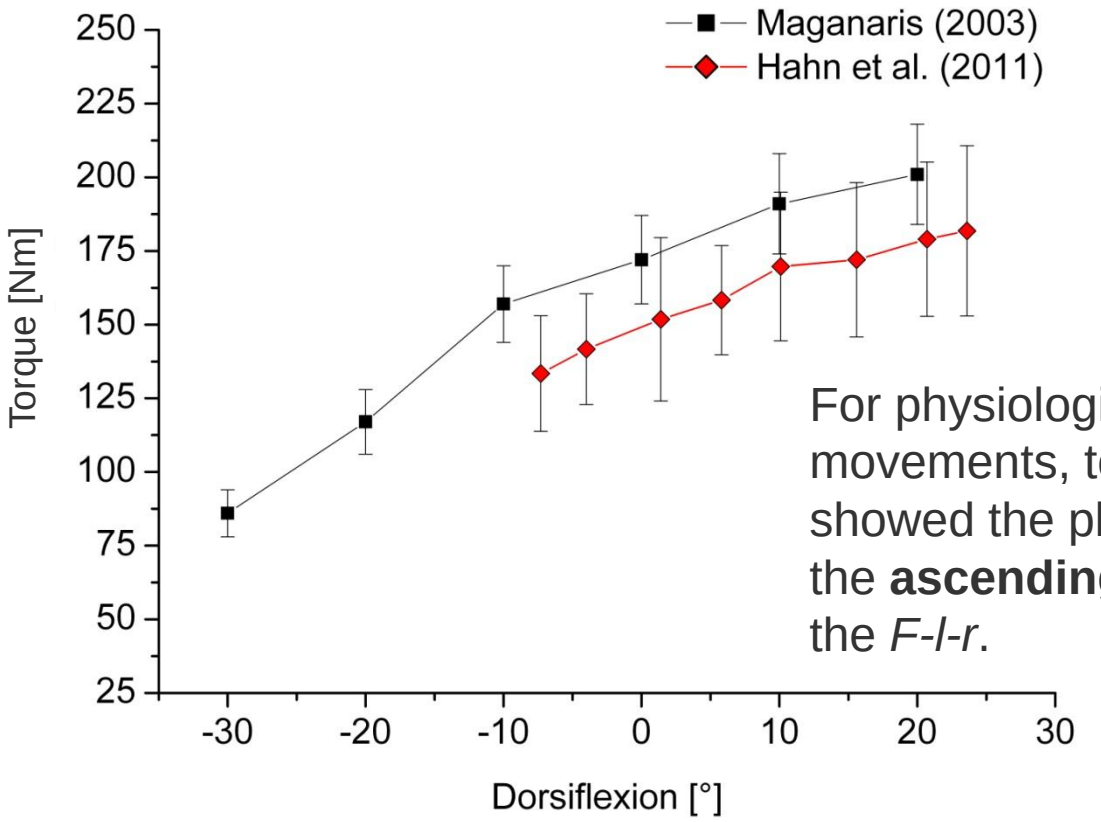
ISEK 2012
XIX CONGRESS OF THE INTERNATIONAL SOCIETY OF ELECTROPHYSIOLOGY AND KINESIOLOGY

Neuromechanics of the ankle joint muscles during isolated and combined activation

[1, 2] Daniel Hahn, [1] Wolfgang, K. Seiberl

[1]Department of Biomechanics in Sports [2]Department of Training & Diagnostics
Faculty of Sport & Health Science, Technische Universität München

Force-length-relation *(F-l-r)* of the ankle joint



For physiological ROM of **single-joint** movements, torque-angle measurements showed the plantar flexor muscles acting on the **ascending limb and plateau region** of the *F-l-r*.

Force-length-relation *(F-l-r)* of the ankle joint

(Hahn et al., *JBM* (2011), 44:2059-2065)

