A methodological study using a seven-day record

Dietary fiber consumption in an adult Dutch population

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For estimating group means of daily dietary fiber intake, equal precision can be obtained by using a seven-day record method or by collecting one-day records from twice as many subjects.

It has been suggested by Burkitt et al. (1) that the incidence of atherosclerosis and large bowel diseases in Western communities might be linked to a low intake of dietary fiber. Dietary fiber has been defined as the plant polysaccharides and lignin which are resistant to hydrolysis by the digestive enzymes of man. The main components of dietary fiber are cellulose, hemicellulose, pectic substances (polygalacturonic acid compounds) and lignin (2). Different components of dietary fiber have different physiological effects. Pectic compounds have been reported to be effective in lowering serum cholesterol, and compounds from wheat bran stimulate colonic function (3,4).

Dietary fiber consumption can be estimated from food balance sheets. These assess the national food supply by adding imported food and home produced food and by subtracting exported food and food used by non-civilians. According to Dutch food balance sheet data (5-7), dietary fiber consumption has changed. It decreased between 1951 and 1961, mainly because of a decline in the consumption of bread, other unrefined cereal products, and potatoes (Table 1). Although the consumption of these products continued to decrease in the following decades, total dietary fiber consumption did not decrease, because of an increase in the consumption of other vegetables and fruits.

Since food balance sheet data can give only a very rough picture of the annual per capita availability of foods (8), we decided to conduct a survey to assess total dietary fiber and pectin intake of a representative sample of the adult Dutch population (25 to 65 years of age), using a seven-day record method. As a byproduct we obtained an estimate of the size of a sample providing one-day records that is required to give the same precision as seven-day records for assessing the average energy and dietary fiber intake of a group.

The authors wish to thank the dietitians and students who cooperated in this survey for their valuable assistance and Jan Burema and Clive E. West, Ph.D., for their advice and help in preparing the manuscript.

Methodology

SELECTION OF THE POPULATION SAMPLE. In order to obtain a sample that was representative of the Dutch population, a random sample of 150 adults (25 to 65 years old) was taken from the registration of the municipality of Rhenen (a city with 15,500 inhabitants). The population of Rhenen has been shown to resemble the Dutch population in the following demographic characteristics (9):

- Distribution of different age categories: zero to 19 years of age, 37 and 36 percent for Rhenen and the Netherlands, respectively; 20 to 39 years of age, 26 and 26 percent; and 65 years of age and older, 11 and 10 percent.
- Proportion of people married: 49 percent for Rhenen and 48 percent for the Netherlands.
- Number of persons per household: 3.6 for Rhenen and 3.7 for the Netherlands.
- Educational level of the working population: elementary school, 43 and 34 percent for Rhenen and the Netherlands, respectively; high school, 40 and 44 percent; college and postgraduate level, 6 and 7 percent; and unknown, 11 and 15 percent.
- Distribution of workers over occupational categories: 69 white collar workers per 100 blue collar workers for Rhenen and 87 per 100 for the Netherlands.

DATA COLLECTION. The advantages and disadvantages of different dietary survey methods have been reviewed by Marr (10). As no single method has been shown to give completely accurate results and to be free from the limitations of carrying out consumption studies with free-living subjects, the choice of the method to be used depends primarily on the objectives of the study. Other factors influencing the choice of method include: the characteristics of the people to be tested and the availability of funds, personnel, time, and equipment (10,11).

To reach the objective of our study, we selected a seven-day record method. We asked the participants to note, in specially designed diaries, their daily food consumption in household measurements for seven successive days in January and February 1977. Trained dietitians and postgraduate students in human nutrition visited the participants on four occasions. The first visit was an introductory talk to explain the objectives of the study and to ask subjects to participate. A second visit was made one day before the participants were scheduled to start with their food-intake records for seven days. During this visit instructions on filling in the diaries were given.

