Relations of Clinical and Dietary Findings in Nutrition Surveys

IRVIN C. PLOUGH, M.D., and EDWIN B. BRIDGFORTH, A.B.

An objective of the nutrition survey program of the Interdepartmental Committee on Nutrition for National Defense (ICNND) is the appraisal of the nutritional status of population groups.

The ICNND survey teams have studied military populations as a whole and have used three general approaches (*1*). Large numbers of individuals were examined clinically, and biochemical studies were performed on a subsample. Food and nutrient intakes were determined both in military messes and in households.

Although the three survey methods, clinical, biochemical, and dietary, require quite different procedures, one would expect them to give the same general results in the evaluation of nutritional status. Interrelations may be limited by the fact that the three approaches measure different temporal aspects of nutriture. The diet survey gives present intake, biochemical studies, that of the recent past, and clinical examination tends to give a history of a longer period in the past. Attempts were made in individual survey reports for the Philippines and Spain to correlate the results of the three approaches, but with little success. One difficulty was that the dietary nutrient intake figures, the incidences of clinical findings, and the means of the biochemical results showed little variation within each survey. It is therefore of interest to combine the data from a number of surveys and look for interrelations within the whole. Such a study should allow an evaluation of the reliability of the data and perhaps also of the survey technique. Integration of all findings might also lead to other results, for example, a better evaluation of human dietary requirements.

Dr. Plough, Lieutenant Colonel, Medical Corps, U.S. Army, is commander of the Army Medical Research and Nutrition Laboratory, Fitzsimons General Hospital, Denver, Colo. Mr. Bridgforth is assistant professor of biostatistics, department of preventive medicine, Vanderbilt University Medical School, Nashville, Tenn.

Methods

The data used in this analysis were taken from reports of nutrition surveys in Iran, Pakistan, Korea, the Philippines, Turkey, Libya, Spain, and Peru, published by the Interdepartmental Committee on Nutrition for National Defense. Several of these reports have also been published in scientific journals, although in somewhat less detail. The material analyzed here comprises results of surveys of military populations only, since military feeding practices permit the application of dietary survey procedures to large homogeneous groups. Thus, the average calculated nutrient intakes in military messes should approximate the intakes of individuals more exactly than can be expected in surveys of households.

The mess surveys were done by either the food inventory or recipe method. From the weights of food items consumed per man per day the nutrient intakes were calculated from tables of food composition, with major reliance on the U.S. Department of Agriculture Handbook No. 8 (*2*) and the U.N. Food and Agriculture Organization's tables of food composition (*3*). In many surveys composite food samples were also taken for chemical analysis for nutrient composition. Analyzed values for nutrients were used where possible except for vitamin C. In the latter instance calculated values were used because of the lability of vitamin C in stored samples and because of the frequent presence of interfering substances, particularly in cooked foods.

Large numbers of men were examined for clinical evidence of nutritional deficiency. Systematically selected men from those examined clinically also had blood and urine samples taken for biochemical analysis. Further details of the survey procedure are given in the individual survey reports and the ICNND Manual for Nutrition Surveys.

In the 8 nutrition surveys analyzed, a total of 58 military kitchen surveys were completed in 57 locations. The clinical and biochemical data analyzed were obtained on those subjects examined at these 57 separate locations. The groups included men from the messes surveyed and persons in the same location who ate in other messes. In analyzing the data it was necessary to assume that the nutrient intakes measured in one mess were representative of all mess halls at that location. Food for these messes was generally obtained locally so this assumption seemed reasonable. Thus, 57 sets of more or less complete data were selected which included nutrient intakes and clinical and biochemical findings in regard to these nutrients. The U.S. Army Medical Research and Nutrition Laboratory will publish detailed tabulations of these data, together with graphic correlations between dietary, clinical, and biochemical results.

Examination of the study data revealed reasonable homogeneity within each country. The findings in each nation were therefore averaged to give eight sets of data, parts of which are presented in the table. Unfortunately, only five sets of biochemical data are available because of varying methods of presentation. In taking the averages, the clinical and biochemical findings were weighted for the number of men in each group. Unweighted arithmetic means were taken of the dietary data, because no decision could be made, a priori, whether to weight the averages by the number of men fed in the mess, by the number of men examined in that location, or in some other way.

