

Functional Anatomy of Kangaroo Rats

Abstract Body : Introduction and Objective: Kangaroo rats are highly specialized for bipedal hopping locomotion. In their native habitat, these animals experience a range of complex and demanding terrain, ranging from soft sand to irregular rocky slopes. We hypothesize that the anatomy of the foot-ankle muscle-tendon complex enables these animals to navigate such terrain while maintaining smooth hopping locomotion. Therefore, the goal of this project was to characterize the functional morphology of the plantar foot and plantaris muscle-tendon unit.

Materials and Methods: I dissected the foot and ankle of five desert kangaroo rats (*Dipodomys deserti*) with body masses ranging from 83g-115g. Once exposed, the motion of the plantaris tendon was recorded with video while alternatively pulling on the tendon proximal and distal to the calcaneus. The video data was analyzed using image processing software (Kinovea) to quantify changes in length and metatarsophalangeal (MTP) joint angle.

Results: The plantar foot anatomy of a kangaroo rat consisted of three layers. The first layer: Plantaris Tendon has bilateral attachments on the calcaneus and continues to the MTP joint where the tendon for digits 1-3 splits into two to insert onto the medial and lateral aspects of the middle phalanx. However, digit four was found to be structurally different. Its tendon does not split and instead travels laterally and inserts onto the medial middle phalanx. The actions of the plantaris muscle is plantarflexion at the ankle joint and flexion of the MTP and proximal interphalangeal (PIP) joints. The second layer, FDL, runs posterior to the medial malleolus and inserts onto the distal phalanx of digits 1-4. The actions of FDL are plantarflexion at the ankle joint and flexion of the MTP, PIP, and DIP joints. The third layer consists of the FDB. The FDB muscle originates from the tarsal sheath and inserts onto the medial and lateral aspects of the proximal phalanx of digits 1-4, which results in flexion at the MTP joint. With an understanding of the plantar foot anatomy of a kangaroo rat, the change in tendon length with toe flexion and extension was quantified. The average change in tendon length for the tibial portion and plantar portion was approximately 2.76mm and 2.492mm, respectively. There is no significant difference between the two but it does demonstrate how the tibial portion can be slightly more flexible than the plantar portion of the plantaris tendon. Similarly a greater change in tendon length and angle change is noticed with toe extension but no difference when comparing the tibial and plantar portion of the plantaris tendon.

Conclusions: The outcome of this study is the first plantar foot anatomy atlas of the kangaroo rat, which has 3 layers: plantaris tendon, FDL, and FDB. The quantifying the change in plantaris tendon length with toe extension and flexion, there is a greater change when toes are extended but not a significant difference when comparing the tibial portion versus the plantar portion of the plantaris tendon. This could imply the importance of how the plantaris tendon functions in unison with its bilateral attachment at the calcaneus, where some forces could be transferred.

Significance: Understanding how underlying anatomy enables animals to maneuver in complex terrain with outstanding stability has the potential to inform the design of new lower limb prosthetics and legged robots, most of which currently perform very poorly under these conditions.