Table 1. **Dietary fiber consumption in The Netherlands per capita per day as determined from Dutch food balance sheets, 1951-1976 (5-7)**

foods	*dietary fiber intake*					
	1951		*1961*		*1976*	
	gm./day	*% of daily intake*	*gm./day*	*% of daily intake*	*gm./day*	*% of daily intake*
bread and cereals	13.6	50	9.9	41	8.0	32.5
potatoes	6.4	24	5.5	23	5.2	21
other vegetables	4.6	17	5.1	21	6.3	26
fruit	1.7	6	2.3	10	3.5	14
other (nuts, raisins, chocolate, etc.)	0.7	3	1.2	5	1.6	6.5
total	27.0	100	24.0	100	24.6	100
energy (kcal per day)	2,820		2,930		2,955	
dietary fiber (gm. per 1,000 kcal)	9.6		8.2		8.3	

Three days later a third visit was made to check if the participants did fill in the diaries correctly. During the last visit (one day after the participants had finished their food-intake records), the diaries were checked and portions of foods frequently used were weighed. According to earlier studies, such a method is comparable with a seven-day weighing inventory but is considered less demanding for the participants (12,13).

In order to avoid bias in the information on food intake through systematic differences in consumption on different days of the week, an equal number of persons commenced recording their food intakes on each day of the week.

CALCULATION OF NUTRIENT INTAKE. Each item on the food record was coded by the interviewer and checked by a colleague. For the conversion into nutrients, we used a computer program based on a nutrient file compiled from the Dutch food composition table (14,15) and from additional data on dietary fiber and pectin (Table 2) (16-19).

STATISTICAL METHODS. A mixed model analysis of variance (20) with two factors was applied, namely random person's effects and fixed day-of-the-week effects. Expressions were derived for sample sizes of equivalent one-day and seven-day record methods. These expressions make it possible to estimate, for instance, the number of participants giving one-day records that would have been needed to equal the precision of the 100 participants giving seven-day records in this study.

Results and discussion

RESPONDENTS. One hundred reliable records were received from the 150 persons contacted; 7 were away at the time of the study; 7 submitted unreliable records; and 36 refused to participate. The group that did provide reliable records was still representative of the adult population of Rhenen with regard to age, sex, and the average number of persons per household. In comparison with other studies, the non-response rate of 33.3 percent is not exceptionally high (10).

ENERGY AND DIETARY FIBER INTAKE. Average energy intake was 2,370 kcal (2,790 kcal for men and 2,040 kcal for women) per day; protein, carbohydrate, fat, and alcohol contributed 14, 42, 40, and 4 percent of kilocalories, respectively. This level and pattern of energy intake can be considered as "normal" for an adult population in a

Table 2. The proportions of dietary fiber and pectin in some foods*

foods	*dietary fiber*	*pectin*†
	←gm./100 gm.→	
whole wheat bread	8.5	0.1
white bread	2.7	0.1
potatoes (Solanum tuberosum L.), old, cooked	3.0	0.2
carrots (Dauscus carota L.), raw	3.2	0.7
lettuce (Lactuca sativa L.), raw	1.3	0.3
peas (Pisum sativum L.), canned	4.7	0.2
tomatoes (Solanum lycopersicum L.), raw	1.4	0.3
apples (Malus pumila Mill.), flesh only	2.2	0.5

*Data from Stasse-Wolthuis et al. (28) and from Katan (32).
†Values are expressed as polygalacturonic acid; 1 gm. pure citrus pectin contains about 0.8 gm. polygalacturonic acid.

highly industrialized country where people, generally speaking, do not perform heavy physical work.

As shown in Table 3, mean dietary fiber consumption for the group was about 24 gm. per day. The mean dietary fiber intake per 1,000 kcal was 10.5 gm. This is comparable with other data collected in food consumption studies by our institute for other groups of the Dutch population. In a large number of 6- to 10-year-old school children (n=675), average dietary fiber intake was 9.2 gm. per 1,000 kcal (21): in 136 adolescents a value of 9.7 was found (22); and about a hundred adult men forming part of the Dutch cohort of the Seven Countries Study (23) were found to consume an average of 8.8 gm. of dietary fiber per 1,000 kcal (24).

The Dutch food balance sheets for 1976 indicate a dietary fiber availability in the daily food intake of 24.6 gm., or 8.3 gm. per 1,000 kcal (Table 1).

