Effect of Exercise on Blood Coagulation Time and Atherosclerosis of Cholesterol-Fed Cockerels

By NELTA HYDE WARNock, M.A., THOMAS B. CLARKSON, D.V.M. AND RICHARD STEVENSON, M.A.

In cholesterol-fed cockerels, brisk walking was found to exert a favorable effect on atherogenesis. In addition, exercise significantly lengthened blood coagulation times and increased body weight gains. Vascular and hepatic cholesterol concentrations were significantly lower in exercised than in nonexercised controls. Biochemical evidence is presented indicating a greater susceptibility of the brachiocephalic arteries to atherosclerosis than the other arteries examined.

Many investigators have suggested that lack of exercise is an important factor in atherogenesis.1-4 Keys and co-workers6 have recently reported a higher incidence of short blood coagulation times among business and professional men than among physically active railroad switchmen. The experiment reported here was designed to determine the effect of exercise on the blood coagulation time and the course of atherogenesis of cholesterol-fed cockerels. In such an experiment the validity of Keys' observations can be tested, in that the effects of extraneous factors can be better controlled, and a less ambiguous determination of the effects of exercise be achieved.

**Method**

Day-old, single-comb, white Leghorn cockerels were fed Purina Mash until they were 3 weeks old. They were then divided into 2 groups and placed in identical cages. Both groups were then given an atherogenic ration (Purina Mash with 1 per cent cholesterol, 4 per cent peanut oil) ad libitum for 14 weeks. The control group, consisting of 10 birds, remained caged throughout the experiment. The exercise group, consisting of 14 birds, was taken from the cage daily (5 days per week) and forced to walk briskly for 1 hour back and forth along a 30-foot concrete runway. It was estimated that the birds walked approximately 4.2 miles per week.

Food consumption remained equal for the 2 groups during the experimental period. Body weights were recorded at 5 and 14 weeks.

Before the daily exercise, .5 to 1 ml. of blood was collected from the alar vein of each bird (nonfasted) at the beginning of the experiment and weekly thereafter, except for seventh week, for 14 weeks. Total serum cholesterol determinations were made on each sample by the method of Zlatkis and co-workers.6

Blood coagulation times were done by the classic capillary tube method at the end of 7 and 14 weeks. The determinations were done in triplicate and the mean of the three determinations recorded as the blood coagulation time for each bird.

Both groups were killed for necropsy study at the end of the 14-week period. At necropsy, the thoracic aorta, abdominal aorta, right and left brachiocephalic, right and left internal iliac arteries, brain, and uniform portions of the liver were removed and assayed for cholesterol by the previously described technic.7

**Results and Discussion**

The results of the weekly serum cholesterol determinations are shown in figure 1. Using the formula of Little* for determining significance between the means of unequally sized groups, the differences in the 2 groups became significant at the fifth week ($p < 0.05$); thereafter, the magnitude of the difference between the 2 groups remained fairly constant.

Data concerning the effect of exercise on body weights of the cholesterol-fed cockerels are presented in table 1. The body weights of the exercised cockerels were significantly greater than for the caged controls. There were no differences in food consumption throughout the experiment. Rinzler and co-workers8 have reported greatly depressed body weight gains in cholesterol-fed rabbits. King, Clarkson, and...
FIG. 1. Effect of exercise on serum cholesterol levels. C, control group; E, exercise group. Ordinate, total serum cholesterol (mg./100 ml.); abscissa, weeks on diet. Standard deviations in mg./100 ml. are indicated at each point.

Warnock\textsuperscript{3} have reported higher average body weights for atherosclerotic cockerels receiving a hypocholesterolizing drug than for untreated cholesterol-fed controls. The difference produced by exercise would appear to reflect a difference in the degree of atherosclerosis of the cholesterol-fed cockerels.

The blood coagulation times at 7 and 14 weeks for the 2 groups of cockerels are presented in Table 2. The blood coagulation time was significantly longer for the exercised birds at 7 weeks and even greater at 14 weeks. These data support the idea that the blood coagulation time differences between professional men and railroad switchmen reported by Keys et al.\textsuperscript{6} are in fact due in large part to differences in exercise.

The tissue cholesterol concentrations of 7 tissues are detailed in Table 3 for both groups. The arterial cholesterol was reduced by exercise in all 5 of the arteries examined. The differences are statistically significant except for the brachiocephalic arteries. The higher cholesterol content of the brachiocephalic arteries as compared with the other arteries in both groups is noteworthy. It has been postulated by Blumenthal\textsuperscript{10} that the branches of the aorta proximal to the heart have an increased susceptibility to plaque formation due to vibrations brought about by sudden changes in the arterial tension during beginning of ejection and upon closure of the semilunar valves.

