DIETARY MANIPULATION OF SERUM TRIGLYCERIDES[1]

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SUMMARY

A group of children who had been treated for protein-energy malnutrition with a high-energy, high-fat diet, presented very low levels of fasting

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Manuscrito modificado recibido: 6–7–79.

1 A preliminary report, entitled "Manipulación Dietética de los Triglicéridos Circulantes" appeared in *Abstracts of the IV Latin American Nutrition Congress* (but was not presented at the Meeting). This was prepared by C.R.C. Araújo in partial fulfillment of the requirements for an MSc. degree from the Universidade Federal de Pernambuco.

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serum triglycerides (50.8 ± 5.9 mg/dl). When the diet was changed to a high-energy, low-fat formula, these levels increased rapidly to normal values (104.9 ± 19.2 mg/dl). Reversing the dietary change produced the opposite effect within 2 days. This effect was also studied in 14 normal adults, who received a high-fat diet *ad libitum* during 5 days. Meals were prepared from common foodstuffs with a high fat content. The hypotriglyceridemic effect occurred in all volunteers. A close relationship was observed between the initial triglyceride concentration and the decrement produced by the high-fat diet (r = 0.97), which did not affect serum cholesterol levels. No consistent response of serum free-fatty acids was detected, while serum proteins remained within normal values. Despite the rather high energy intake, most subjects lost weight during the experimental period. The level of fasting serum triglycerides of the adult volunteers was negatively correlated to the fat content of their self-selected diets. These results are discussed in relation to current ideas about fat requirements.

INTRODUCTION

Since fat can be readily synthesized in the organism from carbohydrates and amino acids, it is generally believed that its only value as a nutrient lies in its function as a carrier of essential free fatty acids, in its possible role in the absorption of fat-soluble vitamins, and in its saciety value. Thus it is a general practice to include fat in Tables of Recommended Dietary Allowances only as an undefined component of the total energy needs.

High–fat diets are believed to cause hyperlipidemia, particularly hypercholesterolemia, which in turn would increase the risk of coronary heart disease and other vascular disorders. Hence some authors recommend that the total fat intake be kept below 35% of the total energy intake (1-3). On the other hand, diets high in fat have proved beneficial in the treatment of protein-energy malnutrition in children, since they provide formula diets with a high energy density for children whose rate of weight gain is dependent on the energy intake during recovery (4). A group of children treated in this manner for malnutrition presented very low levels of circulating triglycerides (6). We were able to establish that this "hypertriglyceridemia" was associated with the high fat intake of the children, and this led us to investigate this effect in more detail. Our results indicate that high-fat diets have potential value in the management of serum triglyceride concentrations in very short periods of time.

MATERIAL AND METHODS

Subjects

Sixteen children treated for malnutrition in the Tropical Metabolism Research Unit (Kingston, Jamaica) and 14 adults from the TMRU staff and from that of the Department of Nutrition of the Federal University of Pernambuco (Recife, Brazil) were studied. The children were between 10 and 20 months of age and they had all been on high-fat foods for at least three weeks. They were approaching or had already reached their expected weight for height (7).

Diets

Two modifications of a standard infant formula were used for the children, containing either 60% or 26% of the total energy as fat (Table 1). The diet was offered in equal portions every four hours and the mean energy intake during the study period was 600 kJ^{-1} d^{-1}. The diets of the adult volunteers were prepared from foodstuffs commonly used either in Jamaica or in northeast Brazil, with emphasis on ingredients with a high fat content, such as bacon, cream, pork chops, salad cream, nuts, butter and cheese. All subjects consumed the diets *ad libitum,*

TABLE 1

COMPOSITION OF MILK DIETS

Component	High fat	Low fat
Dried full-cream milk (g/l)*	190	190
Arachis oil (g/l)	60	–
Sucrose (g/l)	–	50
Cornstarch (g/l)	–	25
Energy (K J/100 ml)	565	469
Protein (g/100 ml)	3.1	3.1
Fat (% of total energy)	60	25

* Proprietary preparation: carbohydrate, 57%; fat, 17%; protein, 16.5%.

while individual intakes were carefully recorded and calculated from a food composition table (8). No restrictions were imposed to the adult volunteers regarding the type of food consumed, with the sole exception of alcoholic beverages. However, the daily intake of fat was always kept over 60% of the total energy by compensating any excess of carbohydrate with lipid-rich foodstuffs. The energy and fat intake on the self-selected diets were calculated through the recall method at randomly selected days.