Multi-joint leg extension =

- combined extension of ankle, knee and hip joint

→ combined activation of lower extremity muscles

A isolated activation of the plantar flexor muscles

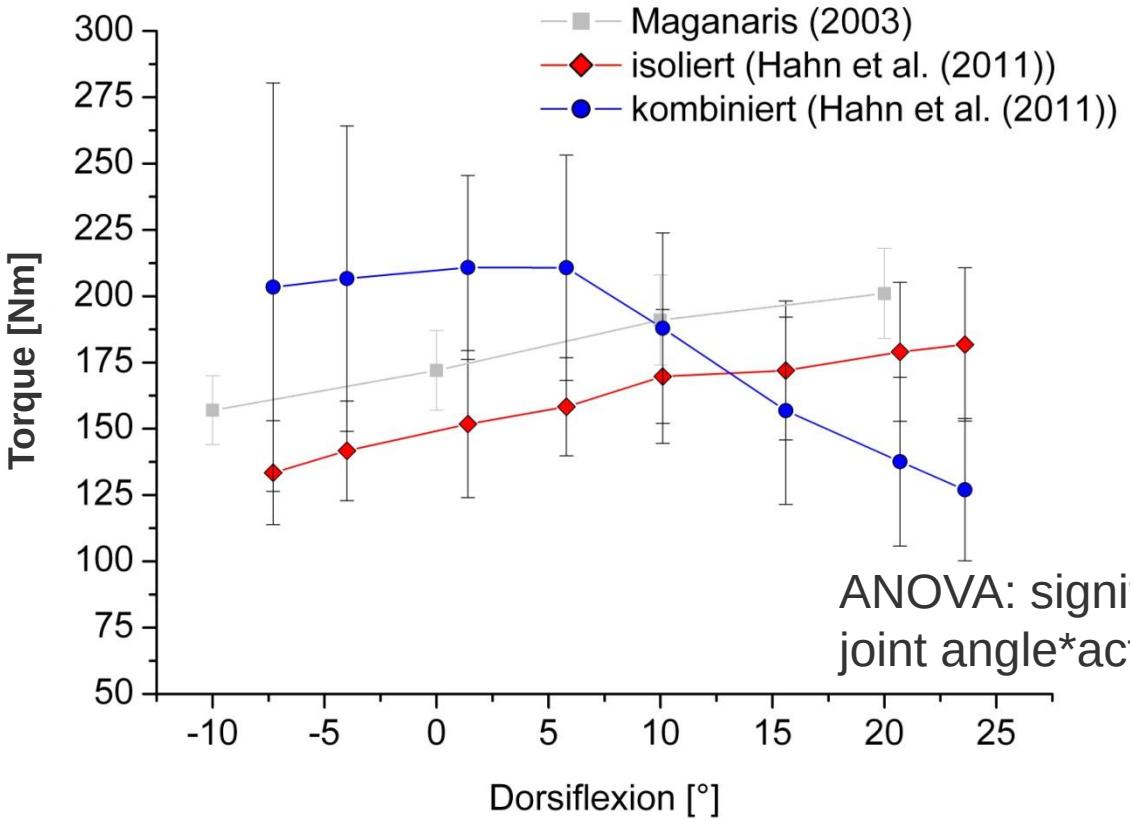
B combined activation of the plantar flexors, knee and hip extensor muscles

A

B

Force-length-relation *(F-l-r)* of the ankle joint

(Hahn et al., *JBM* (2011), 44:2059-2065)



ANOVA: significant effect of joint angle*activation

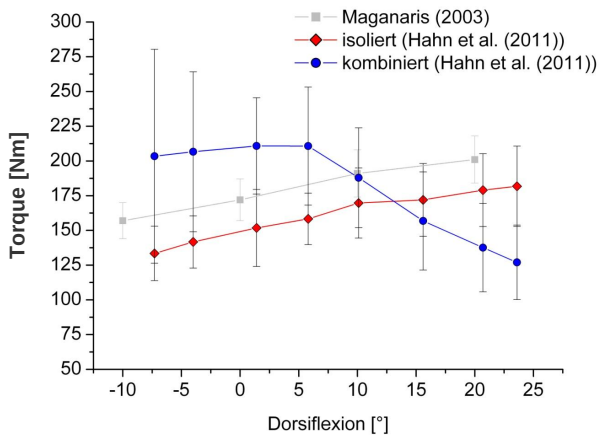
Force-length-relation *(F-l-r)* of the ankle joint

(Hahn et al., *JBM* (2011), 44:2059-2065)

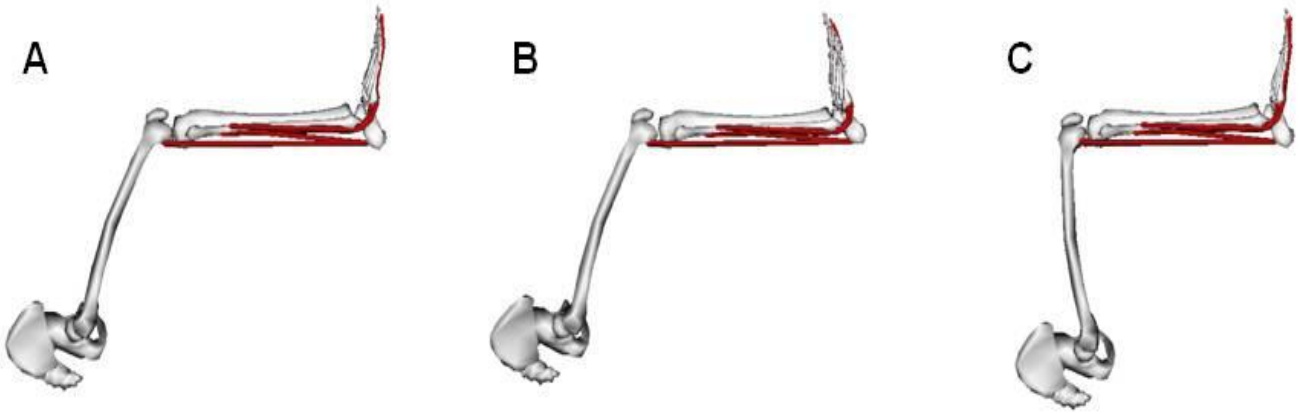
- myofascial force transmission (Huijing & Baan 2003, Maas et al. 2004, Huijing 2009)
  → very small effects *in vivo* (Bojsen-Moller et al., 2010; Maas & Sandercock, 2010)

