棕榈油和棕榈油酸甘油酯对人类脂质和脂肪酸的调节：一个评论

摘要

目前有若干人体临床试验来评估棕榈油对血脂及脂肪酸的影响。这些研究指出棕榈油及棕榈油酸甘油酯在膳食中不会相应地升高血浆甘油三酯和低密度脂蛋白胆固醇水平。应用大量棕榈油于西方膳食中对某些冠心病危险因子起到有益的调节。可引起脱模基脂蛋白（apolipoprotein）B/A比例下降，而高密度脂蛋白胆固醇则因升高而增加。

棕榈油酸甘油酯和各种单不饱和脂肪酸食用油（如亚油酸油、橄榄油等）显示棕榈油酸甘油酯并不增加血浆低密度脂蛋白胆固醇水平。豆蔻酸也许是最有力的升高脂肪酸的饱和脂肪酸。在血脂正常的对象中，棕榈油酸食用油的摄食量对饱和脂肪酸的吸收有抑制作用。可使血浆胆固醇，低密度脂蛋白胆固醇，脂蛋白A（Lp）a升高。

高密度脂蛋白胆固醇降低。除了这些脂肪酸外，棕榈油中的生育三烯酸也许有降低血液胆固醇的作用。这是由于生育三烯酸有抑制HMG-CoA还原酶的作用。这个在棕榈油的新发现，值得对饱和脂肪酸假说及其在脂蛋白调节中的作用进行一个重新的科学评价。

Vervet monkeys and whole-food diets for studying the effects of dietary lipids on plasma lipoprotein metabolism and atherosclerosis

AJS Benadé DSc, JE Finchem, CM Smuts MSc, MJ Weight, PJ van Jaarsveld PhD, MKruger

National Research Programme for Nutritional Intervention Medical Research Council, Tygerberg, South Africa

It is well established that some species of non-human primates are models of choice for polygenic hyperlipoproteinemia and atherosclerosis induced and promoted by diets as consuming man in 1987. The Vervet or African Green monkey (Cercopithecus aethiops) has proved to be an excellent model for studying the effects of a variety of dietary manipulations on plasma lipoprotein metabolism, atherosclerosis and related risk factors.

The potential for using this primate to study the effects of lipid-lowering agents on plasma lipoprotein metabolism and atherosclerosis was recently demonstrated.

Direct comparison of results from the various studies is difficult because of differences between species and diets administered to experimental animals of the same species. The purpose of this communication is therefore to review the results of our own studies which used the African Green monkey, and diets that are realistic for man.

Materials and methods

Vervet monkeys were all healthy and conditioned to the laboratory environment for six months or more. Diets fed were either an average Western diet (WD), a prandial diet (PD) or a high carbohydrate diet (HCD), which have been described in detail elsewhere. The period of time diets were fed ranged from four to 47 months. Diets were composed entirely of normal food items for humans with any added cholesterol and provided a realistic nutritional range.

Comparison of the effect of the amount and degree of unsaturation of dietary fat on plasma low density lipoprotein (LDL) concentration and composition in the African Green (Vervet) monkeys (12 females, age 1.5-4 years). Animals received diets with fat contents of 41, 31 and 18% energy each with a low and high polyunsaturated to satu rated fatty acid ratio (P/S: 0.27-0.38 and 1.13-1.47; major fatty acids were palmitic and linoleic acids) for a period of two months. Cholesterol content of the diet was lowered (6.9-0.3mg/100g). LDL cholesterol concentrations showed significant decreases in all groups when the dietary fat content decreased from 31 to 18% of energy. Dietary P/S ratio only affected LDL cholesterol concentrations during moderate (31% of energy) fat intake. Low density lipoprotein cholesterol increased with a decrease in dietary P/S. The changes in LDL cholesterol concentrations were the result of changes in the number of circulating LDL particles as the molecular composition of the LDL particles was not significantly affected between dietary periods. Dietary fat changes had an influence on the high density lipoprotein cholesterol and plasma triglyceride concentrations. During the high P/S diets, the percentage of lipoprotein (18.3%) in LDL, esterified cholesterol (CE) and adipose tissue triglyceride (TAG) increased as compared to the low P/S diets.