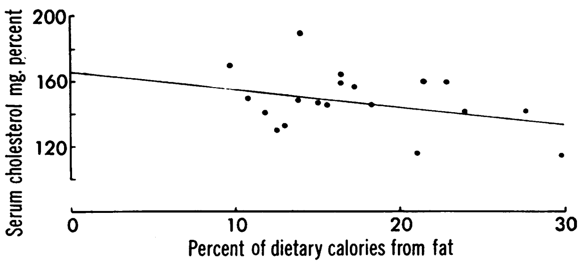
The data presented in the figures include both those from particular locations within countries (filled circles) and the national averages (open circles). Linear regressions were calculated for several sets of data, and in one case a hyperbolic regression was derived after reciprocal transformation of the independent variable. The regressions were calculated from the national figures alone.

Results

The survey results were compared in three general ways: dietary vs. clinical findings, dietary vs. biochemical findings, and clinical vs. biochemical findings. In addition, a few correlations were attempted between selected clinical findings. These various comparisons are described under the headings of individual nutrients.

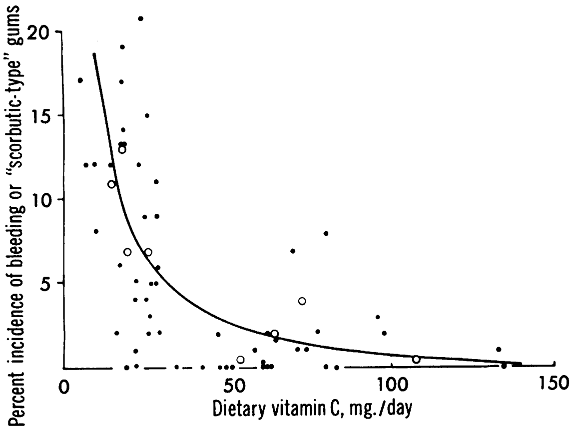
Calories and macronutrients. No correlations were noted between caloric intake and height, weight, percent of "standard weight," or skinfold thickness. There was no interrelation of body weight or percent of "standard weight"

Figure 1. Relation of the serum cholesterol level to the percent of calories in the diet obtained from fat



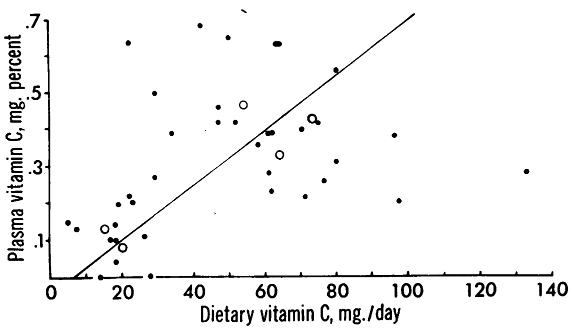
NOTE: The line has the equation, $Y=166-X$.

Figure 2. Relation of the incidence of bleeding or "scorbutic-type" gums to the dietary intake of vitamin C



NOTE: The curve has the equation, $Y=202/X-1.3$.

Figure 3. Relation of the plasma vitamin C level to the dietary intake of vitamin C



NOTE: The line has the equation, $Y=0.007X-0.045$.

with the skinfold thickness. Neither caloric intake nor the parameters of body composition correlated with any of the clinical or biochemical findings. The level of serum protein did not appear to be related to dietary protein intake. A slight negative correlation was observed between dietary fat, expressed as percent of caloric intake, and serum cholesterol level (fig. 1). The equation for the regression line relating these two was $Y=166-X$.

Vitamin C. Clinical findings of bleeding gums or diffusely swollen, dusky, friable gums (recorded as "scorbutic-type") correlated well with the measured dietary intake of vitamin C (fig. 2). The individual mess survey data showed a rather definite cutoff point at about 30 mg. of vitamin C per day, below which an increased incidence of lesions occurred. The mean values for the eight nations showed a more regular progression, described by the equation: $Y=202/X-1.3$.

Dietary vitamin C intakes also correlated reasonably well with the plasma level of the vitamin in the five nations for which data are available (fig. 3). The regression equation relating these two variables was $Y=0.007X-0.045$. The plasma vitamin C level was also negatively correlated with the gingival lesions of swollen, dusky, friable, or "scorbutic-type," gums (fig. 4). Other gingival findings, such as marginal redness and swelling, or recession of the gums, were also slightly correlated with dietary and plasma levels of vitamin C.

