# A mathematical relationship between the fatty acid composition of the diet and that of the adipose tissue in man[1]

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ABSTRACT Based on literature data, the hypothesis is advanced that in human subjects a direct mathematical relationship exists between the average fatty acid composition of the habitual diet and that of the lipid stores of subcutaneous adipose tissue. Since the half-life of adipose tissue fatty acids in man is in the order of 600 days, the fatty acid pattern of depot fat provides a qualitative measure of the fat intake over a period of 2 to 3 years. It is concluded that in long-term experimental and epidemiological nutritional surveys the adipose tissue fatty acid pattern of the subjects is a useful index of the average composition of their habitual dietary fat. *Am. J. Clin. Nutr.* 33: 81–85, 1980.

The fatty acid profile of human subcutaneous adipose tissue is strongly influenced by the fatty acid composition of the dietary fat. Among the adult population, age, sex, and race appear to play a minor role in determining the fatty acid pattern of adipose tissue (1–5). Hirsch et al. (1) suggested in 1960 that the fatty acid composition of human adipose tissue might be related to the intake of dietary fatty acids over a period of 2 to 3 years.

The turnover rate of adipose tissue fatty acids is the major factor determining the time required for an alteration in dietary fat type to be reflected in the fatty acid profile of adipose tissue. Based on measurements of the incorporation of linoleic acid into adipose tissue and assuming that other fatty acids exhibit similar kinetic characteristics, the half-life ($T_{1/2}$) of adipose tissue fatty acids is approximately 600 days (1, 6), the fractional turnover rate (which equals ln $2/T_{1/2}$) being 0.12% per day. The total body fat of men would thus completely be replaced in 800 to 900 days. Indeed Turpeinen (8) reported that a change in dietary fat is optimally reflected in the fatty acid composition of subcutaneous adipose tissue only after a period of at least 3 years.

In the above-mentioned calculations it is assumed that the body-fat mass behaves as a homogeneous entity. However, the turnover rate of plasma free fatty acids, which originate almost completely from the adipose tissue, is in the order of 100 g/day (7). For the adipose tissue fatty acids of a 70-kg man, who carries about 10 kg fat in the adipose tissue, this suggests $T_{1/2}$ of only 70 days. This discrepancy can be explained, as already pointed out by Hirsch et al. (1), by describing the adipose tissue-fat mass as a two-pool system, consisting of a relatively small, readily exchangeable pool, and a large inert pool. In determining the fatty acid profile of total adipose tissue, the analysis will almost completely represent the composition of the large inert pool, reflecting the dietary fatty acid composition in a long-term, rather than short-term sense.

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In some studies the relative percentage of adipose tissue linoleic acid has been used as a criterion of adherence to a fat-modified diet (9–12) or even as a risk indicator for coronary heart disease (13). In this paper, based on data from the literature, a mathematical relationship is proposed between dietary and adipose tissue fatty acid patterns.

## Dietary fatty acids and adipose tissue fatty acids

Table 1 summarizes the design and the results of seven studies in which the fatty acid composition of both dietary and adipose tissue lipids of groups of human subjects was determined. Based on these data, the existence of a mathematical relationship between the fatty acid pattern of dietary fat and adipose tissue glycerides was tested.

With the data presented in Table 1, linear correlation coefficients were calculated of all combinations of dietary and adipose tissue relative percentages of polyunsaturated (P), monounsaturated (M), and saturated fatty acids (S) as well as their ratios (Table 2). The highest correlation coefficients are obtained when P is present in both the dietary and adipose tissue parameter. This may be related to the fact that P is an essential component of human diet. However, the correlation coefficients between the relative percentages of S and M in adipose tissue and in the diet are low. This indicates that the relative percentages of adipose tissue S and M are not only dependent on the proportions of S and M in the dietary fat. Carbohydrate intake, alcohol consumption, energy expenditure and conversion of S into M and vice versa may all influence the final relative percentages of S and M in adipose tissue.

A plot of dietary P versus adipose tissue P, by means of least-squares linear regression, is presented in Figure 1A. A regression coefficient of 0.80 was calculated. The small intercept of the regression line stresses the essential character of dietary P. By comparing Figures 1A and B, it appears that the relative percentage of adipose tissue P reflects the relative percentage rather than the absolute amount of dietary P. This may have been anticipated since percentages of dietary and adipose tissue fatty acids (Table 1) represent molar ratios, as analyzed by gas-liquid chromatography of the methylesters of the component fatty acids. It is clear from Figure 1A, however, that above values of 30%, dietary P does not seem to predict the relative percentage of adipose tissue P. This may be attributed to the large differences in the absolute intake of dietary P in this range. In the studies cited under numbers 6, 8, 9, and 18, the daily intake of P was 30 to 42 and 7 to 8 g, respectively, while the energy intake did not differ significantly. It may be expected that the relative percentage of adipose tissue P at infinite time is determined only by the relative percentage dietary P and by the ratio of fat intake over endogenous fat synthesis.

