Acceleration associated with rotation of Animal Care Systems carousel racks

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The unique design of the Animal Care Systems carousel racks maximizes rodent cage density. The rack rotates on its axis to bring cages directly to laboratory personnel. Acceleration refers to the rate of change in velocity over time (that is, the rate at which an object speeds up or slows down). Since Animal Care Systems carousel racks require rotation to view and access cages, this study was undertaken to approximate the acceleration that a rodent would experience during routine rotation of the rack by personnel, and to compare this motion to those laboratory rodents may undergo routinely in day to day activities.

Materials and Methods

Acceleration was measured using a MicroStrain 3DM-GX1 accelerometer and accompanying 3DMG201 software (MicroStrain, Williston, VT). Acceleration was measured in six different scenarios. For rotation of the Optimice® rack (Animal Care Systems, Centennial, CO), data was taken on either one full rotation of the rack in 30 seconds (recommended speed) (#1) or a full rotation in 12 seconds (much above the recommended speed, almost 3 times faster) (#2). The accelerometer was placed in the front (widest part) of an empty cage since this is where motion experienced in the cage would be highest. Acceleration was also measured while a cage was undocked and docked as gently as possible in both an Optimice rack (#3) and a library-style motorized individually ventilated cage (IVC) rack (#4). Acceleration was then recorded as the Optimice rack was wheeled down the hallway and turned (#5) (as is often done in animal facilities when racks are moved within or between rooms) and compared to the acceleration as a front seat passenger in a car that made a left-handed turn at 16 kph (#6). Each scenario was similarly repeatable for at least 3 trials.

Results

When the rack was rotated at the recommended speed, one full rotation in 30 seconds, acceleration was negligible (less than ±0.05 m/s^2) and therefore undetectable with our sensor (a recording of 0.05 m/s^2 or less is undetectable with the sensor we used). The data has a -3db roll off at 50 Hz; therefore, all data is diminished after ~50 Hz, and no high frequencies are detectable. Acceleration in the Optimice rack when rotated above the recommended speed (one full rotation in 12 seconds (5 rpm)) was recorded at 0.16 m/s^2, considerably less than any of the other scenarios tested except at the recommended rotation speed. The acceleration measured when a cage is undocked and docked as gently as possible in the Optimice and a library-style IVC rack was similar and resulted in the highest measured acceleration in this study (5.1 m/s^2 and 4.7 m/s^2, respectively). A mouse in an Optimice rack moved at 0.3 m/sec experiences what a passenger in a car that turns left at 16 kph might encounter (2.0 m/s^2 vs 1.7 m/s^2) (Figure 1).

Discussion

Animal Care Systems carousel racks require rotation to view and access cages. This study measured the acceleration that a rodent is exposed to during routine rotation of the rack by laboratory personnel, and compared it to those that laboratory rodents may undergo routinely in day to day activities, for example, inhouse transport and undocking and docking of the cage on an IVC rack. Hurst and Litwak (2012) measured accelerative forces associated with routine inhouse transportation of rodent cages. The authors measured forces for different modes of transport within an animal facility, including transport by hand

