# Torque-length relationship of vastus lateralis fascicles: effect of velocity and pre-activation on optimal length

**T. Tallio**[1], A. Nordez[1], L. Lecarpentier[1], S. Dorel[1]

1. Nantes Université, Movement - Interactions - Performance, MIP, UR 4334, F-44000 Nantes, France
Email: sylvain.dorel@univ-nantes.fr

## Summary

This study aimed to investigate the effect of joint velocity (50°.s$^{-1}$ to 450°.s$^{-1}$) and of pre-activation (eccentric or isometric contractions prior concentric) on the torque-length relationship on the vastus lateralis muscle. Fascicle length was measured with dual probe ultrasound. Models nicely fitted the torque-angle and the torque-length relationships ($R^2$ of 0.91 ± 0.08) for each joint velocity except for 450°.s$^{-1}$. We also obtained good fitting of these relationships with pre-activation at 100°.s$^{-1}$ ($R^2$ of 0.90 ± 0.17) but not at 300°.s$^{-1}$. We found no difference of optimal angle nor optimal fascicle length with increased joint velocity. No effect of pre-activation was reported, despite a decrease of maximal torque in isometric pre-contraction. These results suggest a dynamic interaction between muscle and tendon to keep the same optimal fascicle length.

## Introduction

Torque-angle relationship is widely used in research as a proxy of the muscle force-length relationship. This measure is commonly realised in isometric contractions on a single joint at various angles, and compared to multi-joint dynamic tasks [1]. Some studies have demonstrated a shift of the optimal angle when joint velocity increased [2], but none of them, to our knowledge, have investigated if this shift of optimal angle was caused by a shift of the optimal fascicle length. Moreover, a recent study aimed to describe the effect of pre-activation on torque production and fascicle behavior [3], but it did not explore its effect on torque-length relationship. Therefore, this study investigates the effect of velocity and pre-activation on torque-length relationship.

## Methods

21 physically active participants (14 males and 7 females) performed maximal isometric voluntary contractions at six knee angles ranging from 45° to 110° (0° full knee extension) and isokinetic contractions at five velocities ranging from 50°.s$^{-1}$ to 450°.s$^{-1}$). Participants were also asked to do eccentric and isometric maximal contractions prior to the isokinetic ones at 100°.s$^{-1}$ and 300°.s$^{-1}$. Fascicle length of the vastus lateralis muscle was measured with ultrasound using a dual probe customized apparatus. We then modelized torque-angle and torque-length relationships in each condition [4]. After normality check, a one-way ANOVA with repeated measure was used to compare maximal torque, optimal angle and optimal length across all conditions.

## Results and Discussion

Data presented here is for 8 participants, the remaining are still in processing. We fitted with great accuracy the torque-angle (Figure 1) and the torque-length (Figure 2) relationships ($R^2$ of 0.91 ± 0.08), for every joint velocity except 450°.s$^{-1}$. This result could be due to the difficulty of participants to reach this velocity on the ergometer, related to both muscle activation and mechanical braking on the ergometer.

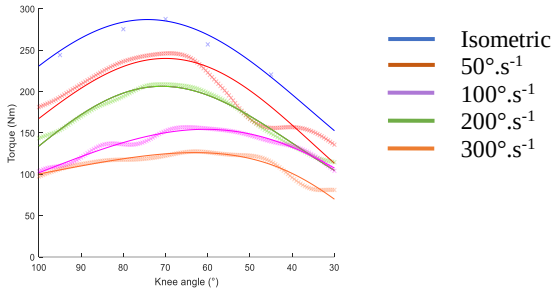


**Figure 1:** Example of the Torque-Angle relationships modelized in isometric and isokinetic conditions on one participant. Cross bars represent experimental data and line the modelized data.

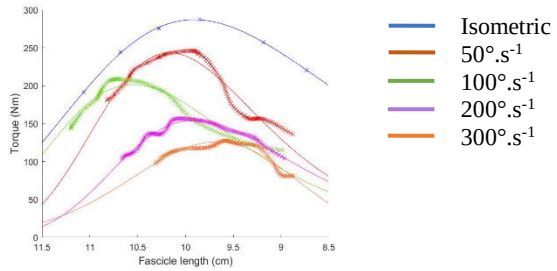


**Figure 2:** Example of the Torque-Length relationships modelized in isometric and isokinetic conditions on one participant. Cross bars represent experimental data and line the modelized data.

For the joint velocities modelized, ANOVA revealed a significant effect of joint velocity on maximal torque ($p<0.001$), as it decreased with the increased velocity. However, we found no effect of velocity on optimal angle despite a low tendency ($p=0.125$) to change. Statistical analysis also demonstrated no effect of joint velocity on optimal length ($p=0.84$), suggesting that it does not affect fascicle length to produce force. For pre-activation, we found a decrease of maximal torque with isometric pre-activation (-13.7% from isokinetic; $p<0.01$) but no differences of optimal angle ($p=0.238$) nor optimal length ($p=0.975$), suggesting different muscle-tendon interactions.

## Conclusions

In conclusion, we demonstrated that an increase of joint velocity was associated with modifications of maximal torque but not with changes of the optimal angle and fascicle length. Pre-activation did not induce alterations of optimal angles nor fascicle lengths. Further analysis will give us a deeper comprehension of muscle-tendon interactions involved in isokinetic testing.

## References

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