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Food intake and energy expenditure of Indian troops in training

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1. Food intake and energy expenditure were determined on 500 soldiers drawn from infantry, artillery and engineer units of the Indian army, for 3 months during winter.

2. The units were located in two different regions of India at altitudes varying from sea level to 2300 m.

3. The energy requirements were assessed from the actual food intake as well as from energy expenditure and from the changes in body-weight and skinfold thickness.

4. The nutritional adequacy of the diet was assessed from clinical examination and changes in blood haemoglobin concentration.

5. The mean energy expenditure was found to be 15·39 MJ (3679 kcal) and on this basis the energy requirement was 16·61 MJ (3970 kcal); energy intake was found to be 16·47 MJ (3936 kcal).

6. The energy contributed by protein, fat and carbohydrate was 0·115, 0·240 and 0·645 of the total intake respectively.

7. There was no significant change in body-weight, blood haemoglobin level and skinfold thickness on this mean daily intake.

Feeding the Indian army, as with other armies, is the responsibility of the State. For accurate planning of the scale of rations, scientific studies are essential to assess the requirement of recruits during training and of trained soldiers in barracks and during field exercises, as well as under other special conditions. Such studies have been made in Western countries from time to time by various workers (Kuhl, Best, Berger, Consolazio & Friedmann, 1952; Ryer, Consolazio & Berger, 1954; Widdowson, Edholm & McCance, 1954; Consolazio, Hawkins, Berger, Johnson, Katzanek & Skala, 1955; Edholm, Fletcher, Widdowson & McCance, 1955; Adam, Best, Edholm & Wolff, 1957; Adam, Best, Edholm, Fletcher, Lewis & Wolff, 1958, 1959; Consolazio, Hawkins, Johnson & Friedmann, 1959; Goldman, 1965; Edholm, Adam, Healy, Wolff, Goldsmith & Best, 1970). Similar studies have also been done on Indian troops to assess their requirements under various operational conditions in the field (Malhotra, 1958; Malhotra, Ramaswamy & Ray, 1962; Rai, Dimri & Uthappa, 1966; Malhotra, Ramaswamy, Sengupta & Venkataswamy, 1967; Rai, Dimri, Uthappa & Sampathkumar, 1967; Verma, Gajapathy & Ghosh, 1967).

Under field conditions, the troops have to operate in different terrains, climates and altitudes and have to do various strenuous duties. These involve digging bunkers and defensive positions, attacking 'enemy' positions, long-distance route marches, loading and unloading. Accordingly, their energy and nutritional requirements in field areas can be expected to be increased. In this paper, the requirement of troops in field areas at altitudes below 2730 m are reported.

EXPERIMENTAL

Subjects and nature of their work

The studies were made on 500 soldiers, 300 in the western region and 200 in the eastern region. They belonged to a mixture of classes, e.g. Jats, Sikhs, Maharashtrians, Biharis. In the western region, one company of 100 soldiers was taken from each of the three units of infantry, artillery and engineers; in the eastern region, two companies of infantry were selected for the study, which lasted from the beginning of November to the end of January. During this period, the troops were engaged in collective training exercises involving route marches, battle courses, maintenance and construction of bunkers, trench digging and cleaning of arms and guns.

Estimation of actual food intake

This was estimated by recording group intake for each company, consisting of 100 subjects, separately for a period of 3 months. Each day, various items of food were taken, representing the official scale of rations for the total dining strength of the company. Each item of food was weighed before and after cooking to determine the ratio, weight before cooking: weight after cooking, so that the amounts of cooked items left-over in the kitchen and the plate wastage could be estimated in terms of the raw ingredients. The subjects were allowed to eat *ad lib*. Provision was made for the issue of extra food if and when needed. The amount of food left-over in the kitchen as well as the plate wastage were recorded. The kitchen wastage of inedible portions, e.g. vegetable peelings and roots, in the preparation of food was also noted. The amount of vitamin C destroyed during cooking of various vegetables was determined by the method of Roe & Kuether (1943).

The subjects were told not to eat any food except that provided to them in the mess. Because the units were located at a distance from the civilian population, alternative food supplies were not readily available. The actual food intake was estimated from the food issued to the cookhouse, wastage of raw, inedible portions of food items in the kitchen, quantities of cooked food left-over in the kitchen, and plate wastage.

