How-To-Do-It

An Inexpensive Variable Speed Treadmill to Measure Physiological Effects of Exercise on Laboratory Mice

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Physical and biochemical changes associated with exercise physiology are currently popular topics of conversation among the nonscientific community as well as areas of active scientific research. The importance of any significant beneficial changes would be of interest to nearly everyone. Because of the heterogeneity of the tested human subjects, however, it is very difficult to determine which individual factors do in fact produce desirable physical changes.

There are reports in the scientific literature of changes in body composition (Oscai & Holloszy 1969), metabolic rate (Holloszy 1977), blood glucose levels (Holloszy 1977), ventricular and total heart mass (Gleason & Vilkari 1968), total serum cholesterol (Lopez & Baldwin 1981), and high-density lipoprotein concentration (Lentonen & Vilkari 1968). Other reports cover total serum cholesterol (Lopez et al. 1981), mitochondrial size and concentration (Mole & Oscai 1971), capillary density (Leon & Bloor 1968) and muscle protein composition (Pitts & Bull 1977). Claims being made by the nonscientific community in the popular press and by personal testimony seem to reflect a desire for increased longevity, increased sexuality, better eyesight, better skin tone and elimination of disease, rather than to be the results of actual scientific research.

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The basic problem associated with measuring exercise physiology changes in human subjects is the difficulty in altering only one variable at a time. In all cases involving large sized groups of humans (N value such that parametric statistical tests could be used to detect significant differences), the subjects cannot be kept homogeneous for all of the variables. Because of differences in dietary intakes, heredity, initial physical state of health, type of exercise, severity of exercise and other variables in large groups of humans, it would seem that subjects other than humans are needed if specific effects are going to be studied. All, or nearly all, of the foregoing variables can be controlled by using specially bred and selected laboratory animals, such as mice or rats.

It is also necessary to record exact measurements of the imposed exercise. This article, with associated photographs and sketches, will provide you with the details for constructing an inexpensive exercise treadmill to use with lab mice or rats. It enables the experimenter to quantify the intensity of the imposed regimen. Various tests which we have run in our lab are also briefly described. The extensiveness of these tests, however, is limited mainly by the facilities of the laboratory.

The primary materials for the treadmill are:

1) at least a 1/15 hp brush type motor i.e. (Dayton 2Z779A);
2) a variable speed control i.e. (Dayton 4X796A);
3) two 10 × 30 cm wooden drums with a central 1 cm axle in each;
4) 2-10 cm pulleys with belt;
5) four 1 cm axle bearings;
6) 30 × 100 cm heavy vinyl cloth for

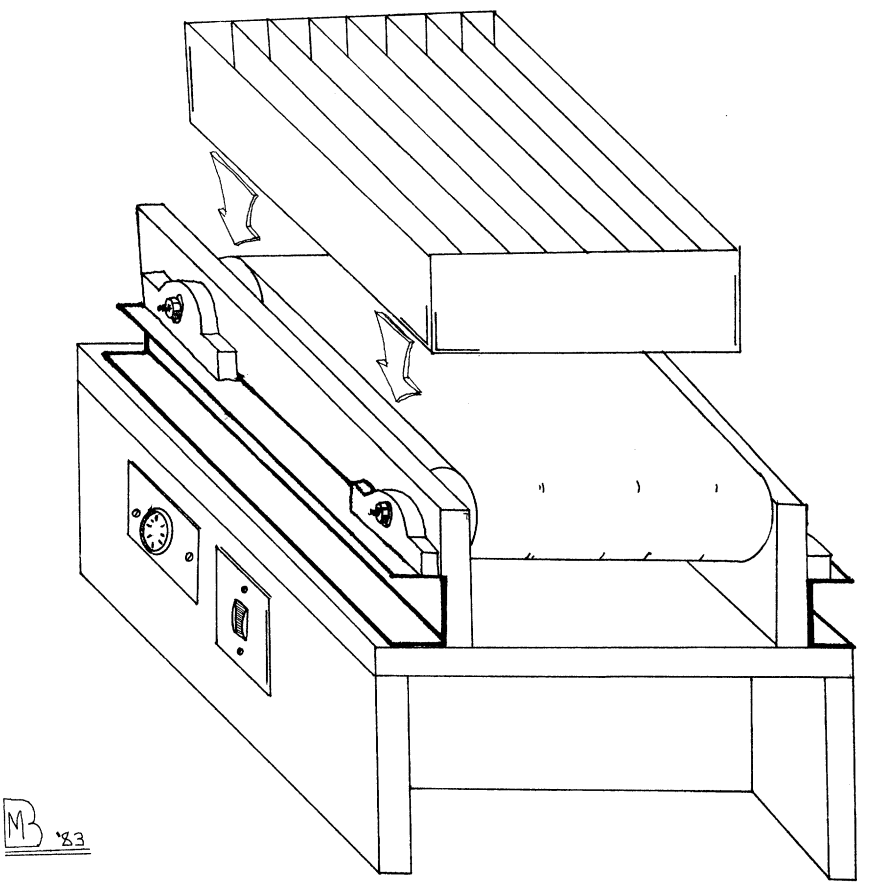

Figure 1. Alternate top sections can be placed over the revolving belt to accommodate larger animals in the treadmill.