Thiamine. Bilateral loss of ankle jerk was not correlated with dietary intake of thiamine (fig. 5), although the urinary excretion of the vitamin was related to the estimated intake of thiamine (fig. 6). The regression equation for the latter two variables was $Y=133X-45$. No correlations were found between other clinical findings, such as calf tenderness or ankle edema, and dietary thiamine, or between these clinical signs and urinary thiamine excretion.

Figure 4. Relation of the plasma vitamin C level to the incidence of bleeding or "scorbutic-type" gums

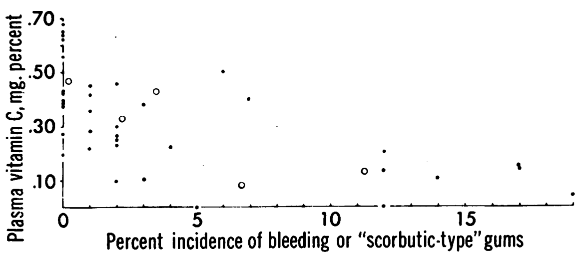


Figure 5. Relation of the incidence of loss of ankle jerk to the dietary intake of thiamine

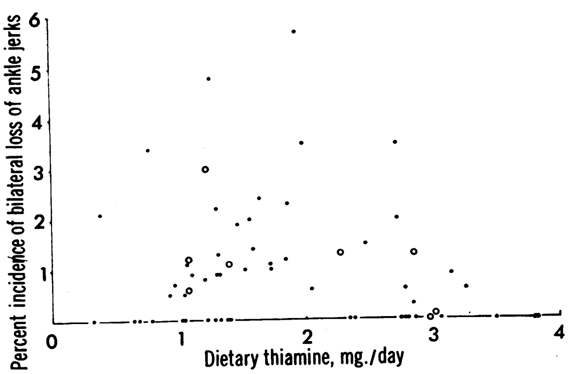
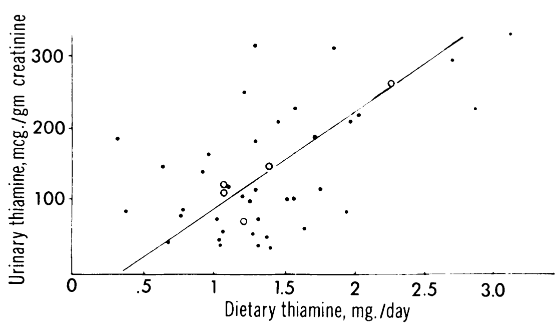
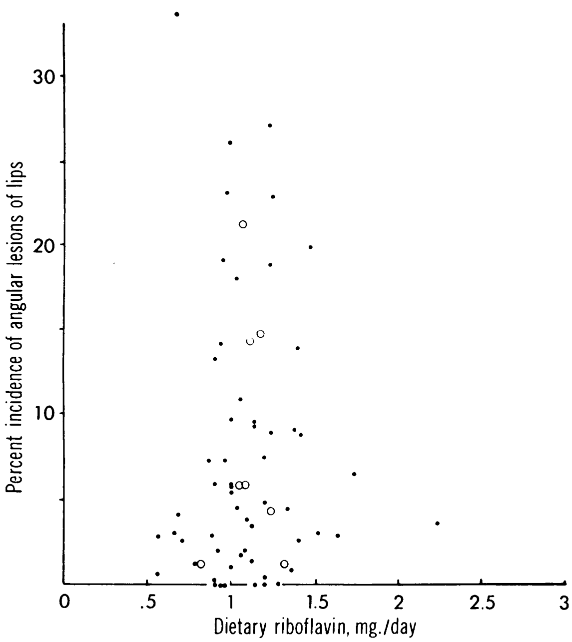


Figure 6. Relation of the urinary excretion rate of thiamine to the dietary intake of thiamine



NOTE: The line has the equation, $Y=133X-45$.