Analytical Methods

Blood samples were always taken after an overnight fast of 8 to 12 hours. Consent was obtained from the children's parents or guardians but, whenever possible, blood samples from the children were taken when these were required for routine diagnostic purposes. Body weight of the adults was measured daily, under standard conditions and by the same operator.

Blood was allowed to clot at room temperature, after which the serum was collected by centrifugation at 4°C and, when necessary, stored at –20°C. Triglycerides were measured by the method of Carlson (9) with a minor modification: the iodine formed upon addition of the chromotropic acid reagent was removed under reduced pressure while the tubes were shaken on a vortex mixer. This rendered colorless solutions before the final incubation, after which blank readings were much lower and sample readings much more reproducible. Cholesterol (10), free fatty acids (11) and total protein (12) were also measured in the sera.

RESULTS

The children fed the high-fat formula presented a mean serum triglyceride concentration of 50.8 ± 5.9 mg/dl. When the fat content of the diet was reduced to 26% of the total energy, there was a significant increase of the triglyceride levels up to 123.5 ± 22.8 mg/dl in 4 to 6 days. The values stabilized thereafter at approximately 120 mg/dl (Fig. 1).

A group of children who had been fed the low-fat formula for 3 to 4 weeks was changed back to the high-fat diet. This reverse change produced a drop in serum triglycerides from

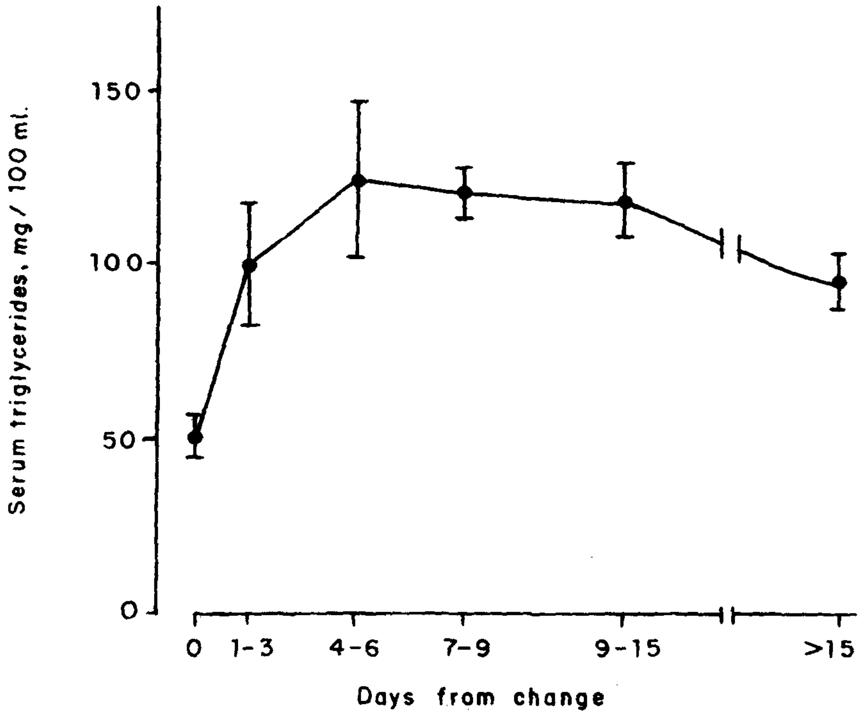

FIGURE 1

Effect upon serum triglycerides of changing the fat intake of children from 60 to 26°/o of the total energy intake. Each point represents the mean ± SD of at least 6 children

104.9 ± 19.2 mg/dl to 37.4 ± 3.2 mg/dl (Fig. 2).

