Adipose tissue linoleic acid as a criterion of adherence to a modified diet

SEYMOUR DAYTON, SAM HASHIMOTO, and MORTON LEE PEARCE

Medical Services of Wadsworth Hospital and Domiciliary, and Research Service, Veterans Administration Center; and Department of Medicine, University of California at Los Angeles School of Medicine, Los Angeles, California 90073

ABSTRACT In elderly, institutionalized men on a diet of high linoleic acid content, there was little correlation after 1 yr between adipose tissue linoleic acid concentration and dining room attendance. The correlation improved thereafter, with a correlation coefficient of +0.81 after 5 yr and +0.74 after 6 yr.

KEY WORDS unsaturated fat · adipose tissue · linoleic acid · diet · adherence to diet · man

It was suggested by Hirsch, Farquhar, Ahrens, Peterson, and Stoffel that the fatty acids of human adipose tissue, which have a half-life of over 1 yr, might provide an estimate of the composition of dietary fat integrated over a period of many years (1). This suggestion has been applied to the problem of appraising adherence in clinical studies involving long-term use of diets high in unsaturated fat (2).

In 1966 we reported that the rise in adipose tissue linoleic acid concentration over a 1 yr period was poorly correlated with adherence to an experimental diet of this type; the chief determinant of the rise in linoleic acid in this interval was initial leanness, and the second in importance, weight change (3). We postulated that analyses done after several years on the experimental diet might reveal better correlation with adherence to diet and less influence by other variables, but available data were insufficient to test this possibility. Information confirming the hypothesis is described in this report.

METHODS

The subjects were elderly, domiciled male veterans living in this Center and participating in a trial of the ability of a diet high in unsaturated fat to prevent complications of atherosclerosis. Mean age on entry into the program was 66 yrs. Men who could be identified as alcoholics, from their records or by interview, were ineligible to participate. No effort was made to record intake of alcohol by the participants. None of the subjects had evidence of intestinal malabsorption on review of their clinical records, but no further effort to exclude this possibility was undertaken.

Dietary fat accounted for 39% of calories, and contained 40% linoleic acid (18:2). The ratio of polyunsaturated to saturated fatty acid was 1.9. The participants had relatively free access to the community, and almost all of them ate some meals outside the Center. Adherence to the experimental diet was monitored by recording punches on meal tickets, which were collected monthly. Opportunities for subversion of the meal ticket system were limited by surveillance of food service by the dietitians and food service workers, who were acquainted with the participants. Nevertheless, these attendance records constitute an imperfect index of adherence, since they prove little information as to ethanol intake and snacks, and fail to distinguish between missed meals and those eaten elsewhere.

Adipose tissue was obtained periodically by aspiration from the buttocks (1), and its fatty acid composition was determined by gas–liquid chromatography. Additional details concerning the study and analytical procedure are described in earlier publications (3–5).

RESULTS

The relationship between adherence to diet and adipose tissue linoleic acid concentration was tested by examining all values obtained within 30 days of the subjects' an-

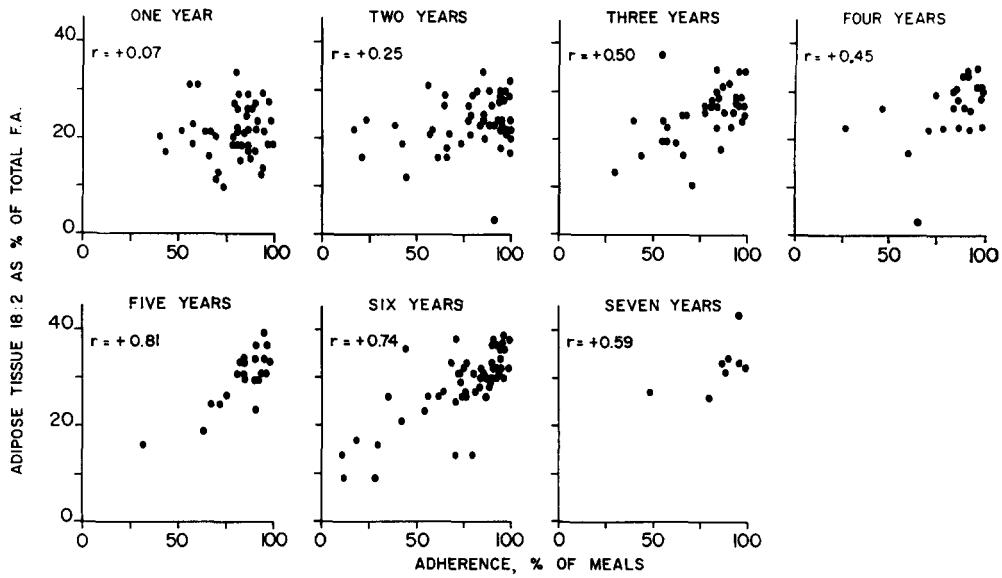

FIG. 1. Relationship between adipose tissue linoleic acid concentration and meal attendance up to the date of the sample. F.A., fatty acid.

niversary dates. Plots of these anniversary values[1] against meal attendance during the elapsed periods are shown in Fig. 1, together with correlation coefficients. The mean 1-yr value was approximately double the baseline concentration of 11% (not shown in the figure); nevertheless, the levels at 1 yr were nearly independent of adherence during this interval. Thereafter, there was a roughly progressive increase in correlation with increasing time on the experimental diet.

