Low Blood Cholesterol Associated with High Calorie, High Saturated Fat Intakes in a Swiss Alpine Village Population

DANIELA GSSELL, M.D.* AND JEAN MAYER, PH.D., D.SC.†

SERUM cholesterol has been extensively related to diet in experimental animals and man. Factors influencing this relationship have been reviewed recently.1 While agreement is not unanimous, the consensus is that prolonged consumption of diets high in fats, and more particularly in saturated fats, tends to elevate serum cholesterol.2

Beginning with the 1934 study of Rosenthal13 and the 1941 study of Snapper1 a large number of workers have compared the populations of the United States and of other prospering Western nations with those of underdeveloped countries in various continents and have emphasized the correlation between fat intake and mortality from atherosclerotic diseases (e.g., Keys in 1953;4 Yerushalmy4 and Ahrens2 in 1957; Stammler in 1958;6 Jolliffe in 19599).

Detailed analyses of dietary fats and serum lipids have been reported for groups in Central America,10–12 Japan,13 South Africa,14 India,15 Spain16 and Southern Italy17 and compared with data obtained in the United States and North Western Europe. The observation that serum cholesterol rises when members of a population hitherto characterized by low levels of dietary fat adopt a high fat diet (such as has been reported for Africans,18,19 Yemenites,20 certain Spanish,16 and Italian groups,21 Central Americans22 and Koreans23) has been taken by almost all authors as a confirmation of the paramount influence of dietary factors on serum cholesterol. (An exception is Donnison,14 who as early as 1929 had suggested that changes in socioeconomic status, work pattern and types of stress might be as important.)

The weakness of all these studies, however, is that populations with a low average dietary fat intake are also composed largely of individuals of very depressed socioeconomic status and a high degree of physical activity. While an exceptionally high fat intake has been claimed for Arctic Eskimos in 1908,24 the validity of these data has been questioned.7 To our knowledge, no study of a population with the dietary habits of the western type and a mode of life similar to that of agricultural populations in underdeveloped areas has hitherto been reported.

It was therefore thought to be of interest to collect relevant data on a population characterized at the same time by a high fat intake, a high degree of physical activity and a relatively low socioeconomic status.

From 1957 to 1960 a commission of the Federal Health Office of Switzerland under F. Verzár had carried out extensive surveys in nine different mountain regions in Switzerland, which were reported in 196125 and later compared with working class populations in Basel.27 These surveys showed that Swiss mountain

From the Federal Nutrition Commission of Switzerland and Department of Nutrition, Harvard School of Public Health, Boston, Massachusetts.

* Part of this work was carried out while a Research Fellow in Nutrition, Department of Nutrition, Harvard School of Public Health; Present address: Institute of Experimental Gerontology, Basel, Switzerland; † Associate Professor of Nutrition, Harvard School of Public Health.

This study was supported in part by grants in aid from the National Heart Institute (Grant No. H-2200) National Institute of Arthritis and Metabolism (Grant No. A-2911), the Nutrition Foundation, and the Fund for Research and Teaching, Department of Nutrition, Harvard School of Public Health.

populations are characterized by a high fat intake, a high degree of physical activity and a relatively low socioeconomic status.

For the present study the population of Blatten, Loetschental, situated in the Valaisian Alps of Switzerland was chosen. The physical status and nutritional intake had been assessed in 1938. For a parallel study in a Swiss town we referred to a sample of workmen surveyed by the forementioned commission in Basel in 1961.*

**DESCRIPTION OF REGION; SAMPLING**

Blatten is situated at 5,057 feet (1,542 M.) in a remote valley of the Southern part of the Alps. In 1856 the village was comprised of 356 inhabitants living in four separate settlements. All inhabitants are of German Swiss origin (Walser). They support themselves by farming performed under extremely difficult conditions. Up to 1955 the village was separated by several miles from the next road fit for automobiles, trucks or carts. Farming areas are spread on steep slopes varying in altitude from 4,000 to 8,000 feet. All distances have to be walked. Mules are rare and expensive; hay, wood, dung, building material, food and milk are usually carried on the back. Men frequently carry loads of 100 pounds or more; loads of up to 60 pounds have been seen to be carried even by elderly women.25 During the summer, the greater part of each family, including all school age children, walk daily up to the high pastures or "Alps" situated at an altitude 1,500 to 2,500 feet higher where cows and goats are kept and carry the milk back down to the village. The villagers sell little to the outside, save a few goats in the fall. Young adults often leave the valley for the greater part of the year to work in town, and thus contribute some outside income to the economy of the village.

