

# Soft knee exosuit

## Completely supports sit to stand

### Introduction

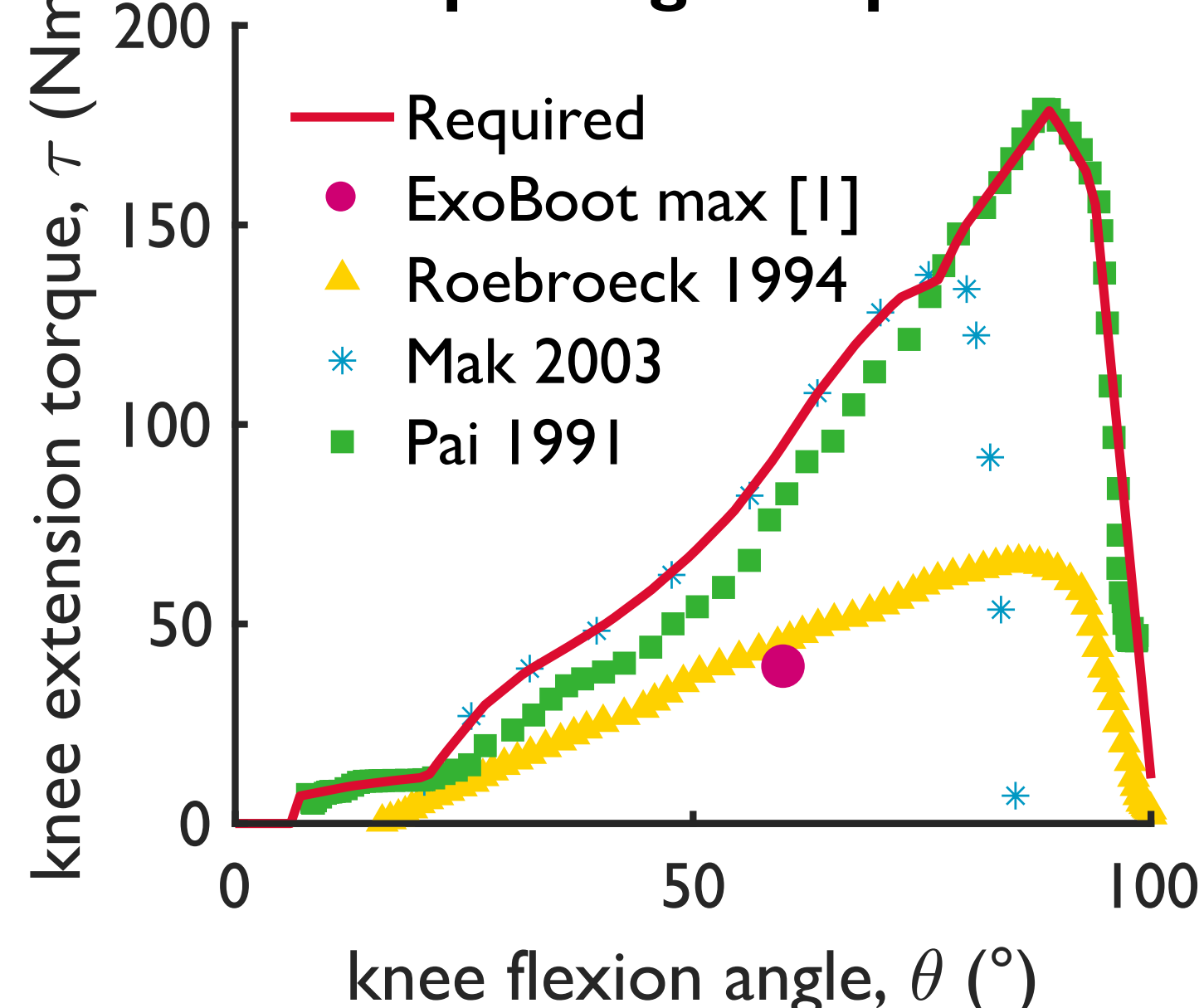
#### Soft actuators:

- + Safe (yield to excessive forces)
- + Ergonomic (move with/conform to the body)
- + Don't fully support many everyday movements like sit to stand (STS) [1]

