nutrition survey

Nutritional status of institutionalized and noninstitutionalized aged in Belfast, Northern Ireland

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ABSTRACT A multifaceted analysis of the nutritional status of 196 subjects, aged over 65, institutionalized in hospitals, residential accommodation, and sheltered dwellings and of noninstitutionalized subjects was undertaken. Subjects of hospital and home, with or without multivitamin supplementation, were grouped separately. The study comprised of 3-day weighed dietary record, biochemical determinations, and clinical examination. The energy intake of females of hospitals and sheltered dwellings was comparatively low. Dietary nutrients most lacking were potassium, magnesium, vitamin D, and vitamin B_6. Calcium and vitamin A intake were adequate. Clinical deficiency was rare. Subclinical deficiency was highly prevalent and the deficiency incidence was: anemia 18.6%, ascorbic acid 29.2%, thiamin 13.8%, riboflavin 7.1%, vitamin B_6 42.3%, and vitamin D 47.0%. Some kind of mineral or vitamin deficiency was observed biochemically in 91.3% of the nonmultivitamin supplemented group and 64.3% of the multivitamin supplemented group. Regular intake of multivitamin raised the blood levels of riboflavin and ascorbic acid to normal in all, but failed to raise the thiamin and vitamin B_6 levels to the normal acceptable levels in 2.9 and 20% of the subjects, respectively. Suggestions are made concerning possibly higher recommended allowance. *Am. J. Clin. Nutr.* 32: 1934–1947, 1979

There is considerable apprehension in Britain that subclinical malnutrition exists in the aged population leading to poor health, apathy, and disinterest in food (1). Subclinical malnutrition can easily precipitate to the stage of frank malnutrition under environmental and pathological stresses to which the aged are very prone (2). Institutionalization has been suggested as one of the few factors that renders elderly people particularly vulnerable to nutritional deficiency (3). The prevailing socioeconomic conditions have increased the need for institutionalizing the aged in recent years. However, only a few nutritional status studies have been conducted in institutions in the United Kingdom. These studies have concentrated either only on dietary intake (4–8) or on biochemical status of a few nutrients such as folic acid (9–11), ascorbic acid (10, 12), and iron (13, 14). Despite little knowledge of the prevalence of subclinical deficiency, prescribing of nutrient supplements, such as multivitamins, to the elderly has become a common practice. The effect of regular multivitamin supplementation is, however, not known. It was, therefore, considered interesting to study the nutritional status of multivitamin supplemented and nonsupplemented institutionalized and less active enfeebled noninstitutionalized aged. The present paper details the dietary intake, biochemical status, and the effect of regular supplementation on the biochemical vitamin status.

Subjects and methods

Caucasian subjects, at least 65 years of age at the time of the study, considered free of acute illness and eating a regular diet were selected at random from home and three types of institutions that are used to house the aged

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(long-stay wards of special geriatric units in general hospitals, residential accommodation, and sheltered dwellings). Subjects from hospitals and home receiving multivitamin supplementation regularly for at least a period of 3 months were also selected at random and grouped separately. A minimum period of 3 months of institutionalization was essential for inclusion in the institutionalized groups. The subjects were selected from long-stay wards of special geriatric units of three hospitals, two sheltered dwellings, and one block of residential accommodation. These separate institutions were taken as representative of the three types of care. The subjects attending the review clinic of a hospital and with no history of institutionalization for the previous 3 months were selected at random and formed the noninstitutionalized group. These subjects lived in their own homes with or without relatives. The selected subjects were studied under six groups as shown in Tables 1 and 2.

The dietary intakes of subjects in hospitals (group IH and IHM) and residential accommodation (group RA) were weighed and recorded for 3 consecutive weekdays by the investigator. Subjects residing in their homes (group H and HM) and sheltered dwellings (group SD) were asked to weigh and record their dietary intakes for 2 weekdays and 1 weekend day (Thursday, Friday, Saturday, or Sunday). The supervision was restricted to two visits, one before and one at the end of the period of dietary study. The data collection by weighed method was possible, since the subjects who were mentally or physically unable to look after themselves were usually provided with a home-help or had a relative who looked after them. The dietary intake data were computer analyzed using the food tables (15). The dietary intake data of all nutrients except potassium and magnesium were compared with the recommended dietary intake (RDI) (16). Dietary potassium and magnesium intakes were compared with the suggested requirements (17, 18).

A sample of approximately 55 ml of overnight fasting blood was drawn from each subject on the 4th day after the 3-day dietary study for the residents in hospital (group H and HM) and sheltered dwellings (group SD) were obtained within 2 weeks of the dietary intake record. The blood samples were collected, stored, and analyzed according to the specific methods used for estimation (Table 3). The vitamin D status was assessed in only 49 subjects residing at home (group H) and insitutionalized in hospital (group IH).

Each subject was examined by a physician within 3 weeks of the collection of the blood sample. The clinical assessment included investigations for accepted signs of malnutrition, surgery undergone, diagnosis, and medication.

The correlation between various variables was made for each group and sex separately by Spearman's rank correlation analyses (33).

Results

A total of 196 subjects (51 males and 145 females) were studied (Table 1). The age of the subjects ranged from 65 to 95 years (Table 2) and the average of the total sample was 79.3 years (SD = ± 7.34).

Subjects institutionalized in hospitals (group IH and IHM) and residential accommodation (group RA) were provided with meals from the central kitchen of the institution. The residents of the residential accommodation (group RA) were encouraged to sit in groups of four during meal hours and were served their meals under the supervision of a trained matron. The elderly in the sheltered dwellings (group SD) were provided with all the facilities to do their own cooking, though other alternatives such as club meals and meals on wheels were also provided. The latter facility was widely used (Table 2). The subjects living at home (group H and HM) did their own cooking or depended on spouse, relative, or home-help for preparation of their meals (Table 2). In the total sample, regular alcohol consumption was noted in 15 subjects (29.4%), with rather low consumption (568 ml Guinness twice a day) by the hospitalized subjects. The incidence of smoking was over 50% in the males residing at home, residential accommodation, and sheltered dwellings (Table 2).

