Pre- and post-natal growth acceleration and increased sugar consumption in Canadian Eskimos

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Summary: A striking increase in birth weights and height measurements in children of Canadian Eskimos was observed in recent years.

The growth acceleration seen to varying degrees in different Eskimo groups appears most closely to parallel the increase in the per capita annual sugar consumption which has more than quadrupled during the last decade in some trading areas of the Canadian Central and Eastern Arctic, while the per capita consumption of protein derived from animal sources shows a reverse relationship.

Canadian Eskimos do, therefore, contrary to what is stated in earlier publications, conform to the general secular growth acceleration patterns observed in all populations coming under the influence of modern civilization. They do not, however, conform to the commonly held explanation for this acceleration, namely increased consumption of high-quality proteins, since their traditionally extremely high consumption of meat and fish decreased markedly during the same period.

Our observations confirm the relation of growth acceleration and consumption of sugar first established by the Swiss pediatrician, Eugen Ziegler. A hypothesis first advanced by Ziegler is elaborated to link this growth acceleration, in particular the extraordinary increase in birth weight, to "pseudo-diabetic" oral glucose tolerance patterns described previously by the author in a large proportion of Eskimos.

Measurements made during the last century of school, college and university students and of drafted military recruits in several countries of North-Western and Central Europe and in North America have confirmed the popular belief held in these industrialized nations that nowadays children tend to grow taller than their parents and grandparents did.

Not only was acceleration of growth and developmental phases (e.g. puberty) observed but also a definite and substantial increase in the final height measurements was found.

Between 1880 and 1950 in the United States and North-Western Europe, the average rates per decade for different age groups of this "secular growth acceleration" were of the following order: 1.5 cm. and 0.5 kg. at ages 5 to 7 years, 2.5 cm. and 2 kg. at adolescence and 1 cm. per decade for adults.[1] Between 1830 and 1960, the menarche tended to occur an average of four months per decade earlier.[2]

A number of explanations have been put forward. Nutritionists and pediatricians have been inclined to attribute these changes to "better nutrition", i.e. particularly high-quality proteins derived from animal sources.[3] Others, such as demographers and anthropologists, have implicated "hybrid vigour" as a factor.

The Swiss pediatrician Eugen Ziegler[4-9] was the first to draw attention to the close relationship between growth acceleration and per capita sugar consumption, and attributed the former to the "sugar climate" prevailing during the years of growth. The latter concept has failed to find wide acceptance mainly because consumption of both sugar products and animal-derived proteins showed parallel trends in most periods and populations for which data on consumption and growth measurements had been collected.

Observations of pre- and post-natal growth patterns of Eskimos in the Canadian Arctic may help to elucidate the relative roles of the factors involved in the world-wide phenomenon of growth acceleration in the last century, since Eskimos have shown, in contrast to the affluent societies of the Western world, divergent trends in the consumption of the two nutrients of greatest interest in this context, namely animal proteins and refined carbohydrates, in particular sucrose.

I will present data on the dietary changes in Canadian Eskimos and on their growth rates, and also make some observations on the degree and timing of hybridization in relation to observed growth trends in the different groups.

The populations

Essential to my argument is the fact that in respect of all the parameters discussed Eskimos are not

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homogeneous. There are wide variations across the Canadian Arctic in the degree and duration of acculturation involving the transfer from a hunting to a trapping economy and now, in many areas, to a wage-earning living based on permanent settlements. This, of course, greatly influences diet and energy expenditure. There are also great differences between groups of Canadian Eskimos with regard to the timing and intensity of genetic transfer from Caucasian contacts to the Eskimos. In some areas this was associated with whaling activities that reached a peak before the turn of the century in the Eastern Arctic and shortly thereafter in the West, but this influx stopped everywhere more than half a century ago. In other areas the fur trade and government provided the major source of hybridization, but this is quite recent compared to the whalers and far less intense.

Because they are contrasting groups of Eskimos on whom I have most data I will concentrate on three particular groups—the Coppermine Eskimos of the Central Arctic at Coppermine and the Eskimos of the Mid- and North Baffin Island around the trading posts of Pangnirtung and Pond Inlet (Fig. 1).

The population in the two last-mentioned areas in the eastern part of the Canadian Arctic had rather intensive contact with whalers in the second half of the last century. There has been only minimal new racial admixture in the last 50 years from traders, police and others, and the population, since the heavy new gene flow three to six generations ago, has again become a fairly homogeneous and stable one.

The Coppermine population in the Western Central Arctic presents a very different picture. The earliest contacts of lasting impact were in the second decade of this century and only very few hybrids resulted, all of them well known and recognizable as such. The low degree of hybridization was confirmed by a detailed geneological study and extensive blood group examination.[10, 11]

We must, therefore, conclude that in the three population groups for which data are presented, hybridization was either minimal in degree or too distant in the past to be a major factor in the growth acceleration observed in the children of the last generation.

TABLE I
1964 daily per capita consumption of major nutrients in four Canadian-Eskimo settlements vs. 1955 U.S.A. consumption

	Total calories	*Proteins (g.)*	*Fat (g.)*	*Carbohydrates (g.)*
Holman Island	2859	280	79	230
Coppermine	2536	271	64	213
Pangnirtung and Cumberland Sound	2788	318	53	254
Frobisher Bay	2097	128	57	254
Urban area, U.S.A., 1955*	3200	103	155	275

*From U.S.A. Urban Area Household Food Consumption Survey 1955.

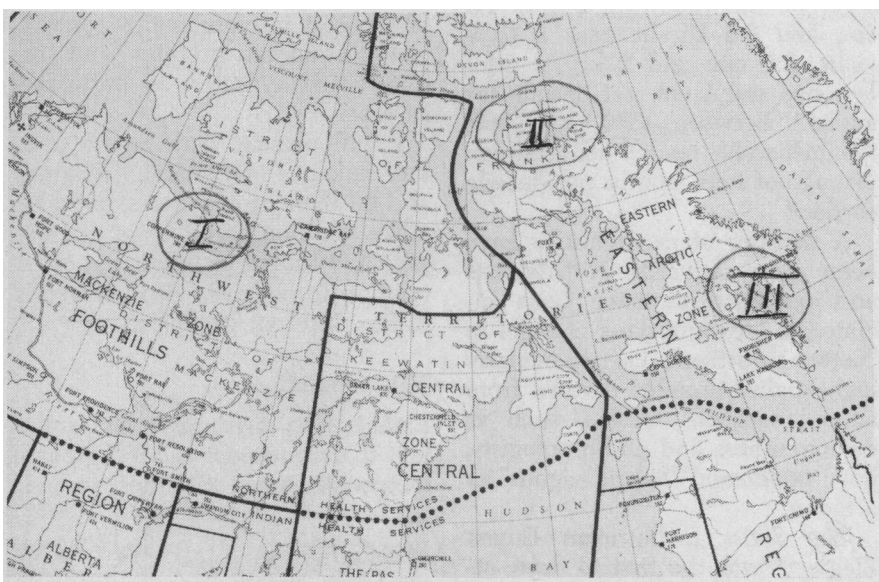

FIG. 1—Map of Northern Canada. The three areas where nutritional and anthropometric data were collected for this study are circled: (1) Coppermine; (2) North Baffin Island (Pond Inlet and Arctic Bay); (3) Cumberland Sound (Pangnirtung).