The level of dietary fiber intake in the Netherlands seems to be close to that recently reported for West Germany and Great Britain. Average daily intake of dietary fiber was about 22 gm. per day for various West German groups (25), 19.9 gm. per day for a British adult population (26), and 24 gm. per day for our subjects. The Germans, however, derived an average of 11 gm. per day from cereals and the British only 6.1 gm. For the Dutch this figure was 7.7 gm. Although these differences partly reflect the amounts of bread consumed (27,28), the type of bread also appears to play a role. In 1978, white bread accounted for about 80 percent of the British bread consumption (29), whereas in West Germany dark, fiber-rich bread is generally consumed. The situation in the Netherlands is intermediate, with 50 to 60 percent of the bread consumed being brown or wholemeal (7). Such data suggest that the differences between these countries in the consumption of specific types of fiber may be appreciable and larger than the differences in total fiber intake.

Pectin intake in our study was 2.4 gm. per day as opposed to 3 gm. for British subjects (26). However, the methods used to determine the pectin contents of foodstuffs were not comparable, which makes the apparent difference in pectin intake difficult to interpret.

IMPORTANT FOOD SOURCES OF DIETARY FIBER AND PECTIN. Table 4 shows the sources of dietary fiber and pectin, divided into five main groups of foodstuffs. The large standard deviations show that the main sources of fiber varied widely between persons. Thus, measurement of the consumption of just a few fiber sources (e.g., bread and vegetables) would lead to large errors in the estimation of total fiber intake. As already suggested by the food composition data in Table 2, most of the dietary pectin was contributed by fruits and vegetables. Thus, measurement of the consumption of fruits and vegetables alone might be a useful shortcut method for estimating pectin intakes.

Table 3. Intake of dietary fiber and pectin in adult Dutch men and women assessed by a seven-day record method

fiber and pectin	*men (n=44)*	*women (n=56)*	*total sample (n=100)*
dietary fiber (gm./day)	27.5±7.8*	21.3±4.7	24.0±6.9
dietary fiber (gm./1,000 kcal)	10.1±2.5	10.8±2.6	10.5±2.6
pectin (gm./day)	2.5±0.8	2.4±0.7	2.4±0.8

*Mean ± standard deviation.

Table 4. Contribution of various food groups to the average dietary fiber and pectin intake of an adult Dutch population (n=100)

food	*dietary fiber*		*pectin*	
	gm./day	*% of intake*	*gm./day*	*% of intake*
bread and cereals	7.7±5.4*	32	0.18±0.09	7
potatoes	4.1±2.5	17	0.35±0.22	14
other vegetables	5.7±3.3	24	0.81±0.31	34
fruit	3.6±2.4	15	0.96±0.63	40
other sources	2.9±3.2	12	0.11±0.08	5
total intake	24.0	100	2.41	100

*Mean ± standard deviation.

IDENTIFICATION OF SUBGROUPS WITH HIGH OR LOW FIBER INTAKES. In order to evaluate different ways of identifying subjects with high or low dietary fiber intake in the community, subjects were divided into quartiles according to either their average daily total fiber intake or their intake per 1,000 kcal (fiber density). Men and women in the lowest quartile of total fiber intake ate less than 21.4 and 18 gm. per day, respectively, while men and women in the highest quartile of the distribution ate more than 30 and 22.5 gm. per day, respectively. The very narrow range of dietary fiber intake of women is due to a narrow range of energy intake and also to little variation in eating patterns.

As shown in Figure 1, classification by fiber density of the diet (grams of fiber per 1,000 kcal) yielded entirely different groups of high and low fiber consumers. For example, eight subjects (indicated by encircled points in Figure 1) fell into the highest quartile of fiber consumption according to one classification but into the lowest quartile according to the other. More than half of the participants who were graded as low, medium, or high fiber consumers by one criterion would have to be reclassified if the other criterion were used. If this should prove to be a general finding, then the interpretation of epidemiological studies relating fiber consumption to disease may depend on whether intake is expressed in grams per day or grams per 1,000 kcal. There appears to be at present no physiological reason to prefer either method.