Dietary intake and biochemical findings

Thirty-two subjects had energy intakes <⅔ of the RDI (16), while protein intakes were

TABLE 1
Details of the six groups

No.	Groups	Description	Multivitamin supplementation	Males	Females	Total no. of subjects
1	IHM	Institutionalized in hospital (long stay ward of geriatric units)	+	11	43	54
2	IH	Institutionalized in hospital (long stay ward of geriatric units)	−	13	30	43
3	RA	Institutionalized in residential accommodation	−	9	17	26
4	SD	Institutionalized in sheltered dwellings	−	3	17	20
5	H	Residing at home	−	10	27	37
6	HM	Residing at home	+	5	11	16

TABLE 2
Details of subjects in the six groups

Details	Groups					
	IHM	IH	RA	SD	H	HM
No. of subjects	54	43	26	20	37	16
Age (yr)	79.6	81.4	80.6	78.7	76.8	77.1
Mean	65–93	65–94	65–95	68–89	65–89	70–91
Range						
Period of study	Nov. 1974–April 1975	Sept. 1975–Nov. 1975	Dec. 1975–Feb. 1976	June 1975–Aug. 1975	Dec. 1974 Jan. 1976	Dec. 1974–Jan. 1976
Preparation of meals (No. of subjects)						
Self	0	0	0	20	17	4
Home help or others	0	0	0	0	20	12
Institutionalized	54	43	26	0	0	0
Meals on wheels (No. of subjects)	0	0	0	11	3	0
Percentage smoking	11.1	7.0	23.1	20.0	29.7	25.0
Percentage consuming alcohol	3.7	9.3	11.5	15.0	10.8	6.3
Multivitamin supplementation (No. of subjects)						
Juvel	54	0	0	0	0	11
Allbee	0	0	0	0	0	1
Fesovit	0	0	0	0	0	3
Orovite	0	0	0	0	0	1
Folic acid supplementation	19	4	0	1	7	6

<⅔ RDI in seven subjects (Table 3). The correlation of energy and protein intake was significant ($P < 0.05$) for all the groups except for the females in group RA. The subjects with energy intakes <⅔ RDI had a higher incidence of low serum albumin (38.7%) than in the remaining sample (18.9%). Similarly, an abnormal albumin/globulin ratio <1.00 was seen more frequently in the low energy intake group (42.5%, 28.8%).

Calcium and iron intakes were adequate in the majority of cases, but magnesium, potassium, vitamin B_6, and vitamin D were lacking in the diet (Tables 4 and 5). The mean consumption of vitamin A was higher than the RDI (16) of 750 μg/day in all the groups. However, the individual intake showed a wide range.

The mean intake of ascorbic acid was higher than the recommended in the males of three groups and in four groups of females. Fifty-three subjects, 12 males (23.5%) and 41 females (28.3%) of the total sample consumed <⅔ RDI of ascorbic acid. The thiamin and riboflavin intakes by males and females of the six groups are presented in Table 5. Fourteen subjects (three males and 11 females) consumed <⅔ RDI of thiamin. Mean riboflavin intakes were below the RDI in all except the females of residential accommodation (group RA). Seventeen males (33.3%) and 26 females (17.9%) had riboflavin intakes <⅔ of the RDI.

The criteria used for biochemical findings are presented in Table 3. The hematological results (Tables 6 to 8) showed that 33.3% males and 12.3% females of the total sample were anemic (hemoglobin <13.0 g/100 mg in males and <12.0 g/100 mg in females) and for each of the six groups, a higher percentage of males than females were anemic. Of the 31 iron-deficient subjects, only 12 were anemic. Of these iron-deficient anemic subjects, four had only iron deficiency, while six had combined deficiency of iron and folic acid. In the total sample, a microcytic blood picture was obtained in 41 subjects and of these 11 were anemic. A macrocytic blood picture was observed in only two males, one each from group IHM and RA and of these only one was anemic (hemoglobin = 12.3 g/100 ml) and had low serum folate level (1.9 ng/ml). A hypochromic blood picture (mean corpuscular hemoglobin concentration <30 g/100 ml) was obtained in six subjects and of these two were anemic. The cause of anemia was not evident biochemically in these two subjects.

Sixty-eight subjects (19 males and 49 females) had low serum folate levels (<3.5 ng/ml) and of these 12 were anemic (Table 6). One of these, as already mentioned, had a

TABLE 3
Biochemical methods and criteria employed to evaluate nutritional adequacy

Items	Metabolite measured	Substrate used	Method used	Criteria used for low and deficient status
Hematological	Hemoglobin[a]	Whole blood	Coulter-model-S	M. 13 g/100 ml (19) F. 12 g/100 ml
	Mean corpuscular volume	Whole blood	Coulter-model-S	84–99 μ^3
	Mean corpuscular hemoglobin concentration	Whole blood	Coulter-model-S	<30 g/100 ml[b]
Protein	Albumin	Serum	Technicon SMAC	<3.5 g/100 ml[b]
Calcium[c]	Serum calcium	Serum	Technicon SMAC	<8.7 mg/100 ml[b]
Iron	Percentage saturation (iron/total iron binding capacity)	Serum	Young and Hicks (20)	<16% (21)
Folic acid	Serum folate	Serum	Microbiological assay using lact. Caes. var. rhamnosus (20)	<3.5 ng/ml[b]
Vitamin B_{12}	Serum vitamin B_{12}	Serum	Microbiological assay using lact. leichmannii (22)	<150 pg/ml[b]
Ascorbic acid	Plasma ascorbic acid	Plasma	Denson and Bowers (23)	<0.3 mg/100 ml (24)
Thiamin	ETK—EC 2.2.1.1	Whole blood	Smeets et al. (25)	>1.20 (25)
Riboflavin	EGR—EC 1.6.4.2	Whole blood	Nichoalds (26)	⩾1.20 (27)
Vitamin B_6	EGPT index—EC 2.6.1.2	Whole blood	Woodring and Storvick (28)	>1.15 (28)
Vitamin D	25,hydroxyvitamin D	Serum	Preece et al (29)	3.8 ng/ml (30)
Vitamin A	Serum carotene	Serum	Varley (31)	40 μg/100 ml (32)
Alkaline phosphatase[c]	Serum alkaline phosphatase	Serum	Technicon SMAC	13 KA[b]