All healthy Blattendorf adults (excluding pregnant women) over thirty years of age living in the region at the moment were included in the study. Twenty children (ten boys and ten girls) randomly chosen were added. Microsamples for serum cholesterol determination were drawn from ninety-nine persons in March 1961. The 1958 survey26 had included 279 persons for physical examination and 214 for dietary surveys.

A parallel study of a working class group in a Swiss city was considered necessary to provide data adequate for comparison. Fifty families from a suitable population in Basel volunteered (twenty workmen of a chemical firm, fifteen streetcar drivers and conductors, fifteen elementary school teachers) and were surveyed from January to March 1961. Samples for serum determinations were drawn in the course of a physical examination conducted in the homes. All healthy adults (excluding pregnant women) over fifteen years of age were included.

### Table 1

<table>
<thead>
<tr>
<th>Age (yr.)</th>
<th>Blatten</th>
<th>Basel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Mean</td>
</tr>
<tr>
<td>6-10</td>
<td>10*</td>
<td>140</td>
</tr>
<tr>
<td>11-14</td>
<td>10</td>
<td>182</td>
</tr>
<tr>
<td>15-19</td>
<td></td>
<td>171</td>
</tr>
<tr>
<td>20-29</td>
<td></td>
<td>172</td>
</tr>
<tr>
<td>30-39</td>
<td>5</td>
<td>168</td>
</tr>
<tr>
<td>40-49</td>
<td>9</td>
<td>185</td>
</tr>
<tr>
<td>50-59</td>
<td>16</td>
<td>195</td>
</tr>
<tr>
<td>60-69</td>
<td>7</td>
<td>197</td>
</tr>
<tr>
<td>70 or more</td>
<td>7</td>
<td>187</td>
</tr>
</tbody>
</table>

**Note:** No. = number of determinations; S. D. = standard deviation.
* Ten to fourteen years of age.
Blood Cholesterol and High Calorie, High Saturated Fat Intakes

Forty school children (twenty boys and twenty girls) between six and fourteen years of age randomly chosen among these families were added. The results of the dietary surveys and of the examination of the general physical status are reported elsewhere.

METHODS

Dietary data were obtained in Basel and Blatten using the fourteen day survey and inventory method as described by FAO. All foods consumed were weighed. Calculations of nutrients were based on the International Food Composition Tables as adapted for Swiss conditions by Hoegl and Lauber. Serum cholesterol determinations were carried out in the Nutrition Department of the Harvard School of Public Health on quick frozen (dry ice) samples using the micromethod of Carpenter, Gotjis and Hegsted. The cholesterol content of foods consumed was calculated according to the tables of Hardinge and Crooks, and the fatty acids content according to Goddard and Goodall.

RESULTS

Table 1 shows the serum cholesterol levels at the various ages. For each group the number of subjects (No.), mean value (mean), and standard deviation (S. D.) are given. The standard error in thirty-five duplicates was 10 mg. per 100 cc. for Blatten and 19 mg. per 100 cc. for Basel.

COMMENTS

Figures 1 and 2 compare our findings with values in the literature. For the United States the 1955 data of Lawry et al. on 1,394 men and 412 women are presented; these have been compared with the findings on eighty-one men and fifty-seven women of Rural Guatemala and fifty men and forty-nine women in Costa Rica by Scrimshaw and co-workers. Similar data for the United States had been reported in 1939 by Barker and since 1950 by
Lewis,34 Adlersberg,35 Gertler,36 MacMahon,37 Orwis,38 and others covering more than 20,000 persons. The 1950 findings of Keys et al. show a slightly delayed rise with age.39 The Danish investigations of Kornerup40 conducted in 1950 include eighty men and thirty-seven women. The data of Buerger and Moebius,41 published in 1934, covered fifty-nine German men. The figures include observations on seventy-one Italian men obtained by Keys in 1954,17 101 South African European and 218 South African Bantu men obtained by Walker in 1954,14 133 rural Indians obtained by Padmavati in 195915 and a study on poor and well to do Spaniards by Keys in 1954.16 Values in several hundred American children have been published in 196118 and can be compared with Scrimshaw’s findings for Central American children of three different socioeconomic groups.19

Comparison of these data shows that in Blatten, men at age thirty to thirty-nine have a lower serum cholesterol level than any other population studied, with the exception of Guatemalan Indians. In their forties these men show an increase which, however, falls far short of the values usually found in western populations. The findings in children are similar to those in urban Guatemala. Findings in women are close to those in Costa Rica.