No difference in response was observed between the children already recovered and those who were still rapidly gaining weight.

In the adult volunteers, fasting serum triglycerides were measured while on self-selected diets, and daily after initiating the high-fat feeding experimental period. The total energy intake and the relative fat intake of each volunteer during these two periods are shown in Table 2. The values for the period of high-fat intake are the mean of three to five daily estimations.

Fasting serum triglycerides decreased in all volunteers 24 h

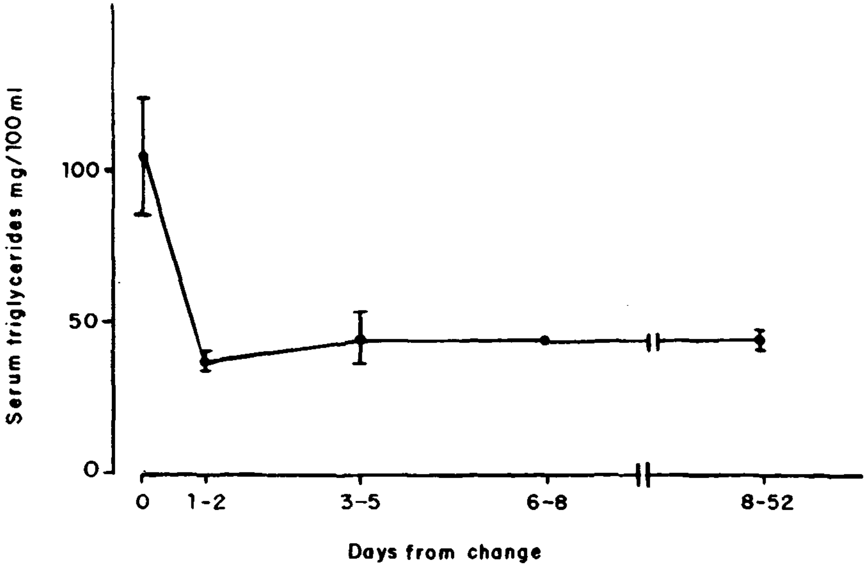

FIGURE 2

Effect upon serum triglycerides of changing the fat intake of children from 26 to 60% of the total energy intake. Each point represents the mean ± SD of at least 6 children

after the change of diet, while the mean serum cholesterol level showed a modest decrease (Table 3). No significant changes were observed in serum free fatty acids or serum total protein, all these values being within normal limits (not shown).

There was a significant correlation ($r = 0.97$) between the initial triglyceride concentration of the adults and their response (decrement) to the high-fat diet. The values for all subjects fitted the same regression line despite the differences in the actual composition of the dishes between Jamaica and Recife (Fig. 3).

Two of the volunteers in the first experiment in Jamaica reported their impression of having lost weight during the experimental period, a reason why body weight was recorded in the Recife experiment. Figure 4 shows that, despite the rather high energy intakes, weight losses did occur in all but one of the volunteers, the maximum loss being 3.2 kg over the 5-day experimental period.

