Science & Cycling
4-5 Juli 2018, Nantes, France

MUSCLE-TENDON BEHAVIOUR DURING SPRINT IN ROAD CYCLISTS: EFFECT OF THE FORCE-VELOCITY CONDITION.

Robin Maxime, Hauraix Hugo, Nordez Antoine, Dorel Sylvain.

University of Nantes, Laboratory “Movement, Interactions, Performance” (EA 4334), Faculty of Sport Sciences, France

INTRODUCTION: The “force-velocity” test in cycling is classically used to determine the maximal force- and power-velocity capacities of the lower limb muscles (Dorel, 2018). However, the biomechanical constraints related to this multi-joint task induce a specific coordination of muscles with different architectural and anatomical properties. From recent years, ultrasound allowed to better understand the muscle-tendon interactions in vivo and to determine the contributions of tendinous tissues and contractile structures during tasks such as walking or running (Ishikawa et al., 2005). The aims of the current study were i) to describe fascicle-tendon behaviours of a mono-articular muscle: *vastus lateralis (VL)* and a bi-articular muscle: *gastrocnemius lateralis (GL)* during sprint cycling and ii) to determine whether both fascicle and muscle-tendon unit shortening velocities are influenced by the force-velocity condition (i.e. pedalling rate).

METHODS: Eleven highly trained cyclists (21.9 ± 4.5 years, 177.5 ± 4.7 cm, 67.3 ± 4.6 kg, > 12 000 km/year) performed two series of 4-s maximal sprint cycling in four isokinetic conditions on a Lode Excalibur sport (60, 90, 120 and 160 rpm), with 3 min of rest between each sprint and 20 min recovery period between both series. The muscle-tendon unit (MTU) length was obtained using anthropometric models and kinematics data (optitrack, 120 Hz). Ultrafast ultrasound was used to measure the fascicle length of *VL* in the first series, and *GL* in the second series (Aixplorer, Supersonic Imagine; 500 to 2000 Hz according to the pedalling rate). An automatic tracking method (Farris et al., 2016) allowed to obtain fascicle length (and velocity by derivative) during the entire pedalling cycle, and the tendinous tissues length was calculated as the difference between muscle-tendon unit and the horizontal length of fascicle (Kurokawa et al., 2001).

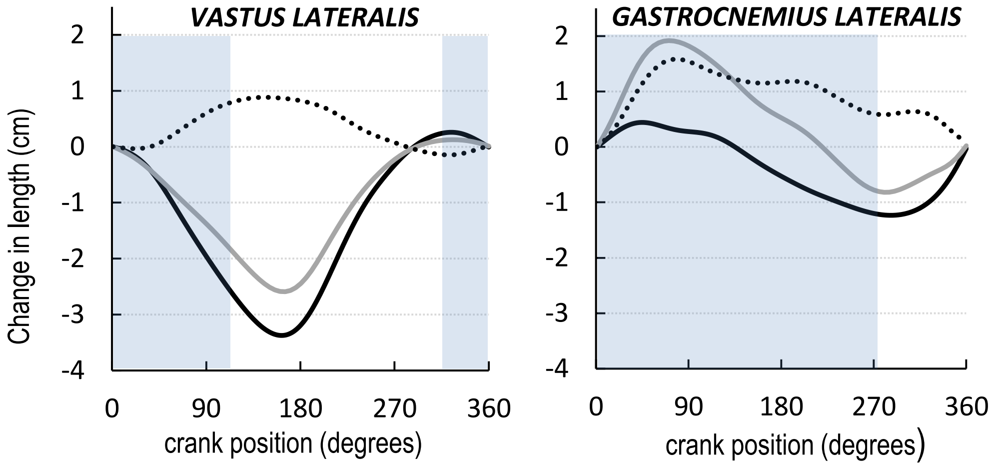

Figure 1: Length changes of fascicle (▬), muscle-tendon unit (▬), and tendinous tissues (······) of VL and GL as a function of crank position (0° = crank up) during the sprint at 120 rpm. Blue area represents the period of activity of each muscle.