#### High torque actuators:

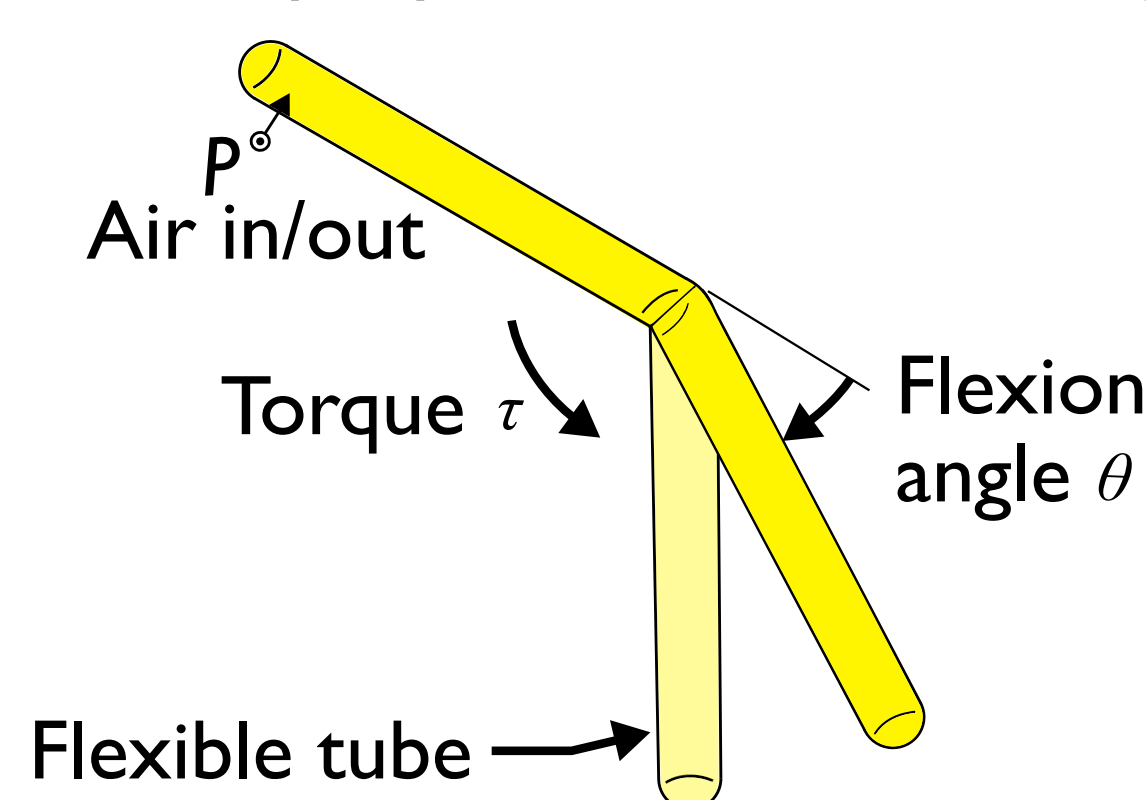
- + Assist the completely paralyzed
- + Augment workers in demanding situations
- + Apply rehabilitation therapy to stiff joints

#### STS torque-angle requirements



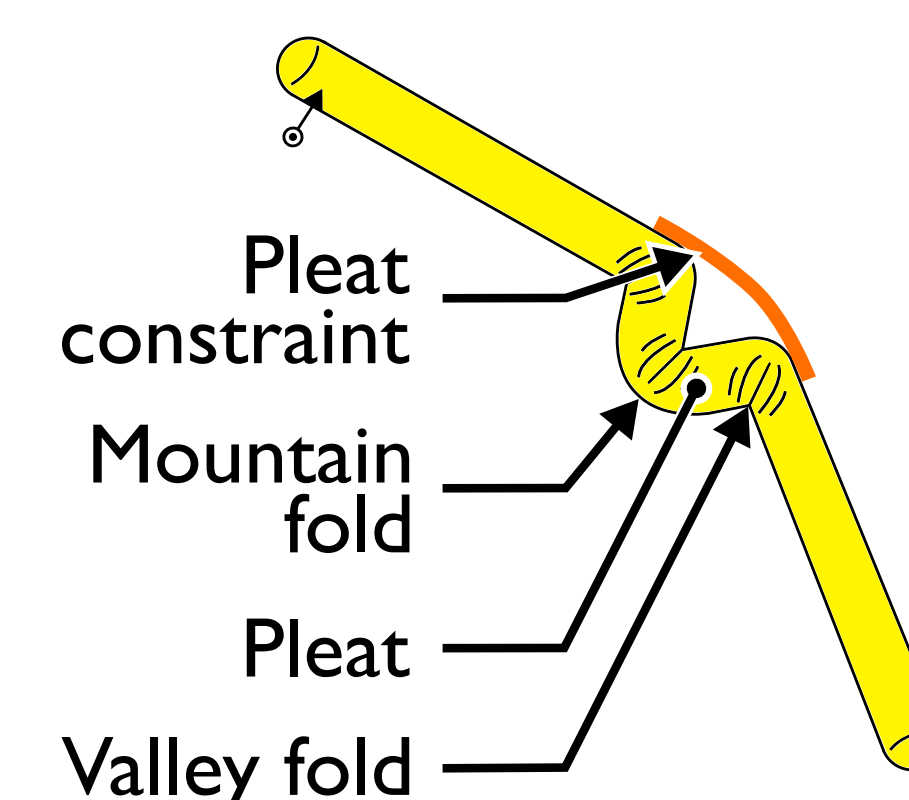
#### Pneumatic Interference Actuator (PIA) [2]:

- + Torque generated by volume change of buckling tube
- + No torque produced when straight



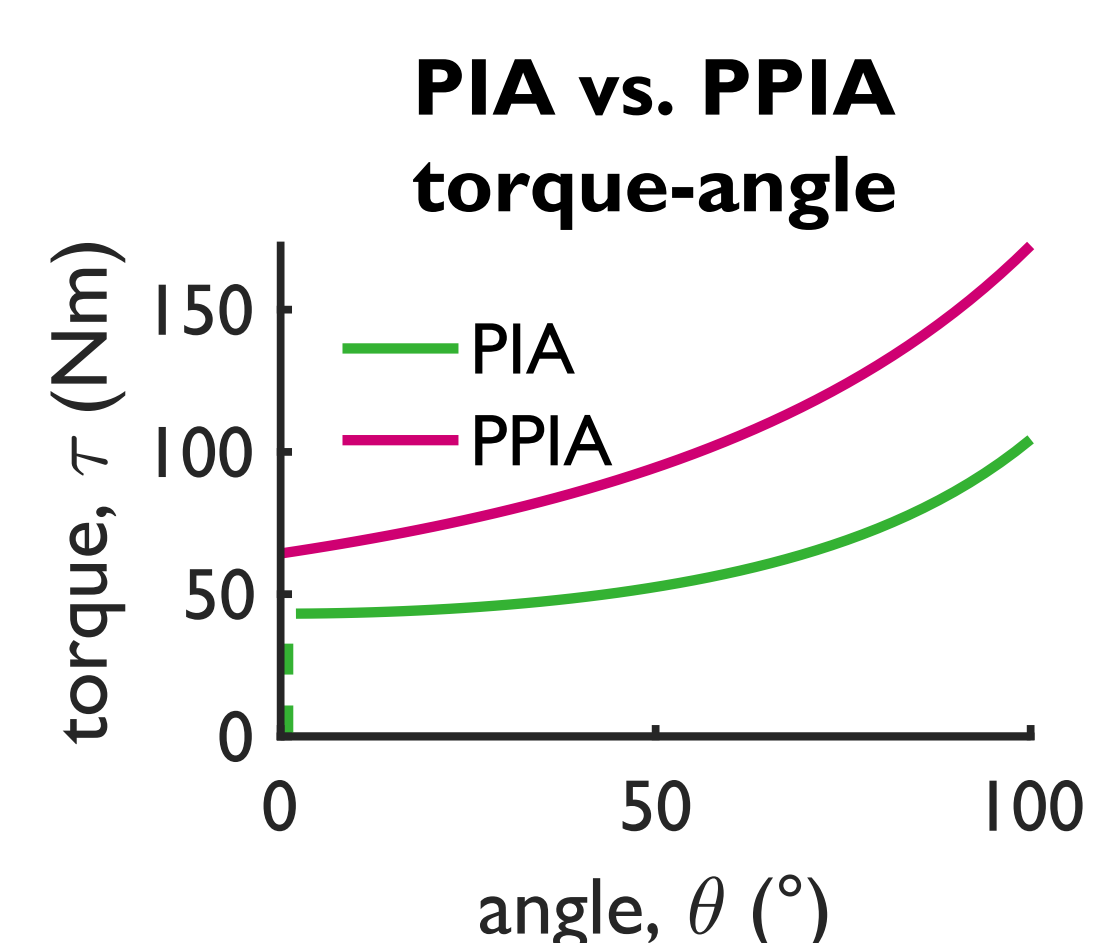
#### Pleated PIA (PPIA) [3]

