and harmful habits and correct way of life to achieve better health conditions and improve chance for a longer life.

References

AHLUWALIA, N., LAMMI-KEEFE, CJ., BENDEL, RB., MORSE, EE., BEARD, J.L. & HALEY, N.R. (1995): Iron deficiency and anemia of chronic disease in elderly women: a discriminate-analysis approach for differentiation. *Am. J. clin. Nutr*., *61*, 590–596.

ANTAL, M., REGÖLY-MÉREI, A., VARSÁNYI, H., BIRÓ, L., SÁGI, K., MOLNÁR, D.V., ZAJKÁS, G., NAGY, K., AVAR, Z. & BIRÓ, G. (1997): Nutritional survey of pregnant women in Hungary. *Int. J. Vitamin Nutr. Res*., *6*7, 115–122.

BAYKAN, M., ÇELIK, S., ÖREM, A., MALKOC, M., ERDÖL, C., BAYKAN, E.C., ÖREM, C. & KARAHAN, B. (2001): Iron status and its relationship with lipid peroxidation in patients with acute myocardial infarction. *Acta Cardiol*., *56*, 277–281.

BEAUFRÈRE, B., CASTANEDA, C., DEGROOT, L., KURPAD, A., ROBERTS, S. & TESSARY, P. (2000): Report of the IDECG Working Group on energy and macronutrient metabolism and requirements of the elderly. *Eur. J. clin. Nutr., 54*, S162–S163.

BÍRÓ, GY. (2002): Could we find a suitable method for assessment of average dietary intake? *Acta Alimentaria, 30*, 343–354.

FAO/WHO/UNO (1985): Energy and protein requirements. Report of a Joint. Expert Consultation. Tech. Rep. Ser. 724, WHO Geneva, pp. 71–112.

INGELBLEEK, Y. & YOUNG, V. (1994): Transthyretin (prealbumin) in health and disease: nutritional implications. *A. Rev. Nutr*., *14*, 495–533.

JOHNSON, C.L., RIFKIND, B.M., SEMPOS, C.T., CARROLL, M.D., BACHORIC, P.S., BRIEFEL, R.R., GORDON, D.J., BURT, V.L., BROWN, C.D., LIPPEL, K. & CLEEMAN, J.I. (1993): Declining serum total cholesterol levels among US adults. *J.A.M.A. 269*, 3002–3008.

KASDAN, T.S. (1996): Nutritional care in anemia. -in: MAHAN, K.L. & ESCOTT-STUMP, S. (Eds): *Krause's food, nutrition, diet therapy*. 9th ed. WB. Sannders Co, Philadelphia, pp. 717–736.

KENNEDY, E.T., BOWMAN, S.A., SPENCE, J.T., FREEDMAN, M. & KING, J. (2001): Popular diets: correlation to health, nutrition and obesity. *J. Am. Diet. Assoc*., *101*, 411–420.

LEAN, M.E.J., HAN, T.S. & MORRISON, C.E. (1995): Waist circumference as a measure for indicating need for weight management. *Br. med. J.*, *311*, 158–161.

LÜHRMANN, P.M., HERBERT, B.M. & NEUHÄUSER-BERTHOLD, M. (2001): Underreporting of energy intake in an elderly German population. *Nutrition, 17*, 912–916.

NCEP EXPERT PANEL (2001): Executive summary of the third report of the national cholesterol education program. Detection, evaluation, and treatment of high blood cholesterol in adults (Adult treatment panel III). *J.A.M.A*., *285*, 2486–2497.

OLIVARES, M., HERTRAMPF, E., CAPURRO, M.T. & WEGNER, D. (2000): Prevalence of anaemia in elderly subjects living at home: role of micronutrient deficiency and inflammation. *Eur. J. clin. Nutr*., *54*, 834–839.

ORTEGA, R.M., ROSARIO REDONDO, M., ZAMORA, M.J., LÓPEZ-SOBALER, A.M. & ANDRÉS, P. (1995): Eating behavior and energy and nutrient intake in overweight/obese and normal-weight Spanish elderly. *Ann. Nutr. Metab*., *39*, 371–378.

PREISSINOTTO, E., PISENT, C., SERGÍ, G., GRIGOLETTO, F. & ENZI, G. (2002): Anthropometric measurements in the elderly: age and gender differences. *Br. J. Nutr., 87*, 177–186.

ROLLS, B.J. & HILL, J.O. (1998): *Carbohydrates and weight management.* ILSI Press, Washington, DC, pp. 29–45.

SALONEN, J.T., NYYSSÖNEN, K., KORPELA, H., TUOMILEHTO, J., SEPPÄNEN, R. & SALONEN, R. (1992): High stored iron levels are associated with excess risk of myocardial infarction in eastern Finnish men. *Circulation, 86,* 803–811.

SEIDELL, J.C. & VISSCHER, T.L.S. (2000): Body weight and weight change and their health implications for the elderly. *Eur. J. clin. Nutr., 54*, S33–S39.

SEIDELL, J.C., KAHN, H.S., WILLIAMSON, D.F., LISSNER, L. & VALDEZ, R. (2001): Report from Centers for Disease Control and Prevention. Workshop on Use of Adult Anthropometry for Public Health and Primary Health Care. *Am. J. clin. Nutr*., *73*, 123–126.

SEMPOS, C.T. & LOOKAR, A.C. (2001): Iron status and the risk of coronary heart disease: an example of the use of nutritional epidemiology in chronic disease research. *J. Nutr. Biochem., 12*, 70–182.

SOCHASKI, M.A., BARTFAY, W.J., THORPE, S.R., BAYNES, J.W., BARTFAY, E., LEHOTAY, D.C. & LIU, P.P. (2002): Lipid peroxidation of protein modification in a mouse model of chronic iron overload. *Metabolism*, *51*, 645–651.

SULLIVAN, J.L. (2001): Misconceptions in the debate on the iron hypothesis. *J. Nutr. Biochem*., *12*, 33–37.

STRANDBERG, T.E., VALVANNE, J., ERKINJUNTTI, T., SORVA, A. & TILVIS, R.S. (1992): Serum lipids, health and one year mortality in randomized age cohorts of 75, 80 and 85 years: the Helsinki Ageing Study. *Nutr. Metab. cardiovasc. Dis., 2*, 101–105.

WHITTAKER, P. & CHANDERBHAN, R.F. (2001): Effect of increasing iron supplementation on blood lipids in rats. *Br. J. Nutr., 86*, 587–592.

WHO (1972): *Nutritional anaemia's report*. Group of Experts, WHO Tech. Rep. Ser. 503, WHO Geneva.

WHO (1995): *Physical status: the use and interpretation of anthropometry*. Report of a WHO Expert Committee. Tech. Rep. Ser. 854. WHO, Geneva, p. 344.