[a] Subjects with hemoglobin concentration <13 g/100 ml for men and <12 g/100 ml in females were considered anemic (19). [b] Levels based on values obtained from normal adult blood donors. [c] Serum calcium <8.7 mg/100 ml and alkaline phosphatase >13 KA units indicates osteomalacia biochemically.

TABLE 4
Daily dietary intake of energy, protein, calcium, iron, magnesium, and potassium (mean ± SD), and the frequency and percentage distribution of subjects with intake <2/3 RDI in the males and females of the six groups

Groups	Sex	No. of subjects	Mean ± SD and number and percentage consuming <2/3 RDI					
			Energy[a]	Protein	Calcium	Iron	Magnesium	Potassium
			kcal	*g*	*mg*		*mEq/day*	
IHM	M	11	2023 ± 389	63.6 ± 11.2	970 ± 246.3	10.0 ± 1.53	17.6 ± 3.3	56.5 ± 11.3
			2[b] (18.2)[c]	(0)	(0)	(0)	11 (100)[d]	8 (72.7)[e]
	F	43	1576 ± 246	49.6 ± 9.7	854 ± 121.7	7.3 ± 1.69	14.0 ± 2.3	46.0 ± 7.7
			7 (16.3)	1 (2.3)	(0)	18 (41.9)	43 (100)	43 (100.0)
IH	M	13	1747 ± 292	54.5 ± 10.7	791 ± 87.9	8.9 ± 2.20	14.9 ± 2.2	48.7 ± 6.8
			2 (23.1)	1 (7.7)	(0)	2 (15.4)	13 (100)	13 (100.0)
	F	30	1476 ± 219	50.5 ± 9.2	763 ± 140.5	7.8 ± 1.81	13.5 ± 3.0	42.9 ± 7.9
			6 (20.0)	1 (3.3)	(0)	9 (30.0)	30 (100)	30 (100.0)
RA	M	9	2016 ± 481	54.4 ± 14.4	892 ± 81.8	9.5 ± 2.58	18.4 ± 3.2	58.6 ± 12.6
			(0)	(0)	(0)	1 (11.1)	9 (100)	7 (77.8)
	F	17	1752 ± 256	50.5 ± 7.6	868 ± 142.7	8.2 ± 1.71	15.6 ± 2.3	53.7 ± 9.3
			(0)	(0)	(0)	3 (17.6)	17 (100)	15 (88.2)
SD	M	3	1963 ± 198	52.0 ± 14.2	619 ± 242.8	8.2 ± 2.88	11.4 ± 1.6	31.0 ± 3.4
			(0)	(0)	(0)	1 (33.3)	3 (100)	3 (100.0)
	F	17	1559 ± 436	50.5 ± 12.6	654 ± 222.8	8.6 ± 2.86	12.5 ± 3.1	41.1 ± 10.3
			4 (23.5)	(0)	1 (5.9)	5 (29.4)	17 (100)	17 (100.0)
H	M	10	2552 ± 806	71.7 ± 20.7	1000 ± 397.6	12.2 ± 5.22	19.3 ± 8.6	56.0 ± 16.8
			1 (10.0)	(0)	(0)	3 (30.0)	7 (70.0)	7 (70.0)
	F	27	1765 ± 544	51.9 ± 15.5	711 ± 284.9	8.6 ± 3.25	15.1 ± 5.9	45.4 ± 15.1
			7 (25.9)	3 (11.1)	(0)	7 (25.9)	23 (92.0)	24 (88.9)
IH	M	5	1715 ± 596	55.7 ± 9.6	668 ± 154.2	9.3 ± 0.94	13.4 ± 2.7	43.5 ± 6.8
			1 (20.0)	(0)	(0)	(0)	5 (100.0)	5 (100.0)
	F	11	1772 ± 444	58.6 ± 18.0	719 ± 305.1	9.9 ± 2.91	17.4 ± 7.9	50.4 ± 14.7
			1 (9.1)	1 (9.1)	(0)	2 (18.2)	10 (87.5)	9 (81.8)

[a] RDI (16) Energy (kcal/day) Males—65–75 = 2350 Females 65–75 = 2050
>75 = 2100 >75 = 1900
Protein (g/day) Males—65–75 = 59 Females 65–75 = 51
>75 = 53 >75 = 48
Calcium (mg/day) = 500
Iron (mg/day) = 10

[b] No. of subjects with intake <2/3 RDI. [c] Percentage of subjects with intake <2/3 RDI. [d] No. (percentage) of subjects with intake <0.5 mEq/kg per day (18). [e] No (percentage) of subjects with intake <65 mEq/day (17).