The rank-correlation coefficient describing the relationship between these individual correlation coefficients and time on the diet was +0.821; $P = 0.017$. Because the calculated correlation coefficient was lower at 6 and 7 yr than at 5 yr (Fig. 1), we applied "t" tests to pairs of correlation coefficients in order to evaluate the possibility that this might represent a significant decline. The data summarized in Table 1 indicate that the decline after 5 yr was not significant.

To evaluate the possibility that the poor correlation at 1 yr might be due to the rather wide range of time intervals (i.e., 335 to 395 days), we repeated the analysis of 1-yr data including only samples obtained within 10 days of the anniversary data. The correlation coefficient, based on 30 samples, was +0.02.

DISCUSSION

The fact that linoleic acid level was nearly independent of adherence to diet early in the study, but became increasingly correlated after several years, suggests that a given adherence level is associated with a family of concentration–time curves that rise at different rates but approach the same asymptotic level. The previously reported relationship to leanness is entirely compatible with this conclusion. It would be expected a priori that the level of linoleic acid at infinite time would be determined only by the mean dietary concentration and by the ratio of fat intake to endogenous fatty acid synthesis rate. On the other hand, leanness would be expected to affect the rate of rise toward the asymptote. As reported earlier (3), the data fit the function $L = 35.6 - 24.2e^{-0.00102t}$, in which L = linoleic acid percentage, t = time on diet in days, and the constant 0.00102 is the reciprocal of mean turnover time of adipose tissue triglyceride. With a small triglyceride pool in a lean subject, turnover time would be shorter than the mean and L would accord-

TABLE 1 EVALUATION OF THE RISE IN CORRELATION COEFFICIENT WITH INCREASING TIME ON EXPERIMENTAL DIET

Year	Correl. Coef, Linoleate Concn vs. Meal Attendance	P Value*	t Test,† 5-Yr Correl. Coef vs. Correl. Coef at Given Year		t Test,† 6-Yr Correl. Coef vs. Correl. Coef at Given Year	
			t	P	t	P
1	+0.07	>0.05	3.85	<0.001	4.29	<0.001
2	+0.24	0.05	3.20	<0.005	3.42	<0.001
3	+0.05	<0.005	2.03	<0.05	1.82	>0.05
4	+0.45	<0.025	2.10	<0.05	1.89	>0.05
5	+0.81	<0.001	—	—	0.67	>0.5
6	+0.74	<0.001	0.67	>0.5	—	—
7	+0.59	>0.05	0.89	>0.3	0.57	>0.5

* Probability that the population correlation coefficient is ≤0.

† t Tests were performed on the transformation $z = 0.5 \ln [(1 + r)/(1 - r)]$, which has an approximately normal sampling distribution (6).

[1] It is possible that the increment in linoleic acid concentration, rather than the observed value, would be more informative, but base line values were not obtained for many of the early participants.

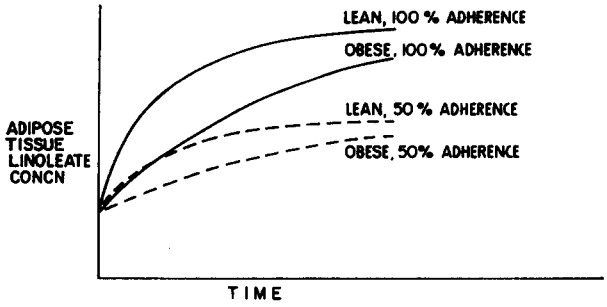

FIG. 2. Schematic representation of the effect of leanness and adherence to diet upon adipose tissue linoleic acid concentration.

ingly be higher. When t is small, changes in the turnover constant have a large effect on L; when t is large, the right-hand term approaches zero and changes in the turnover constant have a small effect on L. This concept is illustrated schematically in Fig. 2. A similar argument can readily account for the rapid rise in linoleic acid of depot fat during weight gain.

The unexplained variance in adipose tissue linoleic acid concentration probably is due largely to the uncontrolled number of meals eaten outside the center. Nevertheless, it is concluded that in subjects on a diet high in unsaturated fat for 5 or more yr, linoleic acid content of depot fat is a useful index of individual adherence.

We are indebted to Barbara Doubek, Natalie Fisher, Paul Hanlon, Loretta Karolewics, and Pat Yelenosky for expert laboratory assistance; to Dr. Wilfrid Dixon for biostatistical consultation; and to Miss Elva Hiscock and Mrs. Mildred Ridge for the dietetic aspects of the program.

This study was supported in part by grants from the Arthur Dodd Fuller Foundation and the National Institutes of Health, U.S.P.H.S. (HE-04900). Computing was performed at the Health Sciences Computing Facility, U.C.L.A., supported by grant FR-3 from the National Institutes of Health.

Manuscript received 13 March 1967; accepted 20 June 1967.

REFERENCES

1. Hirsch, J., J. W. Farquhar, E. H. Ahrens, Jr., M. L. Peterson, and W. Stoffel. 1960. *Am. J. Clin. Nutr.* **8:** 499.
2. Christakis, G. J., S. H. Rinzler, M. Archer, S. A. Hashim, and T. B. Van Itallie. 1965. *Am. J. Clin. Nutr.* **16:** 243.
3. Dayton, S., S. Hashimoto, W. Dixon, and M. L. Pearce. 1965. *J. Lipid Res.* **7:** 103.
4. Dayton, S., S. Hashimoto, and M. L. Pearce. 1965. *Circulation.* **32:** 911.
5. Dayton, S., S. Hashimoto, and J. Jessamy. 1961. *J. Atherosclerosis Res.* **1:** 444.
6. Dixon, W. J., and F. J. Massey, Jr. 1957. Introduction to Statistical Analysis. McGraw-Hill Book Company, New York. 2nd edition. 200.