Daily activity routine

In each unit, ten subjects representing different sections of the company were chosen to fill in the 'time and motion study' forms (Passmore & Durnin, 1955). For these, they were required to keep a fairly accurate, 24 h record of their daily activities for 15 d of each month. From the analysis of these records, the time spent by each of these subjects in various types of activity during 24 h was calculated. The mean values were taken as representing the activities in which the company was engaged during the study period.

Energy cost of various activities

The energy cost of most of the tasks which a soldier is required to do had been determined earlier (Malhotra, 1958; Malhotra *et al.* 1962). The values obtained were gross energy values and took into account the basal metabolic rate and the specific dynamic action of food, as the measurements were made 1–2 h after breakfast or lunch. During the present study, the energy cost of a few representative tasks was estimated for troops in the western region, and the values obtained were compared with those obtained in the earlier study. The results indicated that the values obtained earlier could be applied to this study also. In addition, the energy cost of the tasks not considered in earlier studies was estimated during this trial using the same technique.

Body-weight, skinfold thickness and haemoglobin level

All measurements were made at the start of each study and every 2 weeks thereafter. The body-weight was recorded using an Avery balance (Avery India Limited, India) with a sensitivity of 50 g. The skinfold thickness was measured at two positions, (*a*) over the middle of the triceps, (*b*) at the inferior angle of the scapula, using Lange's caliper (Cambridge Scientific Industries, USA) with an accuracy of ± 1 mm. Haemoglobin level was determined by Sahli's method (Kolmer, Spaulding & Robinson, 1969).

Clinical examination

A clinical examination of all the subjects was made at the start of each study and periodically thereafter, according to the recommendations of the nutritional survey reported by Wilson, Schaefer, Darby, Bridgforth, Pearson, Combs, Leatherwood, Greene, Teply, Plough, McGanity, Hand, Kertesz & Woodruff (1964).

Environmental temperature

During the study period, in the western region the maximum and minimum temperatures were recorded, and in the eastern region dry-bulb and wet-bulb temperatures were recorded from 08.00 to 22.00 hours.

RESULTS

Meteorological conditions

In the eastern region, the dry-bulb temperature ranged from 10 to 31° and the wet-bulb temperature from 8·5 to 26°. Although there was no rainfall, the humidity was very high, approaching 90% on some days. The troops wore woollen shirts during the day and an additional jersey at night.

In the western region the maximum temperature ranged from 3·3 to 27·5° and the minimum from −5·6 to 15·0°. On certain occasions in this region there was snowfall at the stations situated at an altitude of 2300 m. The troops wore jerseys and woollen shirts during the day and an additional greatcoat during the night in December and January.

Food intake

The total food intake and the intake of various items of food for the different companies are compared in Table 1. The over-all mean energy value of the food consumed was found to be 16·47 MJ (3936 kcal) and varied from 16·22 to 16·72 MJ (3877 to 3996 kcal) in different companies, the highest being in the engineers'

Table 1. *Mean intake (g/d) of food items included in the rations given to soldiers in different units of the Indian army**

Food items	Energy content (kJ/g)	Western region: Infantry	Western region: Artillery	Western region: Engineers	Eastern region Infantry	Mean
Atta (rice)	14·35	614	627	602	610	611
Dhal	14·64	79	86	85	83	83
Oil (hydrogenated)	37·65	77	63	82	78	75
Milk: Powdered	—	26	—	—	—	—
Fresh (ml)	2·80	—	250	250	250	250
Cane sugar	16·61	90	90	90	90	90
Meat	6·48	87	99	110	78	94
Potatoes	4·05	100	79	92	106	94
Onions	2·01	30	31	44	45	38
Other vegetables	1·63	130	124	126	146	132
Fruit: Citrus	0·33	13	10	22	37	21
Non-citrus	0·42	36	22	16	15	22
Tea	—	9	9	9	9	9
Common salt (sodium chloride)	—	14	19	18	17	17
Toffee	—	—	—	—	0·5	—
Jam	—	—	—	—	2	—
Condiments	8·36	10	10	10	10	10
Food energy (MJ(kcal)):						
Total		16·36 (3910)	16·22 (3877)	16·72 (3996)	16·57 (3961)	16·47 (3936)
Range		13·29–19·22 (3176–4593)	13·56–16·96 (3280–4054)	15·13–19·59 (3616–4682)	13·62–19·63 (3255–4691)	

* For details of subjects, see p. 230.

regiment. There was wide scatter of energy intake on different days, depending on the activities of the troops. Whenever they went on cross-country exercises, they had to carry packed meals and, therefore, had a lower energy intake. On return also they had a comparatively lower intake, due to fatigue. On succeeding days they ate more to compensate for this low energy intake.