TABLE 1
Fatty acid composition of dietary and adipose tissue lipids of human subject groups studied by various authors

| Reference | Subjects | No. of subjects | Mean duration of diet | Mean relative percentage of fatty acids: Diet S | Diet M | Diet P | Adipose tissue S | Adipose tissue M | Adipose tissue P |
|---|---|---|---|---|---|---|---|---|---|
| 8 | Control group | 300 | 3 yr | 54 | 33 | 14 | 31 | 58 | 11 |
| | Experimental group | 300 | 3 yr | 27 | 36 | 37 | 22 | 47 | 31 |
| 16 | Americans | 50 | Life | 38 | 45 | 13 | 32 | 55 | 10 |
| | Japanese | 56 | Life | 27 | 35 | 26 | 28 | 51 | 17 |
| 17 | Students | 22 | 9 mo/3–4 yr | 32 | 43 | 21 | 24 | 58 | 13 |
| 6 | Control group | 10 | 5 yr | 45 | 42 | 12 | 27 | 58 | 10 |
| | Experimental | 15 | 5 yr | 23 | 37 | 39 | 20 | 44 | 32 |
| 9 | Control group | 19 | 3.5 yr | 43 | 41 | 16 | 30 | 59 | 11 |
| | Experimental group | 23 | 3.5 yr | 32 | 32 | 35 | 26 | 52 | 22 |
| 18 | Korean monks | 17 | 5.5 yr | 25 | 35 | 40 | 30 | 52 | 19 |
| | Korean farmers | 8 | Life | 30 | 35 | 35 | 33 | 54 | 13 |
| | Korean city dwellers | 15 | Life | 41 | 39 | 20 | 29 | 54 | 18 |
| | American soldiers | 19 | 3 yr | 52 | 38 | 10 | 30 | 60 | 9 |
| 19 | School children | | Life | 52 | 30 | 18 | 38 | 49 | 14 |

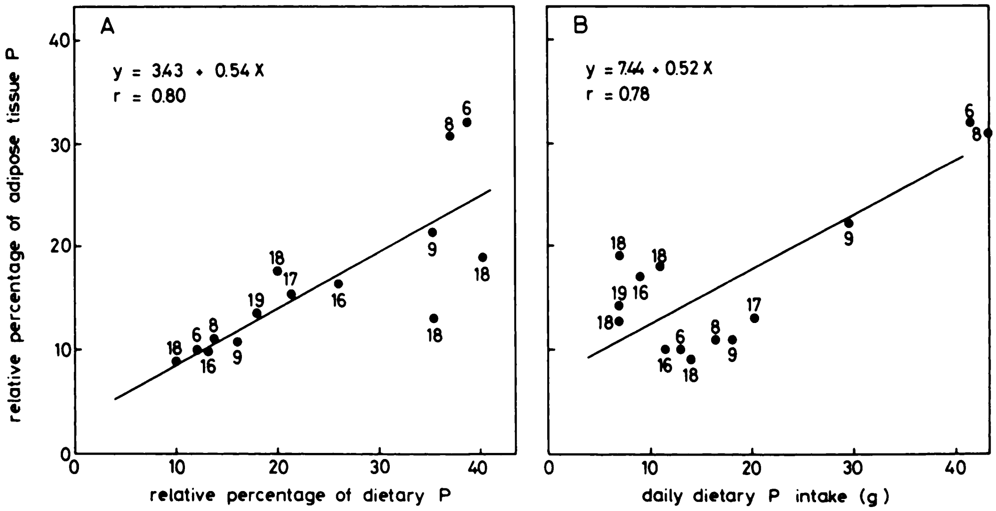


FIG. 1. A, relationship between the relative percentages of P in the diet and in adipose tissue. Data were derived from Table 1; the numbers with the *dots* correspond to the references used. B, relationship between the daily dietary intake of P and the relative percentage of P in adipose tissue. The numbers with the *dots* correspond to the references used.

