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BRIEF COMMUNICATION

Activity Disc and Cage for Continuous Measurement of Running Activity and Core Temperature in Hamsters

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BORER, K. T. AND R. DENNIS. *Activity disc and cage for continuous measurement of running activity and core temperature in hamsters.* PHYSIOL BEHAV **50**(5) 1057–1061, 1991.—We describe a design for the modular horizontal activity disc and tandem cages suitable for continuous monitoring of spontaneous running and of core tempertaures in golden hamsters. An acrylic disc is equipped with a short brass axle. It is mounted inside a brass rotation sleeve at a 15° angle off the horizontal plane. The disc module fits firmly inside either half of the tandem cage when activity measurements are needed. Easy removal allows for alternative use of cages. Minor modifications of disc dimensions and of disc base permit the use of activity modules with juvenile hamsters. The short distance between disc surface and cage floor permits continuous measurement of core temperature as well as running activity.

Running wheels Cage design

ACTIVITY discs are devices which freely turn in the nearly horizontal plane and are used to measure levels of spontaneous running in small rodents. They are less frequently used than the activity wheels or drums which freely turn in the vertical plane, and to our knowledge, no commercial source of activity discs is available. Since they offer some special advantages in the studies of the controls and of the biological effects of running activity, we here review these advantages and provide a design for their construction.

APPLICATIONS OF THE ACTIVITY DISC

Activity devices are used to study endogenous rhythmicity of locomotor behavior (17) and to assess the motivational status of an animal (11, 14, 15), psychomotor effects of drugs (16), and biological effects of habitual exercise (4–6, 12). Not only are there species differences in the volume and pattern of voluntary running with the same type of activity device, but there are also species differences in the expression of this behavior using different activity devices (1). We have made extensive use of the horizontal activity disc in our studies with the golden hamsters (*Mesocricetus auratus*) and find that in this species the activity disc stimulates a higher volume of running than the vertical wheel and is thus the activity device of choice.

In a comparison of running activity elicited by either a disc or a vertical wheel in four species of laboratory rodents, the disc stimulated 12% more running activity in hamsters (13.2 ± 0.8 vs. 11.8 ± 0.8 km/day) while vertical wheels were between eight and twenty times more effective in gerbils, rats and ground squirrels (1). By stimulating a high volume of voluntary running, activity discs provide a sensitive device for studies utilizing spontaneous running behavior as the research object or as a research tool. Thus with the aid of this device we have been able to show that the stage of hamster development (5), its body energy content (2, 3, 10), the integrity of its limbic forebrain circuit (7, 9, 10), and the degree of stimulation of its opiate receptors (16) all significantly affect the volume of spontaneous running activity. In addition, we have discovered that habitual spontaneous running in mature hamsters induces oversecretion of growth hormone (6), accelerates somatic and skeletal growth (8), reverses photoperiodic anestrus (4), and leads to elevation of body core temperature (12).

Use of activity discs has been hampered by the lack of a standardized commercially available device. Our early disc design was an elaboration of a device described earlier (13). It precluded the possibility of simultaneous measurement of spontaneous activity and body core temperature because the distance between the disc surface and the receiver board located below the cage floor prevented the reception of radio signals. This disc was complicated to construct, prone to damage, and difficult to