- + Pleat added to tube (two valley folds and a mountain fold)
- + Pleat constraint keeps pleat in tube



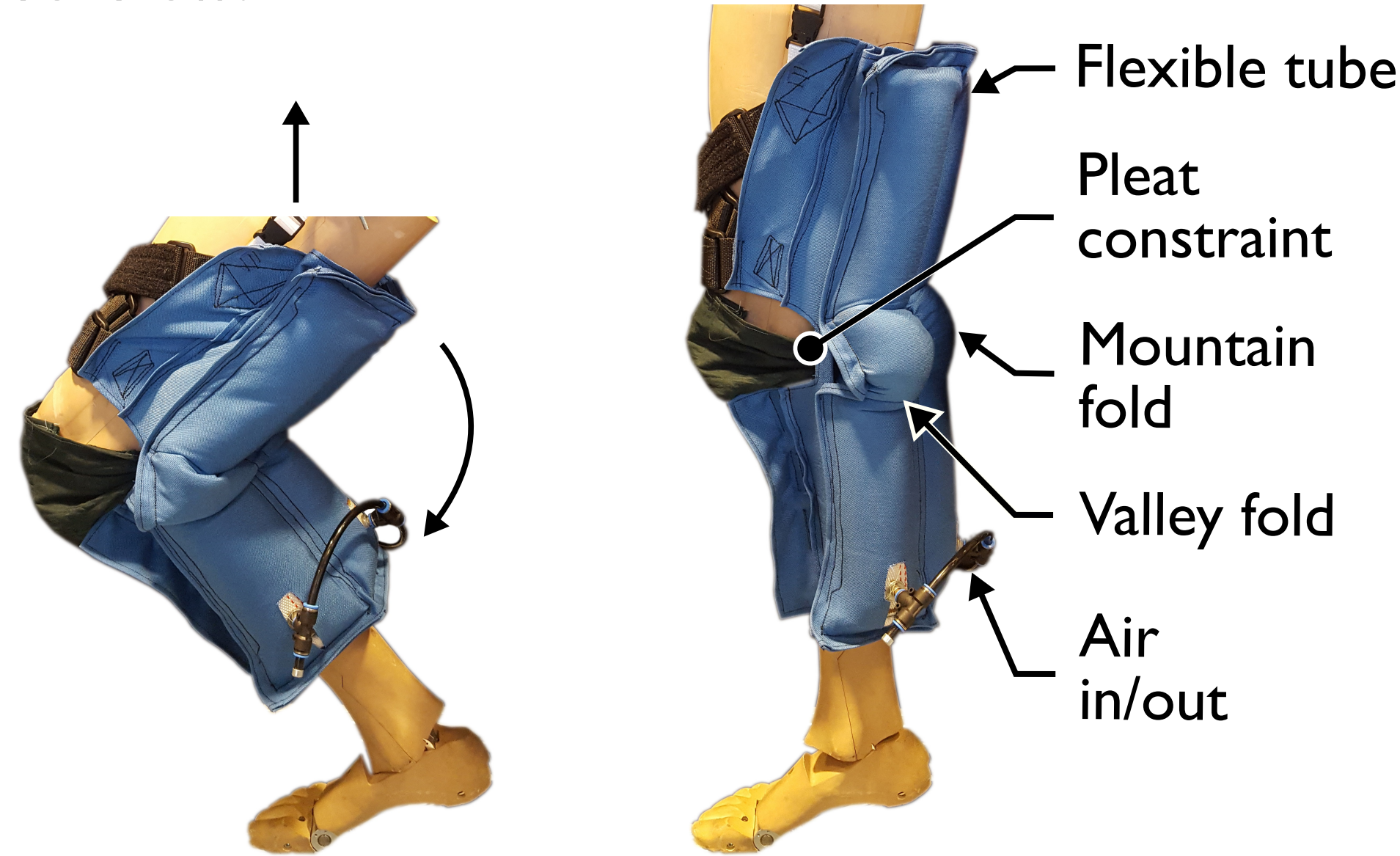
#### Pleated PIA (PPIA)