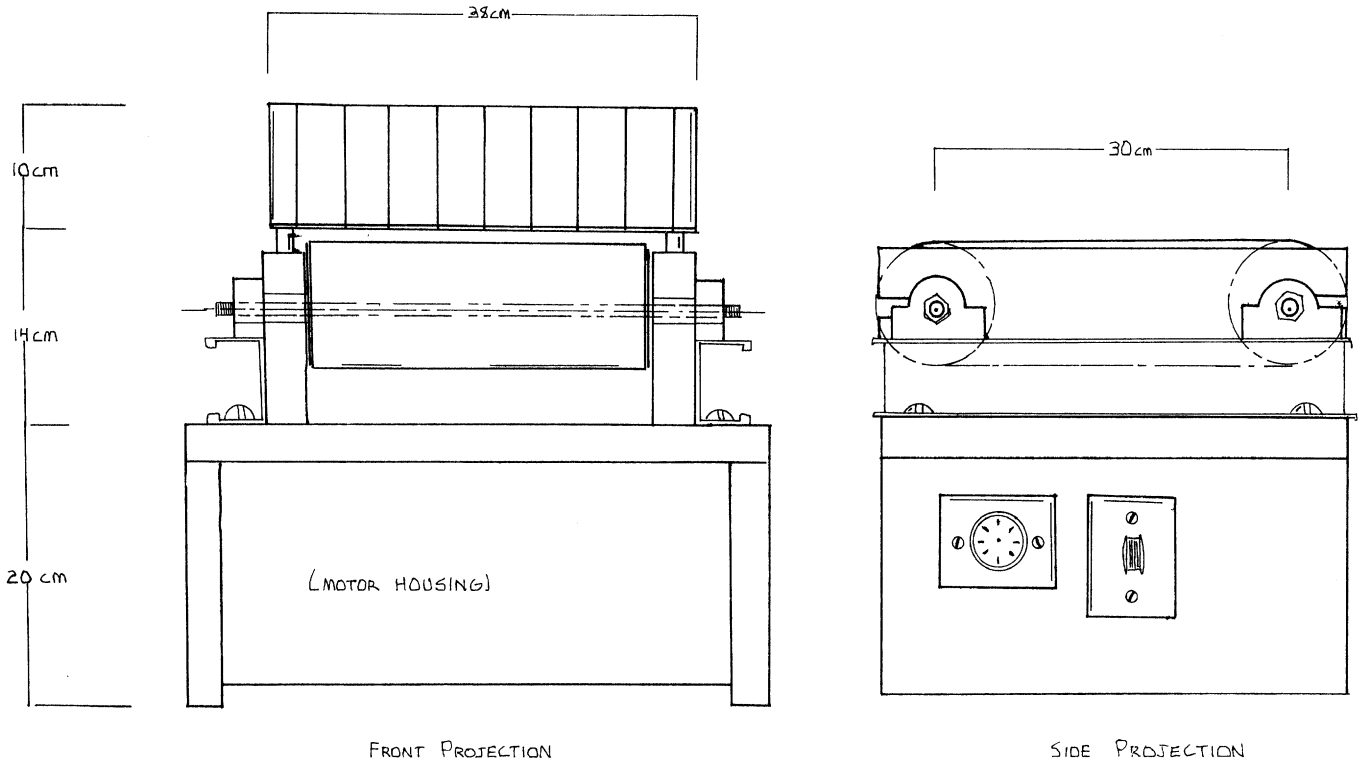

Figure 2. This treadmill was constructed (excluding labor) for under $75.00. All components can be purchased locally.

treadmill;
7) 7-10 × 30 cm plexiglass separaters;
8) adequate wood supports; and
9) misc. screws and staples.

The supporting wooden frame is cut and constructed as per diagram A. The rollers are attached within the mounted bearings and the pulleys, belt and motor are then mounted and adjusted as necessary. The heavy vinyl cloth can be stretched over the rollers and stapled together. The upper plexiglass dividers are necessary in order to guide the running rodents and to prevent confusion in the exercise pattern.

The treadmill could also be constructed with an elevating support on the bottom which would allow for an inclined grade variable to be considered. One method would be to simply block up one end of the treadmill to produce a given incline.

With this inexpensive apparatus and with carefully planned procedural steps, one can in fact measure physiological changes associated with a well defined exercise program in laboratory animals. Whether such results are applicable to man is, of course, open to debate.

As with humans, lab animals require a conditioning period involving both the time and the intensity (rate of treadmill movement) of exercise. We have found that lab mice 6-8 wks. of age can easily be conditioned over a two-week period of time to run for 20 min. at a rate of 12 meters/min. Although unconditioned to running in a regular pattern, they learn very quickly the correct direction of movement. It is suggested however, even after the conditioning period, that the animals not be left unsupervised. Minor accidents, which are rare, could result in some degree of cloth burn.

