A STUDY OF THE EFFECT OF TEMPERATURE ON PROTEIN INTAKE.

BY W. DENIS AND P. BORGSTROM.

(From the Laboratory of Physiological Chemistry of the School of Medicine, Tulane University, New Orleans.)

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There is a wide-spread popular impression that less food, and particularly less protein, is eaten during warm than during cold weather, and, furthermore, the opinion is frequently expressed that in the tropics a lower food intake is needed than in the countries of the north.

The experimental and statistical work which has been carried out on this phase of the nutrition problem has been admirably discussed in considerable detail by Greenwald (1) who summarizes the situation in the following terms: "It is a generally accepted belief that less food is required in summer than in winter and less in the tropics than in temperate climates. But there are very few accurate observations and such as there are do not support this belief." As an extremely complete bibliography is furnished by Greenwald we will here omit references to the early work on this subject.

Some years ago we were struck by the low figures for urinary nitrogen obtained by medical students at this Institution, who were carrying on metabolism experiments on themselves as a part of the routine laboratory work in the course in biological chemistry. Our experience in this type of experimental work, gained at one of the large New England medical schools, had led us to expect figures for total urinary nitrogen in the 24 hour urines of active young men to be in the neighborhood of 15 to 18 gm., whereas our students, almost without exception reported values of not more than half this amount.

Such results were, of course, viewed with suspicion, but as calculation of the creatinine coefficients (2) gave figures which were
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well within the normal limits, and when several 24 hour collections gave similar creatinine figures, we were compelled to conclude that we were not dealing with cases of incomplete urinary collection, but with dietary habits which were not in accord with the accepted normal average.

In order to obtain more comprehensive figures on the subject, we have, during a period of 3 years, collected data on the 24 hour excretion of total urinary nitrogen and creatinine by medical students who were eating their customary diet, at the University dining hall, at boarding houses, fraternity houses, or at their own homes, and who were entirely ignorant of the nature of our inquiries, although they were trained in the technique of accurate urine collections, and were aware of the fact that by means of the creatinine values we were in a position to check the accuracy and faithfulness of their collections. After the elimination of the material supplied by a few subjects who, we had reason to believe, were not trustworthy, it was found that we were in possession of figures obtained on 233 men and 9 women. The number of women is so small that the figures obtained for them have been omitted from the average results recorded in Table I which, therefore, apply only to our male subjects.¹

Our material was obtained during the month of April in 1922 and 1923 and during July, 1923. In 1924 the experiments were carried on from February 20 to March 6. Our nitrogen determinations were made by the Kjeldahl method and the creatinine by the modified micro technique of Folin (3) using creatinine zinc chloride as a standard.

The figures for temperature were taken from the monthly report of the local office of the United States weather bureau.

The age of our subjects was found to be mainly between 18 and 22 years, together with a few older men, the oldest being not more than 30.

¹ The figures obtained on nine women were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary nitrogen, gm.</td>
<td>7.72</td>
<td>10.62</td>
<td>4.05</td>
</tr>
<tr>
<td>Creatinine coefficient.</td>
<td>7.37</td>
<td>8.50</td>
<td>5.97</td>
</tr>
<tr>
<td>Body weight, kg.</td>
<td>55.50</td>
<td>65.91</td>
<td>45.00</td>
</tr>
</tbody>
</table>

1 The figures obtained on nine women were as follows:
Our students come chiefly from the Southern States, so that it would appear that food habits in this group must be of a distinctly localized variety.

An inspection of the data collected in Table I shows that the average 24 hour excretion of urinary nitrogen by our entire group of 233 subjects amounted to 10.63 gm. or, if calculated to the 70 kilo man equivalent, to 11.07 gm.

10.63 gm. of nitrogen are equivalent to 66.43 gm. of protein, and if we make the commonly accepted assumption that approximately 10 per cent of the food protein is lost in the feces this would

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of subjects</th>
<th>Average weights</th>
<th>Average urinary nitrogen per 21 hrs</th>
<th>Average creatinine coefficient</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kp.</td>
<td>gm.</td>
<td></td>
<td>°C.</td>
</tr>
<tr>
<td>1922</td>
<td>62</td>
<td>66.80</td>
<td>10.27</td>
<td>9.01</td>
<td>22.94</td>
</tr>
<tr>
<td>1923</td>
<td>75</td>
<td>67.35</td>
<td>10.61</td>
<td>8.70</td>
<td>21.00</td>
</tr>
<tr>
<td>(Summer)</td>
<td>18</td>
<td>64.86</td>
<td>9.43</td>
<td>8.79</td>
<td>26.77</td>
</tr>
<tr>
<td>1924</td>
<td>78</td>
<td>68.00</td>
<td>11.18</td>
<td>9.03</td>
<td>13.05</td>
</tr>
<tr>
<td>Average...</td>
<td>233</td>
<td>67.23</td>
<td>10.63</td>
<td>8.93</td>
<td></td>
</tr>
<tr>
<td>Average per 70 kg. man equivalent..</td>
<td>11.07</td>
<td>9.30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

bring the total average protein intake of this group to 73.8 gm., a figure considerably below the average of 121 gm. which Pearl (4) has recently calculated to represent protein intake in the United States and approximately half as large as the 150 gm. “American Standard” protein diet of Atwater.