Results of this study provide evidence that the amount of dietary fat had a greater influence on plasma cholesterol concentration than a moderate change in dietary P/S in Vervets. The effects of dietary fat on plasma cholesterol were mainly through changes in LDL cholesterol concentrations. The animals showed marked individual differences in LDL cholesterol concentration response to both the amount and the degree of unsaturation of fat in the diet.
The finding that LDL particle mass was also not significantly different by dietary fat changes supports the findings in both Vervest\textsuperscript{15} and humans\textsuperscript{14}. The loading of LDL with sterol and unesterified cholesterol increased LDL particle mass reported in some studies in non-human primates fed an atherogenic diet probably resulted from excessive cholesterol intake\textsuperscript{15,16}.

The influence of fish oil supplementation on plasma lipoproteins and arterial lipids in Vervest\textsuperscript{17} details of the study were previously reported. Briefly, the experimental design was as follows: Vervest (20 males, 17 females; all adults) were divided into four comparable groups, two groups were retained on the Western atherogenic diet (WAD) based on milk, eggs, meat, legumes, cereals, sugar, fruit, vegetables, butter and sunflower oil (35% of fat, 31.0 mg chole/100 kcal), one of which was supplemented with fish oil (WAD/Fo; \( n = 9 \)), while the other received the same diet (WAD/So; \( n = 9 \)) supplement. The remaining two groups were changed from the WAD to a high carbohydrate diet (HCD). One group was supplemented with the same FO supplement (HCD/Fo; \( n = 9 \)) and the other group received the sunflower oil (HCD/So; \( n = 10 \)) supplement. Nine female Vervests that were never exposed to the WAD served as a reference group and received a high carbohydrate diet. Vervests were terminated after 20 months.

Fish oil supplementation did not change the cholesterol concentrations of plasma cholesterol or LDL significantly (Table 1). Vervests supplemented with fish oil had an increased (2.7 times; \( p < 0.001 \)) content of total cholesterol in their aortic intima compared to the WAD/So group. The same trend was also evident after FO was supplemented to the HCD.

The effect of fish oil on lipoprotein and arterial total cholesterol levels\textsuperscript{17}

<table>
<thead>
<tr>
<th>WAD/So</th>
<th>WAD/Fo</th>
<th>HCD/So</th>
<th>HCD/Fo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td>333</td>
<td>345</td>
<td>146</td>
</tr>
<tr>
<td>(mg/dL)</td>
<td>(125.2)</td>
<td>(121.0)</td>
<td>(23.1)</td>
</tr>
<tr>
<td>LDL</td>
<td>300</td>
<td>316</td>
<td>165</td>
</tr>
<tr>
<td>(mg/dL)</td>
<td>(158.9)</td>
<td>(134.2)</td>
<td>(21.2)</td>
</tr>
<tr>
<td>Intima</td>
<td>32.5</td>
<td>39</td>
<td>44</td>
</tr>
<tr>
<td>(mg/dL)</td>
<td>(26.6)</td>
<td>(78.3)</td>
<td>(70.9)</td>
</tr>
</tbody>
</table>

Table 1. The effect of fish oil on lipoprotein and arterial total cholesterol levels. Atherogenic and prudent diet experiments\textsuperscript{17,15,24,29}

- **Compartments**: WAD, HCD, Intima, Plasma
- **Fatty acids**: C18:2w6, C18:3w3, C20:4w6, C20:5w3
- **Intima-C**: C18:3w3, C20:5w3

**THE EFFECTS OF DIETARY LIPIDS ON PLASMA LIPOPROTEIN METABOLISM IN VERVEST MONKEYS**

The effect of cholesterol and type of fat in the diet on the LDL composition of the African Green monkey\textsuperscript{20} Malan\textsuperscript{20} studied the effect of cholesterol and type of fat in the diet on the LDL composition of African green monkeys (15 adult males) receiving diets containing a constant amount of fat (40% of energy) and which varied only in the amount of cholesterol (16.4 or 0.0 mg/100 kcal) and in the type of fat (PO/0.3 or 1.2 present in the diet). Cholesterol was found to exert a significant and independent effect on the LDL total cholesterol, LDL-C, LDL free cholesterol (LDL-FC), LDLP apolipoprotein B (LDL-apoB) and LDL triglyceride (LDL-TG) concentrations.