Kitchen and plate wastage

In the standard tables (Director-General, Armed Forces Medical Services, India, 1968; Indian Council of Medical Research, 1968) we used for the estimation of energy and nutrient contents of fresh vegetables, potatoes, onions, fruits, and other items which have an inedible portion (kitchen wastage), values are given for the edible portion, with separate values for the amount of wastage expected from each of these items.

In the present study, the kitchen wastage of these items was found to be within the range indicated in the standard tables. For the other items, e.g. cereals, cane sugar, cooking oil, etc. there was practically no wastage, as the cooked food left-over from one meal was served at the next meal in a different form. There was, however, some plate wastage which varied from company to company. The highest wastage of 2% recorded for the engineers was the result of incorrect baking of chupatties. For the other units, plate wastage varied from 0·4 to 0·7% (Table 2).

Table 2. *Mean amount (g) and energy content (kJ(kcal)) of plate and kitchen* wastage of food items included in the rations given to soldiers in different units of the Indian army*†

	Western region						Eastern region	
	Infantry		Artillery		Engineers		Infantry	
	Amount of wastage	Energy content	Amount of wastage	Energy content	Amount of wastage	Energy content	Amount of wastage	Energy content
Food items								
Whole-wheat flour or rice	4·1	58·6 (14)	3·3	50·2 (12)	18·0	263·6 (63)	7·0	104·6 (25)
Dhal	0·2	4·2 (1)	1·5	20·9 (5)	5·0	71·1 (17)	0·5	8·4 (2)
Vegetables (fresh)	2·5	4·2 (1)	—	—	3·8	8·4 (2)	2·0	4·2 (1)
Wastage of food energy:								
Total		67·0		71·1		342·5		117·2
% Total energy in ration (17·26 MJ (4126 kcal)/man per d)		0·4		0·4		2·0		0·7

* Inedible portion (e.g. peelings and roots) left-over in preparation of the food, and cooked items left-over in the kitchen.

† For details of subjects, see p. 230.

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Table 3. *Daily energy expenditure of soldiers in different units of the Indian army**

		Western region						Eastern region	
		Infantry		Artillery		Engineers		Infantry	
Activity	Rate of energy expenditure (kJ(kcal)/min)	Time spent in activity (min/d)	Energy expenditure (kJ(kcal))	Time spent in activity (min/d)	Energy expenditure (kJ(kcal))	Time spent in activity (min/d)	Energy expenditure (kJ(kcal))	Time spent in activity (min/d)	Energy expenditure (kJ(kcal))
Sleep†	4·35 (1·04)	415	1807·48 (432)	435	1891·17 (452)	421	1832·59 (438)	420	1828·41 (437)
Toilet and bathing†	12·15 (2·90)	83	1008·34 (241)	75	962·32 (230)	70	719·65 (172)	85	983·24 (235)
Polishing	8·37 (2·00)	15	125·52 (30)	—	—	6	50·21 (12)	15	125·52 (30)
Bed making	12·17 (2·91)	11	133·88 (32)	—	—	12	196·65 (47)	12	196·65 (47)
Light walking with equipment	18·37 (4·39)	110	2020·87 (483)	120	2209·15 (528)	74	1363·98 (326)	40	736·38 (176)
Climbing uphill	25·60 (6·12)	68	1740·54 (416)	—	—	—	—	—	—
Firing practice	14·88 (3·56)	9	133·88 (32)	6	87·86 (21)	—	—	65	949·77 (227)
Parade†	25·23 (6·03)	30	790·78 (189)	18	472·79 (113)	—	—	30	786·59 (188)
Battle physical efficiency tests	41·32 (9·88)	8	330·54 (79)	—	—	—	—	—	—
Eating	6·28 (1·50)	50	313·80 (75)	50	313·80 (75)	49	305·43 (73)	50	313·80 (75)
Sentry duty†	10·05 (2·40)	72	723·83 (173)	92	924·66 (221)	15	150·62 (36)	60	602·50 (144)
Games	20·92 (5·00)	15	313·80 (75)	10	209·20 (50)	22	460·24 (110)	45	941·40 (225)
Water carrying	14·41 (3·44)	9	129·70 (31)	—	—	—	—	—	—