Figure 7. Relation of the incidence of angular lesions of the lips to the dietary intake of riboflavin



Riboflavin. No clinical findings could be correlated with dietary intake of riboflavin. The signs tested included circumcorneal injection, nasolabial seborrhea, angular scars of the lips, angular lesions, cheilosis, filiform papillary atrophy of the tongue, papillary hypertrophy, fissures, red tip or margins of the tongue, magenta tongue, geographic tongue, and scrotal dermatitis. As an example, the incidences of angular lesions of the lips versus dietary riboflavin are presented (fig. 7). A combined scoring procedure was also set up using the four signs, circumcorneal injection, angular lesions, magenta tongue, and scrotal dermatitis. The incidence of each sign was weighted in inverse proportion to its overall incidence in the eight surveys. However, the sum of the weighted incidence rates again did not correlate with the dietary intake of riboflavin.

The urinary riboflavin excretion did tend to be related to the dietary intake of the vitamin (fig. 8), but the red blood cell riboflavin, measured only in the surveys in Spain and Peru, did not.

Niacin. Clear-cut cases of pellagra were not found in any of the eight surveys, and the lesions of thickened, pigmented pressure points and hyperpigmentation of the skin did not correlate with dietary intake of niacin. The

Figure 8. Relation of the urinary excretion rate of riboflavin to the dietary intake of riboflavin

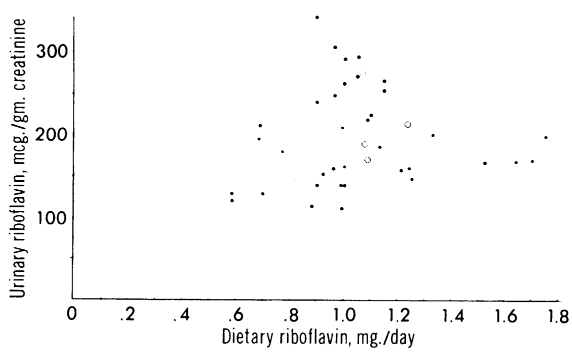
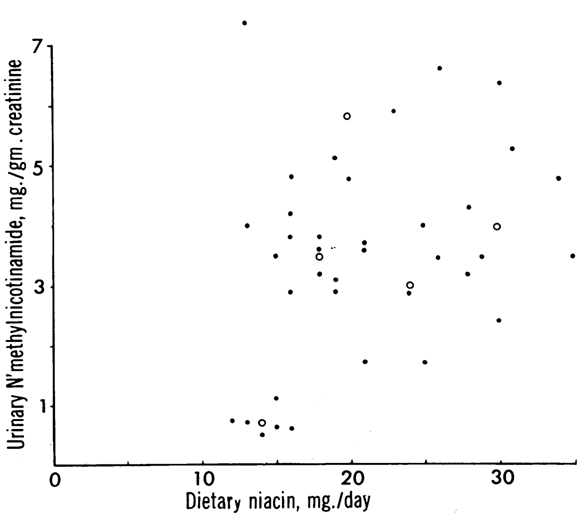


Figure 9. Relation of the urinary excretion rate of N'-methylnicotinamide to the dietary intake of niacin



urinary excretion of N′-methylnicotinamide appeared to be related to the dietary intake of niacin (fig. 9), although most of this correlation was contributed by the low excretion rates of the Libyan survey.

Vitamin A. No correlations were evident between dietary intake of vitamin A and the incidences of follicular hyperkeratosis, either generally or on specific parts of the body, or of Bitot's spots, nor did dietary vitamin A correlate with serum vitamin A or carotene.

Iron. No relations could be discerned between dietary intake of iron and the incidence of the various lesions of the tongue, or between dietary iron and hemoglobin levels, hematocrit, or mean corpuscular hemoglobin concentration.

Discussion

It might be expected that the three general approaches to assessment of nutritional status would give results in individuals or population groups that would compare reasonably well with each other. It should be pointed out, however, that the present assessment procedures have many inherent sources of error. The most obvious errors in clinical examination procedure are the different criteria for diagnosis of a lesion employed by the examiners in the Philippines and Spain although this can be reduced by discussion among examiners and by test exercises in standardization. It is also recognized that a physician's judgment may change unconsciously with time during a given survey. Such examiner differences are likely to be especially great when the population surveyed has lesions of mild degree, as was the case in these nutrition surveys.

As noted previously, the dietary survey results can be misleading as a result of using average figures. Individuals may consume specific nutrients in quantities differing widely from the average consumption. Biochemical data are often claimed to be the most accurate, but these suffer, as do the clinical and dietary results, from errors in sampling, and the average values employed here restrict their usefulness in depicting variations in the nutritional status of the population.

