HAL
open science

Force-Velocity-Endurance (FoVE) Model: a new in situ method for functional muscle evaluation in murine models.

Maximilien Bowen, Christophe Hourdé, Anne-Cécile Durieux, Damien Freyssenet, Pierre Samozino, Baptiste Morel

To cite this version:

Maximilien Bowen, Christophe Hourdé, Anne-Cécile Durieux, Damien Freyssenet, Pierre Samozino, et al.. Force-Velocity-Endurance (FoVE) Model: a new in situ method for functional muscle evaluation in murine models.. 20th annual congress of the French Myology Society, Nov 2023, La Baule, France. hal-04285501

HAL Id: hal-04285501

https://hal.science/hal-04285501

Submitted on 14 Nov 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Force-Velocity-Endurance (FoVE) Model :

A new in situ method for functional muscle evaluation in murine models

M. Bowen[1], C. Hourde[1], A-C. Durieux[2], D. Freyssenet[2], P. Samozino[1] and B. Morel[1*]

LIBM, [1]Savoie-Mont Banc University, Chambéry, France. [2]Jean Monnet University, Saint-Etienne, France

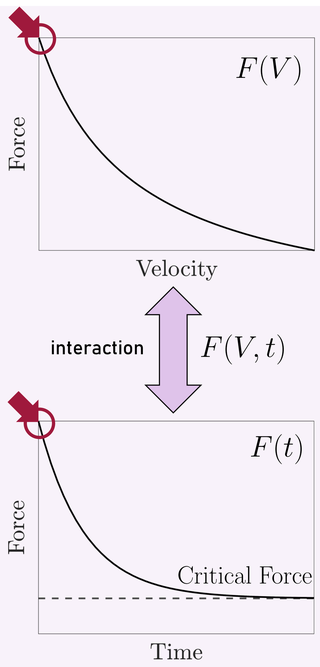
This work was supported by French National Research Agency [ANR -22-CE14-0073] - *baptiste.morel-prieur@univ-smb.fr

Introduction

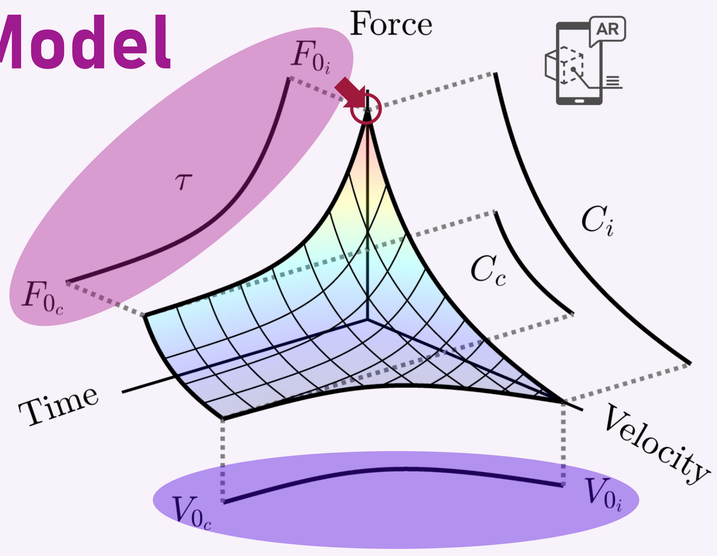
In murine models, muscle evaluation is traditionally based on muscle mass or force capacity under isometric conditions at null velocity.

Maximal isometric force (○) is a specific condition of two relationships: the **Force-Velocity F(V) [1]** at V=0 and **Force-Time F(t) [2]** at t=0 (without fatigue).

F(V) and **F(t)** have been studied separately, while interactions exist. Muscle functional capacities can be explored using a Force-Velocity-Endurance Model **F(V,t).**



Model



Single Integrative FoVE Model :

Explains the evolution of force **F** as a function of 2 variables: Velocity **V** and time **t** (fatigue).