A. Diet and prenatal growth acceleration

Nutritional changes rather than hybridization and, in particular, increased consumption of high-quality proteins are favoured by most researchers as the main cause of the secular growth acceleration first observed in the affluent Western countries and, since World War II, also in Japan.

The 1964 annual per capita consumption data for protein, fat and carbohydrates in two Eastern and two Western Arctic trading districts are listed in Table I. Three of these communities are living more or less along traditional lines and one, Frobisher Bay, with a more urbanized population, has only one-third of the protein consumption of the nearby Cumberland Sound, a predominantly hunting population. The total carbohydrate consumption was, surprisingly, almost as high in the hunting areas as in the urban population. Table II demonstrates, however, that the conventional breakdown of nutrients into proteins, fat and carbohydrates is not the whole story. The consumption of disaccharides (mainly sugar and sucrose-containing products) and polysaccharides (mainly in the form of cereal products), i.e. *rapidly* and *slowly* absorbed and metabolized carbohydrate, has shown divergent trends in the developed countries and obviously the Eskimos are now following suit. Eskimos have been eating fairly substantial amounts of carbohydrates (although these only rarely replace animal proteins as the main energy source) since fur trapping was introduced into the different Arctic areas some 30 to 60 years ago. However, this carbohydrate was mainly in the form of

TABLE II
Per capita consumption of refined and unrefined carbohydrate in Cumberland Sound (Trading Post, Pangnirtung)

Year	*Disc list population*	*Actual trading population*	*Sugar, etc. (lbs.)* *Total*	*Per cap.*	*Cereal and flour (lbs.)* *Total*	*Per cap.*
1959	524	500	12,995	26	78,160	156.31
1960	540	520	19,572	37.6	90,240	173.5
1964	568	550	36,000	65.5	110,700	201.3
1967	580	560	58,376	104.2	98,521	175.9

flour, oats and other cereals and a modest amount of bulk sugar. "Luxury" sugars, such as candies, sweet biscuits, chocolates and soft drinks, formerly were practically unknown but their consumption has skyrocketed during the last five to 10 years.

While cereal and flour consumption was about at the average Canadian level 10 years ago and increased moderately since then, it is now declining despite a continuing decrease in protein consumption. This may partly reflect lower energy requirements of a non-hunting population, but is also due to the rapid rise of sugar consumption, from 26 lbs. per capita in 1959 to 104.2 lbs. in 1967. The relation of rapidly absorbable disaccharides to slowly absorbed polysaccharides has risen from 22.2/100 in 1959 to 79/100 in 1967 (in all of Canada it was 88/100 in 1960 and 104/100 in urban United States areas in 1955).

I shall later adduce evidence to show how these rapidly absorbable carbohydrates may affect the homeostasis of blood sugar and the most important balancing hormones, namely insulin and growth hormone, but it is quite obvious from the foregoing that lumping together disaccharides and polysaccharides as carbohydrate in dietary calculations, as is routinely done by most dietitians, would have missed this—what I consider is the most important factor in bringing about secular growth acceleration.

Tables III and IV and Fig. 2 focus on the rate of increase of sugar consumption which was demonstrated in the foregoing table as showing the greatest quantitative change. This is related to birth weights recorded in the last 10 years in Coppermine (Table V) and for shorter periods, as unfortunately no older records are available, in the two other Arctic districts (Tables VI and VII).

All babies were weighed, shortly after delivery, on standard balanced baby scales. Increases in mean birth weights for the periods compared were found statistically highly significant in Coppermine and Pangnirtung ($P < 0.01$) but not quite significant ($P > 0.1, < 0.2$) in Pond Inlet.

A striking parallel is seen in all three localities in regard to changes in recorded birth weights and annual per capita sugar consumption. The increase in both was slower in the west, at Coppermine, where higher levels of sugar consumption and birth weights prevailed since construction of the DEW line, which employed a great proportion of Coppermine Eskimos. A much more precipitate rise in both sugar consumption and birth weights occurred in the two Eastern Arctic trading districts which, after the whaling period around the turn of the century, had settled back to hunting and trapping in small camps with only minimal increases of carbohydrates in their diet, mainly in the form of cereal staples. This situation prevailed until some five years ago when a government-sponsored mass movement of camp Eskimos into settlements started. At the height of house construction most former hunters were employed, and sugar and sucrose product sales jumped sharply during those years, exceeding those of the formerly more affluent Western Arctic. Mean birth weights increased by more than 1 lb. in one year in Pangnirtung 1966 to 1967, following the movement of the camp population to the main settlement and by 7.2 oz. from 1967 to 1968 in Pond Inlet.

I was impressed during my 1955-

TABLE III
Coppermine sugar and flour consumption

Year	*Trading area population Dependent on store supplies (corrected for hospital patients and hostel children)*	*Sugar (bulk only)* *Total*	*Per capita (lbs.)*	*Flour (bulk only)* *Total*	*Per capita (lbs.)*
1962	360	16,697	46.3	30,425	84.48
1964	405	20,097	49.62	45,640	112.69
1967	500	30,450	60.9	51,360	100.72

TABLE IV
Increase in sales of sugar and sweets in North Baffin Island (Arctic Bay)

Item		*1967 (lbs.)*	*1968 (lbs.)*
Sugar, granulated		16,000	22,700
Honey	Calculated sugar content in lbs.	47	60
Molasses		226	238
Jams		375	478.5
Syrup		100	120
Chocolate		350	750
Carbonated drinks		312.5	437.5
Candy		1000	1800
Estimated sugar content of sweet biscuits		350	750
Total sugar content		18,760 lbs.	27,334 lbs.
Trading area population		225	246
Estimated per capita sugar consumption		83.38 lbs.	111.11 lbs.
Increase in % in one year: *32.8%*			