Table 3 *continued*

Activity	Rate of energy expenditure (kJ(kcal)/min)	Western region: Infantry: Time spent in activity (min/d)	Western region: Infantry: Energy expenditure (kJ(kcal))	Western region: Artillery: Time spent in activity (min/d)	Western region: Artillery: Energy expenditure (kJ(kcal))	Western region: Engineers: Time spent in activity (min/d)	Western region: Engineers: Energy expenditure (kJ(kcal))	Eastern region: Infantry: Time spent in activity (min/d)	Eastern region: Infantry: Energy expenditure (kJ(kcal))
Cookhouse working	13·05 (3·12)	17	221·75 (53)	—	—	46	598·31 (143)	25	322·17 (77)
Loading and unloading†	23·43 (5·60)	5	117·15 (28)	23	627·60 (150)	20	510·45 (122)	—	—
Bunker repair	17·43 (4·17)	18	313·80 (75)	—	—	27	464·42 (111)	—	—
Arms cleaning†	12·16 (2·91)	64	778·22 (186)	20	242·67 (58)	—	—	84	1020·89 (244)
Patrolling	18·55 (4·43)	30	556·47 (133)	44	866·08 (207)	—	—	66	1242·65 (297)
Rest and relaxation	7·17 (1·71)	286	1673·60 (400)	291	1506·24 (360)	287	1606·66 (384)	120	702·91 (168)
Reading and writing	9·17 (2·19)	52	476·98 (114)	35	322·17 (77)	57	523·00 (125)	50	460·24 (110)
Washing clothes†	12·55 (3·00)	27	338·90 (81)	23	288·67 (69)	12	150·62 (36)	22	276·14 (66)
Physical training†	36·82 (8·80)	5	184·10 (44)	12	468·61 (112)	21	736·38 (176)	—	—
Camouflage and concealment	22·45 (5·37)	41	920·48 (220)	—	—	—	—	55	1221·73 (292)
Road construction	26·65 (6·37)	—	—	—	—	157	4184·00 (1000)	—	—
Office work	7·83 (1·87)	—	—	—	—	35	274·05 (65)	—	—
Guard duty†	5·28 (1·26)	—	—	—	—	42	221·75 (53)	—	—
Area cleaning†	22·14 (5·29)	—	—	—	—	48	1062·74 (254)	—	—

Table 3 *continued*

Activity	Rate of energy expenditure (kJ(kcal)/min)	Western region: Infantry: Time spent in activity (min/d)	Western region: Infantry: Energy expenditure (kJ(kcal))	Western region: Artillery: Time spent in activity (min/d)	Western region: Artillery: Energy expenditure (kJ(kcal))	Western region: Engineers: Time spent in activity (min/d)	Western region: Engineers: Energy expenditure (kJ(kcal))	Infantry: Time spent in activity (min/d)	Infantry: Energy expenditure (kJ(kcal))
Equipment maintenance	16·36 (3·91)	—	—	—	—	11	179·91 (43)	—	—
Breaking firewood	20·40 (4·87)	—	—	—	—	8	163·18 (39)	—	—
Artillery gun training	14·67 (3·51)	—	—	77	1129·68 (270)	—	—	—	—
Levelling ground	16·73 (4·00)	—	—	31	518·82 (124)	—	—	50	836·80 (200)
Digging	30·17 (7·21)	—	—	19	573·21 (137)	—	—	15	451·87 (108)
Working gradients	20·92 (5·00)	—	—	16	334·72 (80)	—	—	—	—
Fire-fighting	25·10 (6·00)	—	—	25	627·76 (150)	—	—	—	—
Clearing bushes†	25·57 (6·11)	—	—	18	460·24 (110)	—	—	—	—
Standing at attention	10·04 (2·40)	—	—	—	—	—	—	40	401·66 (96)
Rifle drill	14·64 (3·50)	—	—	—	—	—	—	66	966·50 (231)
Floor sweeping	10·38 (2·48)	—	—	—	—	—	—	25	259·41 (62)
Total daily energy expenditure (MJ(kcal))			15·15 (3622)		15·03 (3594)		15·75 (3765)		15·63 (3735)

* For details of subjects, see p. 230.