DIFFERENCES BETWEEN DIETARY FIBER INTAKE ON WEEKDAYS AND WEEKENDS. Food consumption patterns of individuals are known to vary considerably from day to day (10). However, part of this apparent variation may be due to systematic effects of specific days of the week on food intake. Analysis of variance did in fact reveal a

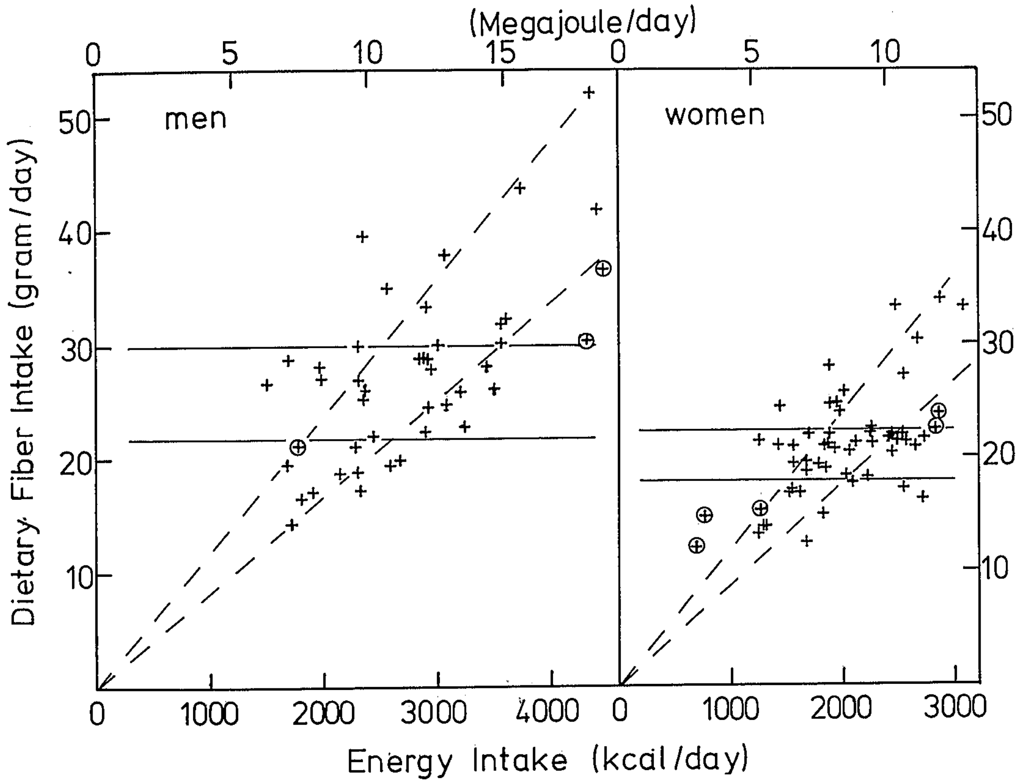

FIG. 1. *The relation between the average daily dietary fiber and energy intake. The horizontal lines represent the 25th and 75th percentile of total dietary fiber intake, expressed in grams per day. The oblique broken lines represent the 25th and 75th percentile of fiber density, i.e., the dietary fiber intake expressed in grams per 1,000 kcal. All points to the left of the upper broken line refer to subjects with fiber densities in their diets exceeding the 75th percentile of fiber density. Encircled points refer to subjects with absolute fiber intakes above the 75th percentile but fiber densities below the 25th percentile, or vice versa.*

significant between-days effect on the intake of dietary fiber. This can mainly be attributed to a difference between dietary fiber intake on days during the week and during weekends. As shown in Table 5, dietary fiber intakes were significantly lower during the weekends. This stresses the importance of a design that is well-balanced over the days of the week in order to avoid bias in the estimation of the population mean.

SAMPLE SIZE REQUIREMENTS FOR DIFFERENT DESIGNS. The aim of a food consumption study is often to obtain an estimate of the mean intake of energy or of certain nutrients in a population. The precision of the estimated group mean, as expressed by its standard error or variance, depends on the number of subjects or respondents (N), the number of daily records (k) provided by each respondent, the between-subjects variance (V_B), and the residual within-subjects variance (V_R). The precision can be increased by increasing N or k or both. The variance component V_B cannot be influenced by the investigator, and the variance component V_R to only a small extent. The variance component V_R includes random day-to-day variations within one person and errors in measurement. The variance (V_M) of the esti-

Table 5. Comparison of the dietary fiber intake on weekdays (Monday to Friday) and on weekends (Saturday and Sunday)

days	*dietary fiber intake*			
	men (n=44)		*women (n=56)*	
	gm./day	*gm./1,000 kcal*	*gm./day*	*gm./1,000 kcal*
weekdays	28.7± 8.5*	10.7±2.8	21.9±5.0	11.4±2.7
weekends	24.5±10.2	8.8±3.7	19.7±6.7	9.6±3.5
significance of the difference	$p<0.01$	$p<0.01$	$p<0.05$	$p<0.01$