- force transfer from proximal to distal by biarticular muscles
  (Van Ingen Schenau et al. 1987)

- neurophysiological reasons (Hultborn et al. 1987)



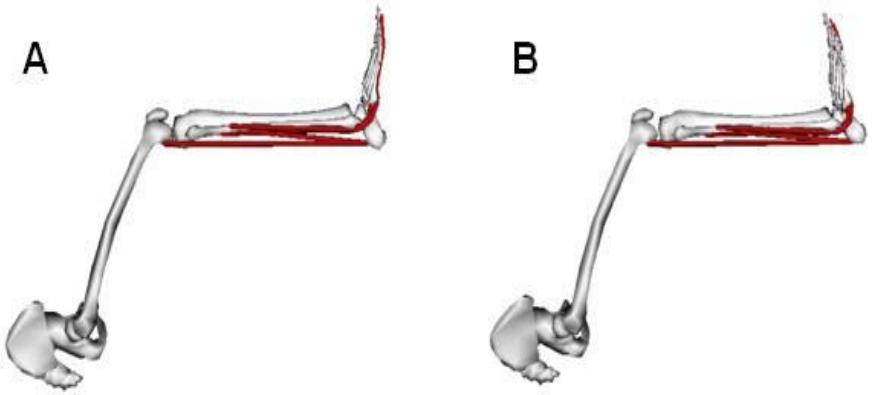
Methods



Knee 60° / Ankle 0° | Knee 60° / Ankle -20° | Knee 90° / Ankle 0°

- n = 5 healthy male subjects
- 3 different knee/ankle joint configurations
- **isolated** *versus* **combined** maximal voluntary contractions (MVC)
- measurement of ankle joint torque (IsoMed2000 dynamometer)
- muscle activation by surface EMG (VL, RF, VM, BF, ST, LG, MG, SOL, TA)
- ANOVA ($p < 0.05$)

Force transfer from proximal to distal?



Knee 60° / Ankle 0° Knee 60° / Ankle -20°

Comparison **A** *vs.* **B**:

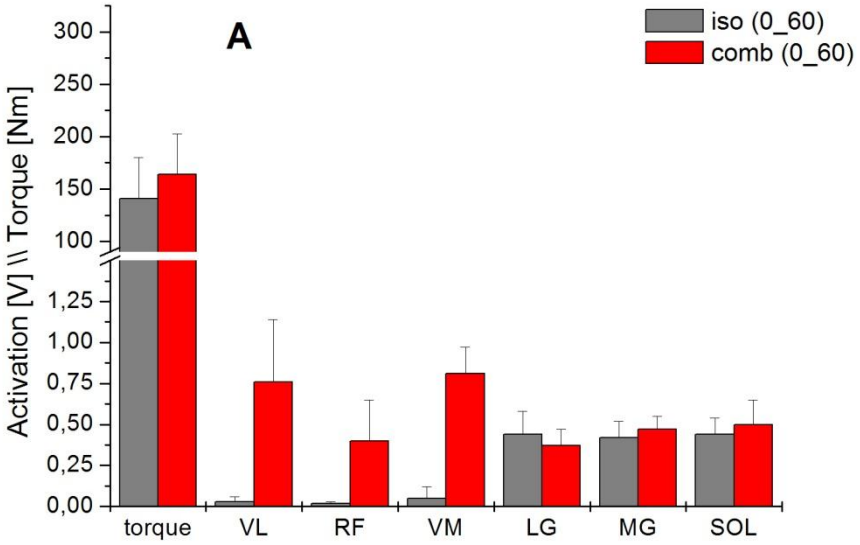
muscle length closer to l_0 (m. triceps surae) due to Δ20° ankle joint angle (**B**)