A great variety of conditions can be imposed upon the animals and several different factors can be quantified. The general guidelines to follow in conducting research with animals on the treadmill are as follows:

a.) Establish the rationale for conducting the research.
b.) Design the experiment so that all of the variables except one are controlled.
c.) Determine the experimental time period. Two time periods should be considered—when the first effects are observed and the effects at the conclusion of the experimental periods. Our experience has indicated that significant changes, if they occur, will appear within a ten-week period.
d.) Each group of animals should have at least six members for statistical analyses of the collected data.
e.) The animals need to be appropriately conditioned on the treadmill. The velocity and time will vary with the experimental animals used. We have found a two-week time period to be adequate for 4-week-old lab mice. The belt velocity should be increased from 4 to 12m/min. over 14 days. Some of the experiments we have performed in our high school research lab are listed below.

Experiment I.

Total cholesterol can be determined in a reasonably short period of time using the Ferro and Ham spectrophotometric method (Bauer, Acherman & Toro 1974).

Female lab mice, aged 30 weeks at

the start, were exercised on the treadmill at 12 m/min for 15 min. time periods following a two-week conditioning period. The three groups were:

Group 1. Cage exercise only
Group 2. Exercise 1 period (15 min)/wk
Group 3. Exercise 5 periods (15 min)/wk

At the conclusion of nine weeks of exercise, total cholesterol was determined for each group of six mice.

We have also performed determinations of HDL and LDL cholesterol using the Dow Chemical Co. Kits (Indianapolis, IN), however, these tests are very time consuming and relatively expensive.

Experiment II.

Post exercise oxygen consumption was also determined in our lab using the Phipps-Bird Manometer. Young female mice, aged four weeks at the start (mean mass of 22 g), were divided into four exercise groups. The four groups were:

Group 1. control-cage exercise only
Group 2. 10 min/day at 12 m/min for 5 days/wk
Group 3. 20 min/day at 12 m/min for 5 days/wk
Group 4. 40 min/day at 12 m/min for 5 days/wk

Following two weeks of conditioning and 11 weeks of exercise the post-exercise oxygen consumption was determined in multiple manometers immediately after the exercise period. These values need to be corrected to STP. Resting metabolic rates can also be determined and compared with post exercise metabolic rates.

Experiment III.

It is possible to calculate the percentages of the lipid intakes utilized by the different exercising groups. A diet of a known composition is fed to the mice, i.e. Purina Rodent Chow, and the feces are assayed for lipid content using the Van de Kammer Method (Van de Kammer 1949).

At nine weeks into the exercise period, the groups described in Experiment I. were analyzed for lipid utilization.

A variation of this experiment could involve altering the lipid composition of the diet.

Experiment IV.

Measurement of urine ketone levels can be coupled with the above metabolism experiment. Maintaining the mice in Nalgene Metabolic chambers and using Ames N-Multistix reagent strips, we verified the presence of the expected ketone in the three groups of Experiment I.

Percentage mass changes, food consumption, water intake, muscle protein concentration, urine metabolities, blood glucose, and hemoglobin concentrations are other values one can easily calculate to note any significant effects of treadmill running. Controlled experiments, involving only one changed variable, will allow students to make more definitive statements about the benefits of exercise programs.

References

Borer, K.T. et al. (1979). The effect of exercise and dietary protein levels on somatic growth, body composition, and serum lipid levels in adult hamsters. *Journal of Nutrition, 109*, 222-228.

Bauer, J.D., Ackerman, P.G.M. & Toro G. (1974). *Clinical laboratory methods*. St. Louis: C.V. Mosby Co.

Gleason, T.T. & Balwin, K.M. (1981). Cardiovascular responses to treadmill exercise in untrained rats. *Journal of Applied Physiology, 50*(6), 1206-1211.

Holloszy, J.O. et al. (1977). Physiological consequences of the biochemical adaptations to endurance exercise. *Annals of the New York Academy of Sciences, 301*, 440-450.

Lentonen, A. & Vilkari, J. (1978). The effect of vigorous physical activity at work on serum lipids with a special reference to serum high-density lipoprotein cholesterol. *Alta. Physiol. Scand., 104*, 117-121.

Leon, A.S. & Bloor, C.M. (1968). Effects of exercise and its cessation on the heart and its blood supply. *Journal of Applied Physiology, 24*(4), 485-490.

Lopez, S.R. et al. (1981). Decreased and continued physical activity and plasma lipoprotein lipids in previously trained men. *Atherosclerosis, 39*, 307-311.

Mole, P.A. & Oscai, L.B. (1971). Effects of exercise on cardiac weight and mitochondria in male and female rats. *American Journal of Physiology, 220*(6), 1944-1948.

Oscai, L.B. & Holloszy, J.O. (1969). Effects of weight changes produced by exercise, food restriction or overeating on body composition. *Journal of Clinical Investigations, 48*, 2124-2428.

Pitts, G.C. & Bull, L.S. (1977). Exercise, dietary obesity and growth in the rat. *American Journal of Physiology, 232*(1), R38-44.

van de Kammer, J.H., Huinink, H.T. & Weyers, H.A. (1949). Rapid method for the determination of fat in feces. *Journal of Biological Chemistry, 177*, 347-355.