Another basic problem is that the three approaches measure different chronological aspects of nutritional status. The dietary survey notes the average nutrient intakes at the time of the survey. Although the measured intakes may be satisfactory, they may not have been so in the past, and vice versa. The biochemical results reflect the nutrient accumulation by individuals in the relatively recent past. This interval varies for different nutrients. Body stores of vitamin C are relatively small, so that concentrations of ascorbic acid in the blood reflect the intake during the preceding few weeks (*4*). However, large amounts of vitamin A may be stored, and the level of this vitamin may remain satisfactory despite 2 years or more of restricted intake (*5*) of vitamin A and beta-carotene. For development of discreet clinical findings of avitaminosis an even longer period sufficient for exhaustion of particular tissue stores is probably required. Furthermore, once a lesion has been produced, it may require much time to revert to normal, especially on dietary intakes which are only slightly above the body's requirement. Indeed, some lesions or their sequelae may be permanent.

In regard to total food consumption, one would expect correlations between intake and body weight or body size to be masked by the large variations produced in caloric requirement by different levels of activity. Reference of the measured body weight to a standard for height might be expected to uncover a correlation with intake. Unfortunately, the standard weight table widely employed (*6*) depicts for a given height a regular increase in weight with age. This reflects the American population of 1912, from which the table was calculated. There is, however, no valid reason to assume that after the early twenties an individual should gain weight, presumably fat, with each year of age. This problem arising from the use of the standard weight table can cause difficulty in interpretation of survey results, as illustrated by the age-height-weight data from the Philippines (see table). The mean age was 30 years and there was an age-specific mean percent of "standard weight" of 90.8. If the observed height and weight are used and one enters the standard weight table at age 22, the mean age of the other populations surveyed, the percent of "standard weight" is 93.0, more comparable with the other results. Problems of this

Mean clinical, biochemical, and dietary findings in eight nutrition surveys

	Iran	Pakistan	Korea	Philippines	Turkey	Libya	Spain	Peru
	Clinical findings							
Number of examinations	1,730	1,568	1,365	433	1,431	538	1,985	1,315
Age (years)			25	30	22	24	22	21
Height (inches)			64.6	63.9	65.6	66.4	64.8	63.5
Weight (pounds)			129.3	121.2	142.2	133.7	135.5	133.7
Percent of "standard weight"	99.3		96.7	90.8	105.5	95.8	102.5	105.9
Skinfold thickness, arm (mm.)			5.5	6.7	7.0		9.9	9.0
Bitot's spots (percent)			.3	.2	.2	.0	.1	.0
Angular lesions of lips (percent)	14.6	.8	14.2	1.3	21.3	5.8	4.7	4.3
Cheilosis (percent)	3.4	.3	1.9	2.0	27.4	.2	11.3	2.4
Atrophy of filiform papillae of tongue (percent)	6.9	.3	1.2	3.1	9.0	.4	1.2	1.6
Glossitis (percent)			.1	.0	.9	.0	.0	.1
Magenta tongue (percent)			1.0	.0	.1	.2	.6	.1
Marginal redness or swelling of gums (percent)	21.9	25.3	21.6	12.9	32.9	45.3	13.8	22.9
Bleeding or "scorbutic-type" gums (percent)	13.0	6.6	.4	.2	11.3	6.7	2.2	3.5
Follicular hyperkeratosis (percent)	31.7	33.4	4.2	2.2	19.4	11.9	23.0	20.5
Scrotal dermatitis (percent)				1.2	1.6	.9	.1	.2
Thickened pressure points (percent)				11.3	.1	.9	.0	.3
Hyperpigmentation (percent)				.2	.3	5.9	.2	.3
Loss of ankle jerk (percent)	1.3	.0	.1	1.2	1.3	3.0	1.1	.6
Calf tenderness (percent)			.1	.1	.8	.4	.3	1.8
Ankle edema (percent)	.6	.0	.1	.1	.2	.0	.0	1.1
	Biochemical findings							
Number of determinations	410	409	271	96	277	142	481	260
Hemoglobin (gm. percent)				14.4	15.0	14.7	15.5	14.3
Serum vitamin A (mcg. percent)				46	35	33	37	37
Serum carotene (mcg. percent)				72	59	153	79	71
Serum vitamin C (mg. percent)				.47	.03	.08	.33	.43
Serum cholesterol (mg. percent)				170	191		148	138
Urinary thiamine (mcg./gm. creatinine)				110	265	73	147	126
Urinary riboflavin (mcg./gm. creatinine)				148	172	192	279	217
Urinary N'-methylnicotinamide (mg./gm. creatinine)				5.8	4.0	.7	3.5	3.0
	Dietary survey findings [1]							
Number of mess surveys	5	9	4	9	7	6	11	7
Total number of rations	25,000	8,000	17,000	3,100	27,000	3,700	24,000	6,500
Calories	3,860	3,510	3,790	2,740	3,670	3,170	3,290	3,060
Protein (gm.)	137	91	128	100	120	96	109	120
Fat (gm.)	*74	*106	*43	29	*59	*80	74	52
Vitamin A (I.U.)	*3,760	*2,900	*1,220	2,340	2,060	1,660	*1,680	4,360
Thiamine (mg.)	*2.86	*2.98	*3.02	1.09	2.29	1.22	1.40	1.08
Riboflavin (mg.)	*1.18	*1.32	*1.11	.83	1.09	1.08	1.07	1.24
Niacin (mg.)	*34	*26	*21	20	*30	14	18	24
Vitamin C (mg.)	*18	*26	*108	*54	*15	*20	*64	*73
Iron (mg.)	*35	*21	*34	24	50	12	72	67