- + Torque produced when straight
- + Increased torque

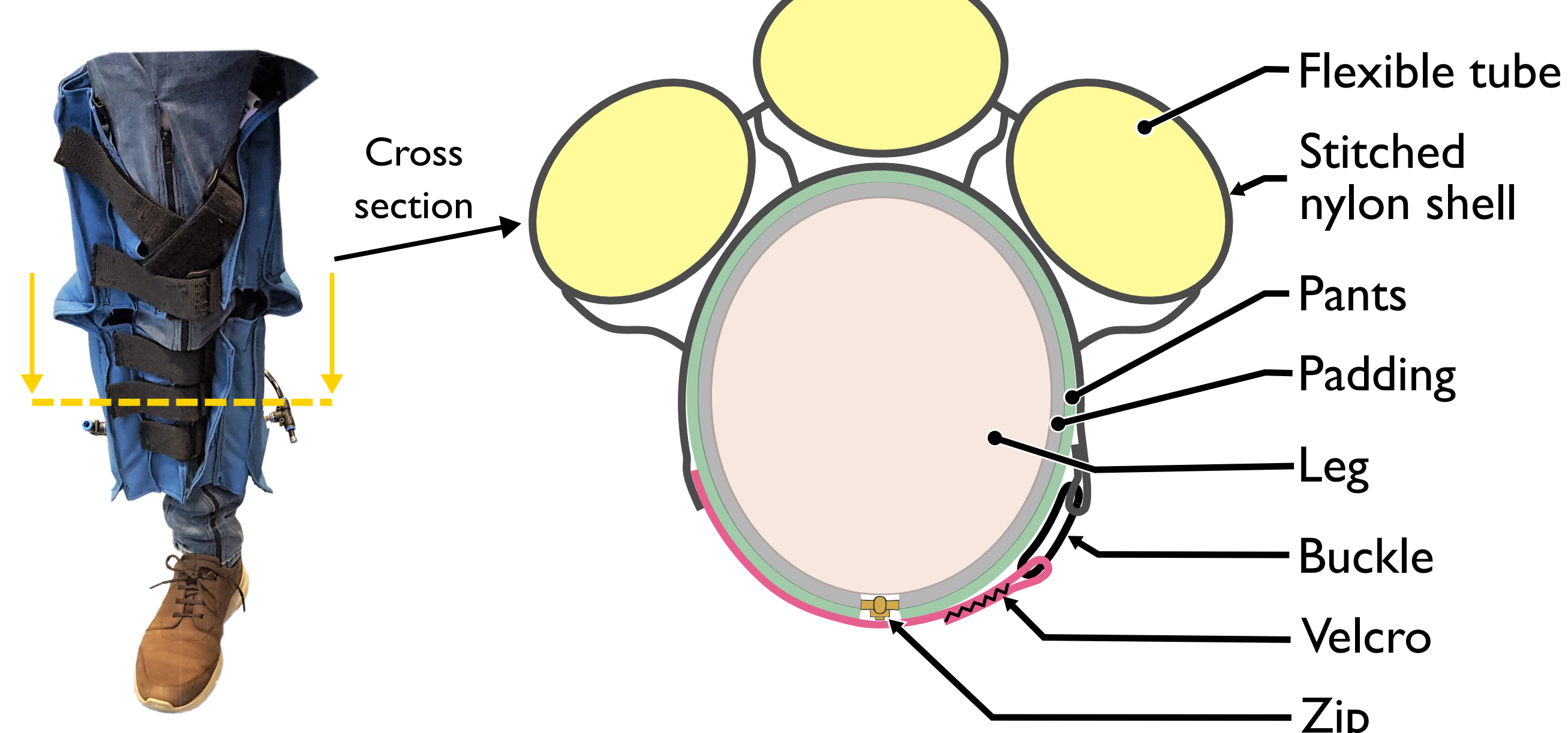


#### SLAK (soft lifting assister for the knee) STS prototype construction

##### Overview:



##### Attachment:

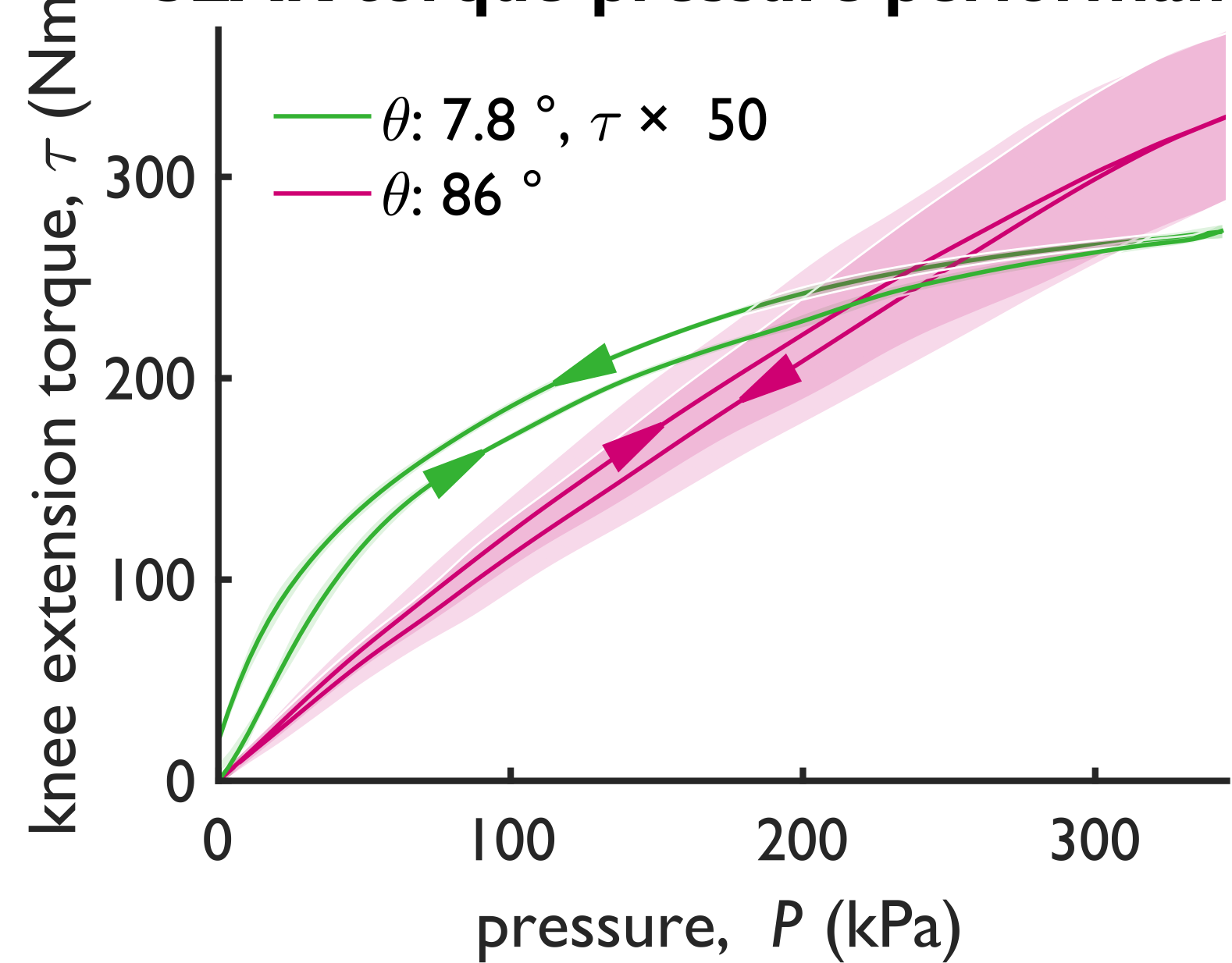


### Results

#### Angle fixed:

- + Torque increased with pressure and flexion angle
- + Linearity increased with flexion angle
- + Hysteresis low and changes direction with pressure
- + Shown are results  $\pm 2$  SD (n = 6)