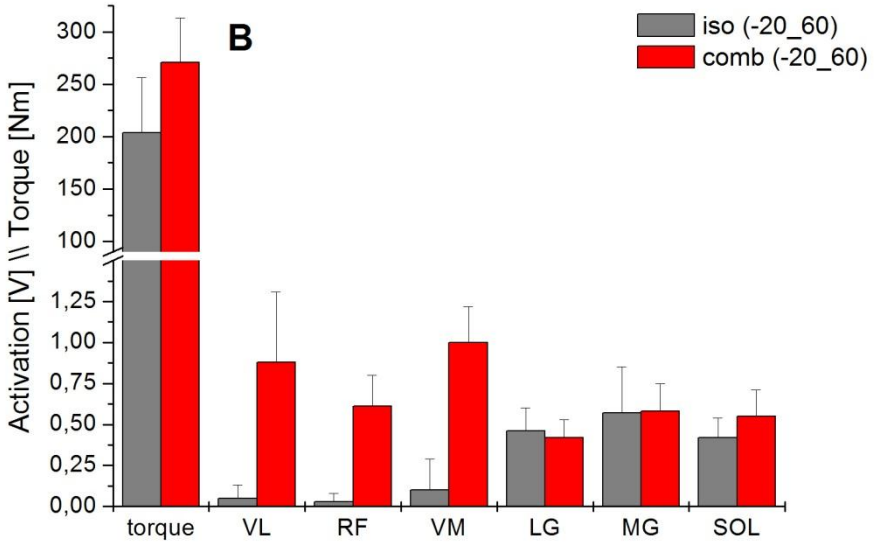
Hypothesis 1 → reduced torque (**A** *vs.* **B**) during isolated activation.

Hypothesis 2 → enhanced torque (**A** & **B**) during **comb.** *vs.* **iso.** activation.

Hypothesis 3 → ΔT (combined-isolated) **A ≤ B**

Results – force transfer (A vs. B)

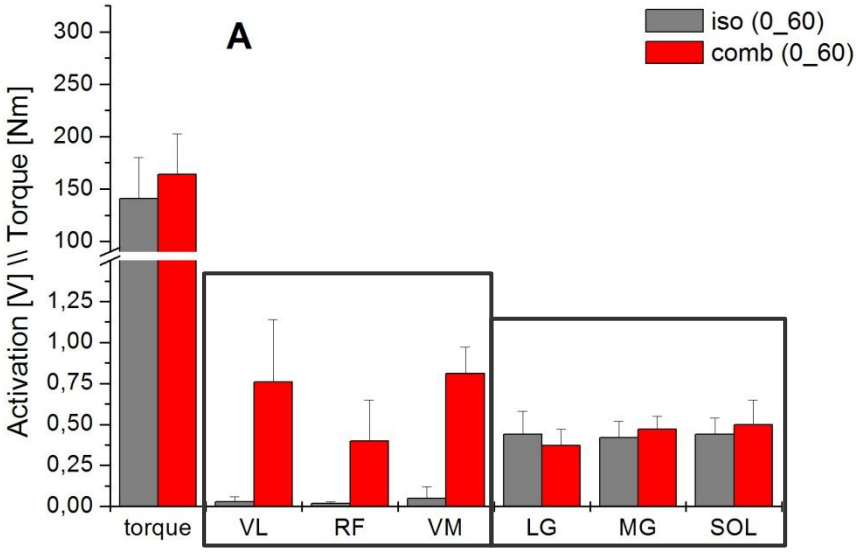


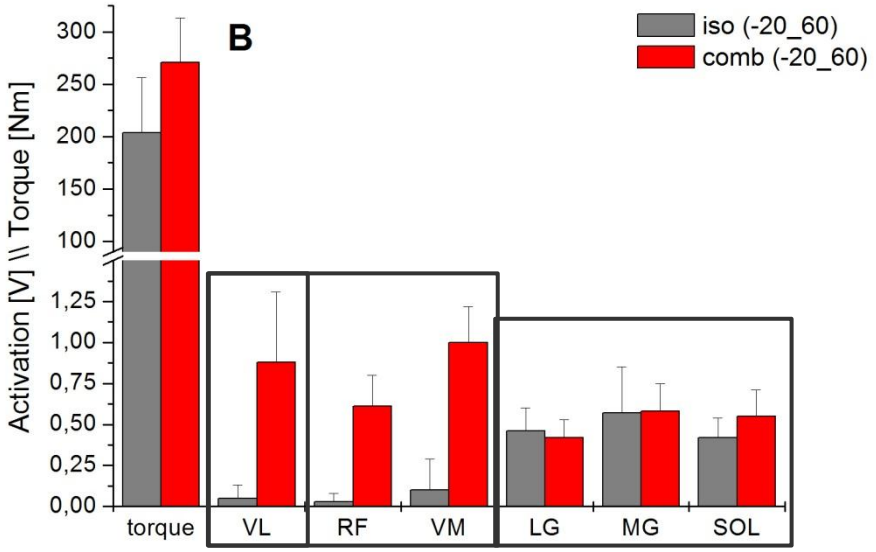


$T_{\mathbf{A}\_iso}$ = 141±39 Nm, **<** $T_{\mathbf{B}\_iso}$ = 204±52 Nm

✓ Hypothesis 1 → reduced torque (**A** *vs.* **B**) during isolated activation ($p < 0.05$).

