

# PASSIVE MUSCLE FORCE MAY PROPEL THE FINGER DURING TOUCH-TYPING

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## The Keystroke Movement

Touch-typing on a computer keyboard involves many highly coordinated movements of the upper extremity. The fundamental movement, however, is the keystroke (Flaunders, 1992). During an isolated keystroke, the fingertip first rises on average 16 mm above the intended key, a back swing of sorts. It then accelerates downward depressing the key overcoming the force needed to activate the switch mechanism. The maximum downward velocity (~0.5 m/s) occurs as the fingertip first contacts the keycap. After about 100 ms the fingertip rises releasing the keycap.

## Fine-wire EMG of Extrinsic Finger Muscles

The fine-wire EMG signals of the extrinsic muscles of the index finger indicate that the finger flexors do not actively propel the finger downward towards the key (Dennerlein, 1998). Rather the onset of EMG activity is 50 ms prior to the first contact of the fingertip with the keycap, 13 ms after the downswing has begun (Figure 1). Since EMG precede the actual force production by as much as 50 ms the role of the flexor activation must be to overcome the force of the key switch. The switch force alone is enough to stop the motion of a slower moving fingers. But what does propel the finger downward?

## Tendon force during a keystroke

During the open carpal tunnel release surgery of five carpal tunnel syndrome patients, a tendon-force transducer (Dennerlein, 1997) was mounted on the flexor digitorum superficialis of the long finger. The patients then tapped on a key switch simulating touch-typing. A video camera recorded the position of the fingertip. One of the five subjects replicated the back swing motion observed in touch-typing. During the back swing and downswing movements, the tendon force followed a repeatable pattern with respect to the fingertip position (Figure 2).

## Discussion

The force levels seen in the tendon followed a pattern very similar to the passive muscle force curves (e.g. McMahon, 1984). According to a simple mechanical representation of the finger rotating about the MP joint, the tendon force is large enough to accelerate the finger to velocities observed in touch-typing. Hence, the back swing motion of the finger increases the passive force of the flexor muscles. The extensors then simply let go of the finger and allow the potential energy stored in the elastic like properties of the muscle tendon unit to accelerate the finger. This "elastic" force returns to zero when the finger approaches the keycap, but this occurs with the onset of the active muscle force.

There are several limitations to this study. First, the role of the intrinsic muscles during a keystroke is still unknown. Second, the tendon force data is from only one subject during a tapping, not a typing task. Third, there were no EMG recorded during the tendon force experiment, and fourth, the motion data was from a 30 Hz video camera with poor accuracy. Nonetheless the data is still very suggestive towards the use of passive muscle force to propel the finger during a keystroke.

## References:

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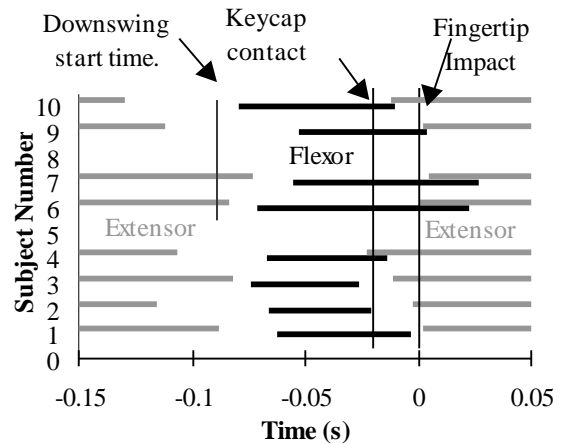


Figure 1: EMG Timing where the onset of the flexors is after the downswing begins (Dennerlein, 1998).

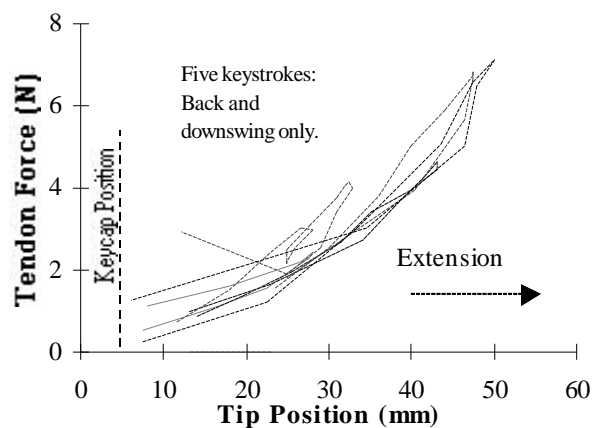


Figure 2. Tendon force during the back and downswings.

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