There was a significant interaction between cholesterol and P/S in their effect on the LDL composition. The effect of the cholesterol was significant only at low P/S ratios. The low cholesterol, low P/S diet was characterised by an enrichment of the LDL particles with CE at the expense of TAG as well as by a significant increase in the LDL molecular weight (MW).

Although the P/S also exerted significant effects on the LDL composition, it was less marked than that of cholesterol. At low cholesterol diets, the P/S significantly affected all the LDL parameters. At the high cholesterol, low P/S diets compared to the low P/S diets. At a high cholesterol diet, the increase in the P/S caused significant decreases in the content of the LDL-C and in LDL-MW. Results of this study concerning the LDL compositional changes in response to increased intake of dietary cholesterol are consistent with those from previous studies using nonhuman primates.

The most critical part of the methodology to optimise visualisation of atherosclerosis is to use an advanced technique to reduce the presence of fat in the wall of the arterial vessels. This method is the most critical part of the methodology to optimise visualisation of atherosclerosis.\textsuperscript{20}

A new method was developed to improve the visualisation of atherosclerosis by using a fluorescent dye that accumulates in the wall of the arterial vessels. This method was used in a new study to improve the visualisation of atherosclerosis in the monkey. The results of this study will be published in a forthcoming issue of the Journal of Atherosclerosis. Further studies are planned to explore the potential of this method in other animal models and human subjects.
The finding that LDL particle mass was also not influenced significantly by dietary fat changes supports findings in both Veretski et al. and humans. The loading of LDL with esterified and unesterified fat, and increased LDL particle mass reported in some studies in non-human primates fed an atherogenic diet probably resulted from excessive cholesterol intake.10-12

The influence of fish oil supplementation on plasma lipoproteins and arterial lipids in Veretski et al.13 Details of the study were previously described. Briefly, the experimental design was as follows: Vervets (20 males, 17 females; all adults) were divided into four comparable groups, two groups were retained on the Western atherogenic diet (WAD) and two groups on the WAD with added fish oil (WADO; n = 9), while the other two groups received the sunflower oil diet (WSDO; n = 10). The sunflower oil was supplied to the WAD group as a reference group and had never been exposed to the WADO diet served as a reference group and had received a high carbohydrate diet. Vervets were terminated after 20 months.

Fish oil supplementation did not change the cholesterol concentrations of plasma cholesterol or LDL significantly (Table 1). Veretski et al.13 found that group WADO had increased its 2.7 times; p < 0.001) content of total cholesterol in their atherogenesis compared to the WADO group. The same trend was also evident after FO was supplemented to the HCD.

### Table 1. The effect of fish oil on lipoprotein and arterial total cholesterol levels

<table>
<thead>
<tr>
<th></th>
<th>WADO</th>
<th>WADO</th>
<th>HCIAD</th>
<th>HCDFO</th>
<th>MCDFO</th>
<th>HCDFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>15</td>
<td>15</td>
<td>12</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
| WAD: Western atherogenetic diet; HCD: High carbohydrate diet; values in parenthesis are SD; Significant difference between WADO and HCDFO or HCDFO and HCIAD: p<0.001; p=0.001

**EFFECTS OF DIETARY LIPOSIDS ON PLASMA LIPOPROTEIN METABOLISM IN VERETS MONKEYS**

**Atherogenic and prudent diet experiments**14-16,24-29 Five pairs of monkeys were fed based on results of an experiment which incorporated major improvements in methodology in relation to atherosclerosis, diets and clinical control. The experiment involved the use of premenopausal Vervets were used. Environment in terms of photoperiod, temperature, air circulation and access by potential disease vectors was controlled.

Fish oil was the most critical part of the methodology to optimise visualisation of atherosclerosis.17-20 An improved procedure commenced under surgical anaesthesia by flushing of the heart and arterial blood pressure maintained by a constant arterial pressure (100 mm Hg) and flow, which prevented arterial clotting. Perfusion of the arteries with fixative via the left ventricle, with lung function supported by a ventilator, followed immediately after flushing, with the heart still beating. This method enhanced qualitative results and enabled definition of atherosclerosis by precise cellular, extracellular and morphometric criteria for the first time, including peripheral and coronary atherosclerosis. As a result, a strong positive relationship between atherosclerosis, hypercholesterolaemia and known dietary risks, was confirmed in adult female Vervets. The prudent diet was not associated with definitive atherosclerosis, but failed to regress components of advanced atherosclerotic plaque, such as cholesterol crystals, calcification and fibrosis, which had formed in adult female Vervets. The prudent diet would be more effective for preventing atherosclerosis than treating advanced lesions, and this may well apply to people. Significant coronary atherosclerosis and myocardial scarring, which as an infection, did not develop in adult females at dietary risk for 47 months.