† Values taken from Malhotra (1958); Malhotra, Ramaswamy & Ray (1962).

Table 4. *Mean daily energy expenditure in graded activities of soldiers in different units of the Indian army* located from sea level up to 2300 m altitude*

			Western region						Eastern region			
			Infantry		Artillery		Engineers		Infantry		Mean	
Grade of activity	Activity	Energy expenditure for activity (kJ(kcal)/min)	Time spent in activity (min)	Energy expenditure (MJ(kcal))	Time spent in activity (min)	Energy expenditure (MJ(kcal))	Time spent in activity (min)	Energy expenditure (MJ(kcal))	Time spent in activity (min)	Energy expenditure (MJ(kcal))	Time spent in activity (min)	Energy expenditure (MJ(kcal))
Very light	Sleep, sitting, resting, drinking	4·2–8·4 (1·0–2·0)	718	3·99 (811)	776	3·74 (894)	839	4·65 (991)	590	2·85 (680)	731	3·53 (844)
Light	Bathing, reading, writing, arms cleaning, toilet, boot polishing	8·5–12·6 (2·1–3·0)	366	4·00 (956)	232	2·40 (574)	157	1·68 (401)	393	4·32 (1033)	285	3·10 (741)
Moderate	Rifle firing, artillery gun training, climbing up-hill, walking	12·7–16·7 (3·1–4·0)	25	0·35 (85)	106	1·56 (372)	89	1·28 (307)	206	3·05 (730)	106	1·56 (373)
Heavy	Games, patrol duty, levelling ground	16·8–25·1 (4·1–6·0)	248	4·90 (1171)	226	4·54 (1085)	216	4·51 (1079)	206	4·17 (996)	226	4·53 (1083)
Very heavy	Parade, digging, loading truck, clearing bushes	25·2–33·1 (6·1–8·0)	70	1·99 (476)	88	2·38 (569)	117	3·38 (807)	45	1·24 (296)	80	2·25 (537)
Maximal	Physical training	> 33·1 (> 8·0)	13	0·51 (123)	12	0·42 (100)	22	0·75 (180)	—	—	12	0·42 (101)
Total				15·14 (3622)		15·04 (3594)		15·75 (3765)		15·63 (3735)		15·39 (3679)
Range				13·90–16·53 (3322–3950)		12·28–16·52 (2934–3949)		13·16–19·56 (3145–4674)		13·47–19·18 (3219–4584)		

* For details of subjects, see p. 230.

Table 5. *Mean initial and final values for body-weight, blood haemoglobin level, and skinfold thickness of soldiers in different units of the Indian army* during energy expenditure trials for a period of 13 weeks*

(Mean values with their standard errors)

Unit	No. of subjects	Body-wt (kg) Initial Mean	SE	Body-wt (kg) Final Mean	SE	Haemoglobin (g/l) Initial Mean	SE	Haemoglobin (g/l) Final Mean	SE	Skinfold thickness (mm) Triceps Initial Mean	SE	Triceps Final Mean	SE	Subscapular Initial Mean	SE	Subscapular Final Mean	SE	Height (m) Mean	SE
Western region: Infantry	85	67·1	4·9	66·5	7·5	141	11	138	12	8·6	3·8	8·5	3·7	9·9	3·8	9·4	3·4	1·721	0·046
Artillery	78	61·2	6·8	61·4	6·5	128	11	136	7	8·8	4·5	8·4	3·9	12·4	4·2	12·0	4·6	1·735	0·045
Engineers	56	58·7	6·6	59·2	6·0	129	8	145	15	7·9	3·4	7·8	3·0	11·3	3·9	10·7	3·8	1·667	0·042
Eastern region: Infantry	170	65·9	5·6	65·9	6·3	124	13	131	13	7·8	3·4	7·9	3·4	9·5	2·5	9·5	3·4	1·749	0·053

* For details of subjects, see p. 230.