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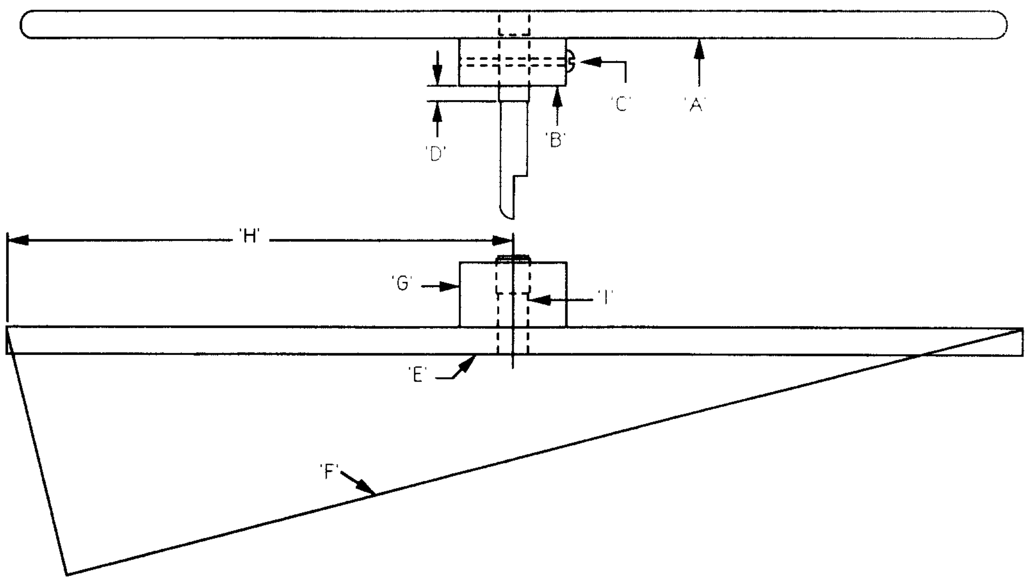

FIG. 1. Design of a horizontal activity disc (top) and its support base (bottom) in side view. Letter designations are: 'A' for disc, 'B' for acrylic rod segment, 'C' for the pin which immobilizes disc axle within the acrylic rod, 'D' for the protrusion of the axle sleeve beyond the segment, 'B,' 'E' for the support plate, 'F' for the length of the triangular walls of the support base, 'G' for the acrylic rod mount for the rotation sleeve, 'H' for the 127.5 mm distance between the upper edge of the support base and the rotation sleeve, and 'I' for the hole housing the rotation sleeve.

maintain. To resolve these several problems and increase the uniformity of function, we have recently designed a hamster activity disc which is easy to construct to specifications and trouble-free to maintain. Its modular design allows for its insertion inside cages, described here, which are suitable for continuous monitoring of running and body temperature. With a change in the diameter of the disc, this design permits measurement of running activity in hamsters of different sizes. This report describes our design for construction of a horizontal activity disc and of six tandem cages which can serve for continuous monitoring of running activity and of core temperatures in twelve individually housed hamsters.

DESIGN OF ACTIVITY DISC MODULES

Activity Discs

To construct twelve activity discs of dimensions that are appropriate for mature Syrian hamsters (*Mesocricetus auratus*), we use one half of a sheet of acrylic measuring 1219 mm (48 in.) × 1219 mm × 6.35 mm (0.25 in.). This sheet is first cut into three pieces, 715, 260 and 240 mm wide. The largest piece is used to make twelve discs 237 mm in diameter ('A' in Fig. 1). For use with juvenile hamsters, disc diameter is scaled down to 150 mm (5).

What remains of the largest piece (738 × 237.5 mm) is cut into ten of the 24 required strips 41 mm wide and 368 mm long for use as supports for the floor panels f and g. Other remnants are cut into fillet strips 15 to 25 mm wide for use as structural reinforcements of wall joints and as supporting braces for the partitioning wall.

Support Bases

The other two pieces (260 and 240 mm long) are cut into 12 rectangles, each 100 mm wide. The larger rectangles form the support plate upon which the disc is mounted ('E' in Fig. 1). The smaller rectangles are cut diagonally to form two orthogonal triangles ('F' in Fig. 1) with a 260 mm hypotenuse. The hypotenuse of the two triangles is affixed to the two sides of the support plate with dichloromethane solvent to produce a 15° incline off horizontal in the disc base and in the plane of the mounted disc. Thin fillet strips are glued inside the joints of the support base for greater structural support, leaving 10 mm of joint at either end uncovered.

Disc Axles

An acrylic rod 25.4 mm (1 inch) in diameter is next cut crosswise into twelve segments 11.5 mm long and into twelve segments 12.7 mm long. Shorter segments are glued in the center on the underside of the activity disc ('B' in Fig. 1). Longer segments ('G' in Fig. 1) are glued with their center 127.5 mm from the upper edge ('H' in Fig. 1) of the support plate.