*Mean ± standard deviation.

mated group mean can be expressed as:

$$V_M = (V_B + V_R/k)/N.$$

As can be seen from this formula, increasing the number of food record days (k) reduces only the contribution of the variance component V_R, whereas the contribution of both variance components is influenced by the sample size. A certain required precision (e.g., a 95 percent confidence interval, not greater than about 10 percent of the mean value) does not fix k and N but can be attained by a number of equivalent (k, N) combinations. The optimal choice for a combination could be based on considerations of cost (20,30). We wish to demonstrate which designs are equivalent in the sense of yielding the same precision and how these different combinations of k and N depend on the ratio of the within-persons variance over the between-persons variance. We will call this ratio λ, where

$$\lambda = V_R/V_B$$

The design requires that data be collected evenly over the various days of the week. This can be accomplished by increasing the sample size to the nearest multiple of seven and by having an equal number of subjects starting their record(s) on each day of the week.

It follows from the above formula that two different designs can yield the same group mean variance V_M and thus the same precision for the estimated group mean when:

$$N_k/N_h = (1 + \lambda/k)/(1 + \lambda/h),$$

where k and h indicate two different choices for the number of food record-days per subject. In our study the number of days for each person was seven ($h = 7$). It follows that for an equivalent design with a smaller number of food record-days per subject (k), the required sample size is given by:

$$N_k = N_7\,(1 + \lambda/k)/(1 + \lambda/7).$$

The value of λ for a specific nutrient in a specific population can be estimated either beforehand from other data or afterwards, as in the present study. From an analysis of variance with two factors, namely person's effects and day-of-the-week effects, λ may be estimated as $h/(F\text{-}1)$, where F is Fisher's F-ratio of the mean squares of the between-persons component and the residual component of the variance, and where $h = 7$ in the present case. In Table 6 the results from our study regarding λ and sample size of equivalent designs for the intake of energy and dietary fiber are given. As can be observed from this table, there is little difference between the λ values of men and women.

These findings show that the precision for measurement of dietary fiber intake obtained by using one-day food records from twice the number of individuals is comparable to that obtained from a seven-day food record. For the measurement of energy intake, only 1.5 times the number of individuals is required for the one-day record method to obtain the same precision as with the seven-day record method.

However, the choice between a one-day and a seven-day record method also depends on the aim of the study. For example, if the purpose is to compare the nutrient intake during the week with that at weekends, a seven-day method would be preferable to a one-day record method. If the aim is to study the contribution of various food groups to nutrient intake, on an aggregate level, a one-day or two-day record method may be more appropriate.

As an illustration of the use of λ values, we applied them on the results of our own study. The approximate number of one-day records required for a 95 percent confidence interval for the population mean, allowing for a specified imprecision of $2d$, is given by the following well-known equation:

$$N_1 = (4/d^2)\,(V_B + V_R).$$

For a design with k records per person, this generalizes to:

$$N_k = (4/d^2)\,(V_B + V_R)\,(1 + \lambda/k)/(1 + \lambda).$$

In Table 7, estimates of $V_B + V_R$ and the required sample size (N) for one-day and seven-day records are given when d equals 10 percent of the group mean. For comparable values when d equals 5 percent of the group mean, the values of N obtained above should be multiplied by a factor of 4, i.e., $(10/5)^2$.

The question arises of how far the results given in Table 7 can be applied to other population groups. It is clear that these results depend on the sum of the residual within-persons and between-persons variance and on the

Table 6. Fisher's F for the between-persons variance, ratio of observed within-individual variation (V_R) over between-individuals variation (V_B) and calculated ratio of sample sizes in equivalent one-day (N_1) and seven-day (N_7) designs yielding the same precision

energy and fiber		F*	V_R/V_B†	N_1/N_7‡
energy	men	13.01	0.58	1.5
	women	11.32	0.68	1.5
dietary fiber	men	6.44	1.29	1.9
	women	5.62	1.52	2.1

*Fisher's F for the between-persons variance.
†$V_R/V_B = 7/(F - 1) = \lambda =$ ratio of the within-persons over the between-persons variation.
‡$N_1/N_7 = (1 + \lambda/1)/(1 + \lambda/7) =$ ratio of sample sizes of equivalent one-day (N_1) and seven-day (N_7) designs yielding the same precision.