TABLE 5
Daily dietary intake of vitamin A, vitamin D, ascorbic acid, thiamin, riboflavin, and vitamin B_6 (mean ± SD), and the frequency and percentage distribution of subjects with intake <⅔ of RDI in the males and females of the six groups

Groups	Sex	No. of subjects	Vitamin A (μg/day) 750 μg[a]	Vitamin D (μg/day) 2.5 μg[a]	Ascorbic acid (mg/day) 30 mg[a]	Thiamin (mg/day) M 65-75 = 0.9[a] >75 = 0.8 F 65-75 = 0.8 >75 = 0.7	Riboflavin (mg/day) M = 1.7 F = 1.3[a]	Vitamin B_6 (mg/day) 2mg[a]
IHM[b]	M	11	962 ± 373.4	1.75 ± 0.55	30.0 ± 6.06	0.86 ± 0.14	1.38 ± 0.31	1.10 ± 0.18
			(0)	5[c] (45.5)[d]	1 (9.1)	(0)	2 (18.2)	10 (90.9)
	F	43	824 ± 214.5	1.86 ± 0.94	23.5 ± 11.49	0.71 ± 0.14	1.13 ± 0.17	0.81 ± 0.18
			12 (27.9)	24 (55.8)	15 (34.9)	3 (7.0)	2 (7.0)	43 (100.0)
IH	M	13	827.3 ± 279.6	1.00 ± 0.94	23.7 ± 6.25	0.68 ± 0.11	1.12 ± 0.16	0.85 ± 0.17
			1 (7.7)	11 (84.6)	4 (30.8)	2 (15.4)	6 (46.2)	13 (100.0)
	F	30	801 ± 305.3	1.08 ± 0.78	26.7 ± 28.8	0.64 ± 0.14	1.01 ± 0.20	0.78 ± 0.17
			3 (10.0)	21 (70.0)	13 (43.3)	1 (3.3)	8 (26.7)	30 (100.0)
RA	M	9	790 ± 185.7	1.25 ± 0.68	36.7 ± 13.07	0.83 ± 0.18	1.42 ± 0.33	1.17 ± 0.39
			(0)	7 (77.8)	1 (11.1)	(0)	1 (11.1)	5 (55.6)
	F	17	972 ± 449.6	1.07 ± 0.39	31.1 ± 9.53	0.81 ± 0.14	1.30 ± 0.39	0.93 ± 0.18
			(0)	17 (100.0)	1 (5.9)	(0)	1 (5.9)	17 (100.0)
SD	M	3	1539 ± 1057.2	4.46 ± 4.84	12.9 ± 6.99	0.67 ± 0.21	1.29 ± 0.42	1.06 ± 0.08
			(0)	1 (33.3)	3 (100.0)	1 (33.3)	1 (33.3)	3 (100.0)
	F	17	890 ± 458.7	1.63 ± 1.64	32.2 ± 21.28	0.67 ± 0.18	0.98 ± 0.30	0.91 ± 0.31
			3 (17.6)	13 (76.5)	7 (41.2)	2 (11.8)	2 (11.8)	15 (88.2)
H	M	10	995 ± 472.3	2.29 ± 1.46	32.4 ± 10.31	1.30 ± 0.68	1.36 ± 0.57	1.25 ± 0.47
			2 (20.0)	3 (30.0)	2 (20.0)	(0)	4 (40.0)	6 (60.0)
	F	27	926 ± 472.0	1.48 ± 0.99	28.9 ± 32.78	0.74 ± 0.28	0.99 ± 0.38	0.91 ± 0.27
			2 (7.4)	19 (70.4)	4 (14.8)	5 (18.5)	9 (33.3)	26 (96.3)
HM	M	5	757 ± 200.3	0.99 ± 0.36	28.2 ± 11.99	0.71 ± 0.12	1.03 ± 0.18	0.91 ± 0.30
			(0)	5 (100.0)	1 (20.0)	(0)	3 (60.0)	5 (100.0)
	F	11	884 ± 329.1	2.13 ± 2.99	53.0 ± 38.84	0.82 ± 0.23	1.19 ± 0.47	1.10 ± 0.44
			1 (9.1)	8 (72.7)	1 (9.1)	(0)	4 (36.4)	8 (72.7)

[a] RDI (16). [b] Juvel (1 tablet/day) all subjects of group IHM and 11 subjects of group HM. Juvel—5000 IU vitamin A, 500 IU vitamin D, 2.5 mg thiamin hydrochloride, 2.5 mg riboflavin, 2.5 mg pyridoxine hydrochloride, 50 mg nicotinamide, 50 mg ascorbic acid. Allbee (1 tablet/day)—one subject of group HM. Allbee—15.0 mg thiamin mononitrate, 10.0 mg ribovlavin, 5 mg pyridoxine hydrochloride, 50 mg nicotinamide, 300 mg ascorbic acid, 10 mg calcium—D pantothenate U.S.P. Fesovit (1 tablet/day)—three subjects of group HM. Fesovit—2 mg aneurine mononitrate, 2 mg ribovlavin, 1 mg pyridoxine hydrochloride, 10 mg nicotinamide, 50 mg ascorbic acid, 150 mg ferrous sulphate, 2.17 calcium pantothenate. Orovite (1 tablet/day)—one subject of group HM. Orovite—50 mg thiamin hydrochloride, 5 mg riboflavin, 5 mg pyridoxine hydrochloride, 200 mg nicotinamide, 100 mg ascorbic acid. [c] No. of subjects with intake <⅔ RDI. [d] Percentage of subjects with intake <⅔ RDI.

TABLE 6
Red cell indices and frequency distribution of subjects with anemia, iron, folate, and vitamin B_{12} deficiency

Groups	Sex	No. of anemic subjects[a]	Red cell picture					No. of iron-deficient subjects	No. of folate-deficient subjects	No. of B_{12}-deficient subjects
			Normocytic	Micro-cytic	Macro-cytic	Normo-chromic	Hypo-chromic			
IHM	M	3 (11)[b]	8 (9)	0	1	11 (11)	0	1 (11)	3 (11)	0 (11)
	F	9 (42)	29 (35)	6	0	39 (42)	3	4 (41)	15 (41)	3 (38)
IH	M	5 (13)	13 (13)	0	0	13 (13)	0	2 (13)	6 (13)	0 (13)
	F	1 (30)	28 (30)	2	0	30 (30)	0	2 (29)	10 (27)	0 (27)
RA	M	3 (9)	5 (9)	3	1	9 (9)	0	2 (9)	3 (9)	1 (9)
	F	1 (17)	13 (17)	4	0	17 (17)	0	3 (17)	4 (17)	1 (17)
SD	M	2 (3)	1 (3)	2	0	3 (3)	0	1 (3)	1 (3)	0 (3)
	F	2 (15)	5 (15)	10	0	15 (15)	0	8 (17)	5 (8)	1 (15)
H	M	3 (10)	5 (10)	5	0	10 (10)	0	3 (7)	3 (5)	0 (3)
	F	4 (26)	21 (26)	5	0	24 (26)	2	3 (26)	13 (26)	2 (24)
HM	M	1 (5)	2 (5)	3	0	4 (5)	1	1 (5)	3 (5)	0 (5)
	F	1 (11)	10 (11)	1	0	11 (11)	0	1 (10)	2 (9)	0 (10)