![FIG. 1. Effect of exercise on serum cholesterol levels.](image.png)

**Table 1.—Effect of Exercise on Body Weights of Cholesterol-Fed Cockerels**

<table>
<thead>
<tr>
<th>Group</th>
<th>Body weights (Gm.)</th>
<th>Fifth week</th>
<th>Significance</th>
<th>Fourteenth week</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>672±128.0</td>
<td>—</td>
<td>—</td>
<td>1655±148.2</td>
<td>—</td>
</tr>
<tr>
<td>Exercise</td>
<td>736±60.0</td>
<td>p&lt;0.2</td>
<td>1868±143.2</td>
<td>p&lt;0.01</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.—Effect of Exercise on Blood Coagulation of Cholesterol-Fed Cockerels**

<table>
<thead>
<tr>
<th>Group</th>
<th>Blood coagulation time (sec.)</th>
<th>Seventh week</th>
<th>Significance</th>
<th>Fourteenth week</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>108±30.7</td>
<td>—</td>
<td>150±50.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Exercise</td>
<td>163±48.2</td>
<td>p&lt;0.01</td>
<td>242±60.0</td>
<td>p&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.—Effect of Exercise on Tissue Cholesterol**

<table>
<thead>
<tr>
<th>Group</th>
<th>Thoracic aorta</th>
<th>Right brachiocephalic</th>
<th>Left brachiocephalic</th>
<th>Abdominal aorta</th>
<th>Internal iliacs</th>
<th>Hepatic</th>
<th>Brain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (age 12 wks.)</td>
<td>5.2±0.53</td>
<td>7.1±0.82</td>
<td>7.5±1.1</td>
<td>9.3±1.96</td>
<td>8.2±1.0</td>
<td>12.0±1.15</td>
<td>48.7±1.0</td>
</tr>
<tr>
<td>Control</td>
<td>17.8±4.96</td>
<td>33.1±11.2</td>
<td>31.1±10.24</td>
<td>18.2±3.29</td>
<td>15.5±4.3</td>
<td>107.2±17.7</td>
<td>68.0±12.95</td>
</tr>
<tr>
<td>Exercise</td>
<td>13.4±4.83</td>
<td>28.5±11.53</td>
<td>25.0±14.16</td>
<td>12.6±3.45</td>
<td>11.8±2.93</td>
<td>74.2±26.42</td>
<td>63.7±9.77</td>
</tr>
<tr>
<td>p</td>
<td>&lt;.05</td>
<td>&lt;0.2</td>
<td>&lt;0.4</td>
<td>&lt;.001</td>
<td>&lt;.01</td>
<td>&lt;.01</td>
<td>&lt;0.5</td>
</tr>
</tbody>
</table>
data presented here for the brachiocephalic arteries support the hypothesis of an increased susceptibility to atherosclerotic degeneration in the immediate branches of the aortic arch since, in cockerels the brachiocephalic arteries originate from the aortic arch proper only about 0.5 cm. distal to the origin of the aorta.

The effect of exercise on lipid metabolism in other animals has been studied by Peltonen and Karvonen and Brown and co-workers. The latter group observed a negative effect of exercise on cholesterol-fed rabbits. In our preliminary experiments cholesterol-fed rabbits were exercised in a revolving cylinder, but the experiment was abandoned because the method of exercising the animals appeared stressful. Stress has been shown to be capable of augmenting the degree of avian atherosclerosis resulting from cholesterol-fat feeding. As nearly as could be determined, brisk walking of the cockerels was in no way stressful.

**SUMMARY**

Evidence is presented that exercise arrests the progress of atherogenesis in cholesterol-fed cockerels. Blood coagulation times are significantly lengthened and body weight gains increased by exercising cholesterol-fed cockerels. Vascular and hepatic cholesterol concentrations were significantly smaller in exercised birds than in nonexercised controls. Biochemical data are presented indicating a greater susceptibility of the brachiocephalic arteries to atherosclerosis than the other arteries examined.

**SUMMARIO IN INTERLINGUA**

Es presentate datos biochimic que indica le susceptibility a atherosclerosis es plus grande in le arterias brachiocephalic que in le altere arterias examinate.

**REFERENCES**

Effect of Exercise on Blood Coagulation Time and Atherosclerosis of Cholesterol-Fed Cockerels
NELTA HYDER WARNock, THOMAS B. CLARKSON and RICHARD STEVENSON

Circ Res. 1957;5:478-480
doi: 10.1161/01.RES.5.5.478

Circulation Research is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1957 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7330. Online ISSN: 1524-4571

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circres.ahajournals.org/content/5/5/478