7 FoVE parameters:

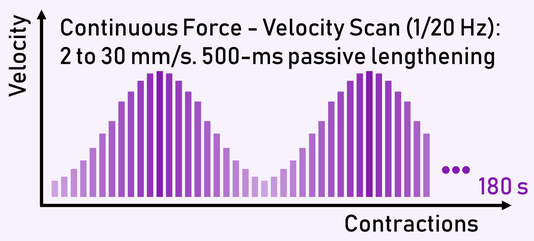
- **F0i** : Initial Isometric Force
- **F0c** : Critical Isometric Force
- **V0i** : Initial Maximal Velocity
- **V0c** : Critical Maximal Velocity
- **Ci** : Curvature of Fi(V) relationship
- **Cc** : Curvature of Fc(V) relationship
- **τ** : Typical decay time of F0 and V0

$$F(V,t) = F_{0_i} \cdot \left(\frac{V_{0_i} - V}{V_{0_i} + C_i \cdot V}\right) e^{-\frac{t}{\tau}} - F_{0_c} \cdot \left(\frac{V - V_{0_c}}{V_{0_c} + C_c \cdot V}\right) \cdot \left(1 - e^{-\frac{t}{\tau}}\right)$$

Protocol

Single in situ FoVE Protocol :

Force measurement during a 3-min continuous scan of imposed velocities, on isokinetic ergometer (Aurora Scientific).



Isolated Muscles (M)

- Tibialis Anterior **TA**
- Gastrocnemius **GA**

Electrical Stimulation (S)

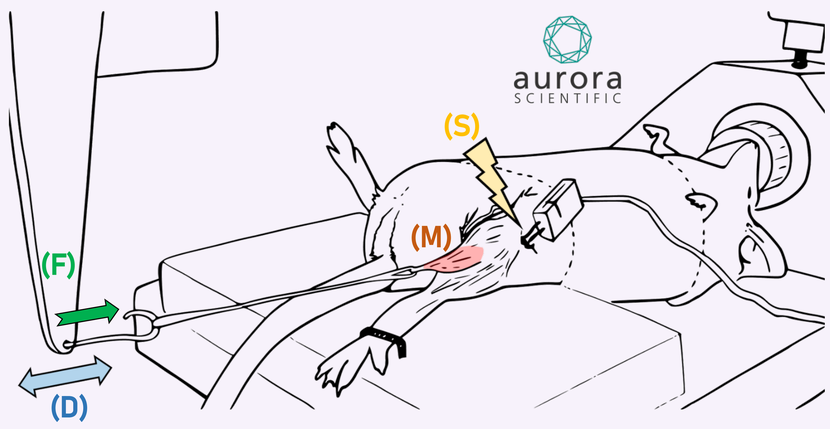
- Tetanic nerve stimulation
- Frequency: 100Hz

Isokinetic displacement (D)

