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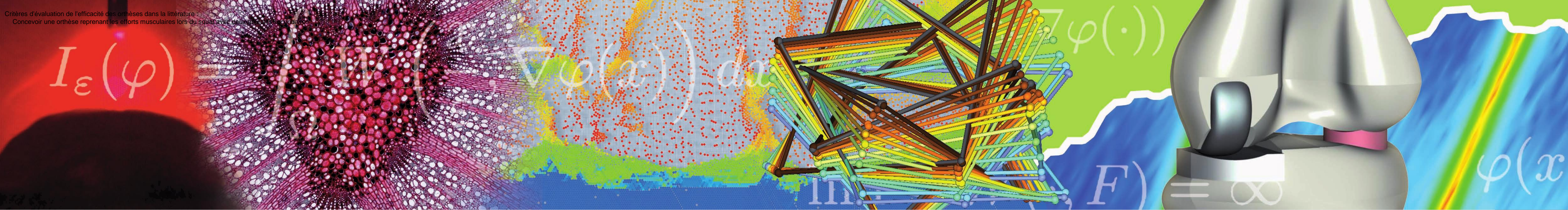
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Development and evaluation of a knee brace for joint stress modulation – A literature review

Léa Boillereaux, Simon Le Floc'h, Abderrahmane Kheddar, Franck Jourdan

In order to relieve the patients suffering osteoarthritis or other cartilage diseases and to facilitate the rehabilitation after an operation, it is necessary to unload the knee during daily living activities.

Doctors usually prescribe the wearing of an unloading orthosis. But are they really efficient ? What are their impact on the tibiofemoral contact forces ?

Evaluation criteria for braces in the literature :

Symptoms	Measures outcomes	Evaluation methods and instruments
Clinical symptoms	Knee pain, joint stiffness and function, quality of life, physical activity	VAS, WOMAC, QoL, KOOS-QoL, IPAQ, UCLA Scale, IKDC
Functional effects	Knee proprioception, stability, posture control	KOOS, KSS, IPAQ, VAS, Lequesne index, Safety and observance
Morphological effect	JSW, JSN, tibio-femoral Angle, hip-knee-ankle angle, condylar separation, angle condylar separation distance	Weight-bearing lower limb radiographs, ultrasound, fluoroscopy, gait analysis, loaded MRI, morphological MRI, WOMMS, BLOCKS grading
Gait effects	Frontal plane kinematics, sagittal plane kinematics, lower limb malalignment, knee adduction flexion angles, knee forces and moments	3D motion analysis, dynamic simulations, gait analysis
Muscle strength	Muscle co-contraction, medial/lateral, flexors/extensors co-contraction ratios	Electromyograms (EMG), muscle MRI

Fig 1 : Quantitative and qualitative orthosis evaluation methods (1)

WOMAC : Western Ontario McCaster Arthritis index

KOOS : Knee injury and Osteoarthritis Outcome Score

KSS: Knee society score

IPAQ: International Physical Activity Questionnaire

The contact force is not measurable in vivo. Therefore, its reduction by an orthosis cannot be directly evaluated.

Decreasing the contact force by recreating the flexion-extension torque via the orthosis, a promising solution ?