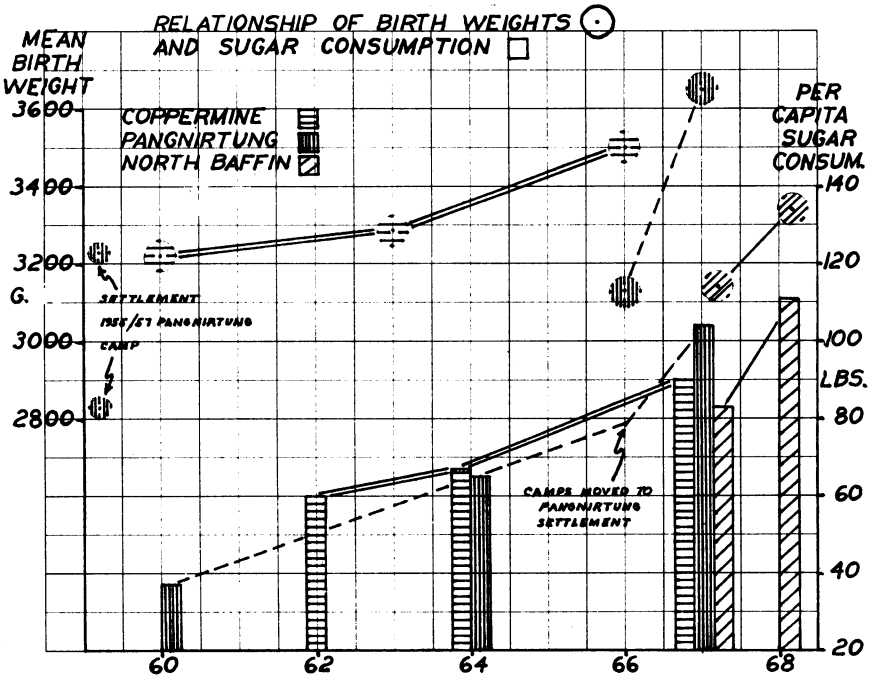

FIG. 2—Relationship of birth weights and sugar comsumption. Birth weights are indicated by circles, per capita sugar consumption by columns. Circles as well as columns are marked by horizontal (Coppermine), vertical (Pangnirtung) and oblique (North Baffin) bars to identify localities. The left ordinate indicates the scale (in grams) for birth weights; the ordinate on the right side shows a different scale in pounds for the per capita sugar consumption in the three different areas. The abscissa indicates the years to which the birth weight and sugar consumption data apply. The graph demonstrates: (1) the same trend of birth weight changes in the three areas; (2) the remarkable parallel in degree of change for both mean birth weights and per capita sugar consumption for each of the areas where reliable data for both could be collected.

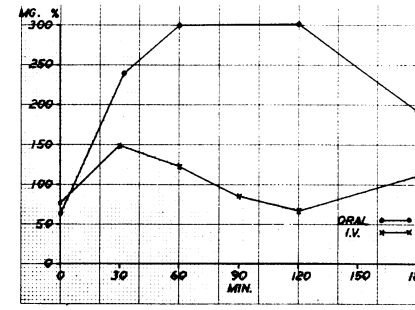

FIG. 3—Depiction of the discrepancy between the oral and intravenous sugar tolerance tests in a 19-year-old non-pregnant Eskimo girl.

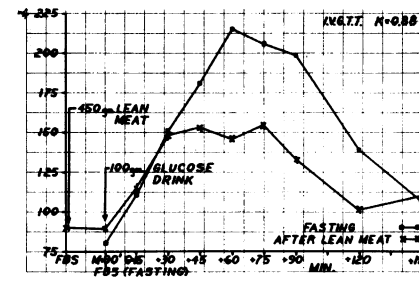

FIG. 4—Influence of protein meal on oral glucose tolerance in a male Eskimo.

57 term as resident medical officer for the Eastern Arctic by the difference in the sizes of babies delivered by Eskimo women coming from hunting camps and those residing in the main settlement around the trading post. Of the term deliveries at that period who were weighed on the first day of life, six were from the settlement and five from hunting camp families. The mean birth weights were 7 lbs. 2 oz. and 6 lbs. 4 oz. respectively (Fig. 2).

The explanation for such an impressive increase in birth weights and particularly its relationship to consumption of sugar demonstrated in several Arctic districts during recent years is obscure but an interesting finding concerning glucose tolerance may have some bearing.

I have published data[12, 13] showing a peculiar discrepancy between oral and intravenous glucose tolerance (Fig. 3) that may relate to a defect in the intestinal insulin-releasing mechanism in Eskimos suggested by the next test series which shows reversal of a "diabetic" glucose tolerance curve to normal after giving low-fat meat one hour before the glucose (Fig. 4).

When consuming loads of rapidly absorbable carbohydrates unpreceded by meat, which was the situation when the camp Eskimos moved to the settlements and hunters worked in construction instead of bringing home meat, the reaction of many Eskimos may have been as follows: High blood glucose peaks or plateaus, as their intestinal insulin-releasing hormone[15-18] was glucose-insensitive and failed to provide a cushion against such peaks, were followed by hypoglycemic reactions as demonstrated in Fig. 5. A most potent physiological stimulus for growth hormone, routinely used, e.g. for investigation of dwarfism, is hypoglycemia. We can imagine, then, what may happen to the

TABLE V

Birth weight of full-term Eskimo babies delivered at the Coppermine nursing station 1958 - 1967*

Period	*No. of babies with recorded data*	*Mothers' Mean age (yrs.)*	*Mothers' Mean parity*	*Birth weights Range*	*Birth weights Mean*	*Birth weights Standard deviation*
Sept/58-Dec/61 (40 mos.).....	34*	27.7	4.65	2.39-4.32	3.22	0.55
1962-1964 (36 mos.).....	46	28.2	5.11	2.53-4.15	3.29	0.37
1965-Aug/67 (32 mos.).....	69	27.4	5.12	2.39-5.00	3.50	0.46

Difference 1958/1961 vs. 1965/1967: 0.38 kg. P: < 0.01

*During the early period (1958-1961) of recorded birth weights in Coppermine a major proportion of the more traditionally living families did not come into Coppermine for deliveries, which were then still fairly frequently performed by native mid-wives in hunting camps, while during 1965-1967 almost all deliveries took place in the Coppermine Nursing Station.

This explains the disproportionately smaller number of recorded birth weights for the two earlier periods. Since camp Eskimos tended to have smaller babies than settlement Eskimos (see Fig. 2 and text), inclusion of these camp-born babies would likely have increased rather than decreased the above calculated differences.

TABLE VI
Birth weights recorded in Pangnirtung Hospital (Cumberland Sound Mid-Baffin)

Year	No.	Mothers' mean Age	Mothers' mean Parity	Birth weights (kg.) Range	Birth weights (kg.) Mean	Birth weights (kg.) S.D.
1966	13	28.8	4.15	2.56-3.74	3.13	.387
1967	16	30.4	5.35	3.01-4.67	3.65	.52

Difference of Means 0.52 kg. P: < 0.01

TABLE VII
Birth weights in Pond Inlet (North Baffin Island)

Year	No.	Mothers' mean Age	Mothers' mean Parity	Birth weights (kg.) Range	Birth weights (kg.) Mean	Birth weights (kg.) S.D.
1967	13*	27.4	5.46	2.53-3.61	3.14	.309
1968	23	26.1	4.61	2.67-4.32	3.34	.42

Birth weight difference 0.20. P: < 0.2 > 0.1

*The main movement of camp Eskimos into Pond Inlet occurred in the spring and summer of 1967. Before then some of the deliveries took place in hunting camps, which explains the much lower figure of births recorded in the Nursing Station for 1967. See footnote to Coppermine and Fig. 2 in regard to birth weights in camp and settlement Eskimos.

fetus of a pregnant Eskimo woman who has such a glucose intolerance and who is subjected to sugar loads without sufficient protective meat meals.

B. Evidence for postnatal growth acceleration

Published anthropometric data on Eskimos are rather scanty and there have been no periodical examinations of the same population group to allow valid comparisons. Numerous remarks by Arctic "old-timers", in particular missionaries, traders and trappers, as well as our own observations and measurements, have, however, impressed me that the Canadian Eskimos have been affected during the last few decades by a growth acceleration comparable to or even exceeding that documented in affluent Western societies.

The only area in the Canadian Arctic where systematic height and weight measurements on a larger and genetically relatively stable population sample (see above discussion of populations) were recorded a generation apart is the Cumberland Sound/Pangnirtung area. Two hundred and sixty Eskimos (132 children, aged 1 to 15 years, and 128 adults) were measured and weighed by Dr. T. J. Orford[19] in 1938 and a slightly larger population sample (total 336 persons) from the same group were measured and weighed by us in 1968. Height measurements in 1938 and in 1968 were taken in stockinged feet and weight measurements were taken on balanced scales, without parka and heavy footwear, allowing only light underwear.