[a] Hemoglobin < 13 g/100 ml in males and < 12 g/100 ml in females (19). [b] The figures in parentheses represent the number of subjects studied.

macrocytic blood picture. In the 12 folate-deficient anemic subjects, seven had only folic acid deficiency, two had combined folic acid and iron deficiency, and the remaining three had combined folic acid and vitamin B_6 deficiency. All subjects with folic acid supplementation had serum folic acid >24 ng/ml.

Subnormal serum vitamin B_{12} levels (<150 pg/ml) were noted in eight of the 175 subjects studied. Two of these subjects had only vitamin B_{12} deficiency while the remaining six had combined deficiency with either folic acid or iron. Anemia was, however, noted in only one female subject who had iron deficiency along with vitamin B_{12} deficiency.

The mean and range of 25, hydroxyvitamin D levels in group IH and H are presented in Table 8. The incidence of vitamin D deficiency was high in both the groups, being 48.1 and 45.4%, respectively. Low calcium levels (<8.6 mg/100 ml) were observed in only eight subjects and of these seven had biochemical osteomalacia with increased alkaline phosphatase values. The 25, hydroxy-vitamin D levels were obtained for only two of the seven osteomalacic subjects and were 4.9 and 2.4 ng/ml, respectively.

The mean values and percentage incidence of deficiency of thiamin, riboflavin, vitamin B_6 (pyridoxine), folic acid, ascorbic acid, and carotene in the males and females of the six groups are presented in Tables 6, 7, 9 and Figure 1. The percentage incidence of deficiencies of thiamin, riboflavin, and vitamin B_6 was highest in group SD. Despite dietary intake being <⅔ RDI in a few subjects (Table 10), regular intake of multivitamin raised the blood levels of riboflavin and ascorbic acid to normal in all. However, regular intake of 2.5 mg thiamin and vitamin B_6, failed to raise the thiamin and vitamin B_6 levels to acceptable levels in two (2.9%) and 14 (20.0%) subjects, respectively. Of these thiamin-deficient subjects, one consumed alcohol regularly and had folic acid deficiency.

The biochemical deficiency of thiamin, riboflavin, vitamin B_6, and ascorbic acid revealed no association with the dietary intake expressed in terms of ⅔ of RDI (Table 10).

The results revealed that 91.3% of the subjects in the nonmultivitamin supplemented groups and 64.3% in the multivitamin supplemented group had some kind of vitamin or mineral deficiency biochemically. However, clinical signs of deficiency were rare. Only one male subject living at home (from group H) was considered undernourished, but no specific signs were observed. This subject not only had an albumin/globulin ratio of 0.86, but had biochemical deficiency of riboflavin, vitamin B_6, ascorbic acid, carotene, and vitamin D. Anemia was noted clinically in three subjects (one male and two females) of sheltered dwelling (group SD). On biochemical examination, the male subject was confirmed anemic (hemoglobin = 11 g/100 ml), while the female subjects had hemoglobin marginally above 12 g/100 ml. Angular stomatitis was observed in only one female subject residing in sheltered dwelling (group SD) and

TABLE 7
Hematological measurements (mean ± SD) in the males and females of the six groups