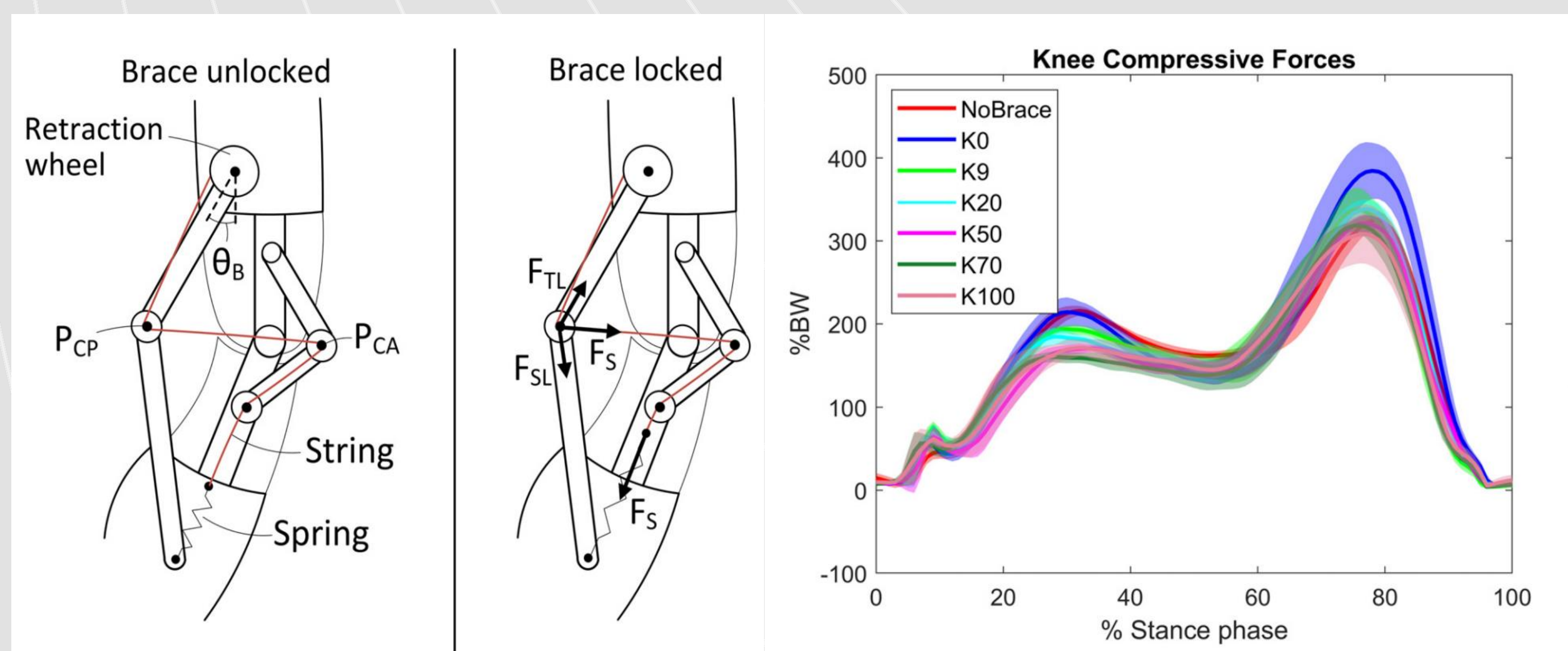


Fig 4 : Unloading brace during stance phase of the gait cycle and evaluation of the device with different stiffnesses (K in N/m) (4)

⚠ Take into account the size of the device and the pressure applied on skin during the conception.

However, several researchers have demonstrated a correlation between contact stress and muscle activity.