Disc axles are 45.72 mm long and made out of a brass rod, 6.35 mm (0.25 inch) in diameter (Fig. 2). The free end of the rod is cut in half to a distance of 10.2 mm, and the outer surface of the halved end is ground smooth (Fig. 2, center). This protects the microswitch lever from breakage during the insertion of the activity disc into the rotation sleeve.

To create a supporting surface for the discs inside the rotation sleeve, twelve segments 15.24 mm in length are cut out of a brass tubing, 6.35 mm (0.25 inch) i.d. and 7.14 mm (9/32 inch) o.d. (Fig. 2, upper right). The edge of the cut segments should be left sharp but free of burrs. The sleeve is next soldered onto the disc end of the axle after light sanding (Fig. 2, lower right). The axle edge of the sleeve should be sharp and free of solder.

A 7.14 mm (9/32 inch) hole through the center of the segment 'B' and the disc fits the completed axle (Fig. 1). The sleeve on the axle should protrude 1.6 to 3.2 mm ('D' in Fig. 1) beyond the disc. The axle is prevented from slipping inside

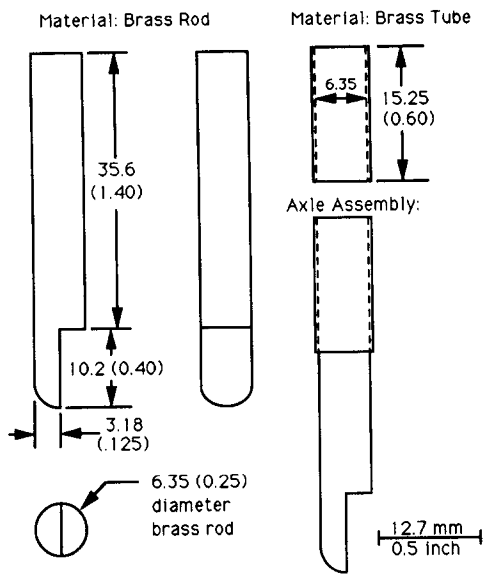

FIG. 2. Design, dimensions, and assembly of the disc axle. Numbers outside the parentheses refer to dimensions in mm, numbers within parentheses are in inches. See text for explanation.

the activity disc by a 1.6 mm pin or a 2/56 inch machine screw ('C' in Fig. 1) inserted into a 1.6 mm hole drilled through the segment 'B' and the contained axle. The axle immobilization step can be done before the permanent attachment of segment 'B' to the disc.

Rotation Sleeves

The disc axle turns inside a rotation sleeve which is made out of two pieces of brass tubing (Fig. 3, top) soldered together (Fig. 3, bottom). The shorter piece 7.62 mm in length (7.14 mm i.d., 7.94 mm, 5/16 inch, o.d.) is fitted 1 mm over the edge of the 20.3 mm length of narrower tubing (6.33 mm i.d., 7.14 mm o.d., Fig. 3, bottom).

The support base is completed by mounting the rotation sleeve inside the support base. A 7.14 mm (9/32 inch) hole ('I' in Fig. 1) through the center of the segment 'G' and the support plate 'E' allows the insertion of the rotation sleeve. Enlargement of the upper 6.3 mm of the hole to a diameter of 7.94 mm (5.16 inch) permits the rotation sleeve to sink deeper inside the support base but prevents it from slipping through the hole. Properly mounted rotation sleeve protrudes 3.2 mm above the surface of segment 'G' and bears the weight of the rotating disc axle.

Assembly of Disc Modules

The completed disc module consists of a disc and axle on one hand, and of an inclined support base on the other (Fig. 1). Different lubricants can be used to minimize disc axle friction inside the rotation sleeve.