Results – force transfer (A vs. B)





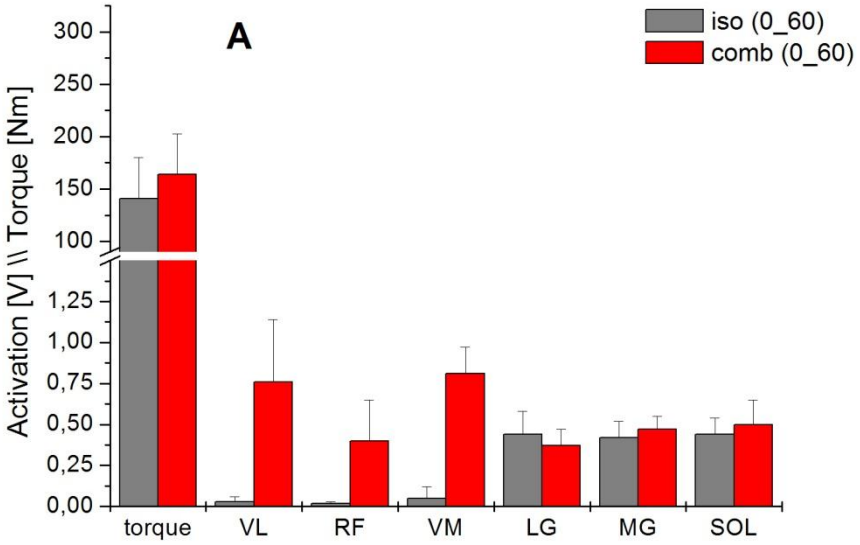
✓ Hypothesis 2 → enhanced torque (**A** & **B**) comb. *vs.* iso. activation ($p < 0.05$).

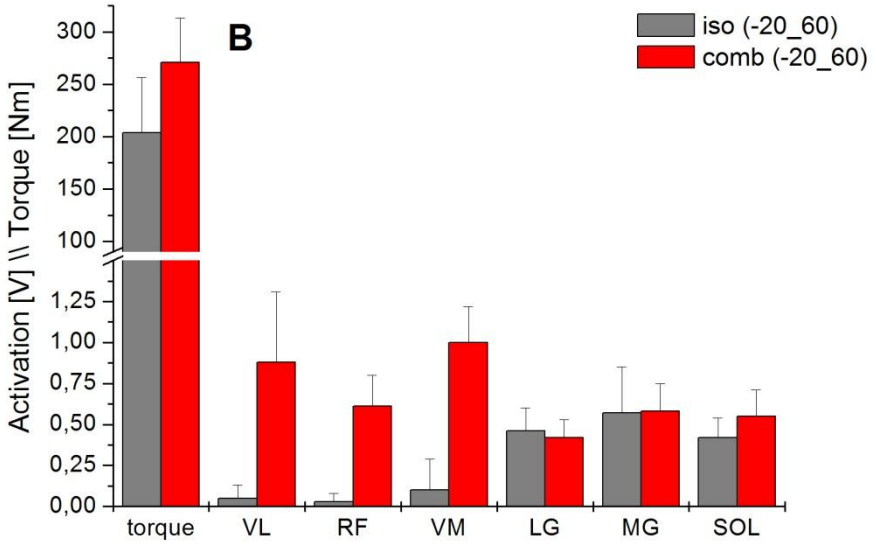
→ **no** difference in EMG of LG, MG and SOL (combined *vs.* isolated)

→ greater QF-activity during combined activation ($p < 0.05$) for **A** & **B**

→ greater VL EMG-activity ($p < 0.05$) for **B** compared to **A**

Results – force transfer (A vs. B)

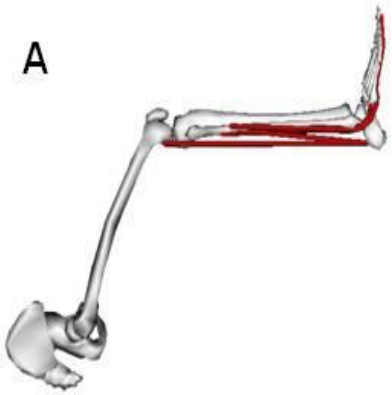




$\Delta T_A = 23 \pm 14$ Nm **<** $\Delta T_B = 67 \pm 30$ Nm

✓ Hypothesis 3 → ΔT (combined-isolated) **A** < **B** ($p < 0.05$).

Force transfer from proximal to distal?