In addition to measurement of true atherosclerosis, 50 variables were monitored, including retinal regularity, intervals and regularity of plasma lipoproteins, 23 chemical pathology variables, haematology and body weight.14 Treatment durations of 15, 20, 25 and 47 months defined a time scale of atherosclerosis in response to well controlled dietary challenge in adult females. Atherogenic and prudent diets were realistic for Westernised people, and no extra pure cholesterol was added because this is not relevant to the human experience. Dietary compliance was proven by measuring fecal intake. The other treatments were constant exposure to either atherogenic, prudent or reference (= negative control high carbohydrate) diets. The reference diet was realistic for Third World people. Mean plasma total cholesterol (mg/dL) in Vervets fed the respective diets stabilised at 147 (reference diet), 174 (prudent diet) and 376 (atherogenic diet). Diets other than the atherogenic diet were fed to 20 adults, back to prudent for 27 months was tested, and the result confirmed that the prudent diet completely reversed hyperlipidaemia. The phenomenon of hyper- and hypolipidaemia was regressed in the atherogenic diet models a similar situation with polygenic atherosclerosis in people. Hypercholesterolaemic response ranged between individuals from 81 to 505 mg/dL or 6239. Red blood cells, retinal regularity and retinal arterial changes in association with the atherogenic diet compared to the prudent diet, haemoglobin was the same and haemoglobin per red cell decreased. Atherogenic and prudent diet experiments were in not necessarily

### Table 2. The effect of fish oil on the fatty acid composition of plasma and intima phospholipid fatty acids

<table>
<thead>
<tr>
<th></th>
<th>WAD/F</th>
<th>HCD/SO</th>
<th>HCD/PO</th>
<th>HCD/F</th>
<th>HCD/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>9</td>
<td>9</td>
<td>10</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Plasma C18:2w6</td>
<td>25.6</td>
<td>18.1</td>
<td>33.3</td>
<td>23.6</td>
<td>31.5</td>
</tr>
<tr>
<td></td>
<td>(2.2)</td>
<td>(1.8)</td>
<td>(2.9)</td>
<td>(1.6)</td>
<td>(1.5)</td>
</tr>
<tr>
<td>C20:3w6</td>
<td>1.5</td>
<td>1.0</td>
<td>2.8</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(1.4)</td>
<td>(0.3)</td>
<td>(1.2)</td>
</tr>
<tr>
<td>C20:4w6</td>
<td>11.2</td>
<td>9.4</td>
<td>8.0</td>
<td>5.9</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(0.5)</td>
<td>(1.0)</td>
<td>(0.5)</td>
<td>(0.5)</td>
</tr>
<tr>
<td>C22:5w5</td>
<td>0.8</td>
<td>3.0</td>
<td>0.4</td>
<td>5.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>(0.1)</td>
<td>(0.7)</td>
<td>(0.1)</td>
<td>(1.1)</td>
<td>(0.1)</td>
</tr>
<tr>
<td>C22:6w6</td>
<td>5.5</td>
<td>8.2</td>
<td>3.0</td>
<td>1.0</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(1.5)</td>
<td>(0.4)</td>
<td>(0.8)</td>
<td>(0.5)</td>
</tr>
<tr>
<td>Intima C18:2w6</td>
<td>5.7</td>
<td>7.4</td>
<td>6.3</td>
<td>7.0</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>(0.8)</td>
<td>(1.3)</td>
<td>(1.0)</td>
<td>(1.7)</td>
<td>(0.8)</td>
</tr>
<tr>
<td>C20:3w6</td>
<td>1.0</td>
<td>1.3</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>(0.3)</td>
<td>(0.2)</td>
<td>(0.4)</td>
<td>(0.3)</td>
<td>(0.2)</td>
</tr>
<tr>
<td>C20:4w6</td>
<td>19.6</td>
<td>15.0</td>
<td>18.0</td>
<td>15.5</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td>(2.5)</td>
<td>(2.3)</td>
<td>(2.5)</td>
<td>(2.5)</td>
<td>(1.9)</td>
</tr>
<tr>
<td>C22:5w5</td>
<td>0.2</td>
<td>1.3</td>
<td>1.0</td>
<td>1.1</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>(0.1)</td>
<td>(0.4)</td>
<td>(0.1)</td>
<td>(0.1)</td>
<td>(0.1)</td>
</tr>
<tr>
<td>C22:6w6</td>
<td>3.1</td>
<td>3.7</td>
<td>2.1</td>
<td>3.0</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>(0.3)</td>
<td>(0.7)</td>
<td>(0.5)</td>
<td>(0.5)</td>
<td>(0.5)</td>
</tr>
</tbody>
</table>
| WAD: Western atherogenetic diet; HCD: High carbohydrate diet; HSDO: Sunflower oil diet; FO: Fish oil; HSD: High sucrose diet; values in parenthesis are SD; Significant difference between WADO and HCDFO or HCDFO and HCIAD: p<0.001; p>0.001