Disc revolutions can be recorded by different methods. We frequently affix a subminiature switch (Cherry E61-50H) to the underside of the support plate 'E' so that the excised surface of the rotating axle closes, and the rounded surface opens, the microswitch. Wires connecting the microswitch to the counter circuit are routed under the tapered edge of the support base and threaded through a hole drilled in the side wall of the cage just

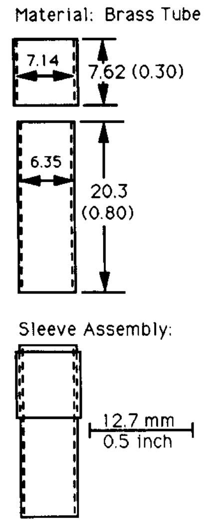

FIG. 3. Design, dimensions, and assembly of the rotation sleeve for the activity disc. Numbers outside parentheses refer to dimensions in mm, numbers within parentheses are in inches. See text for explanation.

above the floor line. Banana plugs and jacks can be used for ease of electrical connection and cage assembly.

Module dimensions ensure a close fit between the narrow ends of the support base and the side walls of tandem cages. Modular design allows for inclusion or removal of activity devices from tandem cages.

Tandem Cages

Each tandem cage provides individual housing for two hamsters and two of them can be constructed out of one sheet of acrylic (2438 × 1219 × 6.35 mm) if cut as shown in Fig. 4. Cages can be designed for permanent construction or for disassembly of walls to facilitate cleaning, storage, or transportation.

Cage walls are cut as shown in Fig. 4 and assembled as shown in Fig. 5. A standard sheet of acrylic will yield an 356 mm by 1219 mm remnant after the parts for two tandem cages shown in Fig. 5 have been cut. This piece is used to produce the remaining 14 strips 360 mm long and 41 mm wide which are then glued along the bottom edges of middle and side walls (d, c and e) to form the support for the floor plates f and g (Fig. 5, left). All the other remnants are used to make fillet strips.

Dichloromethane is used to glue together cage walls, floors, bottom, and acrylic strip reinforcements of the joints if a permanent construction of tandem cages is desired. With the back panel b on a flat surface, side walls c and e are affixed to panel b along its 368.3 mm edges and within its 539.8 mm edges. The center wall d is glued at the midpoint of panel b (Fig. 5, top). Floor pieces are glued next, and fillet strips are used to reinforce all of the joints thus created. The bottom panel h is then affixed to the bottom edges of the back panel b, of the side walls c and e, and of the partitioning wall d to create two enclosures for the radiotelemetry receiver boards (Minimitter Co., Inc., Sunriver, OR). Finally, the front panel a is affixed to the front edges of the walls c, d, and e, and of the floor panels f and g (Fig. 5, upper right) leaving two 41.3 × 260.3 mm apertures for insertion of the temperature telemetry receiver boards.

To produce the collapsible version of tandem cages, panel h is omitted from its design (Fig. 5). Instead of acrylic fillet strips,