Energy expenditure

The energy cost of various activities and the mean time spent in each activity during 24 h, for each of the units, is given in Table 3. Although the activities in which different units were engaged were not the same, because of their different army duties, there was not much difference in their estimated energy expenditure. Their average daily energy expenditure varied from 15·03 to 15·75 MJ (3594–3765 kcal) with the mean value of 15·39 MJ (3679 kcal). Within each company the energy expenditure varied widely on different days; the lowest value was recorded on Sundays and holidays and the highest was during battle courses. These activities have been further classified, on the basis of the severity of the tasks, into six categories varying from 'very light' to 'very heavy'. The duration and the energy expenditure of these activities for the four units are compared in Table 4. On average, the troops were engaged in 'very heavy' work for 80 min and 'heavy' work for 226 min. This finding suggests that the troops were very active during the period of the study.

Changes in body-weight, haemoglobin level and skinfold thickness

Although these measurements were made every 2 weeks, only initial and final values have been given in Table 5, as the intermediate values were not significantly different. Body-weights remained the same for all units throughout the period of the study. Also there was no significant change in haemoglobin level or skinfold thickness. This finding indicates that the ration given to the soldiers was adequate in energy and nutrient contents.

Also clinical examination of the soldiers did not show any evidence of deficiency. The tongue, skin and tendon reflexes were found to be normal.

DISCUSSION

These studies were made from the beginning of November to the end of January, which are the winter months in India. During this period the soldiers were engaged in collective training exercises, and their activity and their energy expenditure was maximum: in summer, the outdoor activities of troops during the day are considerably restricted as a precaution against heat casualties. The studies involved soldiers of different ethnic groups, from different units of the army, who were engaged in exercises on various terrains, and at different altitudes from sea level to 2300 m. Therefore, the nutrient requirements determined in this study should be applicable to troops in all conditions and in all units of the armed services (Wilson *et al.* 1964).

The energy requirements have been estimated on the basis of two different approaches; first, from values for energy expenditure, and secondly, from the actual food intake. The results obtained by both approaches are in close agreement. The average energy expenditure of the troops was 15·39 MJ (3679 kcal)/d and the food energy intake was about 16·47 MJ (3936 kcal)/d. These values agree fairly well when kitchen and plate wastage, and the losses during digestion and absorption are taken into account. The kitchen and plate wastage has been found to vary from 0·4 to 2·0%.

Table 6. *Nutrient content of daily ration and daily nutrient intake of soldiers in different units of the Indian army**

Nutrient	Nutrient content of ration	Nutrient intake: Western region Infantry	Western region Artillery	Western region Engineers	Eastern region Infantry	Mean
Energy: MJ	17·26	16·36	16·22	16·72	16·57	16·47
kcal	4126	3910	3877	3996	3961	3936
Protein (g)	118·3	115·0	114·3	113·3	110·1	113·2
Animal protein: g	25·8	26·0	22·9	24·5	22·4	23·9
% Total	21·8	22·6	20·0	21·6	20·3	21·1
Fat (g)	116·0	99·6	94·9	115·6	109·3	104·8
Carbohydrate (g)	657·5	636·6	641·5	626·0	632·0	634·0
Energy contributed by: Protein: MJ	1·98	1·92	1·91	1·90	1·85	1·90
Proportion of total	0·114	0·118	0·118	0·115	0·114	0·115
Carbohydrate: MJ	11·0	10·65	10·73	10·48	10·58	10·61
Proportion of total	0·633	0·653	0·662	0·627	0·638	0·645
Fat: MJ	4·37	3·75	3·57	4·36	4·12	3·95
Proportion of total	0·253	0·229	0·220	0·260	0·248	0·240
Vitamin A (μg)	1225 (900)†	852	862	1018	1023	939
Thiamin (mg)	3·30 (2·00)†	2·58	2·64	2·62	2·62	2·62
Riboflavin (mg)	2·22 (2·20)†	2·12	2·12	2·10	2·22	2·14
Nicotinic acid (mg)	31·92 (26·00)†	29·18	30·22	30·40	28·76	29·64
Ascorbic acid (mg)	182·20 (35·00)†	80·44	89·66	97·92	122·42	97·62
Iron (mg)	65·06 (20·00)†	60·40	61·98	60·62	61·14	61·04
Calcium (g)	1·12 (0·4–0·5)†	0·90	0·98	1·02	1·00	0·98

* For details of subjects, see p. 230.