### Table 3. Correlation coefficients (r) and p-values between the esterified cholesterol (CE) and free cholesterol (FC) content of the aorta intima and plasma phospholipid (PL) fatty acids

<table>
<thead>
<tr>
<th></th>
<th>Intima-FC</th>
<th>Plasma-FC</th>
<th>Intima-CE</th>
<th>Plasma-CE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PC fatty acid</strong></td>
<td>r</td>
<td>p</td>
<td>r</td>
<td>p</td>
</tr>
<tr>
<td>Plasma C20:4w6</td>
<td>-0.66</td>
<td>0.0029</td>
<td>-0.53</td>
<td>0.0245</td>
</tr>
<tr>
<td>C20:5w5</td>
<td>0.75</td>
<td>0.0004</td>
<td>0.57</td>
<td>0.0126</td>
</tr>
<tr>
<td>Intima C20:4w6</td>
<td>-0.73</td>
<td>0.0007</td>
<td>-0.72</td>
<td>0.0003</td>
</tr>
<tr>
<td>C20:5w5</td>
<td>0.78</td>
<td>0.0001</td>
<td>0.59</td>
<td>0.0055</td>
</tr>
</tbody>
</table>

**The effect of diet on the metabolism of EPA**

Controversy surrounds the beneficial effects of EPA on plaque lipid metabolism because researchers showed that EPA does lower plasma cholesterol concentrations in primates10 while others suggested a cholesterol elevating effect14. Although many factors could possibly explain these divergent results obtained with EPA, the results obtained in the diets which were supplemented could be interpreted14.

In a study reported by van Rooyen et al.16,17,19 Vervets monkeys (20 adults, 20 adults) were fed a diet containing fish oil (9%) and ethanol (9%) reduced in the plasma PC after FO supplementation of the WAD and similar effects were seen after supplementation of the WAD with FO. In the aorta intima the AA was also reduced (P<0.001) on the high fat diet but the linoleic acid (C22:6w3) DHA was also increased after FO supplementation. In the plasma and aorta intima PC, EPA and AA respectively demonstrated the strongest negative and positive correlations with the intima CE and PC contents (Fig. 3).
related to diet. Dietary ascorbic acid requirements under the conditions of experiments are defined. Statistically significant increases in calcium, zinc, vitamin E, and decreased vitamin B6 were associated with the atherogenic compared to the prudent diet (in plasma or serum). A 25% decrease in dietary fat and vitamin B6 requirements resulted from a separate study which detected very low folate status after chronic intakes of the atherogenic diet.21

**Summary and conclusions**

The African green monkey (Cercopithecus aethiops) has proven to be a suitable model for studying the effects of a variety of dietary components on plasma lipoprotein metabolism and atherosclerosis. This rhesus monkey was aged 17 adults females and 17 adults males. The Aethiops were used in this study, which enabled confirmation that atherosclerosis is more pronounced in males. Compliance was proven by physical records of food consumption and by changes in fatty acid content of tissues. Results did not provide any evidence that the fish oil was antiatherogenic. The therapeutic diet effectively reversed lipoprotein infiltration into arteries, as indicated previously by the prudent diet, but again components of advanced atherosclerosis such as cholesterol crystals, calcification and fibrosis did not regress in 20 months. Therefore minimal cerebral atherosclerosis is possibly because the walls of cerebral arteries are thin, almost like veins, which minimises tissue available for lipid accumulation. This suggests that the main pathogenesis of the atheromatous plaque may be by occult embolisation from carotid thrombi.

