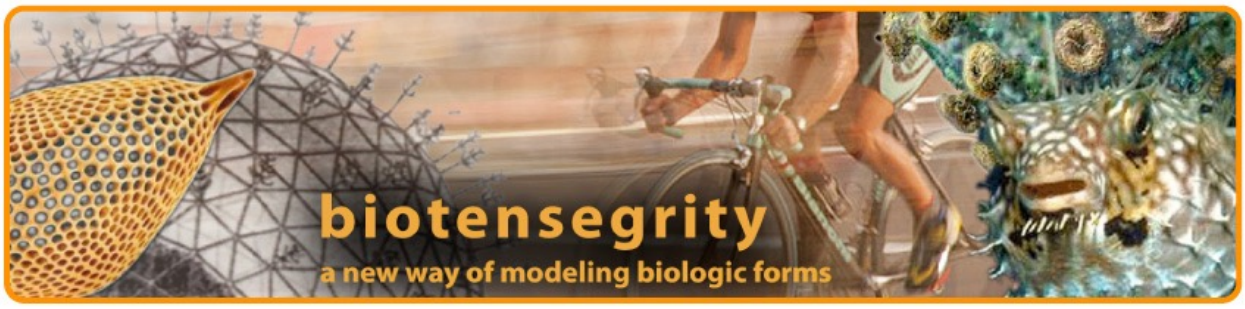
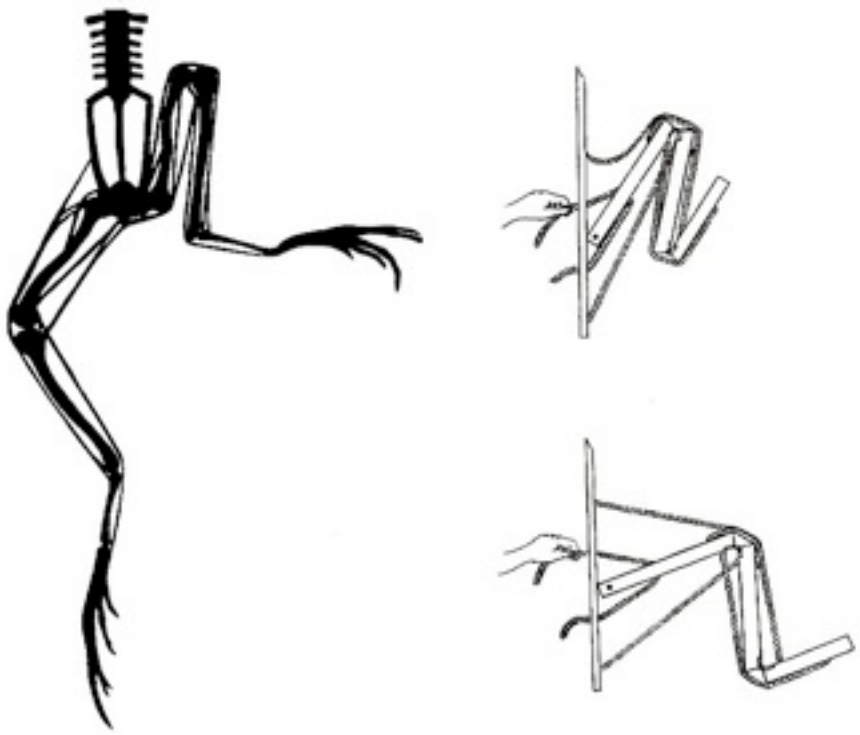


Multi-joint Muscles: The Stealth Movers

Muscles that cross two or more joints (MJM) are common and are part of most motion segments that comprise two or more bones and joints and their associated motors. Lombard (1903) astutely recognized that these muscles had opposite effects on successive joints. For example, the quadriceps muscle group will flex the hip and extend the knee. Its so called "antagonist" (see (Huijing 1999; Huijing and Baan 2001a; Huijing and Baan 2001b for a discussion of the fallacy of agonists and antagonists), the hamstrings, will extend the hip and flex the knee. As reported by Inman (Inman and others 1981), Lombard constructed a model using frogs' legs and replaced the two joint muscles with taught cords. He then put the frog through its jumping paces and demonstrated that flexion of the hip created simultaneous flexion of the knee, ankle and foot, while extension of the hip created simultaneous extension of the knee ankle and foot. Lombard showed that the muscles maintain the same lengths during the entire motion of flexion and extension. Inman explains, that by preventing undue shortening of the muscles during extension, the muscles can continue to exert their maximal tension during the initiation of the leap.



Drawings from Lombard (1903)
Note all major muscles extend over two or more joints. With cords replacing major muscles,flexing and extending the hip produces simultaneous flexion and extension of the knee and ankle

Let's kick this up a notch. What is good enough for the frog should be good enough for us. Evolution dictates that energy efficient mechanisms will always win out and this is certainly an energy efficient mechanism. What Inman failed to note is that the study showed that two joint muscles in the jumping frog and, we can assume, the running human or any other creature using the same balanced muscle technique, will have MJMs that remain isometric and isotonic through a full cycle of movement. It costs energy to increase tension in a muscle, but considerably less energy to just maintain its tone, keeping it isotonic. Isometric and isotonic muscles are 'blind' to EMG evaluations. In other words, the MJMs will be operating, as Inman states, at their maximum tension, but the EMG will read as if they are non-functioning. All that is necessary is some one joint muscle to flip the hip joint, or any other joint in the complex, and that would keep the whole mechanism running.

Sit someone on a bicycle and adjust the seat height to its optimum position. Anyone who has ever ridden a bike knows that point - peddling becomes smooth and easy. At that position, set the muscle tone and then

extending the hip, extends the knee, extends the ankle, and extends the toes, all linked as described in Lombard's experiment. All the MJMs remain isometric and isotonic, and it would take a one joint muscle somewhere in the system to keep the wheels going around. Hooked to an EMG recorder, only one muscle would give a burst indicating any activity, and that may be enough to carry on for several cycles. Studies done as shown here are not with the rider at maximum position on the bicycle, so there are muscle firings all over the place. These firings seem out of synchronization with the activity performed - in my mind I see it as the body is seeking the most efficient use of the muscles that would be to take advantage of the isometric-isotonic synchronizations.

Let's kick this up one more notch. What happens from the hip down can, just as easily, happen from the hips up. There are no boundaries between body and limb, it is a continuum. If all the muscles that cross multiple joints follow that same pattern as described by Lombard in 1903, there could be a kinetic chain that flows from one end of the body to the other. Setting the body tone to just the right level of tension would be like adjusting the bicycle seat to just the right height. As we discussed in the paper on resting muscle tension, each activity is associated with an appropriate myofascial tension that is set throughout the system. If the body takes advantage of the MJM mechanisms as described by Lombard, rhythmic patterned movements such as walking running, swimming, etc., could be accomplished with minimal muscular contractions, with the MJMs in a 'steady state' of tone, and the one joint muscles in the body pumping the swing.

All of this would happen in stealth, as the EMGs would be fooled into thinking that only single joint muscles were functioning. How would we know?

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