Knee 60° / Ankle 0°

Knee 90° / Ankle 0°

Comparison **A** vs. **C**:

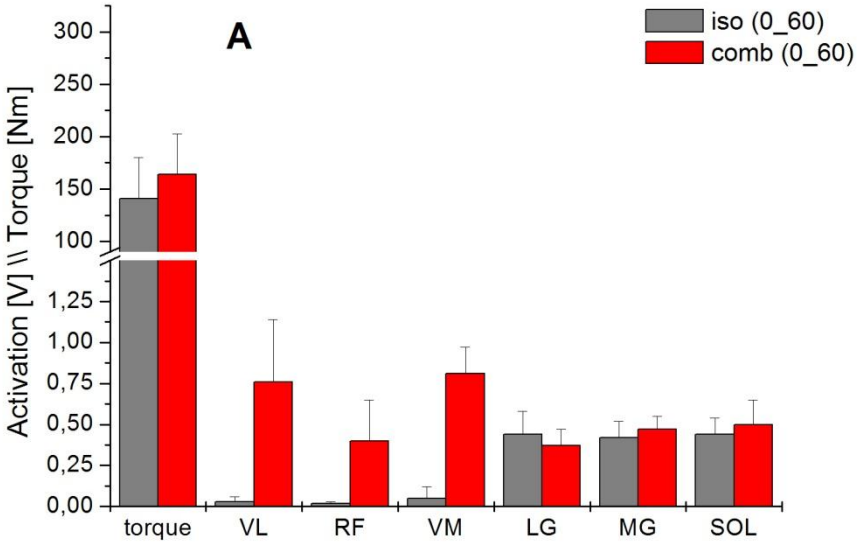
disadvantageous muscle lengths (QF, GM, GL) due to *Δ*30° knee joint angle (**C**)

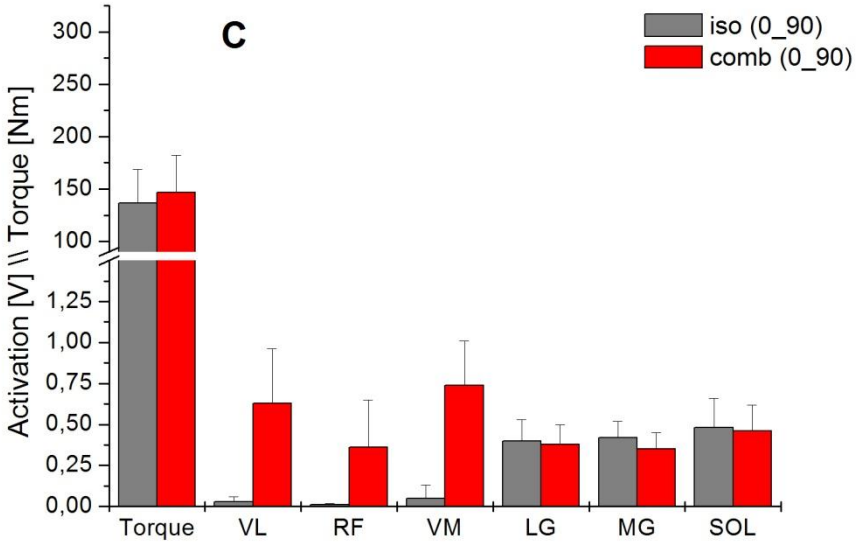
Hypothesis 1 → enhanced torque (**A** *vs.* **C**) during isolated activation.

Hypothesis 2 → enhanced torque (**A** & **C**) during comb. *vs.* iso. activation.

Hypothesis 3 → *Δ*T (komb.-iso.) **A** > **C**.

Results – force transfer (A vs. C)