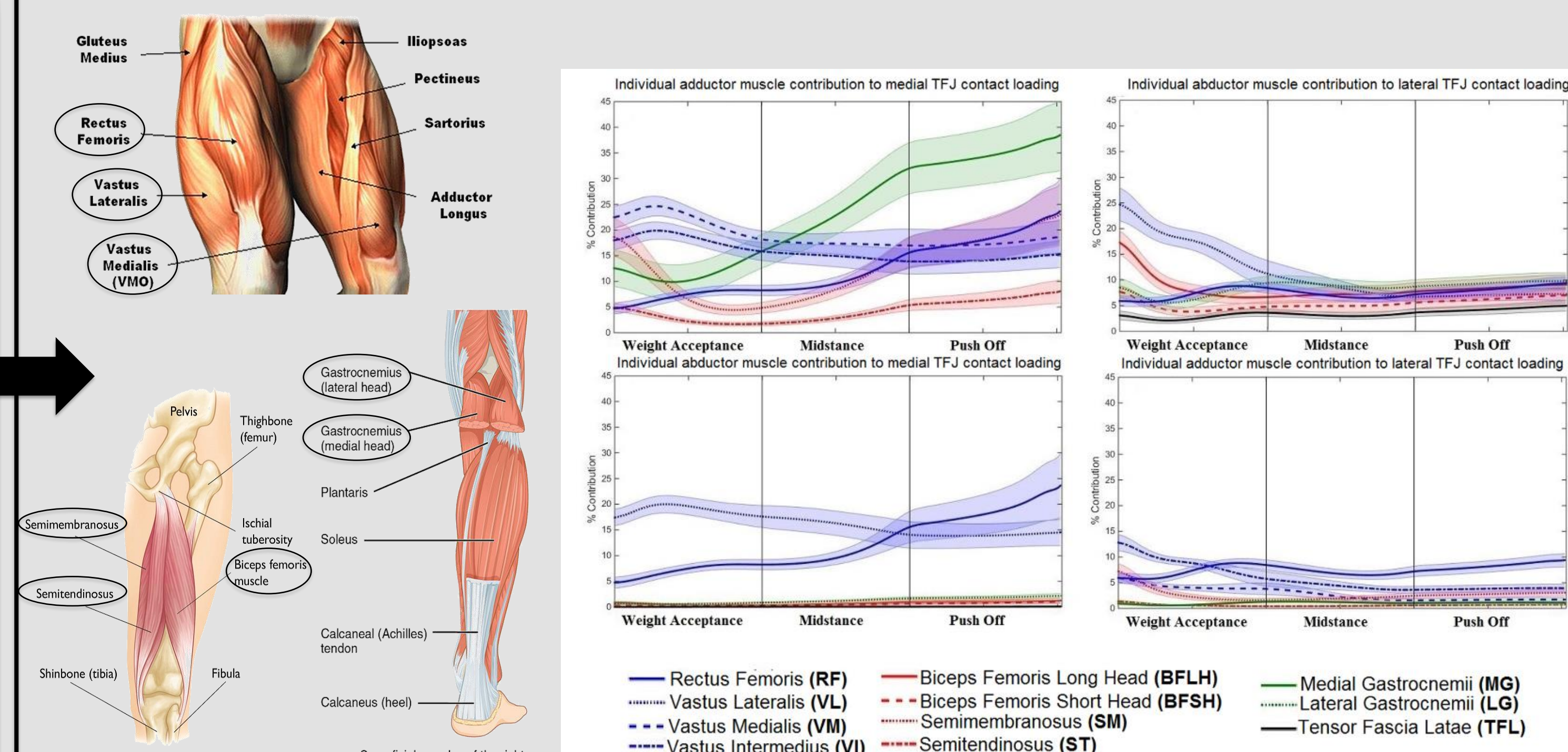


Fig 2 : Muscle's contribution on the tibiofemoral contact force during the stance phase of the gait cycle (2)

Possibility to estimate the contact stress : underfeet force sensors + Electromyography + Numerical model (inverse dynamics, musculoskeletal model)