Tables VIII and IX compare the tabulated 1938 and 1968 data, while Figs. 6 and 7 show them graphically plotted onto norm charts of physical development of North American boys and girls.[20]

Increases in height measurements between 1938 and 1968 were highly significant in statistical analysis (P <0.01) in both Eskimo men and women, while the recorded mean weight loss in both adult males and females did not reach statistical significance.

Smaller numbers in the age

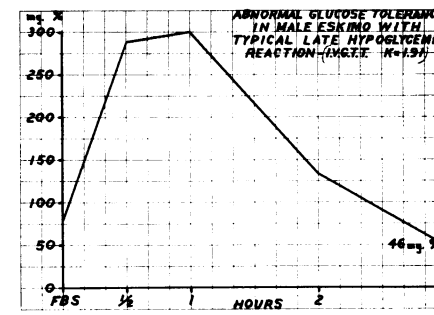

FIG. 5—Abnormal glucose tolerance in male Eskimo with typical late hypoglycemic reaction.

TABLE VIII
Height and weight measurements of male Eskimos from Cumberland Sound, 1968 vs. 1938

Age (yrs.)	No.	1968 Height Mean	1968 Height Range	1968 Height S.D.	1968 Weight Mean	1968 Weight Range	1968 Weight S.D.	No.	1938 Height Mean	1938 Height Range	1938 Height S.D.	1938 Weight Mean	1938 Weight Range	1938 Weight S.D.	Change 1938-1968 Height	Change 1938-1968 Weight
1	0 (3)*	—	—	—	29.33	28-30	0.947	½	29	—	—	22.50	21-24	1.500	?	+6.83***
2	3 (6)	34.58	33.5 -35.25	0.772	31.33	29-37	2.624	4	33.31	32-35	1.083	32.00	31-33	0.707	+1.27	−0.67
3	10	37.78	35-40	1.970	36.30	31-44	4.148	8	34.45	33.5-36.25	1.139	33.57	31-35	1.294	+3.33****	+2.73**
4	11	40.34	38.5 -42.5	0.996	40.91	40-45	1.564	6	37.42	33-39	1.239	39.17	37-42	2.267	+2.92****	+1.74
5	6	41.50	39-44	1.780	40.50	34-45	3.730	4	39.88	39-41	0.740	42.38	38.5-45	2.768	+1.62	−1.88
6	8	43.94	41.5 -48.5	2.232	44.13	39-50	4.314	6	42.83	41.5-44.5	1.106	48.83	45-56	4.776	+1.11	−4.70**
7	4	79.19	44.25-49.5	2.011	53.00	49-58	3.674**	9	43.58	39.75-47	2.383	51.11	43-57	5.195	+3.61***	+1.89
8	9	49.58	48-53	1.719	58.89	54-65	4.040**	4	46.88	45-48	1.139	57.50	50-63	4.822	+2.70***	+1.39
9	4	50.06	46-53	2.612	63.00	58-65	2.915	5	48.55	46-53	2.749	61.00	55-68	5.177	+1.51	+2.0
10	7	52.96	48.5 -55.25	2.160	67.57	59-75	5.949	4	50.31	47.25-54	2.508	66.25	59-74	6.379	+2.65	+1.32
11	10	54.45	52.25-59.5	2.492	72.78	50-103	14.627	2	50.00	49.5-50.5	0.500	66.50	65-68	1.500	+4.45***	+6.28
12	4	55.44	53.5 -56.75	1.303	80.25	70-93	8.699	7	52.14	49-58	3.113	76.00	62-94	11.563	+3.30	+4.25
13	9	56.53	53-60.25	2.572	83.89	70-106	10.609	5	55.15	54-56.5	0.833	81.00	78-85	2.898	+1.38	+2.89
14	7	60.32	58-62.5	1.579	98.57	79-109	9.194	3	57.17	53.5-61	3.064	96.33	87-110	9.898	+3.15**	+2.24
Adults	73	64.21	57-70.5	1.631	137.42	90-175	18.148	32	62.42	56-67	2.507	140.06	108-180	7.123	+1.79****	−2.64

*Some children in age groups 1 and 2 years were weighed only. Where applicable the total number of individuals with weight recordings is stated in parentheses.
**Significant at P < 0.1.
***Significant at P < 0.05.
****Significant at P < 0.01.

TABLE IX

Height and weight measurements of female Eskimos from Cumberland Sound, 1968 vs. 1938

	1968						1938						Change 1938-1968	
		Height			Weight			Height			Weight			
Age (yrs.)	No.	Mean	Range	S.D.	Mean	Range	S.D.	No.	Mean	Range	S.D.	Mean	Range	S.D.	Height	Weight
1	3 (7)*	32.50	30.5 -36	2.483	24.10	20-30	3.512	2	29.25	29-29.5	0.250	23.50	22-25	1.500	+3.25	+ .60
2	3 (6)	33.08	32.5 -33.75	0.513	25.33	22-29	2.867	3	31.67	31-32.5	0.624	24.67	23-26	1.247	+1.41	+ .66
3	9	37.13	35.25-38.75	1.247	34.56	29-45	4.621	4	34.06	31.75-35	1.350	32.00	25-36	4.301	+3.07****	+ 2.56
4	8	38.18	35.75-39.75	1.280	34.25	28-38	2.817	4	33.56	30-39	3.346	35.50	29-41	4.330	+4.62***	− 1.25
5	8	40.44	38.25-43.25	1.309	39.38	35-43	2.342	7	39.75	38-42	2.409	41.00	32-46	4.209	+ .69	− 1.62
6	9	43.44	40-46.75	1.814	44.44	38-50	3.685	6	41.38	35-45.5	3.359	44.67	38-50	5.121	+2.06	− .23
7	8	45.13	43.75-46.5	1.113	48.88	45-54	3.689	6	43.71	40-47.5	2.755	48.50	44-56	4.822	+1.42	+ .38
8	6	46.75	41-50	2.808	54.00	43-58	6.633	3	45.00	42-48	2.449	51.00	46-54	3.559	+1.75	+ 3.00
9	5	50.05	47-53.5	2.030	59.20	55-65	3.487	7	47.92	42.5-52	3.119	59.07	39-75	12.668	+2.15	+ 0.1
10	4	51.31	48-54.25	2.458	62.50	55-70	7.500	5	50.25	48.5-52	1.245	62.40	62-73	5.851	+1.06	+ .10
11	4	53.50	51-57.25	2.700	72.75	62-92	12.070	3	51.00	51.00	—	62.00	60-63	1.414	+2.50	+10.75
12	3	59.83	59.25-60.25	0.423	97.33	86-115	12.658	3	51.83	50.5-54.5	1.886	71.67	60-88	11.898	+8.00****	+25.66**
13	5	59.20	54.5 -61.75	2.694	101.60	82-127	17.048	5	50.50	48.25-51.5	1.129	65.80	59-73	4.534	+8.70****	+35.80****
14	6	60.21	57.75-62.75	1.692	106.00	94-120	9.309	5	58.45	54-64	3.436	108.90	90.5-121	10.121	+1.76	− 2.90
Adults	77	60.33	54-64.25	2.271	121.35	72-215	21.267	96	59.20	50-66	2.870	124.98	86-179	15.875	+1.13****	− 3.63

*Some infants were weighed only. First figures denote number of individuals with both height and weight measurements; those in parentheses, total weight measurements in age groups where applicable.