**Vervet monkeys and whole-food diets for studying the effects of dietary lipids on plasma lipoprotein metabolism and atherosclerosis**

ASIS Benadé, JF Fincham, CM Smuts, MJ Weight, PJ van Jaarsveld, M Kruger


**Effects of fish oil diet on plasma lipoproteins and plasma lipid metabolism in vervet monkeys**

21

20

AJS BENADÉ, JE FINCHAM, CM SMUTS, MJ WEIGHT, PJ VAN JAARSVELD, M KRUGER

related to diet. Dietary ascorbic acid requirements under the conditions of experiments are defined. Statistically significant increases in calcium, zinc, vitamin E, and decreased vitamin B6 were associated with the atherogenic compared to the prudent diet (in plasma or serum). A 25% decrease in dietary fat and vitamin B6 requirements resulted from a separate study which detected very low folate status after chronic intakes of the atherogenic diet.21

**Summary and conclusions**

The African green monkey (Cercopithecus aethiops) has proven to be a suitable model for studying the effects of a variety of dietary components on plasma lipoprotein metabolism and atherosclerosis. This rhesus monkey was aged 17 adults females and 17 adults males. The Aethiops were used in this study, which enabled confirmation that atherosclerosis is more pronounced in males. Compliance was proven by physical records of food consumption and by changes in fatty acid content of tissues. Results did not provide any evidence that the fish oil was antiatherogenic. The therapeutic diet effectively reversed lipoprotein infiltration into arteries, as indicated previously by the prudent diet, but again components of advanced atherosclerosis such as cholesterol crystals, calcification and fibrosis did not regress in 20 months. Therefore minimal cerebral atherosclerosis is possibly because the walls of cerebral arteries are thin, almost like veins, which minimises tissue available for lipid accumulation. This suggests that the main pathogenesis of the atheromatous plaque may be by occult embolisation from carotid thrombi.

**Vervet monkeys and whole-food diets for studying the effects of dietary lipids on plasma lipoprotein metabolism and atherosclerosis**

ASIS Benadé, JF Fincham, CM Smuts, MJ Weight, PJ van Jaarsveld, M Kruger


**Effects of fish oil diet on plasma lipoproteins and plasma lipid metabolism in vervet monkeys**

21

20

AJS BENADÉ, JE FINCHAM, CM SMUTS, MJ WEIGHT, PJ VAN JAARSVELD, M KRUGER

related to diet. Dietary ascorbic acid requirements under the conditions of experiments are defined. Statistically significant increases in calcium, zinc, vitamin E, and decreased vitamin B6 were associated with the atherogenic compared to the prudent diet (in plasma or serum). A 25% decrease in dietary fat and vitamin B6 requirements resulted from a separate study which detected very low folate status after chronic intakes of the atherogenic diet.21

**Summary and conclusions**

The African green monkey (Cercopithecus aethiops) has proven to be a suitable model for studying the effects of a variety of dietary components on plasma lipoprotein metabolism and atherosclerosis. This rhesus monkey was aged 17 adults females and 17 adults males. The Aethiops were used in this study, which enabled confirmation that atherosclerosis is more pronounced in males. Compliance was proven by physical records of food consumption and by changes in fatty acid content of tissues. Results did not provide any evidence that the fish oil was antiatherogenic. The therapeutic diet effectively reversed lipoprotein infiltration into arteries, as indicated previously by the prudent diet, but again components of advanced atherosclerosis such as cholesterol crystals, calcification and fibrosis did not regress in 20 months. Therefore minimal cerebral atherosclerosis is possibly because the walls of cerebral arteries are thin, almost like veins, which minimises tissue available for lipid accumulation. This suggests that the main pathogenesis of the atheromatous plaque may be by occult embolisation from carotid thrombi.