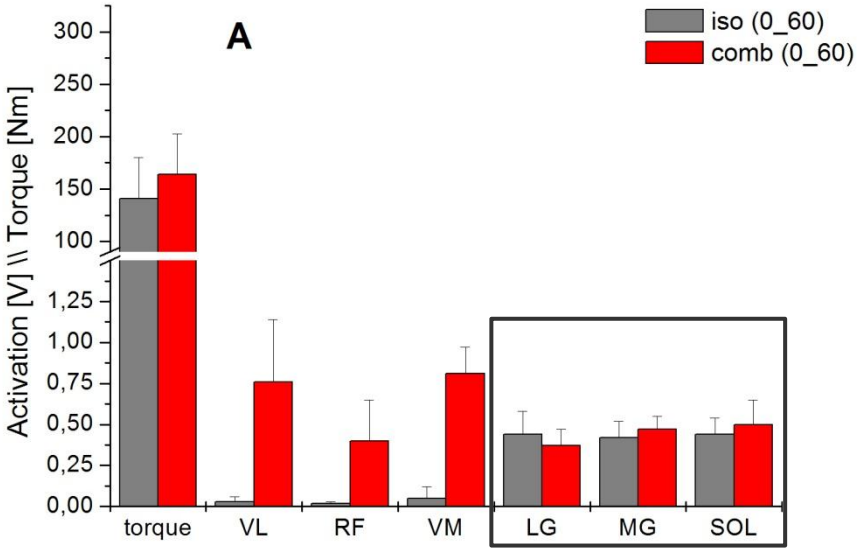


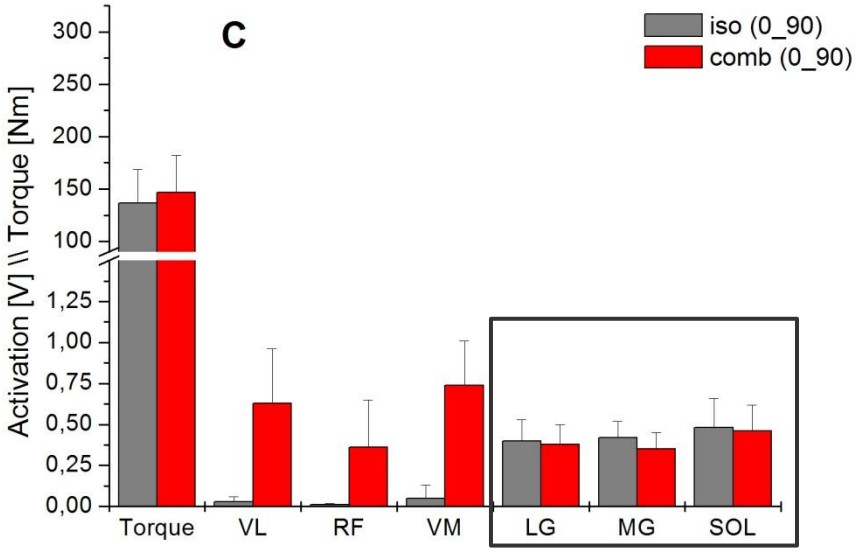
T_{A_iso} = 141±39 Nm

T_{B_iso} = 136±32 Nm

✗ Hypothesis 1 → similar torque (**A** *vs.* **C**) during isolated activation.

Results – force transfer (A vs. C)

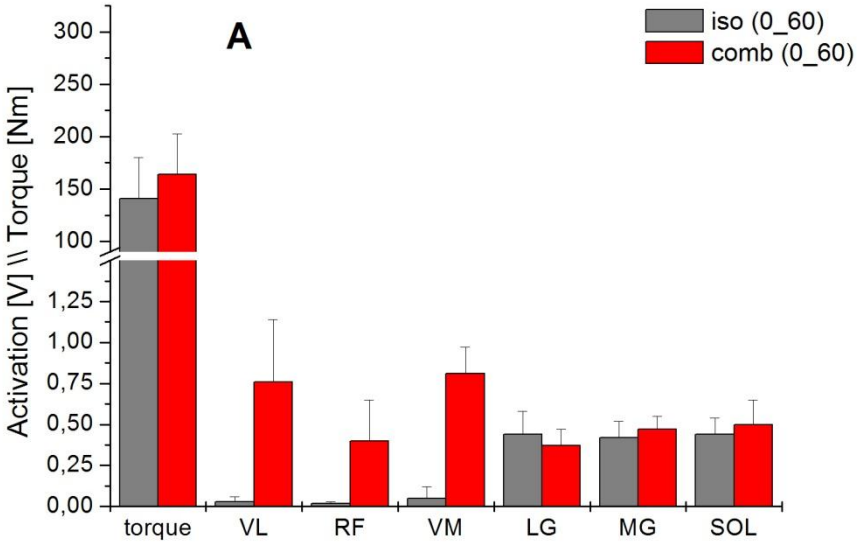


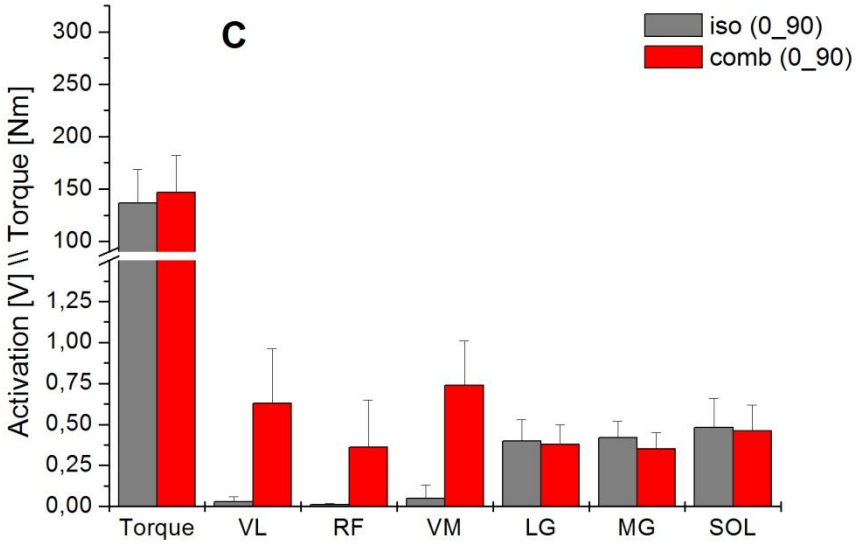


✓ Hypothesis 2 → enhanced torque during **comb.** *vs.* **iso.** activation for **A** ($p < 0.05$) but not for **C** ($p = 0.055$).