When the absolute fat intake is low, the dietary fatty acids, before being incorporated into the adipose tissue, will be considerably diluted with de novo synthesized fatty acids. This may explain that in the subjects described by Scott et al. (18), who consumed small amounts of fats with a high proportion of P, the relative percentage of adipose tissue P was lower than expected (Fig. 1A). Relatively little dilution of dietary P with endogenously synthesized fatty acids may have occurred in the subjects of the studies cited under numbers 6 and 8. The latter subjects showed higher relative percentages of adipose tissue P than would be anticipated from the regression equation (Fig. 1A).

Figure 2 shows the relationship between dietary M/P and adipose tissue M/P, which have the highest correlation coefficient of all parameters of dietary fat and adipose tissue examined (Table 2). Table 2 documents, however, that many other ratios, provided that P is present in both the dietary and adipose tissue parameter, reveal linear correlation coefficients over 0.80.

In order to verify whether extrapolation of these relationships is justified, investigation of the fatty acid composition of food and adipose tissue of people on monotonous diets could provide significant information. Sub-

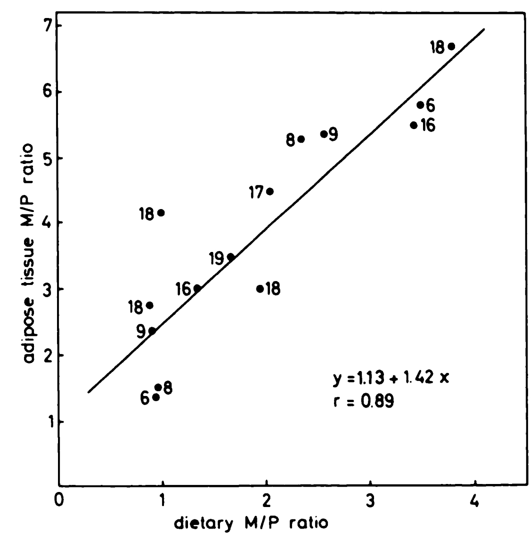


FIG. 2. Relationship between the ratios of the relative percentages of M/P in dietary fat and in adipose tissue. Data were derived from Table 1; the numbers with the *dots* correspond to the references used.

populations of Colombia and Jamaica (14) or Polynesia and New Zealand (15), showing adipose tissue S/P and M/P ratios ranging from 8 to 15, may be interesting in this respect. Unfortunately, data concerning their dietary fatty acid composition are not presently available.

TABLE 2
Linear correlation coefficients between the relative percentages and ratios of relative percentages of dietary and adipose tissue fatty acids

| Adipose tissue | Dietary fat | | | | | |
|---|---|---|---|---|---|---|
| | P | S | M | M/P | S/P | S/M |
| P | 0.80[a] | −0.69[a] | −0.31 | −0.73[a] | −0.72[a] | −0.50 |
| S | −0.44 | 0.59 | −0.25 | 0.26 | 0.43 | 0.65[a] |
| M | −0.74[a] | 0.60 | 0.46 | 0.74[a] | 0.69[a] | 0.34 |
| M/P | −0.86[a] | 0.72[a] | 0.46 | 0.89[a] | 0.86[a] | 0.46 |
| S/P | −0.82[a] | 0.77[a] | 0.26 | 0.79[a] | 0.82[a] | 0.60 |
| S/M | −0.08 | 0.31 | −0.50 | −0.11 | 0.09 | 0.51 |

[a] $P < 0.005$.

## Discussion

Analysis of the fatty acid pattern of human buttock adipose tissue, for which Hirsch et al. (1) introduced a simple and rapid technique, appears to provide an impression of the fatty acid composition of the habitual diet. Because of the slow turnover rate of the bulk of the adipose tissue fatty acids, the fatty acid profile of adipose tissue reflects the average fatty acid composition of dietary fat over a period of approximately 3 years.

In individual subjects this period may fluctuate if body weight changes occur. Weight gain will be associated with a relatively rapid deposition of dietary fat in adipose tissue (6). During periods of negative energy balance, incorporation of dietary fatty acids into adipose tissue will be limited (6). Therefore, the assessment of the retrospective qualitative dietary fat intake from an analysis of adipose tissue fatty acids should only be applied to groups of subjects. In epidemiological nutritional surveys this method may replace dietary history interviews, or may even serve as a control of such questionaires in investigating habitual fatty acid intake.

In studying the effects of long-term experimental diets, using the zero-time adipose tissue fatty acid pattern as control value, the determination of the fatty acid composition of adipose tissue may provide a way of identifying adherents and nonadherents. The investigation of the long-term effects of nutrition information programs may be another application.

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