TABLE 2

TOTAL ENERGY AND RELATIVE FAT INTAKE DURING HIGH–FAT FEEDING OF NORMAL ADULT VOLUNTEERS

Subject	Total energy intake on high-fat diet. KJ/d[a]	Relative fat intake on high-fat diet, o/o of total energy intake[a]	Relative fat intake on self-selected diets, o/o of total energy intake
W. M.	7.743 ± 0.666	63.8 ± 3.1	34.0
L. A.	8.380 ± 1.770	66.9 ± 4.5	31.2
J. O.	7.385 ± 0.748	68.1 ± 3.9	30.9
W. V.	9.001 ± 2.512	69.1 ± 2.8	34.3
A. N.	9.806 ± 1.867	68.9 ± 4.6	38.4
Z. G.	10.102 ± 1.916	66.8 ± 5.9	38.9
E. P.	11.096 ± 1.247	67.3 ± 3.7	38.3
C.M.	13.638 ± 2.428	66.5 ± 4.8	26.7
J. L.	13.929 ± 1.944	70.0 ± 3.5	33.5
M. S.	15.250 ± 2.222	72.4 ± 2.1	35.1
A. S.	10.709 ± 2.183	72.9 ± 2.2	39.6
H. F.	10.645 ± 2.917	69.6 ± 1.5	20.6
G. A.	14.065 ± 2.397	69.7 ± 3.8	22.0
A. A.	13.543 ± 1.285	69.0 ± 5.8	43.2

[a] Mean ± SD.

DISCUSSION

It is apparent that fasting serum triglycerides respond very rapidly to fat intakes of at least 60o/o of the total energy. This effect could, of course, be the reversal of the well known "carbohydrate induction" operating at a different level: fasting serum triglycerides of children on the low-fat formula were within the "normal" range found in the literature for children of similar ages (13, 14) and the same could be said of the adult volunteers on the self-selected diets. However, the hypertriglyceridemic effect of high carbohydrate diets is quite variable and not always demonstrable in normal individuals (15-17), although low carbohydrate, high-fat diets are standard theraphy in patients with

TABLE 3

EFFECT OF HIGH–FAT FEEDING UPON SERUM TRIGLYCERIDE AND CHOLESTEROL LEVELS OF NORMAL, ADULT VOLUNTEERS

Subject	Days on experimental diet					
	0	1	2	3	4	5
	Serum triglycerides, mg/100 ml					
H. F.	382.0	105.0	89.0	78.1	–	–
W. V.	312.8	144.4	167.9	132.1	106.5	122.3
C. M.	238.6	96.8	99.3	89.1	84.5	89.6
L. A.	139.2	113.1	90.1	81.0	69.1	75.8
A. S.	136.0	93.0	74.1	70.6	–	–
M. S.	114.0	71.5	49.5	67.0	–	–
J. O.	103.9	43.5	54.8	55.3	32.8	46.1
G. A.	100.6	44.8	40.9	67.4	–	–
A. N.	88.0	39.4	42.0	21.0	29.2	21.0
Z. G.	81.4	48.1	48.9	39.4	26.6	23.0
A. H.	56.6	39.6	41.6	48.4	–	–
E. P.	52.7	50.2	44.0	49.1	20.0	18.4
J. L.	46.6	22.0	16.4	38.9	20.5	35.3
W. M.	33.3	27.6	19.4	25.0	17.4	15.3
Mean	134.7	67.1	62.7	64.8	45.2	49.6
S.D.	104.5	37.1	39.3	33.2	32.9	37.8
	Serum cholesterol, mg/100 ml					
(Mean)	213.0	223.0	220.8	200.3	191.1	188.9
SD	50.0	58.7	48.6	48.9	54.9	59.2

carbohydrate-induced hypertriglyceridemia (18-21).

The highly significant correlation between the initial triglyceride concentration and its decrease observed in the adult volunteers is suggestive of a "basal" concentration of tryglycerides for each individual, which would be reached upon high-fat feeding. This observation could not be done on the children counterpart as they were being fed formula diets.