→ **no** difference in EMG of LG, MG and SOL (combined *vs.* isolated)

Results – force transfer (A vs. C)





$\Delta T_A = 23 \pm 14$ Nm **>** $\Delta T_C = 11 \pm 11$ Nm

✓ Hypothesis 3 → ΔT (combined-isolated) **A** > **C** ($p < 0.05$)

Conclusion

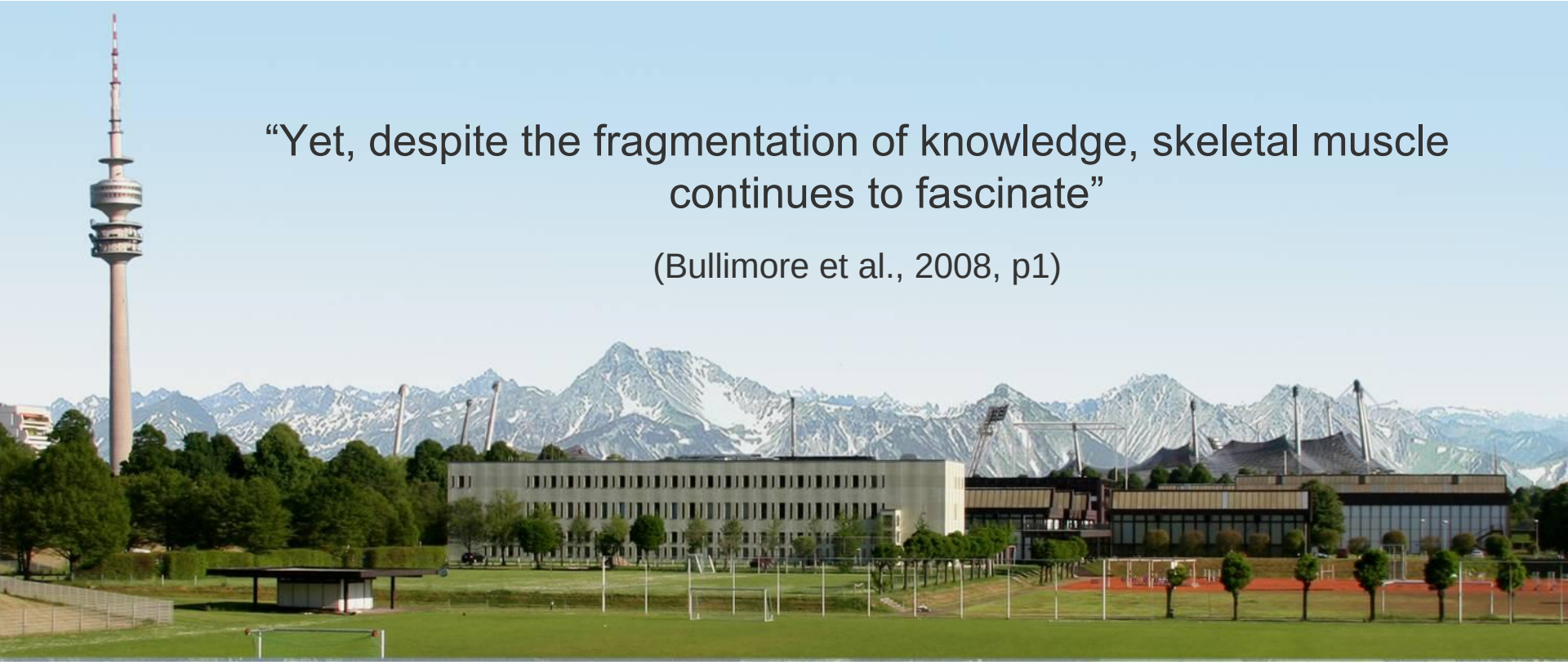
- Force transfer depending on muscle lengths of
  - knee joint (comparison **A** vs. **C**) and
  - ankle joint (comparison **A** vs. **B**)

- Influence of neurophysiological factors
  - change in QF muscle activation without change in knee joint angle

⇨ Future studies to investigate

- mechanical contributions
- neural control

Thanks for your Attention!



“Yet, despite the fragmentation of knowledge, skeletal muscle continues to fascinate”

(Bullimore et al., 2008, p1)

TU Munich Sports Campus