** to ****Degrees of significance (P): see legend to Table VIII.

groups of children, despite larger height increases, accounted for absence of significance in most single age groups ($P > 0.1$).

Height increases were, however, calculated to reach varying degrees of statistical significance (Tables VIII and IX) for age groups 3, 4, 7, 8, 12 and 14 years in boys and 3, 4, 12 and 13 years in girls, while significant weight changes were limited to a weight gain in 14-year-old boys, a weight loss in 6-year-old boys and very marked weight increases in the 12- and 13-year-old girls compared with those of a generation ago.

The lesser degrees of statistical significance reached in the other age groups because of smaller numbers or smaller differences may, nevertheless, gain importance in the presence of the consistent trend seen in both sexes in all age groups, as shown in Figs. 6 and 7, and allow the following observations and conclusions:

1. There has been a marked increase in the height measurements of boys and girls in all age groups. This is of the order of two to three inches in most age groups, with slightly wider gaps in the 1938 vs. 1968 growth curves at ages 3 and 4 years in both sexes and up to 4½″ for 11-year-old boys and over 8″ for 12- and 13-year-old girls, while persisting into a final adult stature increase of 1.79″ for men and 1.13″ for women.

2. In contrast to the means of height, which in 1968 in all age groups of both sexes were consistently above the 1938 values, the weight development did not show the concordant trend usually demonstrated in Western societies. Indeed, the 4- to 6-year-old boys and girls of 1938 were substantially heavier despite their shorter stature than those in the same age groups in 1968 and the adults, both men and women, were 2.6 and 3.6 lbs. respectively lighter in 1968 compared to 1938, despite their taller stature.

3. The wide and parallel gap between height and weight development curves for 1938 and 1968 in Eskimo girls is the impressive exception to the above statement, and this quite obviously represents the growth spurts at the beginning of puberty. A two-year advancement of puberty claimed for Western Europe during the last century appears to have taken place in the mid-Baffin Island Eskimo during the last 30 years, and this appears confirmed by anamnestic data collected by us[31, 32] in different Arctic areas.

4. Comparing the height and weight curves of these Eskimo boys and girls with the norm charts used by North American pediatricians, one is impressed by the observation that in 1938 the mean height development curve for Eskimo boys and girls corresponded quite closely to the minus-two standard deviation curve of American boys and girls, while these very short Eskimo children and adults weighed on an average as much (boys 2 to 9 years) or almost as much as the much taller North Americans (exception: preadolescent boys and particularly girls—see above). The 1968 curves show divergent trends for changes in height and weight development with the effect that both curves move closer to the 16th percentile (i.e.—1st S.D.) of North American

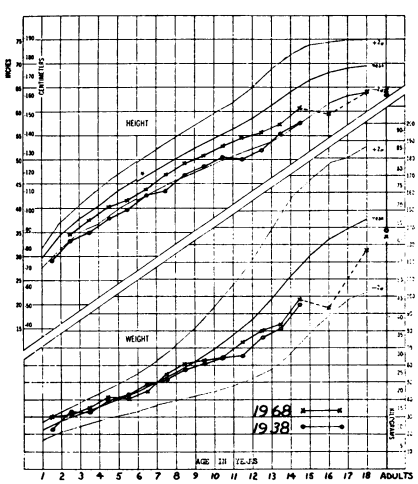

FIG. 6—Changes in growth patterns (height and weight) in male Cumberland Sound Eskimos in a period of 30 years.

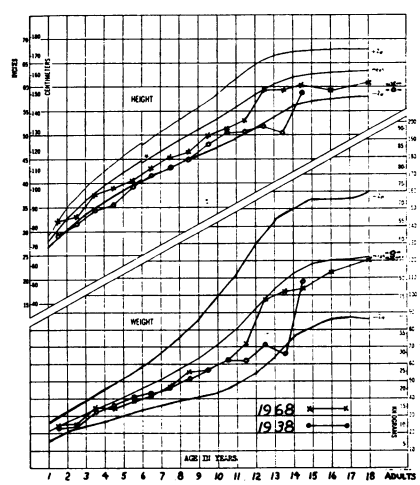

FIG. 7—Changes in growth patterns (height and weight) in female Cumberland Sound Eskimos in 30 years.

physical development charts.

Similar changes took place in other Eskimo groups as demonstrated in a larger group of Eskimo children examined at the time of the ships' arrival in 1964 (424) and 1968 (506) in North Baffin Island. Height and weight measurements were performed in 1964 and 1968 under similar conditions and with identical equipment. For height measurements footwear was removed except for thin socks. For weighing, only bathroom-type spring scales were available, but these were frequently checked and adjusted. Differences naturally developed on a much smaller scale during the short four-year interval vs. the 30-year period compared in Cumberland Sound and reached statistical significance in single age groups only for height increases in 13-year-old boys (+ 2.83 inches) ($P < 0.1$) and for weight loss in 6- to 8-year-old girls and 7-year-old boys at higher significance levels (Tables X and XI), but the consistent trend of development seen in age group cohorts may gain significance, even if for single age groups calculated P factors may remain too high.

Figs. 8 and 9 show clearly in both sexes and all age groups, except 5 to 7 years, marked increases in height while the trend in weight shows a similarity to the findings in the Cumberland Sound Eskimos for the longer period, i.e. no corresponding increase. Weight changes, except for the earlier weight jump at puberty in girls, were inconclusive; indeed they more often indicated a negative rather than a positive trend.

Considering the short interval, the acceleration of height growth in North Baffin Island appears greater than that in the Cumberland Sound Eskimos for the 30-year period and can only be compared with the growth acceleration reported for Japanese school children in the decade after World War II.[21, 22]

It should be mentioned that the North Baffin area was the last to experience the movement of camp populations into main settlements with schooling and housing and concomitant changes in diet and way of life, but the change was at an accelerated rate and intensity, the main impact being in the last five years. This is also reflected in the jump in sugar consumption of one-third in just one trading year (Table IV).

The interesting change of body habitus from the short and heavy build of the traditionally living camp Eskimo should be of great interest to physical anthropologists, who tend to regard stature and habitus as solely constitutional or racial characteristics.