† Recommended dietary allowances (Food and Nutrition Board (UK), 1968).

For the estimation of energy requirements, the maximum value of 2% can be taken. The value obtained for losses during digestion and absorption of food has been estimated to be about 6% (Passmore, Meiklejohn, Dewar & Thow, 1955), thus making a total of 8% which should be added to the value for energy expenditure used in determining the scale of rations. Therefore, on this basis the energy content of the food should be 16·61 MJ (3970 kcal)/d. The actual food energy intake was found to be 16·47 MJ (3936 kcal)/d. Thus the energy intake and the energy requirements calculated on the basis of energy expenditure, are almost in balance, as indicated previously. That the subjects were in energy balance is further supported by the finding that the troops maintained their body-weights on this intake during the 3 months of study. The nutrient content of the ration supplied was also adequate, as the mean value for haemoglobin concentration was approximately 140 g/l, and there was no clinical evidence of any deficiency disease. The troops thus require about 16·74 MJ (4000 kcal)/d in field areas. This value is the same as that for the ration supplied to the Federal Army of West Germany which also provides 16·74 MJ (4000 kcal)/d (Graefe, 1960). For the US Army, the daily energy intake in the mess in field areas has been found to be 15·62 MJ (3733 kcal) in infantry messes, 16·09 MJ (3845 kcal) in engineers' messes and 13·73 MJ (3295 kcal) in artillery messes, with an additional 1·26–1·67 MJ (300–400 kcal) from canteen purchases (Howe & Berryman, 1945). Their total energy intake is therefore almost the same as that of an Indian soldier, although the height and weight of the latter are considerably lower. This is because there is comparatively less mechanization in the Indian army, and many heavy tasks have to be done manually, thereby increasing their daily energy expenditure. Howe & Berryman (1945) have also found seasonal variations in the intake of food of US troops, the maximum intake being between September and November (16·57 MJ (3960 kcal)/d), and minimum between March and May (14·94 MJ (3570 kcal)/d). There is thus a seasonal variation in daily intake of about 1·67 MJ (400 kcal). The requirements for the Indian troops estimated in this study are those for winter months and are the maximum expected for any season. There would be a lower intake in summer, as indicated by results obtained for other armies (Murlin & Hildebrandt, 1919; Howe & Berryman, 1945).

Nutritional content of rations

The official scale of rations for Indian troops in the field is well balanced and contains (g/d) 118·3 protein, 116·0 fat, 657·5 carbohydrate. The proportional contributions of each of these nutrients to the total energy content of the food are protein 0·114, fat 0·253, carbohydrate 0·633 (Table 6). The mean intake during this study was found to contain (g/d) 113·2 protein, 104·8 fat, 634·0 carbohydrate.

Protein

The protein allowance in the official ration (118·3 g) is 1·87 g/kg body-weight per d, whereas the recommended optimum requirement for adults is 1·0 g/kg body-weight per d (Food and Nutrition Board (UK), 1968). The high protein content is mostly provided as large quantities of cereals, which alone supply 64 g protein/d. The other main sources of protein are dhal and vegetables, which provide 28·5 g/d. The vegetable proteins therefore provide 92·5 g/d. The remaining 25·8 g protein are animal proteins derived from milk and meat. The ration supplied to most of the Western armies also has a protein allowance of 2 g/kg body-weight per d. The daily ration supplied to US Army contains 131 g protein (Friedmann, Kraybill & Consolazio, 1959) and that of the Federal Army of West Germany contains 120 g protein (Wirths, 1959); in each instance 50% of the protein is derived from animal sources. The high animal-protein content is a consequence of dietary habits rather than nutritional needs. The high level of proteins in army rations is perhaps justified to stimulate muscle growth during the growing age, improve muscle strength and contribute to quick recovery from disease and injury. It is not, however, necessary for the diet to contain animal proteins in these high proportions, provided that the vegetable proteins are derived from different sources (Albanese & Orto, 1964; Young, 1964). The biological value of mixed vegetable proteins is close to that of animal proteins because of the complementary effect of the different amino acid compositions. Patwardhan, Mukundan, Ramasastri & Tulpule (1949) have reported that a diet providing 79·2 g protein/d, of which 4·7 % is animal protein, produces a positive N balance of 4·61 g/d, whereas the corresponding value is 0·26 g N/d for a diet with the same energy content, but providing 60·1 g protein/d, of which 62·7 % is animal protein. These workers suggested that the higher N balance with predominantly vegetable proteins is the result of a lower urinary N excretion.