Table 7. Sample size required to estimate the group mean of energy and dietary fiber intake with a standard error of less than 5 percent, using one-day or seven-day records

energy and fiber		*mean*	$V_B + V_R$*	N_1†	N_7†
energy (kcal)	men	2,790	930^2	45	31
	women	2,040	640^2	40	26
dietary fiber (gm.)	men	27.5	10.8^2	63	33
	women	21.3	6.8^2	41	20

*$V_B + V_R$: sum of the between-persons variance and the residual within-persons variance.
†$N_k = (4/d^2)\,(V_B + V_R)\,(1 + \lambda/k)/(1 + \lambda)$ for $k = 1,7$: number of one- or seven-day records required for a 95 percent confidence interval for the population mean, allowing for a specified imprecision of $2d$, where $d = \text{mean}/10$.

ratio of the two variances (λ). At present, the literature provides only a few estimates of this ratio, and the values reported vary widely. For instance in a study involving 30 men and 30 women, Beaton et al. (30) reported a value of λ for the energy intake of 1.0 and 1.2, respectively. In our study we found a value of 0.58 for men and 0.68 for women, whereas Liu et al. (31) reported a value of 1.8 for 181 Japanese men living in Japan and a value of 2.2 for 318 Japanese men living in Hawaii.

In comparing these results, one should bear in mind that in addition to different life styles and food habits, the design of the study may also influence the value of λ. Dietary survey method (record or recall), interviewer, day of the week, and possibly effects of time all contribute to the residual variance in addition to the variability of a person's daily food consumption under similar circumstances.

In data presently available, there is a tendency for λ values to be relatively low for energy intake, intermediate for protein, fat, and carbohydrate, and high for fatty acids, dietary fiber, minerals, and vitamins.

In conclusion we recommend, in order to estimate sample size, that the ratio of the residual (V_R) over the between-persons variance (V_B)—i.e., λ—for different nutrients be estimated. The value of λ can be estimated either from other data collected beforehand or from a pilot study.

Summary and conclusions

The intake of dietary fiber was studied in an adult Dutch population aged 25 to 65 years using a seven-day record method. It was found to be 24.0 ± 6.9 gm. per day (mean ± SD) or 10.5 ± 2.6 gm. per 1,000 kcal. The dietary fiber intake per 1,000 kcal (fiber density) was virtually identical to that observed in other age groups of the Dutch population and somewhat higher than values calculated from the Dutch food balance sheets (8.3 gm. per 1,000 kcal). The intake of pectin (as polygalacturonic acid) was 2.4 ± 0.8 gm. per day.

Important sources of dietary fiber were bread and other cereals (32 percent of daily intake), potatoes (17 percent), other vegetables (24 percent), and fruits (15 percent). For pectin, the proportions in those foods were 7, 14, 34, and 40 percent of the daily intake.

Comparison with German and British figures suggests that, although overall intakes of dietary fiber are similar to those in the Netherlands, differences in consumption of dietary fiber from specific sources such as bread may be appreciable.

The intake was significantly higher on weekdays than on weekends.

Ranking the subjects by absolute dietary fiber consumption, expressed in grams per day, and by fiber density of the diet, expressed in grams per 1,000 kcal, yielded entirely different results. Therefore, if one wants to select individuals with "high" or "low" dietary fiber consumption, the decision as to whether the basis of the classification is total daily intake or fiber density of the diet has a great impact on the result.

For estimating group means of daily dietary fiber intake, equal precision can be obtained by using a seven-day record method or by collecting one-day records from twice the number of subjects.

