

# Muscle activity and biomechanics during stair descent after a total knee arthroplasty with either a medial pivot or posterior stabilized implant

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## Introduction

- Gait adaptations persist following total knee arthroplasty (TKA)<sup>1</sup>, with some patients walking with a stiff knee or quadriceps avoidance pattern<sup>2</sup>
- However, the underlying muscle adaptations are not fully understood.
- Studies that evaluated muscle activity in patients after TKA were limited to either level walking, a limited number of assessed muscles, or only compared a single implant design.
- An evaluation of patients' biomechanics and muscle activity with various implant designs is necessary during more demanding tasks.

## Objectives

- The purpose was to evaluate knee biomechanics and activations of quadriceps, hamstrings, and gastrocnemius muscles during a stair descent task after TKA with either a medial pivot (MP) or posterior stabilized (PS) implant and to compare to a group of healthy controls (CTRL).

## Methods

	MP	PS	CTRL
Participants (n)	14	14	14
Male/Female (n)	8/6	8/6	8/6
Age (years)	63.7 ± 5.7	65.6 ± 8.1	64.4 ± 5.6
BMI (kg/m <sup>2</sup> )	27.4 ± 3.5	30.3 ± 3.9 <sup>†</sup>	24.9 ± 2.1

<sup>†</sup> Significant difference from CTRL; MP – MicroPort EVOLUTION<sup>®</sup> MP system with cruciate sacrificing tibial inserts; PS – Zimmer Biomet NexGen<sup>®</sup> PS system with PS tibial inserts; CTRL – healthy control group.

- All patients underwent TKA with the same surgeon (G.D.) using a subvastus approach with mechanical alignment.
- Patients visited the gait lab 12 ± 1 months post-surgery and performed 5 stair descent trials on a three-step staircase at a self-selected pace

### Muscle analysis

- 14 wireless surface electromyography (EMG) electrodes placed bilaterally:
  - Quadriceps: vastus medialis, vastus lateralis, rectus femoris
  - Hamstrings: biceps femoris (BF), semitendinosus (ST)
  - Gastrocnemius: medial and lateral heads
- Maximal voluntary isometric contractions (MVIC) were recorded for each muscle
- Full-body marker set – UOMAM<sup>3</sup>, 10 infrared cameras (Vicon, UK) + 4 force platforms (Bertec, USA & Kistler, CH)

### Variables of interest

- Knee biomechanics, linear envelope, onset time, total time of activation, peak (PeakEMG) and total signal (iEMG) normalized to MVIC
  - Muscle onsets were identified with Teager-Keiser Energy Operator and double threshold onset detection method<sup>4</sup>

### Statistics

- Discrete measures evaluated with one-way ANOVA, knee biomechanics & muscle linear envelopes compared using statistical parametric mapping<sup>5</sup>