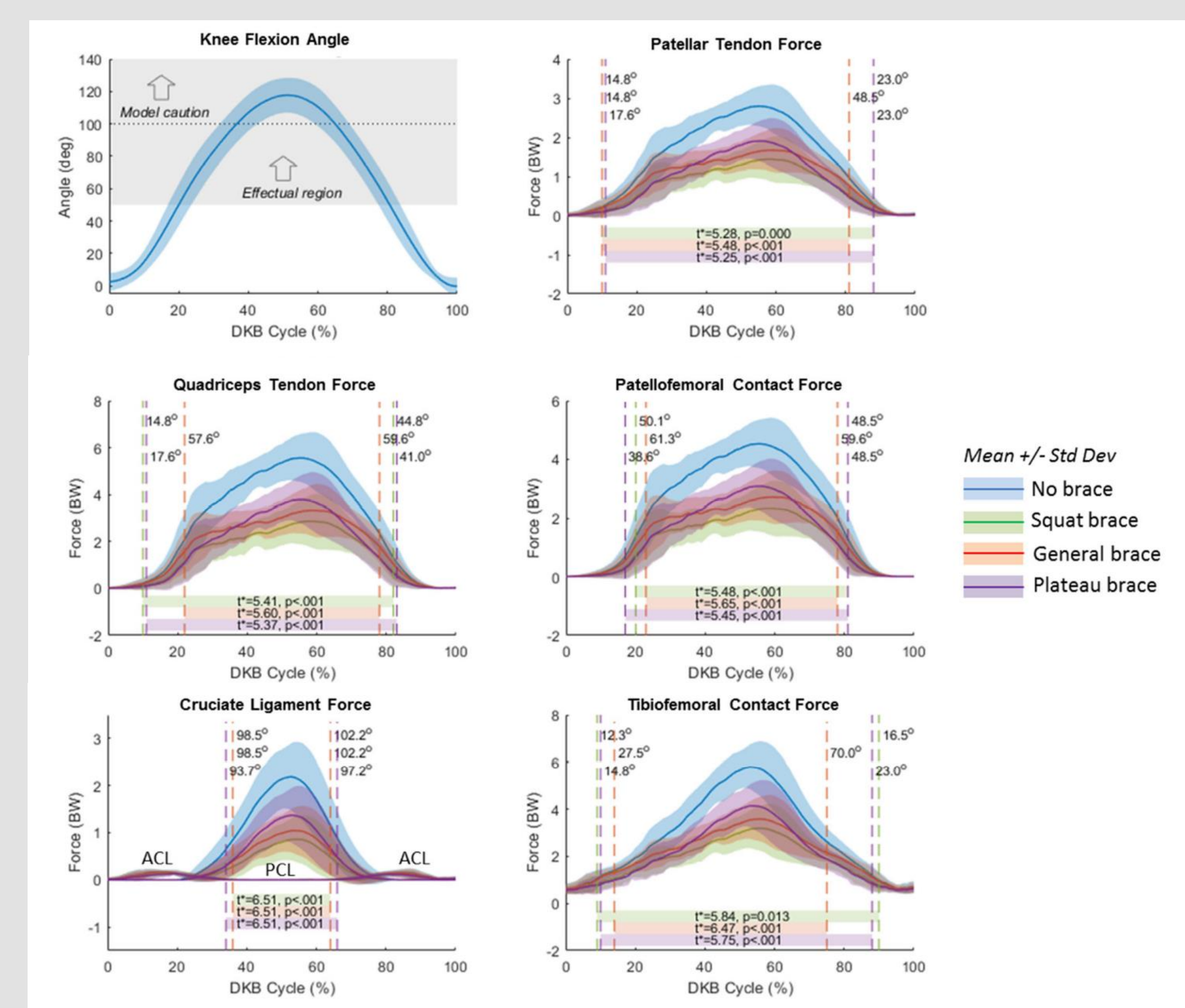


Fig 3 : Evaluation of muscular and ligament forces with different orthosis (3)

Our objective : Designing a brace decreasing the muscular forces during squat movement with two secondary objectives :

(i) Consideration of the shear stresses on skin and the sliding of the muscles on the bones

(ii) Validation of the orthosis with the most quantitative tools possible to show the tibiofemoral contact stress reduction

(1) Methods for evaluating effects of unloader knee braces on joint health : a review – Rizuwana Parween and Al. – Korean Society of Medical and Biological Engineering, 2019

(2) Individual Muscle contributions to tibiofemoral compressive articular loading during walking, running and sidestepping – B.A. Killena

(3) Biomechanical Study of a Tricompartamental Unloader Brace for Patellofemoral or Multicompartement Knee Osteoarthritis – Chris A. McGibbon – Frontiers in Bioengineering and Biotechnology, 2021

(4) Development and Functionnal testing of an unloading concept for Knee Osteoarthritis Patients : A pilot study – Stoltze and Al – Journal of Biomedical Engineering, 2022