Our data suggest that environ-

TABLE X

Height and weight measurements of North Baffin Island male Eskimos, 1964 vs. 1968

	1968						1964						Change 1964-1968	
		Height			Weight			Height			Weight			
Age (yrs.)	No.	Mean	Range	S.D.	Mean	Range	S.D.	No.	Mean	Range	S.D.	Mean	Range	S.D.	Height	Weight
1	3 (17)*	28.92	19.75-36	6.796	26.06	19-35	4.345	0/3*	—	—	—	25.00	20-30	4.082	—	+1.06
2	5/10	34.10	32.25-35.75	1.219	29.50	26-33	1.803	7/12	32.00	30-35	1.927	29.85	24-35	3.505	+2.10	− .35
3	9	35.69	34.25-36.75	0.847	33.78	30-37	2.819	7	35.04	32-37.5	2.053	33.86	30-40	3.482	+ .65	− .08
4	13	39.57	36.75-42.5	1.790	39.69	31-49	4.470	6	37.83	35-41	1.860	39.67	35-43	3.036	+1.74	+ .02
5	6	40.79	38.75-42.25	1.409	41.00	36-45	3.742	9	41.50	39.5-44	1.616	44.67	34-52	6.164	+ .29	− 3.67
6	12	43.75	40.75-46.5	1.639	45.67	40-51	3.704	5	43.40	39-45.5	2.289	47.60	41-50	3.380	+ .35	− 1.93
7	5	44.25	43-47	1.414	46.20	43-50	2.315	6	45.63	42.5-48	1.935	50.83	44-54	3.484	−1.38	− 4.63****
8	6	46.92	45.5 -47.75	0.799	53.33	50-55	1.699	8	46.53	46-50.25	1.651	53.38	50-64	4.270	+ .39	− .05
9	9	50.53	47.5 -55.5	2.529	62.44	48-77	8.629	4	48.00	47.5-49	0.612	58.50	51-63	4.500	+2.53	+ 3.94
10	4	51.56	47.5 -57.5	3.642	65.00	54-72	6.819	6	50.17	49-52	1.027	66.83	64-70	2.115	+1.39	− 1.83
11	5	53.30	49.75-57.25	2.772	73.40	65-83	7.059	13	52.37	49-56.5	2.004	69.85	60-82	6.419	+ .93	+ 3.55
12	8	54.16	52-59	1.999	74.00	64-95	8.646	7	53.07	49.5-61.5	3.837	84.14	66-138	22.465	+1.09	−10.14
13	6	57.96	54.75-62.25	2.505	89.83	73-103	9.788	6	55.13	52-57.25	1.924	85.83	66-99	13.209	+2.83**	+ 4.00
14	4	57.63	55.75-60.25	1.634	88.50	84-99	6.103	8	57.59	54-61.5	2.446	96.83	89-117	14.017	+ .04	− 7.88
15-16	17	61.38	55.75-65.5	3.271	112.06	80-135	17.755	12	60.27	55.25-64.5	2.732	109.17	86-127	13.427	+1.11	+ 2.89
17-19	18	63.36	59.75-68	2.145	130.44	90-155	17.205	10	64.08	61.5-66	1.299	132.80	113-143	8.195	− .72	− 1.36

*Some infants were only weighed and not measured. Where applicable, smaller numbers signify those with both, larger numbers those with weight recordings only.
** to **** Degrees of significance—similar to those in Table VIII.

TABLE XI

Height and weight measurements of North Baffin Island female Eskimos, 1964 vs. 1968

	1968						1964						Change 1964-19-68	
		Height			Weight			Height			Weight			
Age (yrs.)	No.	Mean	Range	S.D.	Mean	Range	S.D.	No.	Mean	Range	S.D.	Mean	Range	S.D.	Height	Weight
1	1 (9)*	32.50	—	—	22.78	20-30	3.489	(0/11)*	—	—	—	22.42	18-30	3.303	—	+ .36
2	5 (9)	33.45	32-35.5	1.208	28.67	22-35	3.944	(5/9)*	32.00	30-33.5	1.140	26.22	20-30	3.881	+1.45	+ 2.45
3	16	35.33	32-38	1.546	32.25	27-40	3.929	12	34.45	30.75-37.5	2.107	32.25	24-38	9.005	+ .88	0
4	11	38.77	37-44.75	2.109	36.73	31-45	3.792	9	37.08	36-38.25	1.014	35.67	31-40	3.162	+1.69	+ 1.06
5	7	39.96	38.25-41.25	1.072	38.57	35-45	3.332	5	39.70	37.5-42	1.469	36.20	30-42	3.919	+ .76	+ 2.37
6	8	42.00	37.25-44	2.078	40.38	34-45	3.159	8	42.07	41-44.5	1.237	46.00	43-52	2.599	− .07	−5.62****
7	9	44.17	39.55-48	2.426	45.89	39-55	4.771	9	45.06	42.5-47	1.301	49.44	43-53	4.717	− .89	− 3.55
8	9	47.22	45-53.75	2.436	50.11	45-59	4.012	6	49.08	45-60	5.199	54.33	49-60	4.189	−1.86	− 4.22****
9	6	48.54	46.5 -52	1.895	56.00	52-60	2.380	7	47.14	42-51	7.032	55.57	42-65	7.997	+1.40	− .43
10	7	50.57	49-52.75	1.115	62.00	56-69	4.000	3	49.17	47.5-50	1.179	58.67	56-64	3.771	+1.30	+ 3.33
11	7	53.21	50.5 -55.5	1.770	72.86	65-82	6.334	7	53.46	51.25-58	2.139	71.29	65-77	3.918	− .25	+ 1.57
12	4	56.31	52.75-59.5	2.419	87.75	66-100	13.046	4	53.75	50.5-57.5	2.391	77.00	60-96	13.077	+2.56	+10.75
13	9	56.31	53-60.25	2.505	84.44	71-105	11.777	10	55.25	50.25-62	3.277	85.50	64-112	16.323	+1.06	− 1.06
14	4	58.19	56.5 -60	1.242	88.50	78-101	9.759	5	58.05	56.25-60	1.345	98.00	90-109	8.222	+ .14	+ 9.50
15-16	10	58.48	51-62	2.759	108.80	95-121	7.454	9	58.61	52.25-61.75	1.933	107.78	84-121	12.264	+ .13	+ 1.02
17-19	18	60.69	57.75-64.25	1.653	116.72	91-140	11.732	22	59.60	57-62.5	1.629	114.41	92-130	10.513	+1.09	+ 2.31

*Some infants were only weighed and not measured. Smaller number signifies those with height measurements, larger number those with weight recordings.
****Degree of significance (P): See Table VIII.

mental changes accompanying the process of acculturation may account at least for part of such differences in phenotype.

Discussion

A multitude of factors can influence growth in an accelerating and retarding sense. Frequent or chronic infections experienced at critical periods of growth are believed to be possible retarding factors. I consider that a series of new epidemics sweeping Baffin Island four to six years ago may have been responsible for the depression in growth curves noticeable in the 5- to 7-year-olds measured in 1968 in North Baffin and to a lesser degree in mid-Baffin (Cumberland Sound) Eskimos.

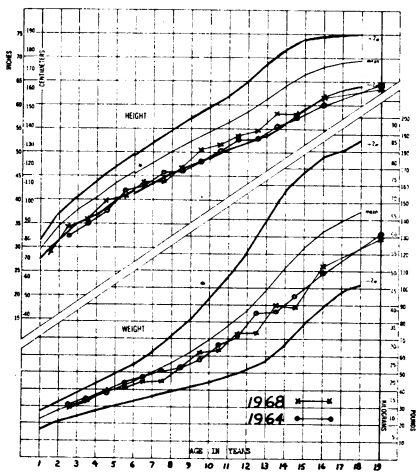

FIG. 8—Changes in growth patterns (height and weight) in male Arctic Bay and Pond Inlet Eskimos in four years.