Values for the men in Basel are markedly lower than those in the United States in men at age forty to forty-nine, but reach American levels after the age of fifty. The serum cholesterol levels in the women in Basel are not different from those found in the United States. The same is true for children under twelve.

**DIETARY FINDINGS**

Table II shows the calorie and fat intakes for some of the populations represented in Figures 2 and 3.
Blood Cholesterol and High Calorie, High Saturated Fat Intakes

Table II
Average Individual Intake of Calorie, Lipids and Protein in Various Epidemiologic Studies of Serum Cholesterol

<table>
<thead>
<tr>
<th>Intake</th>
<th>Blatten Per Person</th>
<th>Blatten Per Calorie Equivalent</th>
<th>Basel Per Person</th>
<th>Basel Per Calorie Equivalent</th>
<th>Rural Guatemala</th>
<th>Costa Rica</th>
<th>Spain Low Economic Urban</th>
<th>Southern Italy</th>
<th>South African Bantu</th>
<th>Rural Indians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories (kcal)</td>
<td>3,011</td>
<td>3,643</td>
<td>2,302</td>
<td>2,693</td>
<td>2,288</td>
<td>2,705</td>
<td>2,722</td>
<td>2,340</td>
<td>19</td>
<td>14-17</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>114.4</td>
<td>138.4</td>
<td>94.2</td>
<td>110.2</td>
<td>23</td>
<td>37</td>
<td>2.9</td>
<td>8.0</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>(% of calories)</td>
<td>34.2</td>
<td>36.8</td>
<td>7.5</td>
<td>12.0</td>
<td>27.3</td>
<td>19</td>
<td>...</td>
<td>14-17</td>
<td>27.5</td>
<td>...</td>
</tr>
<tr>
<td>Animal fat (% of calories)</td>
<td>27.0</td>
<td>25.9</td>
<td>2.9</td>
<td>8.0</td>
<td>2.9</td>
<td>8.0</td>
<td>2.9</td>
<td>8.0</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Saturated fatty acids (% of total fat)</td>
<td>44.8</td>
<td>38.6</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Unsaturated fatty acids (% of total fat)</td>
<td>51.0</td>
<td>55.3</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Linolenic acid (% of total fat)</td>
<td>9.8</td>
<td>10.4</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Cholesterol intake (mg)</td>
<td>372.8</td>
<td>451.1</td>
<td>342.8</td>
<td>401.1</td>
<td>50</td>
<td>150</td>
<td>...</td>
<td>75</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>116.1</td>
<td>140.3</td>
<td>69.9</td>
<td>81.8</td>
<td>67</td>
<td>78</td>
<td>...</td>
<td>75</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Animal protein (g)</td>
<td>82.9</td>
<td>100.3</td>
<td>54.2</td>
<td>63.4</td>
<td>6</td>
<td>17</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

1 and 2. Fat intake in both Swiss populations studied contributes approximately 35 per cent of the total calories. Inasmuch as the data were obtained on a per family basis and the composition of the families (age, sex, number of children) differed between Blatten and Basel (there were proportionately far more children in Blatten than in Basel) the data were recalculated on the basis of individual caloric equivalent according to the generally accepted method for the analysis of such family surveys.46 In this method, the data are recalculated on the basis of “per caloric equivalent” for a consumption unit of standard composition. For example, it will be seen (Table II) that adult men in Blatten consumed about 1,000 calories more than those in Basel. The amount of animal fat as per cent of total calories is the same in both regions. Unlike the other population groups with low serum cholesterol levels, the population of Blatten is not subsisting on a low fat diet.47

Furthermore, the intake of the saturated fatty acids, which have been incriminated in the etiology of high cholesterol levels,48-49 is greater in Blatten than in Basel; whereas the intake of linolenic acid, which has been repeatedly claimed to lower blood cholesterol, is less.*

**Other Variables**

In the comparison between Blatten and Basel, fat intake seems unrelated to serum cholesterol values. Therefore, it is important to discuss other possible variables.

**Other Dietary Findings.** Table III gives other dietary findings for both population groups. It shows that the food intake in Blatten markedly differed from that of Basel in that the villagers consumed more milk and much more cheese. Intake of potatoes, bread, sugar and cereals was also higher; Basel families consumed more vegetables and fruit.