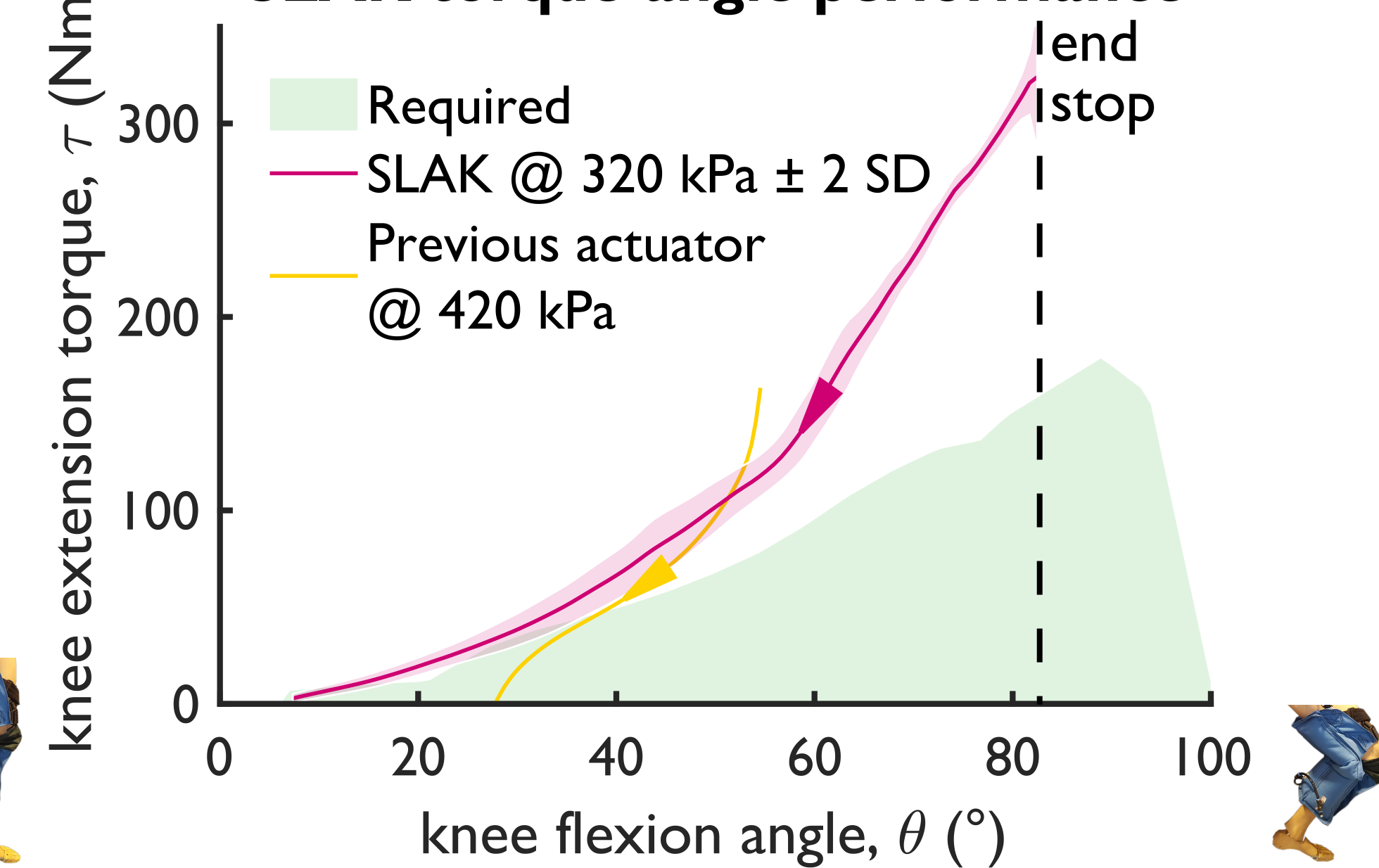
#### SLAK torque-pressure performance



#### Pressure fixed:

- + Quasistatic standing movement
- + Torque requirement met over 93 % of STS motion
- + Torque of 320 Nm at 82° decreases parabolically to 3.8 Nm at 7.9°