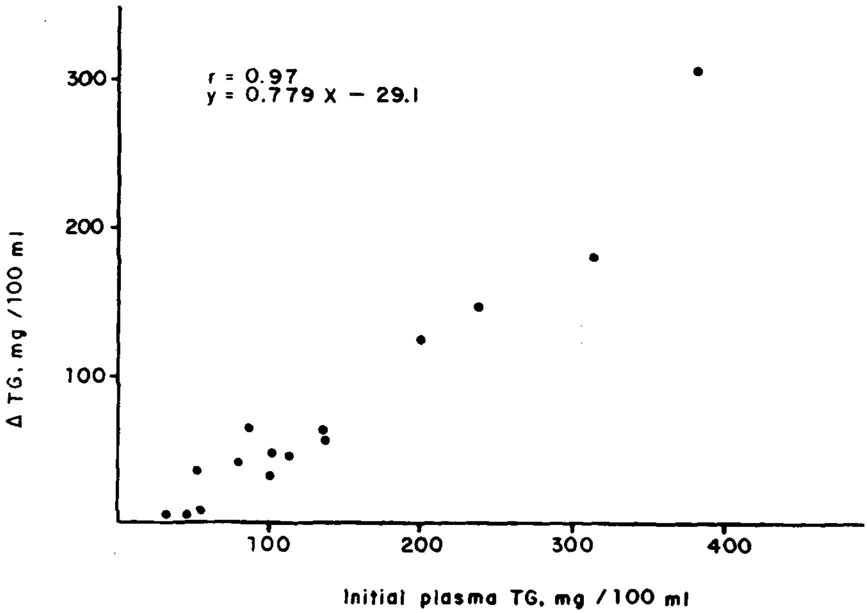

FIGURE 3

Correlation between the initial levels of serum triglycerides of normal adult volunteers and their response to a high-lipid, non-formula diet. TG represents the difference between the concentration of serum triglycerides at the begining and at the end of a 3 to 5 days experimental period

The existence of a correlation such as the one discussed herein implies that a correlation should also be found between the usual fat intake of the subjects and their fasting serum triglyceride levels. This is indeed the case in the subjects we have studied so far, as shown in Fig. 5. This possible relationship should be considered when setting limits for normal serum triglyceride concentrations, although conscious of the fact that our observation should be extended to larger number of individuals.

Cholesterol concentrations also revealed a moderate decrease in the adult volunteers. These were not measured in the children of the present study, but in another series of children fed the high-fat formula it was found that the values were all within normal limits (5).