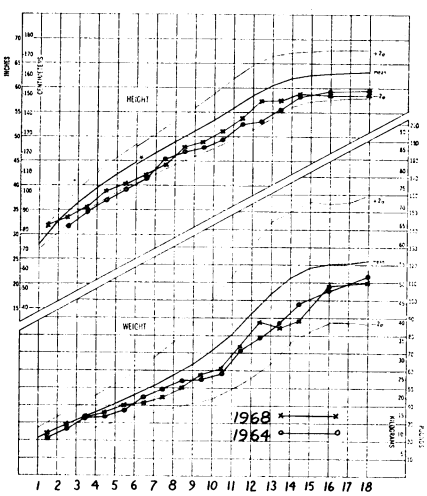

FIG. 9—Changes in growth patterns (height and weight) in female Arctic Bay and Pond Inlet Eskimos in four years.

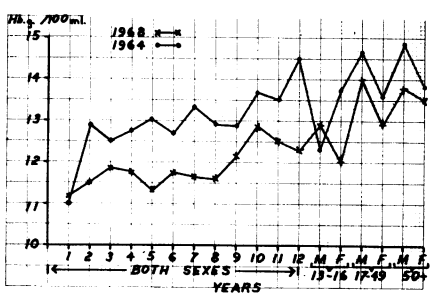

FIG. 10—Hemoglobin levels in Eskimos in Arctic Bay, 1964 and 1968.

Quantity and quality of nutrition are, however, at present generally accepted as the most important factors influencing growth. Practically all discussions on secular growth acceleration mention improvement in nutrition, in particular a higher protein intake, as the main cause. Mitchell[22] uses the example of the remarkable growth acceleration found in Japanese school children (1946-1955) as an argument in favour of the role played by high-quality protein, as consumption of animal-derived protein doubled during the period 1946 to 1952, while protein intake from all sources increased by only 10% and total caloric intake remained unchanged. The much greater increase in consumption of sugar-containing foods during the same period in Japan was not taken into account in this discussion.

Mitchell quotes shortening of legs in piglets deprived of essential amino-acids as support for her hypothesis that an increase in animal protein consumption would favour particularly long-bone growth of the femur, which was proved to be the most important element in growth acceleration in Japanese children. Increased femoral length is presumed to have been similarly important in the United States and European populations where over a longer period total height but no sitting height measurements were performed.

It cannot be denied that *severe* protein restriction, particularly when implying lack of essential amino-acids, does play an important role in stunting growth, as seen in many impoverished populations around the world. If these people show growth acceleration after quantitative and qualitative improvements in their diet, this may rightly be attributed to "better" nutrition, in particular a better supply of proteins of animal origin, and this may rightly be described as "reaching their inherent growth potential with better nutrition". To use these explanations and terms, however, for the entire phenomenon of secular growth acceleration is, in my opinion, incorrect, not justifiable and based on a wrong presumption.

The first observations and best documentation over longer periods of time of "secular growth acceleration" come from such countries as Holland, Denmark and Sweden and the American Midwest, i.e. areas known traditionally for their egg, cheese and meat exports. At the time of the earliest data collections in the second half of the last century and before World War I, a large proportion of the population of these areas was actively involved in the production of these proteins, and "bad times" brought about a local glut of these products and not a shortage.

It would be even more implausible to presume nutritional deficiencies for entrants and absolvents of high-class private schools and colleges, who showed only slight variations from the general growth acceleration trend.

The secular growth acceleration found in our Eskimos to be closely associated with changes brought about by acculturation can certainly not be explained by an increase of high-quality protein in their diet. Indeed, consumption of animal-derived proteins has fallen from over 300 g. per day in traditionally living populations to just over 100 g. per day per capita in more urbanized and acculturated Eskimos (Table I). One must, therefore, challenge the currently prevailing view that the phenomenon of secular growth acceleration is in all populations the consequence and manifestation of "improved nutrition and health". This, I submit, is not the case for Eskimos, and I doubt if this is true for large parts of our affluent societies who have experienced parallel development of curves of growth acceleration and incidence of diabetes mellitus.[24]

Excessive prenatal growth is now regarded with suspicion and probably excessive postnatal growth should be similarly regarded. Birth weight increases (even if less spectacular than demonstrated for our Eskimos, whom I have demonstrated to have a particular weak-

ness to oral glucose loads[13, 14] and growth acceleration have been found to occur in a parallel fashion in different populations.[24-26]

Excessive consumption of rapidly absorbable carbohydrate is known to lead often to hyperinsulinism and wild fluctuations of blood sugar levels. The often resulting hypoglycemic episodes provide the most powerful stimulation for growth hormone release. I suggest that at least some of the factors responsible for the phenomenon of secular growth acceleration have led to many oversized individuals in our society who resemble and possibly are borderline acromegalics and that the entire phenomenon of growth acceleration bears more ominous than healthy connotations.

The emergence in recent years of a high incidence of nutritional anemia[23] in the Canadian Eastern Arctic Eskimos certainly militates against "better" nutrition being responsible for the growth acceleration noted during the same period. Fig. 10 demonstrates the fall of mean hemoglobin values in Arctic Bay and North Baffin Island during the same period, 1964-1968, when the greatest acceleration of height growth was seen.

There are two other Northern populations with documented growth acceleration of interest in regard to protein and refined carbohydrate nutrition, the Lapps and the Icelanders. While hybridization with the much taller Scandinavian peoples cannot be ruled out as an important factor in the height increase of modern Lapps, the Icelanders are a good example of a genetically stable and isolated population with negligible gene flow from outside. They have shown an increase in height measurements during the last 100 years (accelerated particularly during the last 50 years) similar to the other Scandinavians. Ziegler[24] correlated the stature increase to the parallel form of the sugar consumption curve in Iceland and demonstrated that during that same period protein consumption as fish, meat and dairy products declined markedly, but, as in our Eskimos, remained well above the recommended minimal nutritional requirements of carbohydrates.

In view of our evidence confirming the world-wide trend of secular-growth acceleration in (a) a small group of Eskimos followed for 30 years and (b) a larger population sample measured at an interval of only four years, I was surprised to find the statement in a recent publication[27] that the authors failed to find a secular increase in the height of Eskimo school children over a period of 30 years. The authors based their conclusion on a comparison of height measurements of Eskimo children from the Hudson Bay area in 1965 and Eskimo children in 1956-59 in both Northern and Southern Alaskan villages[28] and a very small sample of children measured by Hrdlicka[29] in different Alaskan Eskimo settlements. Significant differences in height of Eskimos from different geographical areas have been demonstrated previously by us.[30] To a lesser degree but nevertheless significantly, such changes have also been found in Alaska and invalidate the conclusion quoted above.

Résumé

L'accélération prénatale et postnatale de la croissance des Esquimaux canadiens et leur consommation de sucre

Au cours des dernières années, on a noté une augmentation considérable du poids à la naissance et de la taille des enfants Esquimaux du Canada.

Cette accélération de la croissance, variable selon les groupes étudiés, présente un parallélisme frappant avec l'augmentation de la consommation annuelle de sucre per capita, qui a quadruplé durant la dernière décennie dans certains postes commerciaux de l'Arctique central et oriental canadien, tandis que la consommation par tête de protéines d'origine animale diminuait proportionnellement.