Groups	Sex	Hemoglobin	Mean corpuscular volume	Mean corpuscular hemoglobin concentration	Serum iron	Total iron binding capacity	Percentage saturation	Serum folate	Serum vitamin B_{12}
		g/100 ml	μ^3	*g/100 ml*	*μg/100 ml*		*%*	*ng/ml*	*pg/ml*
IHM	M	14.0 ± 1.21 (11)[a]	90.7 ± 5.3 (11)	32.7 ± 1.4 (11)	121.8 ± 64.4 (11)	386.8 ± 74.1 (11)	32.9 ± 22.4 (11)	11.4 ± 10.22 (11)	638.2 ± 369.6 (11)
	F	13.3 ± 1.32 (42)	89.7 ± 5.3 (42)	32.6 ± 1.2 (42)	100.9 ± 34.0 (41)	352.1 ± 70.4 (41)	30.1 ± 13.38 (41)	10.6 ± 9.90 (41)	600.4 ± 350.8 (38)
IH	M	13.6 ± 1.48 (13)	89.6 ± 2.8 (13)	33.2 ± 1.8 (13)	81.2 ± 30.5 (13)	327.7 ± 37.7 (13)	24.7 ± 9.5 (13)	4.1 ± 2.47 (13)	403.8 ± 151.6 (13)
	F	13.5 ± 1.10 (30)	90.2 ± 4.8 (30)	33.5 ± 1.0 (30)	84.7 ± 29.2 (30)	338.1 ± 51.4 (29)	25.0 ± 8.76 (29)	6.3 ± 6.14 (27)	496.8 ± 292.7 (27)
RA	M	13.9 ± 2.00 (9)	89.9 ± 7.8 (9)	34.1 ± 1.2 (9)	92.8 ± 24.1 (9)	376.7 ± 82.3 (9)	25.9 ± 9.34 (9)	3.8 ± 1.42 (9)	276.7 ± 156.9 (19)
	F	14.3 ± 1.70 (17)	87.3 ± 6.0 (17)	33.2 ± 1.6 (17)	104.2 ± 48.6 (17)	384.7 ± 48.9 (17)	27.2 ± 12.64 (17)	6.7 ± 4.44 (17)	351.5 ± 150.9 (17)
SD	M	12.4 ± 2.21 (3)	80.3 ± 9.0 (3)	33.7 ± 1.2 (3)	93.3 ± 51.3 (3)	380.0 ± 124.9 (3)	26.5 ± 13.96 (3)	3.7 ± 1.59 (3)	318.3 ± 122.7 (3)
	F	12.9 ± 0.99 (15)	82.5 ± 6.5 (15)	34.1 ± 1.1 (15)	76.5 ± 40.7 (17)	384.7 ± 76.8 (17)	21.6 ± 15.14 (17)	2.9 ± 1.32 (8)	530.7 ± 408.9 (15)
H	M	13.7 ± 1.97 (10)	84.1 ± 7.2 (10)	33.9 ± 1.6 (10)	88.7 ± 49.6 (8)	385.7 ± 91.1 (7)	21.9 ± 11.96 (7)	8.9 ± 9.59 (5)	420.0 ± 268.4 (3)
	F	13.4 ± 1.63 (26)	88.3 ± 5.3 (26)	32.8 ± 2.0 (26)	105.0 ± 45.0 (27)	375.4 ± 87.5 (26)	29.2 ± 12.33 (26)	7.2 ± 7.80 (26)	496.7 ± 329.9 (24)
HM	M	13.8 ± 2.12 (5)	84.0 ± 5.7 (5)	33.6 ± 2.3 (5)	88.0 ± 41.3 (5)	360.0 ± 67.1 (5)	28.4 ± 15.65 (5)	7.5 ± 9.27 (5)	421.0 ± 331.6 (5)
	F	13.6 ± 1.37 (11)	89.2 ± 6.3 (11)	32.8 ± 1.2 (11)	110.0 ± 27.5 (11)	406.5 ± 111.9 (10)	30.4 ± 9.93 (10)	11.0 ± 8.88 (9)	663.5 ± 368.5 (10)

[a] Figures in parentheses denote number of subjects.

TABLE 8
Serum 25,hydroxyvitamin D, serum calcium (mean ± SD), and distribution of subjects with low levels

Groups	Sex	No. of subjects	25,hydroxyvitamin D		Serum calcium (mg/100 ml)	
			Mean ± SD	No. (%) < 3.8 ng/ml	Mean ± SD	No. (%) < 8.7 mg/100 ml
IHM	M	11			9.6 ± 0.34 (11)[a]	
	F	43			9.6 ± 0.55 (42)[a]	2 (4.8)[b]
IH	M	13	4.37 ± 1.48 (7)[a]	3 (42.8)[b]	9.3 ± 0.42 (13)[a]	1 (7.7)[b]
	F	30	5.08 ± 3.65 (20)[a]	10 (50.0)[b]	9.3 ± 0.33 (30)[a]	
RA	M	9			9.2 ± 0.43 (9)[a]	2 (22.2)[b]
	F	17			9.6 ± 0.55 (17)[a]	
SD	M	3			9.3 ± 0.52 (3)[a]	
	F	17			9.6 ± 0.51 (17)[a]	
H	M	10	8.45 ± 6.82 (6)[a]	2 (33.3)[b]	9.8 ± 0.29 (9)[a]	
	F	27	6.29 ± 6.64 (16)[a]	8 (50.0)[b]	9.5 ± 0.65 (25)[a]	3 (12.0)[b]
HM	M	5			10.1 ± 0.33 (5)[a]	
	F	11			9.9 ± 0.67 (10)[a]	

[a] Figures in parentheses represent number of subjects studied. [b] Figures in parentheses represent percentage of subjects with low levels.

this was accompanied by biochemical deficiencies of riboflavin and vitamin B_6 (activity coefficient of EGR = 1.42; EGPT index = 1.20). Two females residing at home (group H) and two males of the sheltered dwelling group (group SD), reported extreme loss of appetite, but had no clinical signs of B-group deficiency. The enzyme function test, however, revealed thiamin deficiency with activity coefficient of TKA above 1.30.

Comments

The dietary intake data obtained were evaluated on the assumption that a habitual intake of <⅔ RDI would indicate a poor diet (34). All subjects institutionalized in residential accommodation (group RA) had adequate energy intake. The practice of sitting in groups during meal hours appeared to result in an overall satisfactory energy intake. However, the lower energy intake by the hospital institutionalized group (group H) was attributable to lack of interest in food and surroundings, poor appetite with limited energy expenditure, lack of attention and encouragement during meals. The subjects of sheltered dwellings (group SD) were considered well enough to look after themselves, however, more than 50% were dependent upon domiciliary meal service during the day and avoided cooking or eating proper evening meals. This not only resulted in low energy intakes but in an overall poor nutritional status.

The nutrients most lacking in the diet were vitamin D, vitamin B_6, potassium, and magnesium. The dietary deficiencies of potassium and magnesium are important in the aged, since frequent use of diuretics can readily result in depletion (35) and cause mental and physical disturbances (36, 37). The need of supplementing the diet with extra milk, citrus juice, and fortified margarine (instead of butter) appears desirable to overcome the dietary deficiency of magnesium, potassium and vitamin D.