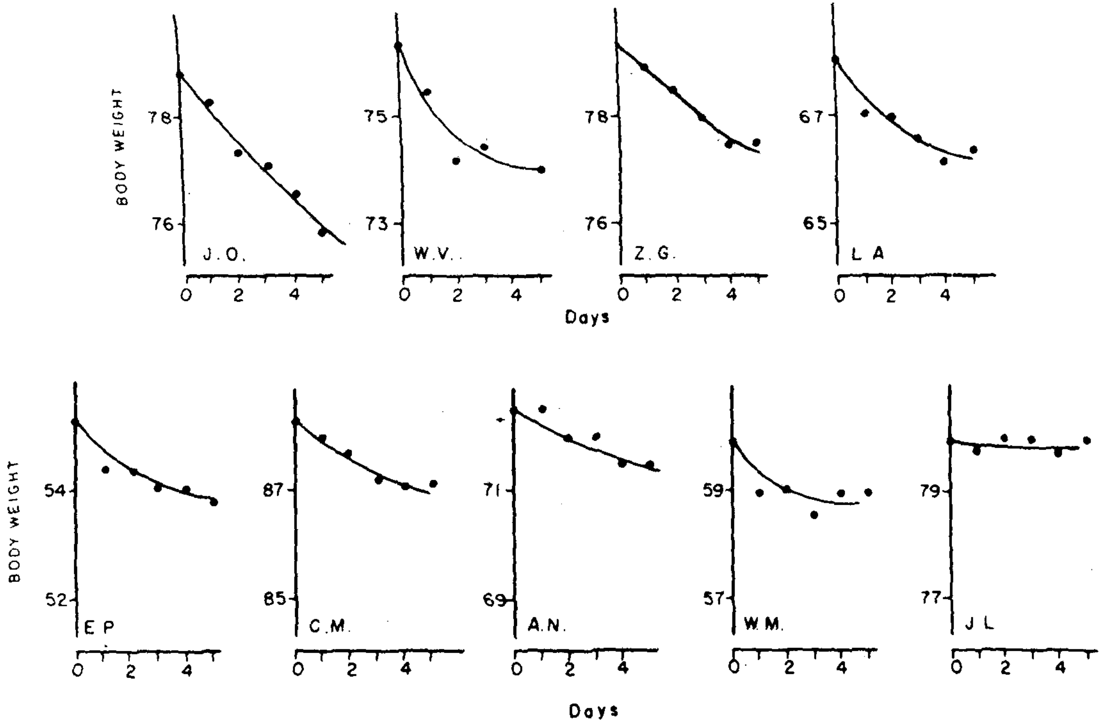

FIGURE 4

Response of body weight of normal adult volunteers to a high-fat, high-energy diet.

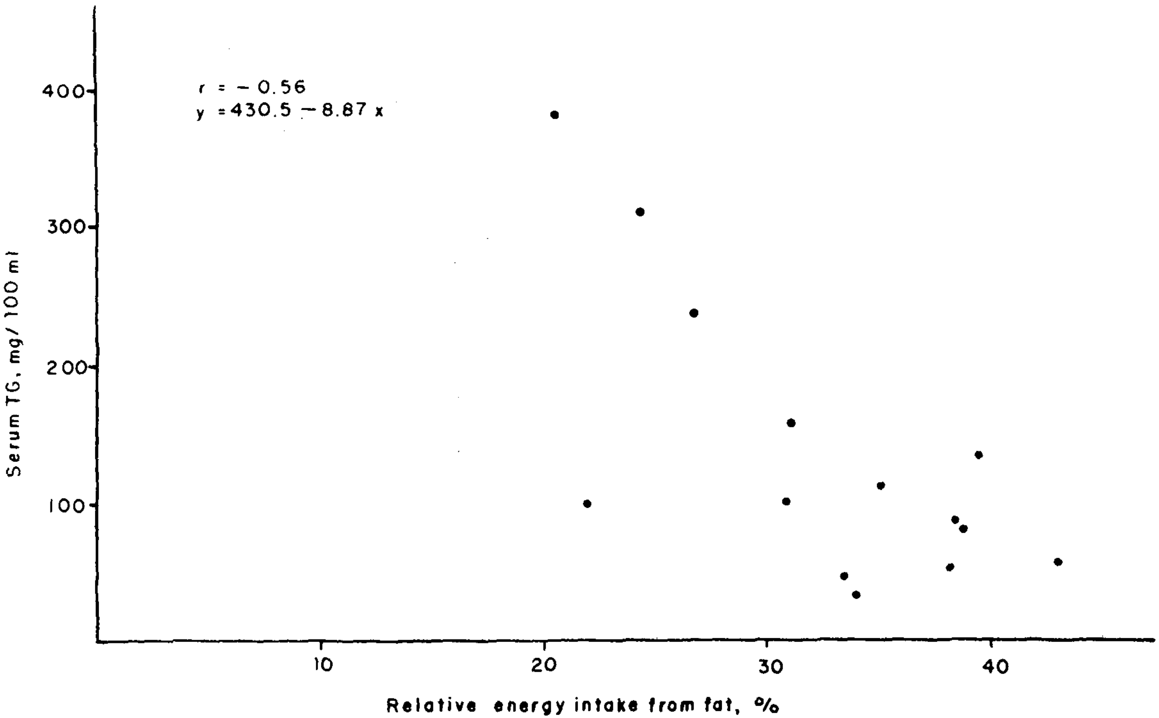

FIGURE 5

Correlation between the relative fat intake (as percentage of energy derived from fat) and fasting serum triglycerides of normal adult volunteers. The fat intake on self-selected diets was calcultated from a food composition table (8)

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