In terms of nutrients, the caloric and protein intakes were definitely higher in Blatten, and the calcium intake was twice as high. Iron and vitamins of the B complex were consumed in about the same amounts as in Basel (although this did not hold in relation to calories). Intakes of carotene, vitamin A and vitamin C were lower in Blatten and, as a matter of fact, well below the Recommended Dietary Allow-

---

* It may be noted, in support of this method of analysis of family data, that individual surveys on elderly persons (sixty and more years) in similar mountain regions had shown the same types of differences: 2,708 calories and 109 gm. fat per day for the average intakes of fifty-six old mountain people against 1,906 calories and 82 gm. fat per day for thirty-seven old people living in Basel.43
Although Females were taller than the usual females, the majority of them were not overweight.2

TABLE III
Main Daily Foods and Nutrients Intake in Blatten and Basel

<table>
<thead>
<tr>
<th>Intake per Day</th>
<th>Blatten</th>
<th>Basel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk (gm.)</td>
<td>679.4</td>
<td>463.3</td>
</tr>
<tr>
<td>Butter (gm.)</td>
<td>6.9</td>
<td>16.4</td>
</tr>
<tr>
<td>Cheese (gm.)</td>
<td>89.0</td>
<td>18.5</td>
</tr>
<tr>
<td>Eggs (gm.)</td>
<td>7.2</td>
<td>23.0</td>
</tr>
<tr>
<td>Meat and fish (gm.)</td>
<td>92.3</td>
<td>96.8</td>
</tr>
<tr>
<td>Margarine (gm.)</td>
<td>2.9</td>
<td>3.6</td>
</tr>
<tr>
<td>Lard (gm.)</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Shortening (gm.)</td>
<td>11.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Oil (gm.)</td>
<td>5.9</td>
<td>10.7</td>
</tr>
<tr>
<td>Potatoes (gm.)</td>
<td>210.5</td>
<td>121.3</td>
</tr>
<tr>
<td>Bread (gm.)</td>
<td>251.5</td>
<td>194.6</td>
</tr>
<tr>
<td>Corn/rice/noodles/cereals (gm.)</td>
<td>80.5</td>
<td>46.6</td>
</tr>
<tr>
<td>Sugar (gm.)</td>
<td>116.0</td>
<td>62.9</td>
</tr>
<tr>
<td>Vegetable (gm.)</td>
<td>52.8</td>
<td>154.5</td>
</tr>
<tr>
<td>Fruit (gm.)</td>
<td>53.9</td>
<td>214.0</td>
</tr>
<tr>
<td>Calcium (mg.)</td>
<td>1,800</td>
<td>900</td>
</tr>
<tr>
<td>Iron (mg.)</td>
<td>13.6</td>
<td>11.8</td>
</tr>
<tr>
<td>Vitamin A (I.U.)</td>
<td>2,286</td>
<td>3,104</td>
</tr>
<tr>
<td>Carotene (I.U.)</td>
<td>1,719</td>
<td>3,093</td>
</tr>
<tr>
<td>Thiamin (mg.)</td>
<td>1.51</td>
<td>1.50</td>
</tr>
<tr>
<td>Riboflavin (mg.)</td>
<td>2.40</td>
<td>2.03</td>
</tr>
<tr>
<td>Niacin (mg.)</td>
<td>13.0</td>
<td>13.5</td>
</tr>
<tr>
<td>Vitamin C (mg.)</td>
<td>46.7</td>
<td>114.7</td>
</tr>
</tbody>
</table>

The main difference in cooking habits between the two locations is that frying is unusual in Blatten. Meat is mainly consumed in the form of dry meat, eaten either boiled or uncooked. Cheese is never used for cooking purposes; potatoes are usually boiled with noodles; vegetables are boiled or prepared as salads. Toxic products ascribed to frying might thus be present to a lesser degree in Blatten foods as consumed. Desserts are extreme rarities in Blatten, sugar being mainly used with coffee. Cooking habits in Basel are of the usual western European type.