Les Esquimaux canadiens par conséquent, et contrairement aux affirmations publiées antérieurement, suivent les courbes séculaires de l'accélération de la croissance qui ont été enregistrées au sein de tous les peuples subissant l'influence de la civilisation moderne. Néanmoins, ceci vient contredire l'explication généralement avancée que c'est l'augmentation de la consommation de protéines de haute qualité qui en est responsable, car durant la même période, leur consommation traditionnellement très élevée de viande et de poisson a fortement diminué.

Nos observations viennent confirmer l'existence du rapport entre l'accélération de la croissance et la consommation de sucre, établi pour la première fois par le pédiatre suisse Eugen Ziegler. Nous croyons fondée une hypothèse déjà avancée par Ziegler et selon laquelle on pourrait relier cette accélération de la croissance (en particulier l'extraordinaire accroissement du poids à la naissance) à une tolérance hydrocarbonée orale "pseudo-diabétique" que nous avions déjà constatée chez une forte majorité d'Esquimaux.

This study was made possible by encouragement, help and contribution of data received from numerous personnel of Medical Services, Department of National Health and Welfare, in particular Dr. G. C. Butler, Director, Northern Region; Dr. T. J. Orford, Medical Officer for Eastern Arctic 1936 to 1940, now Medical Superintendent, Charles Camsell Hospital; Dr. M. Habgood, Zone Director, Inuvik, formerly Frobisher Bay; Miss M. Salter, R.N., and T. Benham, R.N., St. Luke's Hospital, Pangnirtung; and Miss James, R.N., Pond Inlet. We also acknowledge gratefully the assistance given by officers and clerks of the Hudson's Bay Company in numerous northern trading posts in providing consumption data of imported foods.

I am particularly indebted to Dr. Eugen Ziegler of Winterthur, Switzerland, for his many stimulating personal communications and to Dr. J. A. Hildes, Winnipeg, for a critical review leading to the present form of this paper.

ADDENDUM

After the completion of this paper, more birth weight data were received from Pangnirtung, indicating that during 1968 the birth weights did not continue the steep rise seen in 1966-67 but have shown a slight decline. This does not necessarily contradict and invalidate the above observations, and a closer look at the local developments influencing nutritional factors during this period may be of interest.

After completion of the main project of house construction, which took place in 1966-67, many former hunters resumed hunting and again supplied their families with more meat and less store food, although certainly not to the extent they had done in their hunting camps up until 1966. A similar sequence of events occurred in most settlements in the Canadian Arctic and may have had some bearing on the slight decrease in birth weights in a number of districts during 1968 as compared to 1967.

There are, however, other factors to be considered. Illegitimate births have

been rapidly increasing in the larger settlements such as Inuvik, Frobisher Bay and Cambridge Bay and constituted 47.5% of all Eskimo children born in 1968 in Inuvik. Most of the illegitimate children were born of teenage mothers. Such children have not only higher rates of prematurity, stillbirth and other complications, but also tend to be smaller, and this was observed to be markedly so in Inuvik and Cambridge Bay.

Consideration only of babies of multiparous women would eliminate at least this one new confusing factor. Other factors known to depress birth weights have become of increasing importance in recent years in the Canadian Arctic, viz, marked increases in nicotine and alcohol consumption by women and widespread deterioration of general nutritional status.

The composite overall birth-weight figures may, therefore, be less suitable to reflect the relationship investigated in this paper in three smaller groups, where it was more easily possible to elucidate all ecological and social factors prevailing during the periods in question.

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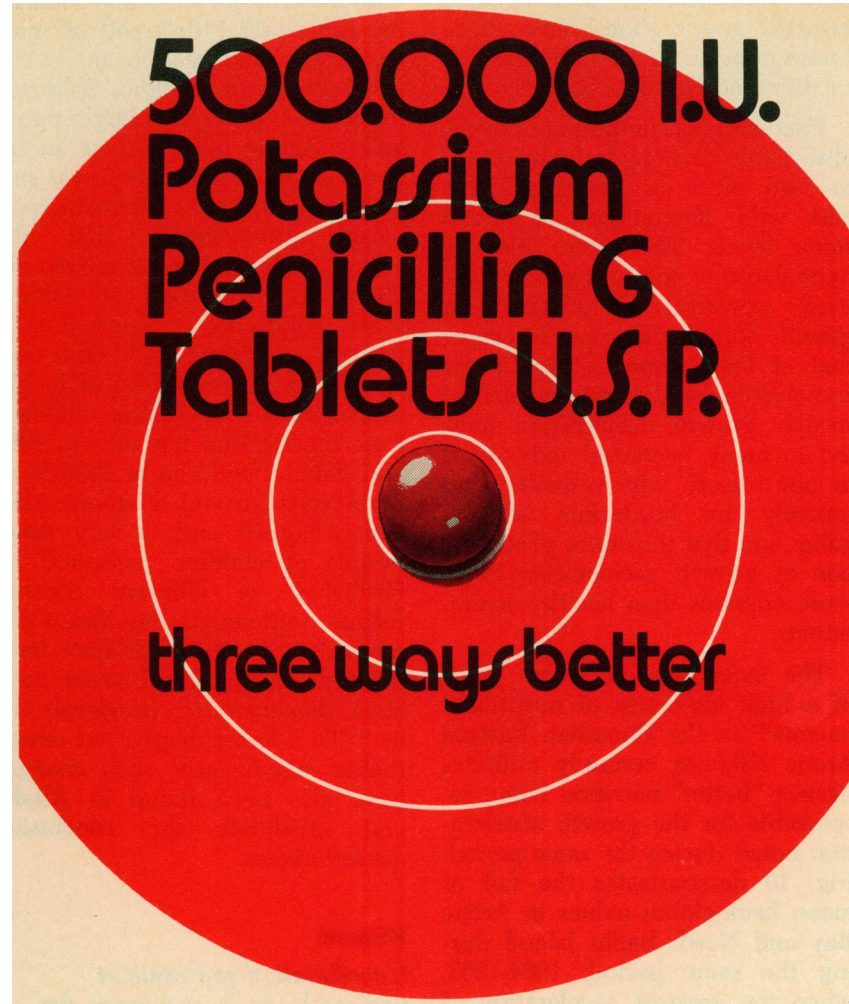

P-50* HORNER

- P-50 tablets are smaller, easier to take
- P-50 is bright red, harder to confuse
- P-50 has a protective charcoal layer under a methylcellulose film — seals in potency, seals out deterioration

COMPOSITION: Each P-50* tablet contains:
Potassium Penicillin G . . . . . 500,000 I.U.
INDICATIONS: For the treatment of mild to moderate infections caused by non-penicillinase-producing "cocci" or other organisms sensitive to penicillin and for the initial treatment of infections of unknown etiology. Especially useful for upper respiratory diseases, otitis media, skin abscesses, venereal diseases, dental infections, and prophylaxis of rheumatic fever.
DOSAGE: One P-50 tablet three times daily or as directed.
CONTRAINDICATIONS: Infection caused by penicillin-resistant organisms and patients with a known sensitivity to penicillin.
SUPPLY: Bottles of 12, 100 and 500 tablets.

*Registered trade mark in Canada of FRANK W. HORNER LIMITED, MONTREAL