The effect of temperature on protein intake is well shown in Table I and in Chart 1, for we were fortunate enough to be able to make observations during a period of midsummer weather, during the coldest weather of an abnormally cold winter, and during the intermediate temperatures which prevail in April.
The constant fall in nitrogen excretion with increase in temperature as shown in Chart 1 is in striking contrast to the small deviation from the horizontal given by the curve for the creatinine coefficients which, for comparison, are plotted on the same chart.

In Chart 2 are presented the results of an analysis of the distribution of nitrogen excretion; this chart brings out the rather interesting fact that 39.49 per cent of our subjects excreted between 9.00 and 10.99 gm. of urinary nitrogen in 24 hours, indicating (if we add 10 per cent of the urinary loss for fecal nitrogen) an intake of 62.5 to 76.3 gm. of protein, while only 30 per cent (7 men) were in the division which excreted 14 to 14.99 gm., of which 4 subjects were in the group taken during the cold weather of February and March, 1924. For comparison we have also shown in Chart 2 the distribution of weight and creatinine coefficients of our subjects.

As stated above, our subjects were eating either at boarding houses, fraternity houses, in their own homes, or at the University dining hall. On the whole it may be said that the average financial standing of each group was about the same. There was but
Chart 2. Showing the distribution of urinary nitrogen, creatinine coefficient, and body weight.
little difference in the nitrogen excretion of these four classes, the highest (11.25 gm.) was given by the fraternity house group (44 subjects, average body weight 68.50 kilos, and average creatinine coefficient 8.81 mg. per kilo of body weight), the second (11.01 gm.) by the boarding house group (86 subjects, average body weight 68.21 kilos, and average creatinine coefficient 8.94 mg. per kilo of body weight), the third (10.80 gm.) by the home group (55 subjects, average body weight 63.38 kilos, and average creatinine coefficient 9.00 mg. per kilo of body weight), and the fourth and lowest (9.45 gm.) by the group who ate at the University dining hall (50 subjects, average body weight 66.4 kilos, and average creatinine coefficient of 8.96 mg. per kilo of body weight).

The data have been analyzed by dividing the results into groups arranged according to the place of residence of the subjects, as it appeared possible that persons who had been accustomed to a colder climate might have continued their food habits when transplanted to a new environment. We have therefore classified our results into five groups, a Gulf State group (180 subjects, average body weight 66.76 kilos, average urinary nitrogen 10.80 gm., and average creatinine coefficient 8.91 mg. per kilo of body weight) which included all individuals whose homes were in the states of Florida, Alabama, Mississippi, Louisiana, and Texas; second, a southern group (34 subjects, average body weight 69.83 kilos, average urinary nitrogen 10.33 gm., and average creatinine coefficient 8.81 mg. per kilo of body weight) which contained those from Georgia, North and South Carolina, Tennessee, Kentucky, Missouri, Arkansas, and Oklahoma; third, a group (8 subjects, average body weight 67.80 kilos, average urinary nitrogen 12.51 gm., and average creatinine coefficient 9.90 mg. per kilo of body weight) from states north of the Mason-Dixon line and east of the Rocky Mountains; fourth, a group (7 subjects, average body weight 67.21 kilos, average urinary nitrogen 10.14 gm., and average creatinine coefficient 9.36 mg. per kilo of body weight) from the states west of the Rocky Mountains; and last, a small miscellaneous group (4 subjects, average body weight 63.75 kilos, average urinary nitrogen 11.39 gm., and average creatinine coefficient 10.35 mg. per kilo of body weight) who did not fit into the above classification and who were chiefly residents of Central and South America, Costa Rica, etc.
This classification has brought out the fact that the group of subjects from the Northern States showed an average excretion of about 2 gm. of nitrogen in excess of the average figure for the groups from the Gulf and Southern States. As, however, the number of subjects in the former group amounted to a total of only eight men whereas the latter contained 214, it would appear unwarranted to assign too much importance to this finding.

SUMMARY.

Analyses of 24 hour urines collected over a period of 3 years from 233 male medical students, who were eating their ordinary diet, at their customary eating places, indicated an average excretion of urinary nitrogen of 10.63 gm. This figure plus 10 per cent added to account for the nitrogen lost through the feces indicates an average consumption of 73.8 gm. of protein, an amount which is distinctly below the average protein intake (121 gm.) recorded for inhabitants of the United States. The relation of low protein intake to poverty is well shown in dietary studies made on special groups of people, but the fact should be emphasized that the subjects of this experiment were all at least comfortably supplied with the necessities of life, many were distinctly well to do, and all were living at eating places where board was paid for on a monthly basis and was supplied in liberal amounts, hence no question of possible economy in the purchase of food need be considered. The suggestion is made that this lowered protein intake may be due to the warm climate in which these subjects were living as it was noted that the average nitrogen of the urines collected during the cold weather of February and March was noticeably higher than in those collected during April and July. The results obtained furnish evidence in favor of the view that increase of temperature is accompanied by a decrease in protein intake, and that, apart from the variations due to seasonal changes, the inhabitants of the semitropical portions of this Country probably consume an amount of protein considerably below the quantity reported as the average intake for the nation.
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