#### SLAK torque-angle performance



### Discussion

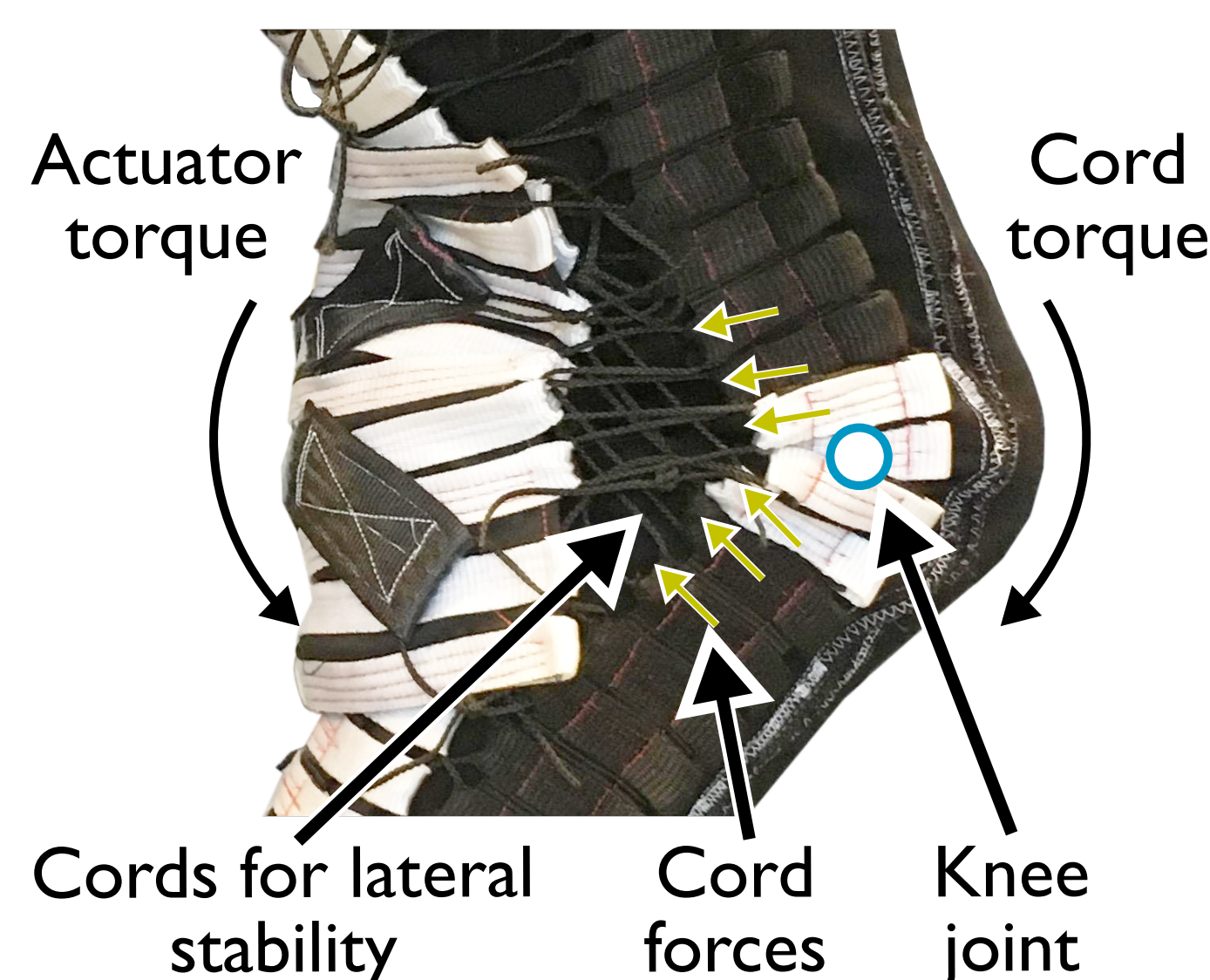
#### SLAK fully supports STS motion when worn, but not on the test leg:

- + Test leg rigidity and smoothness (compared to the body) made it difficult to keep the SLAK in the same place
- + Shifting of the SLAK misaligned it, reducing its torque output
- + The body's compliance and friction coefficient are important factors in determining how much torque can be transmitted to it

#### Parallel PPIAs effectively stabilize each other:

- + The previous PPIA STS pants [3] required cords to laterally stabilize the PPIA. Tension in these cords produced counter torques.
- + Parallel PPIAs do not have these cords, yet do not buckle sideways

#### Previous actuator [3]:



### Conclusion and future work

#### PPIA performance:

- + Met the STS torque requirement for 93 (100) % of the STS range of motion when worn on the test leg (body)
- + Produced  $\geq 320$  Nm @ 320 kPa
- + Had a torque generating range of motion of  $\geq 74.1^\circ$

#### Next:

- + Test the ability of the SLAK to assist healthy subjects with STS
- + Characterize the power and speed of the SLAK