Three decades of gastroenterology in Soweto South Africa: from descriptive to scientific observations
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Citation for published version (APA):
Segal, I. (2002). Three decades of gastroenterology in Soweto South Africa: from descriptive to scientific observations

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Chapter 4

Malabsorption of Carbohydrate Foods by Urban Blacks

Segal I, Walker ARP, Naik I, Riedel L, Daya B, De Beer M

Summary

Prevalences of non-infective bowel diseases are very low in South African urban blacks compared with the white population. In seeking elucidation, using breath hydrogen measurements in series of black and white subjects, small-bowel transit time was determined, and the malabsorption of maize, wheat, and rice investigated. Median transit times in both ethnic groups were similar. Rice was fully, but wheat incompletely absorbed by both groups. Maize, the staple food of blacks, was incompletely absorbed by them, although completely absorbed by the white subjects. Carbohydrate consumption is high in the black population (60 - 65% of total energy intake). It is probable that in blacks, despite their now eating a low-fibre diet, an expected increase in large-bowel diseases has been inhibited in part by the protective mechanism of fermentation of malabsorbed maize and wheat.

Introduction

While prevalences of non-infective bowel disease (appendicitis, diverticular disease, colorectal cancer and ulcerative colitis) in South African whites are similar to those of prosperous Western populations, they are far lower in the black population. In those living in rural areas and pursuing a traditional lifestyle, these diseases are very uncommon or almost unknown. Although prevalences are higher in urban dwellers experiencing a partially westernised lifestyle, they still remain low. As to diet, the traditional food of rural blacks is low in fat but high in dietary fibre. With urbanisation, however, there is increased consumption of fat-containing foods, animal protein, salt and sugar, but a considerably diminished consumption of fibre-containing foods. Such dietary changes would be expected to evoke detectable alterations in disease patterns, including an increased frequency of large-bowel diseases. Yet this has not occurred. Observations at Baragwanath Hospital, Soweto, over the last two decades have revealed very low and scarcely rising frequencies of appendicitis, diverticular disease, colonic polyps and colorectal cancer. It could thus also be conjectured that in view of the dietary changes described, rises in the occurrences of these diseases would become markedly manifest. Since this has not occurred, it could be inferred that the bowel milieu interieur of urban blacks has changed less than would be expected.

To throw light on the situation, it was decided to carry out investigations on: (I) small-bowel transit time; and (II) absorption of rice, maize and wheat flour in healthy urban black and white subjects, using breath hydrogen measurements.
Subjects and methods

Subjects
These included 17 healthy black volunteers (10 women, 7 men; mean age 33.5 years) and 13 healthy white volunteers (8 women, 5 men; mean age 26.2 years). They had no history of gastro-intestinal disease or recent treatment with antibiotics or use of laxatives. All gave written, informed consent. The project was approved by the Human Ethics Committee of the University of the Witwatersrand.

Each subject underwent 4 tests, at weekly intervals, and the H2 response was monitored. The test meals administered were lactose, maize, wheat and rice, respectively.

Hydrogen breath test
To minimise basal breath H2 excretion, subjects were instructed to eat a meal of meat, chicken or fish the evening before each test. The meal was not standardised. After an overnight fast they were asked to rinse with a bactericidal mouthwash. No smoking was permitted. Breath H2 concentration was measured in end-expiratory samples before the ingestion of each test meal, and every 30 minutes thereafter until values returned to basal levels. The hydrogen concentration, in parts per million (ppm), was measured using an electrochemical breath analyser. The periods of observation were 8-11 hours. The fasting breath levels were below 10 ppm in all subjects.

Test meals
The test meals consisted of lactulose syrup (15 ml volume containing 10 g lactulose), 100 g refined rice (79 g carbohydrate) and 100 g refined wheat flour (80.1 g carbohydrate) as cakes, and 100 g refined maize meal (69 g carbohydrate) as porridge. Additional ingredients in the rice and wheat cakes were baking powder (6 g), 1 egg, butter (7 g) and salt. The latter was added to improve taste and the addition does not affect the generation of H2.10,11 The maize meal was boiled with 300 ml water and salt added, and then allowed to cool overnight. After an overnight fast each subject ate the food preparation within 30 minutes.

Calculations and statistics
Oral-caecal transit time was defined as the interval between lactulose ingestion and the first definite sustained rise of H2, i.e. an increase of at least 5 ppm above the base-line, maintained or increased in three consecutive determinations.
The total excess volume of H2 excreted after carbohydrate ingestion or oral lactulose was determined by calculating the area under the breath H2 concentration curve located between a sharp increase (> 5 ppm) and the return of H2 baseline values. For each subject, the quantity (g) of starch metabolised in the colon was calculated by comparing the excess volume of H2 excreted during the total test period after starch ingestion with that excreted after the ingestion of 10 g lactulose, according to the formula \((V1/V2) \times 10\), where \(V1\) is the excess volume of H2 excreted after starch ingestion (ml), and \(V2\) is the excess volume of H2 excreted after oral lactulose (ml), and 10 is the amount of lactulose ingested in g.\(^8\)

Non-parametric statistical analyses were done because of the small sample size. The Mann-Whitney U-test was employed to test for any significant differences between the two population groups.

**Results**

**Oral-caecal transit time**

The median transit time in 17 blacks and 13 whites was 75 minutes (range 30 - 180 minutes) and 120 minutes (range 60 210 minutes), respectively. The differences were not significant (\(P = 0.1\)).