Fat

The fat allowance in the field ration is about 116·0 g/d, of which 80·0 g is in the form of hydrogenated oil and the rest is mainly derived from milk and meat. In Indian field rations, fat provides 0·25 of the total energy, compared to 0·40–0·45 in the field rations supplied to Western armies. The usual recommended allowance for fat is 0·25–0·30 of total energy (Kummerow, 1960). The higher intake by Western armies is the result of a higher intake of meat and eggs, which have a high fat content. As, weight-for-weight, fat provides twice the energy of proteins or carbohydrates, a high-fat diet is required only when the energy expenditure is very high, otherwise it can result in overweight and increased susceptibility to atherosclerosis.

Carbohydrate

Carbohydrate is the main contributing nutrient of the Indian diet. Indian curries, dhal and meat provided in the ration, add flavour and facilitate the consumption of cereals, which are the main source of carbohydrate. The field ration for the Indian army contains 657·5 g carbohydrate, supplying 0·633 of the total energy. In the rations supplied to other armies, carbohydrate provides 0·45–0·60 of the total energy (Howe & Berryman, 1945; Friedmann *et al.* 1959; Lauersen, 1969). The rations of Western armies have a correspondingly higher fat content.

Minerals and vitamins

The vitamin and mineral content of the Indian field ration before cooking are given in Table 6. The ration provides these nutrients in amounts which are higher than the recommended allowances for Indians (Director-General, Armed Forces Medical Services, India, 1968; Indian Council of Medical Research, 1968). A proportion of these nutrients are lost during cooking. However, their loss is reduced considerably as no fluid portion of the vegetables and cereals is discarded during the preparation of Indian dishes and curries. But losses of heat-labile vitamins during cooking of food do occur. The losses of ascorbic acid in Indian-style cooking have been determined and have been found to range from 37·9 to 81·7 % (Malhotra, Rai, Sridharan & Baskaran, 1970). After taking into account these losses, the average ascorbic acid intake was found to be 37·5 mg/d. On this intake there was no evidence of any deficiency disease. The possibility of subclinical deficiency existing is small, as the minimum requirement has now been assessed as 30 mg/d (Hollingsworth, 1970;

Sabry, 1970). Further, the results of studies by Srikantia, Mohanram & Krishnaswamy (1970) on Indians have indicated that maximum leucocyte ascorbic acid concentration can be maintained on an intake of less than 22 mg/d. In view of these findings, the intake of 37·5 mg ascorbic acid/d, after cooking losses, appears to be quite adequate.

The losses of individual B-vitamins during Indian-style cooking have not been determined by us, but according to Director-General, Armed Forces Medical Services, India (1968) these vary from 10 to 60% for thiamin and riboflavin, and 10% for nicotinic acid. For vitamin A, losses are 10% in ordinary cooking and 90% during frying. In rations given to the US Army also, the losses of vitamins have been found to vary from 10 to 80% (Howe & Berryman, 1945), indicating that losses during Indian and Western methods of cooking are not very much different. From the excellent general health, haemoglobin level and absence of clinical evidence of any deficiency disease in these subjects, it can be inferred that the intake of various vitamins and nutrients are quite adequate, taking into account losses during cooking.

From our results, it can be concluded that the scale of Indian field rations provides an adequate diet not only in terms of energy content but in respect of nutrients, e.g. protein, fat, carbohydrate, vitamins and minerals. It satisfies the needs of the troops, which is the foremost requirement from the practical point of view. The ration is comparable with those of armies of the Western countries, yet the ration is compatible with the Indian climatic conditions, dietary habits and economic considerations.

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