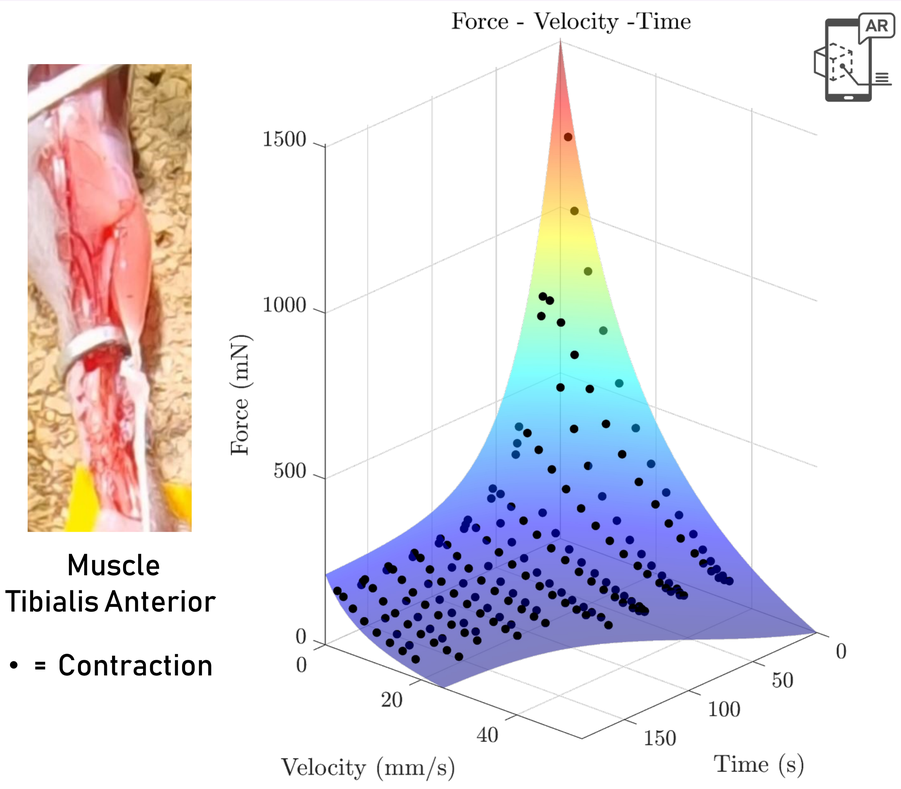
- Range: 2mm/s to 30mm/s
- Shortening: 1.5mm

Force Measurement (F)

- Maximal force
- Concentric phase



n=24 muscles : 12 Mice WT (C57BL/6) (6 ♀; 6 ♂)