The occurrence of biochemically-deficient levels of iron, folic acid, thiamin, riboflavin, and vitamin B_6 was highest in subjects of

TABLE 9
Mean (± SD) and frequency distribution of subjects with low and deficient levels of serum carotene, plasma ascorbic acid, ETK index, EGR activity coefficient, and EGPT index

Groups	Sex	Serum carotene		Plasma ascorbic acid		ETK coefficient (α)		EGR activity coefficient (AC)		EGPT index	
		Mean ± SD	<40 μg/100 ml No. of subjects	Mean ± SD	<0.3 mg/100 ml No. of subjects	α (Mean ± SD)	α > 1.20 No. of subjects	AC (Mean ± SD)	AC ≥ 1.20 No. of subjects	Mean ± SD	Index > 1.15 No. of subjects
		μg/day			*mg/100 ml*						
IHM	M	75.6 ± 30.4 (11)[a]	1	0.97 ± 0.27 (10)	0	1.08 ± 0.07 (11)	0	0.94 ± 0.07 (11)	0	1.04 ± 0.05 (11)	0
	F	70.0 ± 31.7 (41)	5	1.05 ± 0.27 (41)	0	1.08 ± 0.06 (42)	1	0.94 ± 0.07 (42)	0	1.10 ± 0.09 (43)	8
IH	M	65.2 ± 21.9 (12)	2	0.29 ± 0.15 (13)	6	1.11 ± 0.11 (13)	2	1.04 ± 0.08 (13)	0	1.15 ± 0.15 (13)	6
	F	62.7 ± 27.6 (26)	5	0.47 ± 0.39 (28)	10	1.18 ± 0.23 (30)	8	0.98 ± 0.09 (30)	1	1.20 ± 0.16 (30)	15
RA	M	49.7 ± 11.0 (9)	2	0.17 ± 0.14 (9)	8	1.09 ± 0.07 (9)	1	1.03 ± 0.07 (9)	0	1.20 ± 0.11 (9)	6
	F	91.4 ± 48.2 (16)	2	0.41 ± 0.22 (17)	4	1.09 ± 0.09 (17)	2	1.03 ± 0.11 (17)	2	1.23 ± 0.18 (17)	10
SD	M	86.3 ± 30.9 (3)	0	0.20 ± 0.18 (3)	2	1.52 ± 0.38 (3)	3	1.17 ± 0.12 (3)	2	1.27 ± 0.31 (3)	2
	F	98.1 ± 38.2 (16)	0	0.48 ± 0.45 (16)	7	1.18 ± 0.15 (17)	4	1.07 ± 0.14 (17)	3	1.17 ± 0.13 (17)	11
H	M	56.1 ± 31.1 (7)	2	0.38 ± 0.25 (10)	4	1.14 ± 0.09 (10)	2	1.11 ± 0.22 (10)	3	1.19 ± 0.15 (10)	6
	F	67.1 ± 30.0 (27)	6	0.52 ± 0.47 (26)	13	1.15 ± 0.11 (27)	3	1.04 ± 0.14 (27)	3	1.19 ± 0.24 (27)	13
HM	M	72.4 ± 14.0 (5)	0	1.19 ± 0.28 (4)	0	1.11 ± 0.07 (5)	1	0.97 ± 0.04 (5)	0	1.15 ± 0.12 (5)	1
	F	85.6 ± 41.4 (10)	0	1.24 ± 0.23 (8)	0	1.06 ± 0.06 (11)	0	1.00 ± 0.11 (11)	0	1.16 ± 0.10 (11)	5

[a] Figures in parentheses denote number of subjects studied.

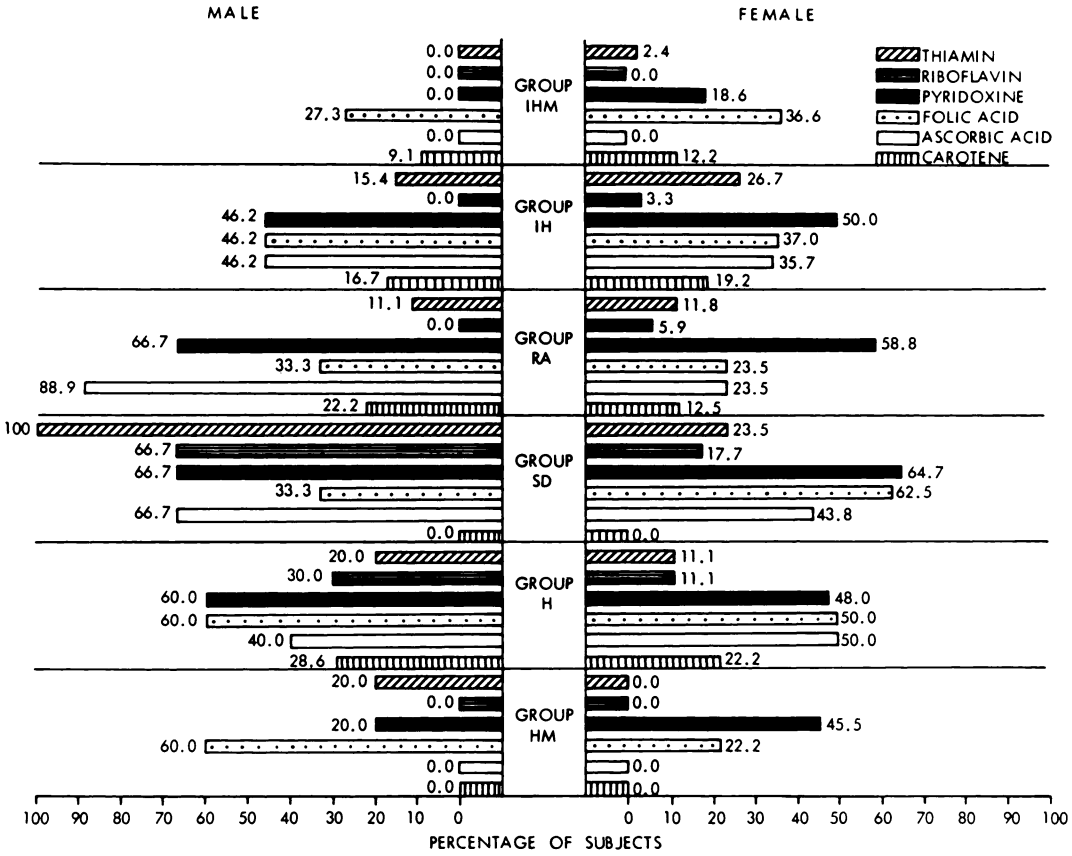

FIG. 1. The percentage distribution of subjects with biochemically low and deficient levels of vitamins in the six groups.