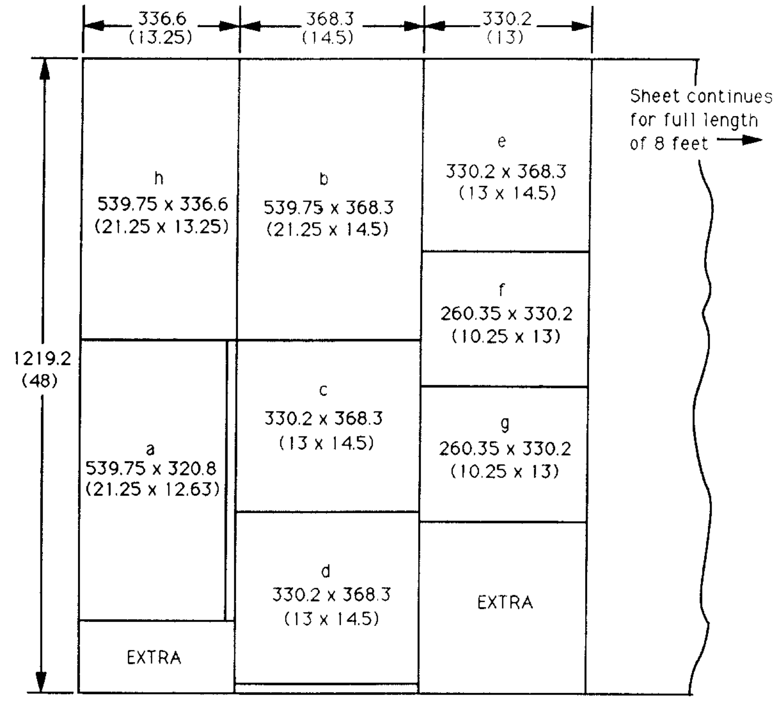

FIG. 4. Configuration and dimensions of acrylic pieces needed for construction of one tandem cage out of one half of a sheet of acrylic. Numbers outside parentheses refer to dimensions in mm, within parentheses, in inches. Panels a and b are for the front and back walls of the tandem cage. Panels c and e are for the side walls and panel d for the partition between the two compartments of the tandem cage. Panels f and g form the floors of the two compartments and panel h forms the floor of the two enclosures for the radiotelemetry receiver boards. See text for details of assembly.

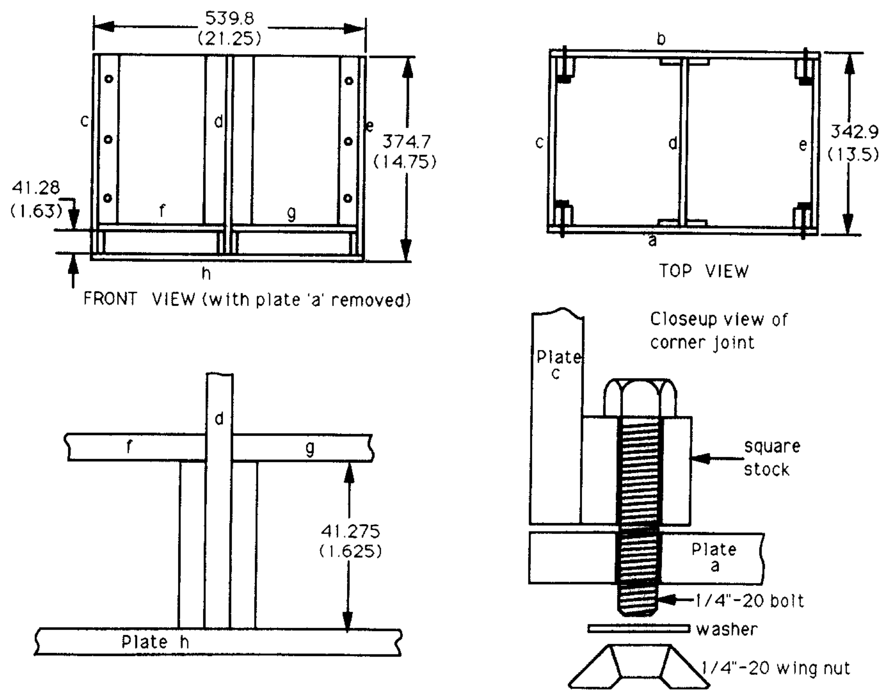

FIG. 5. Assembly of the tandem cage (above), side view left, top view right. The detail (below left) is a close-up view of the joint between the bottom plate h, partition d, and the supports for the floor panels g and f. Detail (below, right) shows the joint between the acrylic stock glued to plates c and e and the panels a and b.

four 320.5 mm lengths of 19 mm or 25.4 mm acrylic square stock are used as attachments for plastic or metal bolts in the four corners of the tandem box (Fig. 5, top). Each square stock piece is glued with dichloromethane to both inside edges of walls c and e, 47.65 mm above their base (Fig. 5, upper right). Next, three holes are drilled through each joint between front or rear panels (a or b) on one hand, and the square stock on the adjacent side walls c and e, on the other (Fig. 5, upper right). Hole size should be appropriate to the diameter of the bolts. The twelve bolts should be longer than the combined thickness of square stock and cage wall to allow for joint tightening with a nut (Fig. 5, lower right). Fillet strips should be used on the front and back walls (a and b, respectively) to create a groove for support of the center partition d.