RESULTS: The behaviour of VL during its period of activity is characterized by a unique phase during which both MTU and muscle fascicle shorten (-20° to 150°, i.e. concentric mode) while tendinous tissues slightly lengthen. For GL two phases were observed: a first during the extension (0-100°) characterized by a dorsiflexion of the ankle associated with a very slight lengthening and shortening of the muscle fascicle (i.e. quasi isometric behaviour), while MTU and tendinous tissues lengthen; a second characterized by a plantarflexion (100-270°) associated with a shortening of the MTU and both the muscle fascicle and tendinous tissues (Figure 1). The ANOVA with repeated measures demonstrates a main effect of the pedalling rate on the mean MTU shortening velocity for VL (5.68, 8.48, 10.09, 13.01 cm. s^{-1}, $p<0.001$) and muscle fascicle (6.83, 10.05, 13.36, 16.77 cm. s^{-1} for 60, 90, 120 and 160 rpm, respectively, $p<0.01$). Concerning GL, no effect of pedalling rate was observed on both muscle fascicle and MTU mean shortening velocities during the period of activity (Figure 2); except a lower muscle fascicle shortening velocity at 60 rpm compared to the other conditions ($P<0.05$).

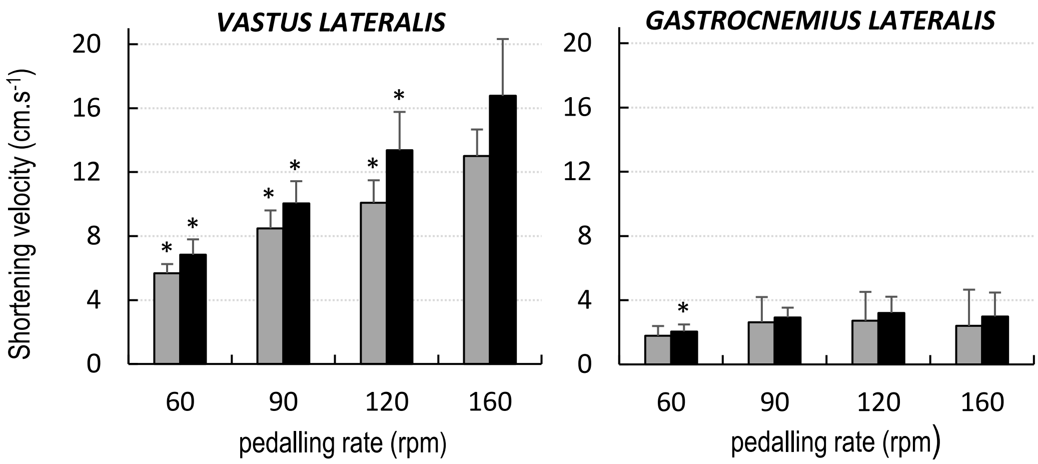

Figure 2: Mean shortening velocity of MTU (grey) and muscle fascicle (black) as a function of pedaling rate (rpm) during their activity period. (* for significant differences between the considered condition and the direct higher pedalling rate condition).

DISCUSSION/CONCLUSION: VL and GL have different muscle-tendon behaviours during a maximal pedalling task. For VL, MTU shortening is largely related to shortening of the muscle fibres and both demonstrate a concentric contraction. Then, the increase in pedalling rate induces an important increase in muscle fascicle shortening velocity and then a decrease in force capability of the contractile component. For instance, in the maximal power output condition (i.e. 120 rpm), the mean muscle fascicle shortening velocity is 20.5 cm. s^{-1} (between 70 and 100°), corresponding to almost 50% of its Vmax determined during single-joint leg extension (Hauraix et al., 2017). The behaviour of GL is more complex with MTU lengthening while fascicle is quasi isometric, followed by a shortening phase of all components, highlighting the role of tendinous tissues (i.e. elastic energy storage-release process). Interestingly, this quasi isometric behaviour may not be influenced by pedalling rate. This is explained by the decrease in the ankle range of motion and length change of the fascicle at high pedalling rates, which can be interpreted as a strategy to limit the increase in shortening velocity and continue to transmit the force to the pedal. These findings have important consequences to better understand the knee and ankle muscle-tendon behaviours during cycling and can help us in orientating strength training routines for cyclists.

Keywords: Force-velocity relationship, Fascicle-tendon interactions, Ultrafast ultrasound, cycling task.

REFERENCES:

- Dorel S, et al., 2018. Mechanical Effectiveness and Coordination: New Insights into Sprint Cycling Performance, in Biomechanics of training and testing.

- Farris, D. J et al., (2016). UltraTrack: Software for semi-automated tracking of muscle fascicles in sequences of B-mode ultrasound images. *Computer methods and programs in biomedicine*.

- Hauraix et al., (2017). Muscle fascicle shortening behaviour of vastus lateralis during a maximal force–velocity test. *European journal of applied physiology*.

- Ishikawa et al., (2005). Interaction between fascicle and tendinous tissues in short-contact stretch-shortening cycle exercise with varying eccentric intensities. *Journal of Applied Physiology*.

- Kurokawa et al., (2001). Behavior of fascicles and tendinous structures of human gastrocnemius during vertical jumping. *Journal of Applied Physiology*.