References

(1) Burkitt, D.P., Walker, A.R.P., and Painter, N.S.: Dietary fiber and disease. JAMA 229:1068, 1974.
(2) Trowell, H., Southgate, D.A.T., Wolever, T.M.S., Leeds, A.R., Gassull, M.A., and Jenkins, D.J.A.: Dietary fiber redefined. Lancet 1:976, 1976.
(3) Kay, R.M., Judd, P.A., and Truswell, A.S.: The effect of pectin on serum cholesterol. Am. J. Clin. Nutr. 31:562, 1978.
(4) Kelsay, J.L.: A review of research on effects of fiber intake in man. Am. J. Clin. Nutr. 31:142, 1978.
(5) Mulder, T.: De voeding in Nederland (1950 t/m 1959). Voeding 23:564, 1962.
(6) Mulder, T.: De voeding in Nederland (1960 t/m 1965). Voeding 28: 634, 1967.
(7) Bosman, W.: De voeding in Nederland in 1976. Voeding 40:351, 1979.
(8) Burk, M.C., and Pao, E.M.: Methodology for large-scale surveys of household and individual diets. Home Economics Report No. 40, USDA, 1976.
(9) Centraal Bureau voor de Statistiek: 14e Algemene Volkstelling annex Woningtelling 28 febr. 1971. Steekproef 1 op 10 (x10) uitkomsten voor Utrecht.
(10) Marr, J.W.: Individual dietary surveys: Purposes and methods. World Rev. Nutr. Diet. 13:105, 1971.
(11) Potgieter, J.F., and Fellingham, S.A.: Assessment of methods for dietary surveys. S. Afr. Med. J. 41:866, 1967.
(12) Bransby, E.B., Daubney, C.G., and King, J.: Comparison of results obtained by different methods of individual dietary survey. Br. J. Nutr. 2:89, 1948.
(13) Eppright, E.S., Patton, M.B., Marlatt, A.L., and Hathaway, M.L.: Dietary survey methods. V. Some problems in collecting information about groups of children. J. Am. Dietet. A. 28:43, 1952.
(14) Nederlandse Voedingsmiddelen Tabel: 29th ed. The Hague: Voorlichtings-Bureau voor de Voeding, 1976.
(15) Hautvast, J.G.A.J.: Commissie uniforme codering voedingsenquêtes; ontwikkeling van een systeem om gegevens van voedingsenquêtes met behulp van de computer te verwerken. Voeding 36:356, 1975.
(16) Hellendoorn, E.W., Noordhoff, M.G., and Slagman, J.: Enzymatic determination of the indigestible residue (dietary fiber) content of human food. J. Sci. Food Agric. 26:1461, 1975.
(17) Katan, M.B., and van de Bovenkamp, P.: Determination of total dietary fiber by difference and of pectin by colorimetry or copper titration. *In* James, W.P.T., and Theander, P., eds.: The Analysis of Dietary Fiber in Food. London, New York: Marcel Dekker Publishing Co., 1981.
(18) McCance, R.A., Widdowson, E.M., and Shackleton, L.R.B.: The composition of foods. Special Report of Medical Research Council No. 213. London: His Majesty's Stationery Office, 1936.
(19) Southgate, D.A.T., Baily, B., Collinson, E., and Walker, A.F.: A guide to calculating intakes of dietary fiber. J. Hum. Nutr. 30:303, 1976.
(20) Snedecor, G.W., and Cochran, W.G.: Statistical methods. Ames: Iowa State University Press, 1976.
(21) Van der Haar, F., and Kromhout, D.: Food intake nutritional anthropometry and blood chemical parameters in 3 selected Dutch schoolchildren populations. Commun. Agric. Univ. Wageningen Pub. No. 78-g, 1978.
(22) Landbouwhogeschool, Vakgroep Humane Voeding: Report on food consumption and nutritional status of adolescents. Pub. No. 77-10, 1977.
(23) Keys, A., ed.: Coronary heart disease in seven countries. Circulation 41 (Suppl. 1), 1970.
(24) Van Staveren, W.A.: Kan de voedingsvezel-opneming van een kategorie volwassenan bepaald worden? Voeding 40:113, 1979.
(25) Kaspar, H., Rabast, U., and Ehl, M.: Studies on the extent of dietary fiber intake in West Germany. Nutr. Metab. 24:102, 1980.
(26) Bingham, S., Cummings, J.H., and McNeil, N.I.: Intakes and sources of dietary fiber in the British population. Am. J. Clin. Nutr.