COMMENTS

Simplicity of design, ease of maintenance, and functional versatility are features of the modular horizontal disc. Disassembly for sanitation or storage is easy. Modular design permits use of animal cages with activity discs present or absent. Minor modifications allow the use of activity discs with hamsters of different sizes. The short distance between the running surface of the disc and the temperature telemetry receiver under the cage floor allows for continuous monitoring of core temperature in running hamsters.

ACKNOWLEDGEMENT

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REFERENCES

1. Borer, K. T. Characteristics of growth-inducing exercise. Physiol. Behav. 24:713–720; 1980.
2. Borer, K. T. The nonhomeostatic motivation to run in the golden hamster. In: Morrison, A. R.; Strick, P. L., eds. Changing concepts in the nervous system. New York: Academic Press; 1982:539–567.
3. Borer, K. T.; Bonna, R.; Kielb, M. Hippocampal serotonin mediates hypoactivity in dietarily obese hamsters: A possible manifestation of aging? Pharmacol. Biochem. Behav. 31:885–892; 1988.
4. Borer, K. T.; Campbell, C. S.; Tabor, J.; Jorgenson, K.; Kandarian, S.; Gordon, L. Exercise reverses photoperiodic anestrus in golden hamsters. Biol. Reprod. 29:38–47; 1983.
5. Borer, K. T.; Kaplan, L. R. Exercise-induced growth in golden hamsters: Effects of age, weight, and activity level. Physiol. Behav. 18:29–34; 1977.
6. Borer, K. T.; Kelch, R. P. Increased serum growth hormone and somatic growth in exercising adult hamsters. Am. J. Physiol. 234: E611–E616; 1978.
7. Borer, K. T.; Kelch, R. P.; Peugh, J.; Huseman, C. Increased serum growth hormone and somatic growth in adult hamsters with hippocampal transections. Neuroendocrinology 29:22–33; 1979.
8. Borer, K. T.; Kuhns, L. R. Radiographic evidence for acceleration of skeletal growth in adult hamsters by exercise. Growth 41:1–13; 1977.
9. Borer, K. T.; Peters, N. L.; Kelch, R. P.; Tsai, A. C.; Holder, S. Contribution of growth, fatness and activity to weight disturbance following septohypothalamic cuts in adult hamsters. J. Comp. Physiol. Psychol. 93:907–918; 1979.
10. Borer, K. T.; Potter, C. D.; Fileccia, N. Basis for the hypoactivity that accompanies rapid weight gain in hamsters. Physiol. Behav. 30:389–397; 1983.
11. Collier, G. H.; Hirsch, E.; Levitsky, D.; Leschner, A. I. Effort as a dimension of spontaneous activity in rats. J. Comp. Physiol. Psychol. 23:858–866; 1966.
12. Conn, C. A.; Borer, K. T.; Kluger, M. J. Body temperature rhythm and response to pyrogen in exercising and sedentary hamsters. Med. Sci. Sports Exer. 22:636–642; 1990.
13. Hoffman, R. A.; Robinson, P. F.; Magalhaes, H. The golden hamster: Its biology and use in medical research. Ames: The Iowa University Press; 1968.
14. Kavanau, J. L. Compulsory regime and control of environment in animal behaviour. I. Wheel running. Behaviour 20:251–281; 1963.
15. Kavanau, J. L. Wheel running preferences of mice. Z. Tierpsychol. 23:858–866; 1966.
16. Potter, C. K.; Borer, K. T.; Katz, R. V. Opiate-receptor blockade reduces voluntary running but not self-stimulation in hamsters. Pharmacol. Biochem. Behav. 18:217–223; 1983.
17. Richter, C. P. Biological clocks in medicine and psychiatry. Springfield: C. C. Thomas; 1965.