[1] Composition from chemical analysis except for values marked with an asterisk.

sort explain, in part, the lack of correlation between percent of "standard weight" and the measurements of skinfold thickness, both of which should vary with the amount of body fat, despite genetic and perhaps environmental influences.

The lack of correlation between dietary protein intake and serum protein levels is explained by the fact that no prolonged critically low protein intakes occurred. The negative correlation observed between dietary fat, expressed as percentage of caloric intake, and serum cholesterol is opposite to that reported in many studies. Perhaps this is fortuitous since other factors, such as degree of saturation of dietary fat, were not evaluated, and much of the fat was of vegetable origin.

The best correlations observed here were between dietary vitamin C intake, plasma vitamin C, and clinical findings in the gums. These observations support the known fact that plasma vitamin C rather quickly reflects dietary intake, and suggest that the gingival lesions are relatively labile clinical findings.

Although none of the clinical signs usually related to thiamine deficiency correlated with dietary intake of thiamine, only one finding, the incidence of loss of ankle jerk, was reported in enough individuals to permit a good comparison. This abnormality can occur unrelated to thiamine deficiency, and is known to increase with age. This is also one of the signs that may not readily be reversed.

The lack of correlation between any of the clinical signs and dietary riboflavin intake is unexpected, particularly since riboflavin is not considered to be stored in the body to any appreciable extent. One explanation may be that very few extremely low intakes of the vitamin were found. Another explanation may lie in the nonspecificity of the indicator lesions.

The definite correlation between urinary thiamine excretion rate and thiamine intake indicates that within wide limits, and in large groups, one can be used as a measure of the other. Although the urinary riboflavin and N′-methylnicotinamide excretion rates may be slightly correlated with intakes of riboflavin and niacin, respectively, prediction of one from the other, even with large groups, would be hazardous. The fact that excretion rates of riboflavin were never seen below 100 mcg. per gram of creatinine suggests the presence of nonriboflavin compounds in the urine which interfered with the analysis. Better survey methods for the assay of riboflavin in urine are being developed.

The lack of any correlation between dietary intake of vitamin A and the blood level is doubtless explained by storage of the vitamin in the body during seasons when the intake is relatively high. The fact that there is no relation between the clinical findings and blood levels may reflect either nonspecificity of the lesions or the long time needed for development of the lesions, or the failure to encounter a population sufficiently depleted to have developed clinical signs of avitaminosis.

The average values of clinical, biochemical, and dietary findings for a national survey tend to intercorrelate better than do values for individual groups. Apparently, the limitations of the methods are not so great that they cannot be reduced by an increase in the size of the sample, especially when large national differences in intakes occur.