32:1313, 1979.
(27) Stasse-Wolthuis, M.: Influence of dietary fiber on cholesterol metabolism and colonic function in healthy subjects. World Rev. Nutr. Diet. 36:100, 1981.
(28) Stasse-Wolthuis, M., Hautvast, J.G.A.J., Hermus, R.J.J., Katan, M.B., Bausch, E.J., Rietberg-Brussaard, J.H., Velema, J.P., Zondervan, J.H., Eastwood, M.A., and Gordon Brydon, W.: The effect of a natural high-fiber diet on serum lipids, fecal lipids and colonic function. Am. J. Clin. Nutr. 32:1881, 1979.
(29) Food Facts. London: Ministry of Agriculture, Fisheries and Food, 1980.
(30) Beaton, G.H., Milner, J., Corey, P., McGuire, V., Cousins, M., He, B.A., Stewart, E., de Ramos, M., Hewitt, D., Grambsch, P.V., Kassim, N., and Little, J.A.: Sources of variance in 24-hour dietary recall data: Implications for nutrition study design and interpretation. Am. J. Clin. Nutr. 32:2456, 1979.
(31) Liu, K., Stamler, J., Dyer, A., McKeever, J., and McKeever, P.: Statistical methods to assess and minimize the role of intra-individual variability in obscuring the relationship between dietary lipids and serum cholesterol. J. Chron. Dis. 31:399, 1978.
(32) Katan, M.B., and van de Bovenkamp, P.: De voeding in Nederland in 1982. Voeding. In press.

Feeding behaviors, food attitudes, and body fatness in infants[1]

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Obesity is one of the major nutritional disorders of our time. There is an interest in the study of infantile obesity because infancy may be a critical period for the development of fat cells (1-6). Although some studies (7-10) are contradictory, a relationship has been shown to exist between infantile obesity and obesity at later ages (11-16). In addition, fatness in infancy and childhood is related to certain health problems (15,17-21).

Behavioral and social factors associated with obesity, as well as biological and nutrient intake factors, need to be investigated (22-24). Theorists (25-29) and researchers (30) have postulated the existence of an association between behaviors surrounding the feeding of infants and the development of obesity. Examples of such behaviors are the misinterpretation of the infant's cues of hunger and satiety and the feeding of the infant for reasons other than hunger. Other literature (31-34) has pointed to mothers' attitudes toward food as a possible cause of fatness in their offspring.

[1]Based on a dissertation submitted by Sandra Morris in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in management, housing, and family development. This research is part of the USDA/SEA Competitive Grants Program Project, "Identification of Infants at Risk for the Development of Obesity." Co-investigators: L. Janette Taper and Cosby S. Rogers.

[2]The authors wish to express their appreciation to Robert B. Frary, PH.D., for his assistance with the statistical analyses; to Melanie McCallister and Lucy Terry, PH.D., for their assistance in data collection; and to Tracy Steffen for her work on coding data.

The purpose of this study was to investigate whether selected behaviors surrounding the feeding of infants and mothers' attitudes toward food can be used to predict body fat in infants. The following behaviors surrounding the feeding of 3-month-old infants were studied as predictors of the infants' fatness at 9 months of age: (a) the type of feeding schedule, (b) the ability of adults to recognize signals of hunger and satiety in the infants, (c) the extent to which adults urge the infants to take more food at the end of a feeding, (d) the extent to which adults feed the infants for reasons other than hunger, and (e) the likelihood that adults will feed the infants one hour after a feeding. Mothers' scores on an instrument measuring attitudes toward food were also studied as predictors of the infants' fatness.

Methodology

SUBJECTS. Parents of 134 infants (66 male, 68 female) volunteered to take part in a two-year longitudinal study of infant growth. All subjects lived within an 85-mile radius of Virginia Polytechnic Institute and State University, Blacksburg. The infants were visited bimonthly, beginning at 1 month of age, for the purpose of collecting a variety of data on feeding and growth. The infants were primarily first-born, white, and middle class, with well-educated parents. All data in this report were collected in the subjects' homes when the infants were 3 and 9 months of age.

FATNESS MEASURE. Skinfold thicknesses appear to be a more accurate measure of body fat than the traditional weight or weight/length ratios (35,36). For this study, infants' triceps skinfold thicknesses were used as the measure of body fatness. The measurements were taken by a trained researcher when the infants were 9 months (36 weeks ± 1 week) of age. As recommended by Fomon (37,38), Lange calipers[3] were used to measure the skin-

[3]Cambridge Scientific Industries, Cambridge, Maryland.