**Vervet monkeys and whole-food diets for studying the effects of dietary lipids on plasma lipoprotein metabolism and atherosclerosis**

ASIS Benadé, JF Fincham, CM Smuts, MJ Weight, PJ van Jaarsveld, M Kruger


**Effects of fish oil diet on plasma lipoproteins and plasma lipid metabolism in vervet monkeys**

21

20

AJS BENADÉ, JE FINCHAM, CM SMUTS, MJ WEIGHT, PJ VAN JAARSVELD, M KRUGER

related to diet. Dietary ascorbic acid requirements under the conditions of experiments are defined. Statistically significant increases in calcium, zinc, vitamin E, and decreased vitamin B6 were associated with the atherogenic compared to the prudent diet (in plasma or serum). A 25% decrease in dietary fat and vitamin B6 requirements resulted from a separate study which detected very low folate status after chronic intakes of the atherogenic diet.21

**Summary and conclusions**

The African green monkey (Cercopithecus aethiops) has proven to be a suitable model for studying the effects of a variety of dietary components on plasma lipoprotein metabolism and atherosclerosis. This rhesus monkey was aged 17 adults females and 17 adults males. The Aethiops were used in this study, which enabled confirmation that atherosclerosis is more pronounced in males. Compliance was proven by physical records of food consumption and by changes in fatty acid content of tissues. Results did not provide any evidence that the fish oil was antiatherogenic. The therapeutic diet effectively reversed lipoprotein infiltration into arteries, as indicated previously by the prudent diet, but again components of advanced atherosclerosis such as cholesterol crystals, calcification and fibrosis did not regress in 20 months. Therefore minimal cerebral atherosclerosis is possibly because the walls of cerebral arteries are thin, almost like veins, which minimises tissue available for lipid accumulation. This suggests that the main pathogenesis of the atheromatous plaque may be by occult embolisation from carotid thrombi.

**Vervet monkeys and whole-food diets for studying the effects of dietary lipids on plasma lipoprotein metabolism and atherosclerosis**

ASIS Benadé, JF Fincham, CM Smuts, MJ Weight, PJ van Jaarsveld, M Kruger


**Effects of fish oil diet on plasma lipoproteins and plasma lipid metabolism in vervet monkeys**

21

20

AJS BENADÉ, JE FINCHAM, CM SMUTS, MJ WEIGHT, PJ VAN JAARSVELD, M KRUGER

related to diet. Dietary ascorbic acid requirements under the conditions of experiments are defined. Statistically significant increases in calcium, zinc, vitamin E, and decreased vitamin B6 were associated with the atherogenic compared to the prudent diet (in plasma or serum). A 25% decrease in dietary fat and vitamin B6 requirements resulted from a separate study which detected very low folate status after chronic intakes of the atherogenic diet.21

**Summary and conclusions**

The African green monkey (Cercopithecus aethiops) has proven to be a suitable model for studying the effects of a variety of dietary components on plasma lipoprotein metabolism and atherosclerosis. This rhesus monkey was aged 17 adults females and 17 adults males. The Aethiops were used in this study, which enabled confirmation that atherosclerosis is more pronounced in males. Compliance was proven by physical records of food consumption and by changes in fatty acid content of tissues. Results did not provide any evidence that the fish oil was antiatherogenic. The therapeutic diet effectively reversed lipoprotein infiltration into arteries, as indicated previously by the prudent diet, but again components of advanced atherosclerosis such as cholesterol crystals, calcification and fibrosis did not regress in 20 months. Therefore minimal cerebral atherosclerosis is possibly because the walls of cerebral arteries are thin, almost like veins, which minimises tissue available for lipid accumulation. This suggests that the main pathogenesis of the atheromatous plaque may be by occult embolisation from carotid thrombi.
related to diet. Dietary ascorbic acid requirements under the conditions of minimal cerebral, and docosahexaenoic acid possibly because the walls of cerebral arteries are thin, almost like veins, which minimises tissue available for lipid accumulation. This suggests that the main pathogenesis of contributive injury may be by occult embolisation from cardiac thrombi.

Summary and conclusions
The African Green monkey (Cercopithecus aethiops) has proven to be a suitable model for studying the effects of a variety of dietary components on plasma lipoprotein metabolism and atherosclerosis. The dietary sodium and potassium intake was a major factor in the development of atherosclerosis in the Green monkeys. The results of this study suggest that the dietary fat intake and the sodium intake in the diet have a significant effect on the development of atherosclerosis. This study also suggests that the dietary fat intake and the sodium intake in the diet have a significant effect on the development of atherosclerosis.

References