Body Size, Weight and Adiposity. There are no known ethnic differences between the two groups. The mean height of males twenty to thirty-nine years of age was 174.5 cm. in Blatten and 173.5 cm. in Basel; for women, the means were 163.2 cm. in Blatten and 161.9 cm. in Basel. Taking as a standard the Metropolitan Life Insurance Tables, 18 per cent of all subjects in Blatten were more than 10 per cent underweight, as compared to 8 per cent in Basel. Twenty-three per cent in Blatten were more than 10 per cent overweight as compared to 30 per cent in Basel. Upper arm skinfold thicknesses were determined to see if this measure of adiposity confirmed weight indications (Table IV). Although more subjects were thus overweight in Basel than in Blatten, this small difference is unlikely to explain the higher cholesterol values. Mann10 and Scrimshaw11 as well as Goffman31 and their associates have been unable to show a correlation between serum lipid values and relative weight. One of us (J. M.) has shown that published values indicate that cholesterol levels correlate better with obesity than with overweight.2 On this basis the fact that skinfold thicknesses are not higher in Basel than they are in Blatten makes it unlikely that the observed differences in cholesterol levels are related to degree of adiposity.

Geographic Situation. Blatten’s altitude of 5,057 feet might lead to speculation about the possible influence of altitude on cholesterol values. No data on the effect of altitude on the same groups have been found in the literature. However, South African Europeans living in Johannesburg at an altitude more than 6,000 feet show levels similar to those seen in the population of the United States. Climate was not found to have any significant influence in a comparison of Maine and Florida populations. A low environmental temperature has been shown to elevate the serum cholesterol but as the average temperature is...
lower in Blatten than in Basel (5.8°C. versus 9.8°C.) any effect would increase rather than decrease the significance of the observed difference.

Smoking Habits. Ever since Hammond and Horn and Doll and Hill showed a relation between smoking habits and coronary heart disease, this variable has been emphasized. The Framingham Heart Study showed a positive correlation between cigarette smoking and cholesterol values. Of the men over twenty years of age 68 per cent were smokers in Blatten and 58 per cent in Basel. This makes it unlikely that this factor can account for the observed difference.

Serum Magnesium. Since magnesium intake has been claimed both epidemiologically and experimentally to be inversely correlated with serum cholesterol, serum magnesium values were determined in thirty individuals of each region, matched for sex and age, by a modification of the method of Schachter. Mean values in Blatten were 2.05 mg. per cent ± 0.45 versus 2.63 mg. per cent ± 0.34 in Basel. Within the two groups no tendency for lower cholesterol values at higher magnesium levels could be shown. The generally lower values in Blatten do not confirm an inverse correlation.

Activity. The two groups studied, however, are very different with respect to physical activity. In the introduction, an attempt was made to describe the intense and continuous physical activity of mountain villagers. Their agricultural work forces them to walk long distances and to overcome great differences in altitude. The physical activity of urban dwellers in a city like Basel is much smaller. This is not to say, however, that the families studied in Basel were particularly inactive; in fact, by urban standards they were moderately active. Not more than 10 per cent of the fifty families had a car. More than half of the men never sat for prolonged periods during their daily eight-hour work. The women studied in Basel (with cholesterol levels similar to those in the United States) displayed the degree of activity characteristic of housework in western countries generally. By no means, however, do they exhibit the constant intense physical activity typical of the mode of life of the mountain population. It seems reasonable to ascribe the lower serum cholesterol levels observed in Blatten, in the face of unfavorable other variables, to the intense physical activity of this population. This does not mean that variables such as the fat content of the diet or the proportion of saturated fat are unimportant. It may mean, however, that they are less important than the activity factor or that they manifest their importance only in physically inactive populations.*

SUMMARY

The serum cholesterol level of the population of a Swiss alpine village was compared to that of a working class group of similar ethnic origin in the city of Basel. Despite their high calorie intake and the high saturated fat content of their diet, the villagers showed a low serum cholesterol level, comparable to that observed in poor underdeveloped populations on low fat diets. The population of Basel showed serum cholesterol levels similar to those in the United States. The differences cannot be explained by differences in weight, adiposity, altitude and climate, smoking habits or serum magnesium. The striking difference in physical activity may be responsible for it.

REFERENCES


* Since this paper was completed, data published on Finnish lumberjacks also support the view that the activity factor is much more important than previously thought in the determination of serum cholesterol.
55. Annalen der Schweizerischen Meteorologischen Zentralanstalt, 1958–1960. (For Blatten the data given are those of Leukerbad, the nearest place where measurements were taken.)
58. Framingham Heart Study: personal communications.
62. HEGSTED, D. M. and GOTSIS, A. To be published.