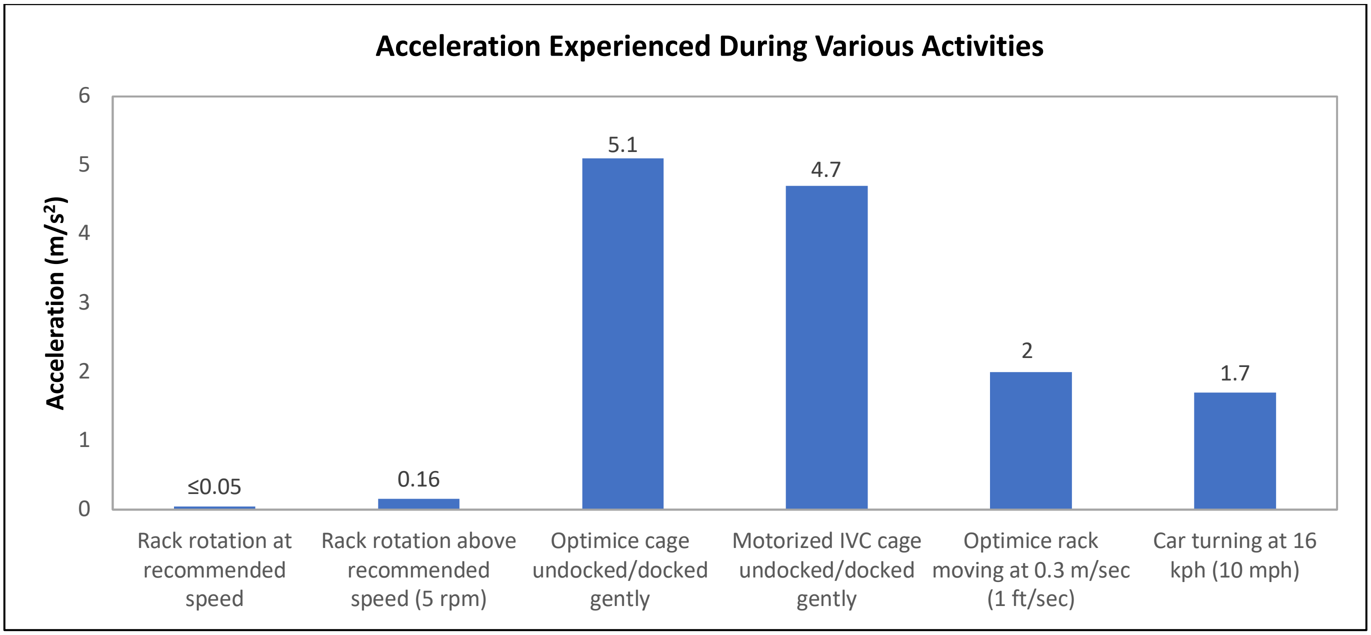

Figure 1. Acceleration experienced during various activities. When the rack was rotated at the recommended speed, acceleration was negligible (≤0.05 m/s^2). When the rack was rotated above the recommended speed, acceleration was considerably lower (0.16 m/s^2) than any of the other additional conditions tested. A cage that was undocked/docked gently in both an Optimice and a motorized rack resulted in the highest acceleration measured (5.1 m/s^2 and 4.7 m/s^2, respectively). Acceleration experienced by a mouse in a cage on an Optimice rack moving at 0.3 m/sec and by a car passenger turning left at 16 kph were comparable (2.0 m/s^2 and 1.7 m/s^2).

and with different types of carts. They found acceleration means for the Z-axis (vertical) between 1.24 m/s2 to 8.60 m/s2 for all the different transport types tested, with up to 17.31 m/s2 as a maximum single value. They also found that static cages on stainless steel shelving and cages on ventilated racks with motors either mounted on top of or remote from the racks experienced acceleration up to 0.1 m/s^2.

Our results found that when the rack is turned very quickly, almost 3 times faster than the recommended speed, acceleration is only 8% of the motion experienced by rodents who are moved on an Optimice rack at 0.3 m/sec and is only 3% compared to a cage that is gently undocked/docked, procedures experienced by mice in the vivarium routinely. The acceleration measured is also exceedingly less (0.3-13%) than the acceleration recorded with routine transportation of rodent cages in the study by Hurst and Litwak. In addition, the average continuous angular acceleration of the rack is much less disruptive than the average intermittent acceleration in the vertical Z-axis experienced during routine transport. Garner *et al.* (2018) found that at an acceleration of 0.05 m/s^2, mice did not show any discernible behavioral response compared to higher speeds tested. Hence, the acceleration in the carousel rack is negligible (±0.05 m/s^2) when the rack is turned at a reasonable speed and less than the acceleration from the constant vibration felt in a standard motorized individually ventilated cage (up to 0.1 m/s^2).

To watch how a petri dish of water behaves when the carousel rack is rotated very quickly (one rotation in 12 seconds), use this link: https://www.youtube.com/watch?v=KqIxfOgz-9I.

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References

Garner AM, Norton JN, Kinard WL, Kissling GE, Reynolds RP. 2018. Vibration-induced Behavioral Responses and Response Threshold in Female C57BL/6 Mice. JAALAS 57(5): 447–455.

Hurst K, Litwak K. 2012. Accelerative Forces Associated with Routine Inhouse Transportation of Rodent Cages. JAALAS 51(5), 544-547.