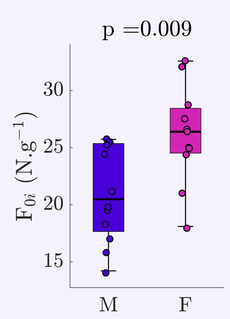


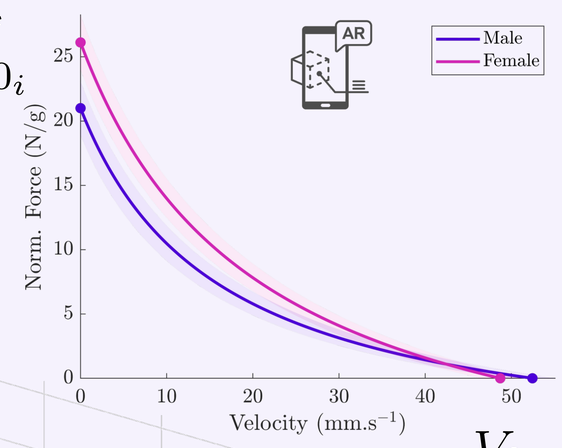
Results

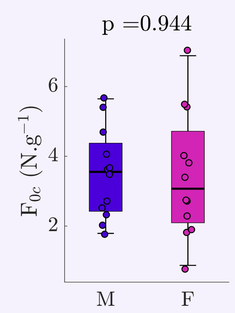
Typical result:
Sexual dimorphism ♀ ♂

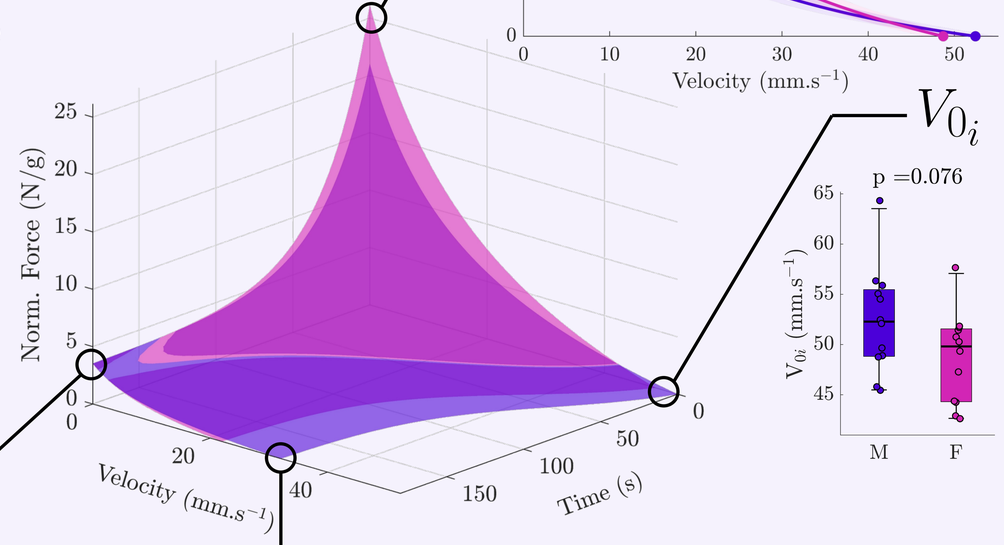
Discrete parameters analysis:

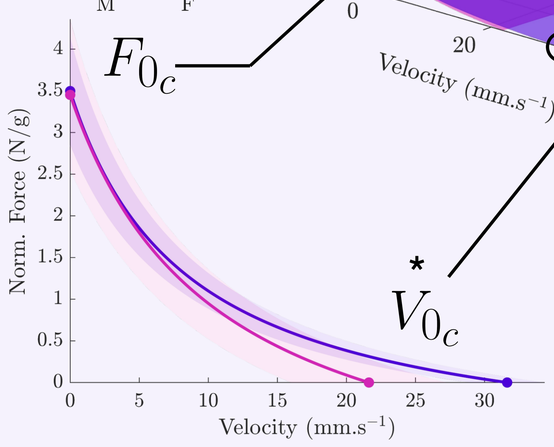
- **F0i** : Female > Male
- **V0c** : Male > Female
- **F0c , V0i , τ** : no diff.

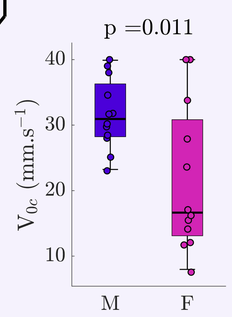












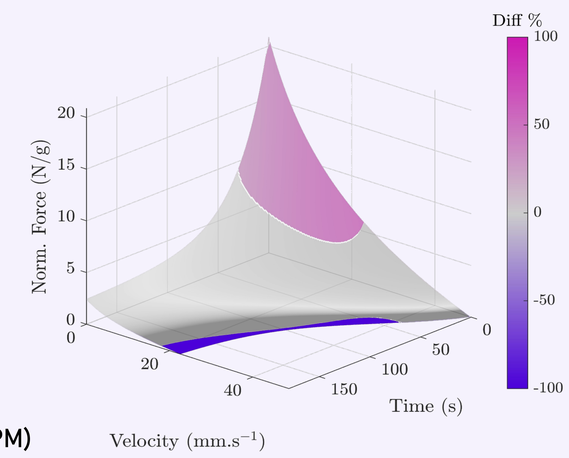
Goodness of fit :
r² = 0,98 ± 0,01
RMSE = 0,3 ± 0,3 N/g

ANOVA 2 factor (Sex / Muscle)

Continuous parameters analysis:

Areas of significant difference between 2 groups (colored area):

Female > Male
Male > Female



ANOVA Statistical Parametric Mapping (SPM)

Conclusion

- The maximal isometric force traditionally assessed does not reflect all muscle contraction capacities.
- FoVE evaluation provides a complete mapping of muscular function by describing the force production capacities at all velocity and fatigue levels.
- FoVE approach can be used in vivo in humans (e.g. translational research).

References

[1] A.V. Hill 1938 The heat of shortening and the dynamic constants of muscle. Proc. R. S.
[2] R.H. Morton 1996 A 3-parameter critical power model. Erg.