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The Effects of the ground reaction force on the muscle-tendon systems about Guinea Pig joints

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Background

Each limb of the limb joints of a quadruped is used differently during locomotion, and it is necessary to recognize the mechanical role each plays. The effects of the ground reaction force on the ankle, knee, and hip joints of Hartley albino guinea pigs were studied in uphill, downhill, and level situations to determine the spring-like capacity of the muscle-tendon systems that act about the limb joints.

Method

Eight guinea pigs ran on a track inside an enclosure which housed four force plates and a dual axis X-ray system to capture 3D motion. The x-rays allowed two high-speed cameras to record videos of the guinea pigs over the force plates. See figure 1 and 2. Movements in the x, y, and z directions were recorded for analysis with the videos. Graphs 1 thru 3 are examples of the force data collected. The guinea pigs ran on a level plane and on a 15˚ incline/decline. Force and X-ray data were collected.

Results

The graphs below show the force data acquired from the force plates. Using these for the force, it can be joined with the X-ray motion to determine joint moments. The product of joint moment and joint angular velocity yields joint power, and the area under the power-time curve gives joint work during each footfall.

Graph 1: A representation of the x, y, and z forces on the FR, HR in a level plane.

Graph 2: A representation of the x, y, and z forces on the LF, LH in a 15˚ incline.

Graph 3: A representation of the x, y, and z forces on the LF, LH in a 15˚ decline.

Discussion

Previous experiments on goats by David Lee proved that
• Foreleg GRF was reduced on an incline
• Hind leg GRF was reduced on a decline
More data will be collected to determine whether the same holds for guinea pigs. Then, the joints can be modeled as actuated by a spring (tendon) and motor (muscle) to determine the capacity for elastic energy storage and the spring constants (stiffness) that minimize work done by the motors. By understanding the movements of the guinea pigs’ joints, the findings can be used later to assess mechanical joint function in animals with weight bearing versus non-weight bearing exercise. These results will help characterize joint dysfunction in osteoarthritis and lead to improved prevention, treatment and management.

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References