Data such as these relating dietary intake of a nutrient to the incidence of clinical findings due to deficiency of that nutrient may be used to appraise the human requirement. Indeed, the data for vitamin C do show a marked increase in gingival findings at intakes below 30 mg. per day, the value used in the United Kingdom as the human requirement. For other nutrients, however, the distributions show little that can be used with confidence to estimate the body's requirement.

Another study of nutrition survey results may be made by grouping the data and presenting percentage distributions based on ranges of values considered to be "low" or "high." Tentative ranges of "deficient," "low," "acceptable," and "high" have been set forth in the ICNND Manual for Nutrition Surveys. The biochemical data were tabulated in this manner in all of the survey reports. Comparisons were made between the biochemical data in this form and the clinical and dietary findings. The results were essentially similar to those reported here, using the mean biochemical values. A different type of transformation of the dietary data was also tested, namely, the expression of nutrient intakes per 1,000 calories. This transformation did not improve any of the correlations with the clinical or biochemical findings.

These results do not invalidate the nutrition survey procedures. They do, however, indicate the relative value of the three different approaches and suggest areas requiring improvement. The detailed and laborious mess survey must remain a standard of reference, although the results are necessarily limited to the period of the survey. The clinical survey is the easiest to perform and, theoretically, should give the measure of nutriture since health, not a specific level of nutrient intake, is the goal of nutritional preventive medicine. As the data show, many errors would be introduced if one relied on the clinical findings alone. The biochemical survey also approaches the evalution of health with more specificity than clinical examination, but as yet even field methods are difficult to carry out; furthermore, they are not available to test many aspects of nutritional status, nor is it possible to observe large numbers of persons with this method.

But nutrition surveys are not designed for the sole purpose of detecting deficiencies. They are intended to provide an appraisal of nutritional level—to give information on food use, nutrients consumed, and sources of nutrients; to indicate whether these observations on diet at a given moment do in fact reflect the usual intake level or pattern; to allow some appraisal of the probable clinical meaning of the cumulative effects of the nutritional level; and to relate these conclusions practically to needs of the country or region toward an improved state of health. When so examined with due consideration of the known physiology of nutrition, findings such as those studied here are exceedingly useful indicators of intake levels, and their meaning for nutritional planning toward better health is increased.

Summary

Data on nutrient intakes were selected from 58 mess surveys in 57 military messes in 8 nations in which nutrition surveys of the military were performed by a standard technique under the auspices of the Interdepartmental Committee on Nutrition for National Defense. These mean data were compared with the clinical and average biochemical findings in troops from the same locations.

The clinical and biochemical findings relating to vitamin C nutriture correlated well with the dietary intakes. The urinary excretion rates of thiamine, riboflavin, and N′-methylnicotinamide correlated roughly with the dietary intakes of thiamine, riboflavin, and niacin, respectively, but the clinical findings widely held to reflect an insufficiency of these vitamins showed scarcely any correlation with dietary intakes. No apparent correlations could be found between the three survey approaches in vitamin A or calorie nutriture. An apparent negative correlation was noted between fat intake and serum cholesterol.

Sources of errors in the interpretation of these findings are identified and discussed. With appropriate recognition of the limitations of each type of evidence and appreciation of nutritional physiology, useful appraisals of nutriture are possible.

REFERENCES

(1) Berry, F. B., and Schaefer, A. E.: Nutrition surveys in the Near and Far East. U.S. Armed Forces Med. J. 9: 91–106, January 1958.

(2) Merrill, A. L., and Watt, B. K.: Composition of foods, raw, processed, prepared. U.S. Dept. of Agriculture Handbook No. 8. Washington, D.C., U.S. Government Printing Office, 1950.

(3) Food and Agriculture Organization: Food composition tables for international use. Rome, March 1954.

(4) Medical Research Council, Great Britain: Vitamin C requirement of human adults. Lancet 1: 853–858, June 1948.

(5) Hume, E. M., and Krebs, H. A., compilers: Vitamin A requirement of human adults. An experimental study of vitamin A deprivation in man. Medical Research Council, Great Britain, Special Report Series No. 264. London, 1949.

(6) Medico-actuarial mortality investigation. Tr. Assn. Life Insur. Med. Directors and the Actuarial Society of America 1: 1–131 (1912).

NOTE: References to the ICNND Manual for Nutrition Surveys and reports of surveys in each of 12 countries are cited on pages 685–686.