TABLE 10

Number of subjects with daily intake of vitamins <⅔ RDI or >⅔ RDI and with biochemically low and deficient levels in the six groups

Nutrient	Criteria	Groups											
		IHM		IH		RA		SD		H		HM	
Thiamin	Intake < 2/3 RDI	3		0		0		3		5		0	
	($\alpha > 1.20$)[a]		(0)		(0)		(0)		(1)		(0)		(0)
	Intake > 2/3 RDI	51		40		26		17		32		16	
	($\alpha > 1.20$)		(1)		(10)		(3)		(6)		(5)		(1)
Riboflavin	Intake < 2/3 RDI	24		14		2		3		13		7	
	(AC ⩾ 1.20)[b]		(0)		(0)		(0)		(3)		(3)		(0)
	Intake > 2/3 RDI	50		29		24		17		24		9	
	(AC ⩾ 1.20)		(0)		(1)		(2)		(2)		(3)		(0)
Vitamin B_6	Intake < 2/3 RDI	53		43		22		18		32		13	
	(EGPT index > 1.15)		(8)		(21)		(13)		(12)		(18)		(5)
	Intake > 2/3 RDI	1		0		4		2		5		3	
	(EGPT index > 1.15)		(0)		(0)		(3)		(1)		(1)		(1)
Ascorbic acid	Intake < 2/3 RDI	16		17		2		10		6		2	
	(PAA < 0.30 mg/100 ml)		(0)		(7)		(1)		(6)		(3)		(0)
	Intake > 2/3 RDI	38		26		24		10		31		14	
	(PAA > 0.30 mg/100 ml)		(0)		(9)		(11)		(3)		(13)		(0)

[a] Figures in parentheses represent number of subjects with biochemically low and deficient levels. [b] AC, activity coefficient.

sheltered dwellings (group SD). These results reveal the failure of this type of institution in meeting the nutritional needs of the aged. In this study, iron deficiency without anemia was common and this concurs with the report of Batata et al. (10). Folate deficiency without anemia was prevalent, the incidence being more than 25% in all the groups and more than 50% in those residing at home not receiving multivitamin (group H) and the sheltered dwelling group (group SD). Deficiency of folic acid has frequently been reported in the elderly people (10, 14, 38) in the United Kingdom. Increased loss of folate in cooking, inadequate ingestion, absorption or utilization (39), low iron, and ascorbic acid status (40, 41), frequent use of drugs such as barbiturate, and regular consumption of alcohol (42) appear to be the causative factors. Vitamin B_{12} deficiency was rare compared to folic acid deficiency. However, the incidence of deficiency noted in 4.6% subjects was comparable to the figures reported in the aged population of Scotland and Ireland (43, 44).

Unlike present findings, the vitamin C status of the aged residing in their own homes and small welfare homes has been found to be superior to those living in large institutions or hospitals (12, 45). Smoking, independent of dietary factors, has been associated with significantly low plasma and leucocyte ascorbic acid levels (46) and this may have attributed to higher incidence of vitamin C deficiency in home and residential accommodation, despite higher dietary ascorbic acid intake. The mean serum carotene levels, observed in the present study, were lower than those reported in studies of the aged from the United States (47, 48). Of the total sample, 13.7% had serum carotene levels less than 40 mg/100 ml, the lower acceptable limit defined by National Nutrition Survey (32). The true significance of low serum carotene levels cannot be assessed satisfactorily, unless the contribution of carotene to vitamin A intake in the diet is known and a state of intestinal malabsorption can be ruled out. Vitamin D status was low in 47% of the 49 subjects studied and the mean levels obtained were much lower than the mean concentration of 12.1 ng/ml reported in a group of normal adults in the United Kingdom (30). Lower dietary intakes and poor exposure to direct sunlight were probably the factors responsible for low 25, hydroxyvitamin D values.

The functional tests, reliable indicators of thiamin, riboflavin, and vitamin B_6 status (24, 49, 50), revealed an occurrence of low and deficient levels in about 50% of the subjects. The deficiency of these B vitamins was not solely due to intake being lower than the recommended. Factors such as impaired absorption, disturbed transformation of the vitamin to its active form or impaired binding of the coenzyme to apoenzyme may have affected the availability of B vitamins at cellular level, despite an adequate intake. However, the lack of relationship between dietary intake and biochemical deficiency may be a reflection of wide individual variations in vitamin requirements due to homeostatic efficiency or deranged metabolism.

Our data showed conclusively that the vitamin deficiency that may have occurred with suboptimal intake of nutrients at home and hospital were significantly reduced by the regular intake of multivitamins. However, it was interesting to note that despite vitamin supplementation, 2.9% of the subjects had thiamin deficiency and 20.0% had vitamin B_6 deficiency. This probably reflects a wide individual variability in vitamin requirements. The recommended intakes are defined to meet the needs of practically "all healthy" persons (51) and do not include the increased need of nutrients that appear to arise in the elderly from disease, metabolic abnormality, structural changes in the gastrointestinal tract due to deficiency of some nutrients or aging. The present study emphasises the need for possibly higher recommended allowance than the present for thiamin, riboflavin, and vitamin B_6. György (52) has suggested that an increase in the recommended allowance of vitamin B_6, from 2 to 25 mg, would prove beneficial in the aged. Higher levels of B vitamins than the present recommended cannot be easily provided in the diet of the aged who have low energy requirements. Additional vitamins may, therefore, be needed in some form of artificial supplementation. However, more extensive study of ill or less active, enfeebled subjects over 65 years would be needed to supply information upon which recommendations concerning vitamin supplementation in this group could be made.

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