**Areas under the breath H\(_2\) concentration curves** (Table I)

The values with regard to ingestion of lactulose, wheat and rice were not significantly different in both groups. There was a statistically significant difference for maize. The median area value for blacks was 24 ml/g carbohydrate and for whites 0 ml/g carbohydrate (\(P = 0.001\)).

**Quantity of carbohydrates malabsorbed** (Table II)

The quantities of lactulose, wheat -and rice malabsorbed between the black and white groups was not significantly different. There was a statistically significant difference in maize malabsorption between the two groups (\(P = 0.0002\)).

Thus, there were no significant differences between the groups in oral-caecal transit time, and in wheat and rice malabsorption. There was, however, a statistically significant difference between blacks and whites with regard to maize absorption.
Table 1. Lactulose, wheat, rice and maize meal malabsorption in black and white subjects (areas under the curve) (ml/g)

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th>Population group</th>
<th>No. of subjects</th>
<th>Min.</th>
<th>Max.</th>
<th>Median</th>
<th>95% CI</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactulose</td>
<td>Black</td>
<td>17</td>
<td>24</td>
<td>262</td>
<td>107</td>
<td>50-126</td>
<td>0.09333</td>
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<tr>
<td></td>
<td>White</td>
<td>13</td>
<td>43</td>
<td>165</td>
<td>89</td>
<td>70-118</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>Black</td>
<td>10</td>
<td>30</td>
<td>214</td>
<td>87</td>
<td>59-189</td>
<td>0.7749</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>9</td>
<td>10</td>
<td>214</td>
<td>100</td>
<td>58-144</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>Black</td>
<td>12</td>
<td>0</td>
<td>51</td>
<td>0</td>
<td>0-10</td>
<td>0.5642</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>10</td>
<td>0</td>
<td>27</td>
<td>4</td>
<td>0-14</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>Black</td>
<td>15</td>
<td>0</td>
<td>99</td>
<td>24</td>
<td>11-43</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>12</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0-5</td>
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</tr>
</tbody>
</table>

*P-value from the Mann-Whitney U-test.
95% CI - 95% confidence interval.

Table 2. Quantity of carbohydrate (g) malabsorbed in black and white subjects

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th>Population group</th>
<th>No. of subjects</th>
<th>Min.</th>
<th>Max.</th>
<th>Median</th>
<th>P-value*</th>
</tr>
</thead>
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<td>Wheat</td>
<td>Black</td>
<td>10</td>
<td>2.69</td>
<td>29.07</td>
<td>9.47</td>
<td>0.93.</td>
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<td>White</td>
<td>9</td>
<td>1.19</td>
<td>21.4</td>
<td>11.57</td>
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<tr>
<td>Rice</td>
<td>Black</td>
<td>12</td>
<td>0.0</td>
<td>4.55</td>
<td>0.0</td>
<td>0.97.</td>
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<tr>
<td></td>
<td>White</td>
<td>10</td>
<td>0.0</td>
<td>2.74</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>Black</td>
<td>15</td>
<td>0.0</td>
<td>9.58</td>
<td>1.9</td>
<td>0.0002</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>12</td>
<td>0.0</td>
<td>1.3</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

*P-value from the Mann-Whitney U-test.

Discussion

The results obtained in the study indicated that malabsorption of wheat occurred in both groups but malabsorption of maize occurred to a significantly greater degree in blacks compared with whites. The importance of the malabsorbed grains is that they act as substrates for fermentation - the process whereby energy-yielding substrates are broken down by anaerobic bacteria. The principal substrates available for fermentation are dietary fibre (non-starch polysaccharides), starch and protein, and the chief end products are various gases, short and branched-chain fatty acids, phenols, amines and ammonia, and the release of energy which bacteria use for their metabolism. It has been suggested that one of the short-chain fatty acids, butyrate, is important in maintaining the health of the large-bowel epithelium and in inhibiting tumour growth. Significant amounts of starch may pass into the large intestine of man on a Western diet. In populations such as South African blacks among whom maize and bread may comprise a very large part of the diet (carbohydrate supplies approximately 60 - 65% of total energy).
substantially more starch will be likely to enter the colon. It is probable that in blacks, despite their now eating a low-fibre diet, an expected increase in large-bowel disease has been inhibited in part by the protective mechanism of fermentation. Why blacks should absorb maize meal less effectively than whites is not clear. Two possibilities should be considered:

1. Thornton et al.\textsuperscript{16} have shown that super-efficient starch absorption, which reduces the supply of carbohydrates to the large bowel, is present in people with colonic neoplasia. Perhaps this super-efficient starch absorption occurred in the white groups we studied. The phenomenon could be related to the rise in the occurrence of large-bowel diseases that occurred in western populations at the beginning of the present century.\textsuperscript{17}

2. Conceivably, in blacks other differences in physiology and metabolism in the colon share responsibility for the higher H2 production and for their lower frequency of bowel diseases. Compared with whites, blacks tend to have shorter total transit times;\textsuperscript{18} they defaecate more frequently;\textsuperscript{19} they void a higher proportion of semiformal or formed stools,\textsuperscript{20} and they have lower faecal pH values. In addition, they have a greater surface area of the colon compared with whites;\textsuperscript{21} and a greater proportion of blacks (72%) than whites are methane producers (52%).\textsuperscript{32} Presumably a combination of these factors continues to protect urban blacks from experiencing the expected marked rises in the occurrences of bowel disease.

The authors gratefully acknowledge the assistance of Dr Cummings, Dunn Nutrition Unit, Cambridge University, UK.

This work was supported by a grant from the South African Medical Research Council.

References