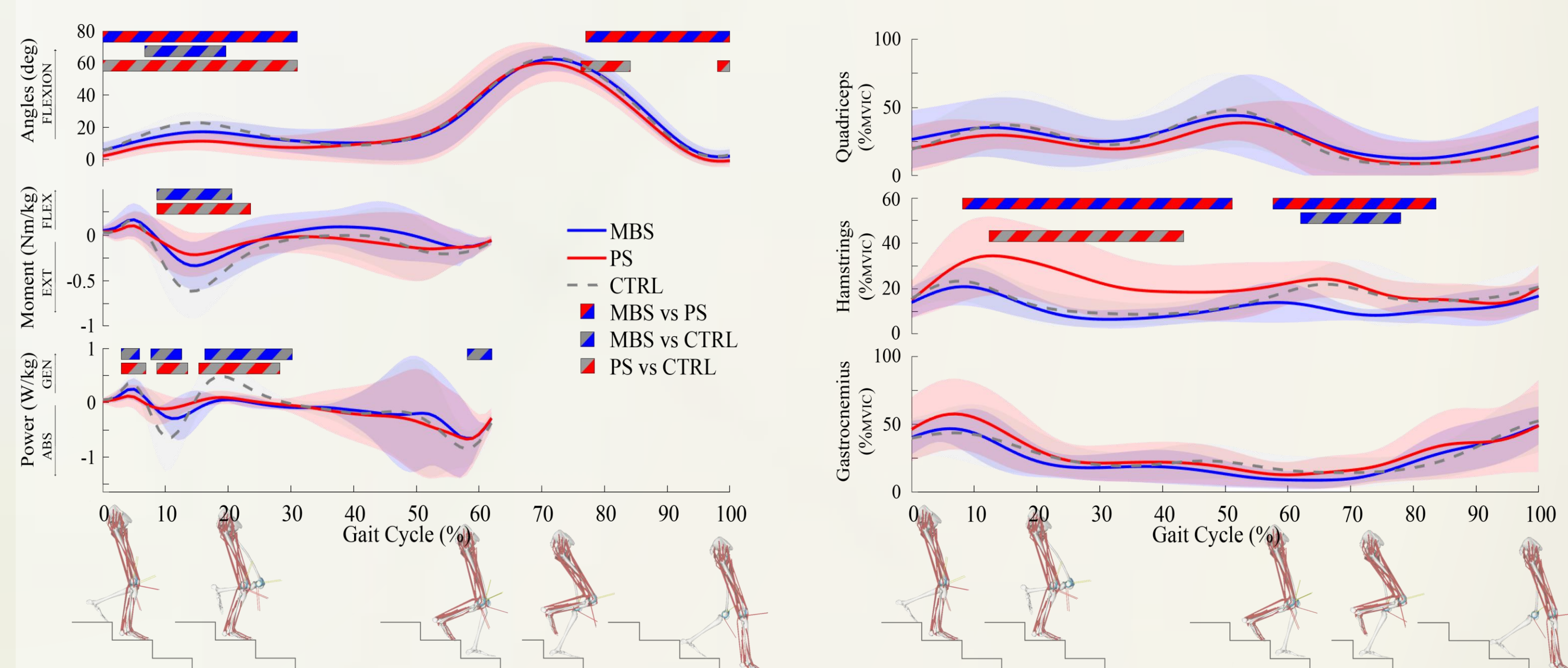
## Results

- No differences in onset times or total time on for the BF or ST existed between the groups.
- PeakEMG and iEMG of the BF and ST muscles were more significant in the PS group than the MP and CTRL.

	MP	PS	CTRL
<b>PeakEMG (%MVIC)</b>			
BF	31.5 ± 14.4*	47.7 ± 21.7* <sup>†</sup>	37.0 ± 14.8
ST	23.6 ± 12.8*	32.0 ± 10.7* <sup>†</sup>	19.6 ± 9.0
<b>iEMG</b>			
BF	253.7 ± 125.8*	438.8 ± 321.4* <sup>†</sup>	295.9 ± 133.6
ST	174.8 ± 93.7*	320.6 ± 185.3* <sup>†</sup>	154.8 ± 89.1

\* significant MP vs PS difference; † significant difference from CTRL

- Linear envelopes of EMG were averaged together for each muscle group (i.e., hamstrings: ST + BF) and compared between the groups (Figure 1).
  - No differences in quadriceps or gastrocnemius linear envelopes existed between the groups
- The PS group had increased hamstrings activation throughout the forward-continuance phase compared to the MP (8 to 51% stair descent cycle (%<sub>SDC</sub>)) and CTRL (13 to 44 %<sub>SDC</sub>).
- Knee extension moments and powers were lower in both the MP and PS groups when compared to the CTRL, especially during single-limb support (Figure 1).



**Figure 1:** Group mean (SD) for knee biomechanics and average linear envelopes of the quadriceps, hamstrings, and gastrocnemius muscles normalized over one stride during a stair descent task. Shaded horizontal bars correspond to where in the stair cycle significant group differences occurred.

## Conclusion

- TKA patients descended a staircase with altered biomechanics compared to healthy controls.
- This may have been a strategy to reduce loading on their operated knee.
- Hamstring muscle timings were similar between the groups. However, the PS group required greater PeakEMG and iEMG of the hamstrings.
- The MP implant was designed with medial congruent tibial inserts providing greater passive stability<sup>6</sup>.
- The PS implant design lacks this passive stability, so it may have required additional hamstrings activation to prevent anterior sliding of the implant during the stair descent task, especially when in single-limb support<sup>7</sup>.

## References

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