

## Reference

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# Designs and performance of microprocessor-controlled knee joints

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## Products

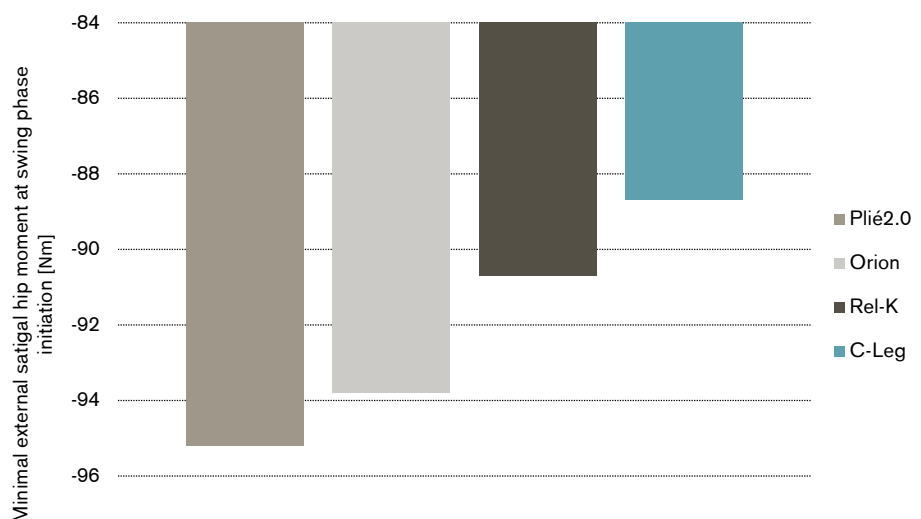
**C-Leg vs Orion, Plié 2.0, Rel-K**

## Major Findings

With C-Leg compared to Plié 2.0, Orion and Rel-K:

- **Swing phase is initiated most easily.**
- **Dampening of the extension movement in stance phase is smoother than with Plié 2.0 and Rel-K which ensures a natural gait pattern.**
- **Maximum knee flexion angle in swing phase is the most constant which ensures toe clearance and therefore may reduce stumbling.**
- **Extension stop at the end of swing phase is reached reliably and therefore controlled positioning of the prosthetic foot is allowed.**

### Effort for swing phase initiation is smallest with C-Leg



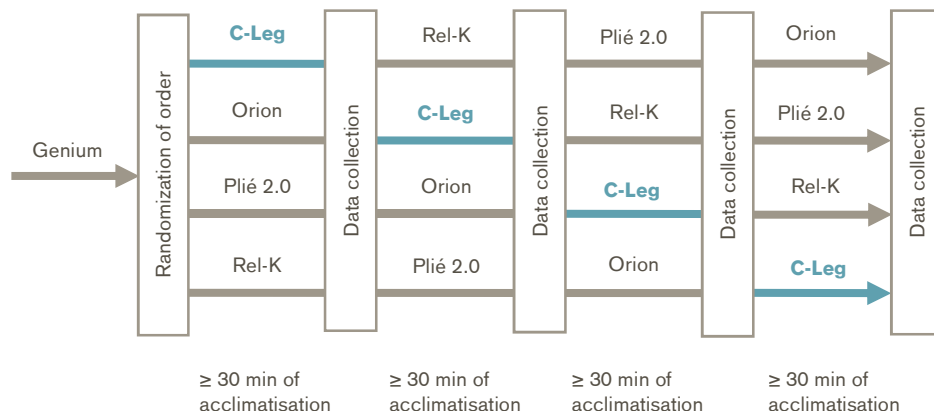
Minimal external sagittal hip moment at swing phase initiation was measured when subjects walked at self-selected walking velocity.

## Population

Subjects:	3 unilateral, transfemoral amputees
Previous prosthesis:	Genium
Amputation causes:	not reported
Mean age:	39 yrs
Mean time since amputation:	25 yrs
MFCL:	K3

## Study Design

Interventional, multiple crossover trial:



## Results

Activities								Participation	Environment
Level walking	Stairs	Ramps, Hills	Uneven ground, Obstacles	Cognitive demand	Metabolic energy consumption	Safety	Activity, Mobility, ADLs	Preference, Satisfaction, QoL	Health economics

Category	Outcomes	Results for C-Leg	Sig.*
Level Walking	Self-selected walking velocity	Subjects walked faster with C-Leg than with: <b>Orion</b> <b>Rel-K</b> Plié 2.0	<b>++</b> <b>++</b> +
		No difference in gait symmetry.	0
Motion Analysis	Motion Analysis	Maximum knee flexion angle in swing phase: the least variation with C-Leg when walking at different velocities → optimal swing phase flexion control.	n.a.
		Extension stop at the end of swing phase → allows for reproducible position of the foot: Mostly reached with C-Leg and Plié 2.0, Rarely reached with Orion and Rel-K.	n.a.
		Smoothest dampening characteristics of the extension movement in stance phase with C-Leg compared to: <b>Plié 2.0</b> <b>Rel-K</b> Orion	<b>++</b> <b>++</b> +
Technical Analysis	Technical Analysis	<b>Minima of external sagittal hip moment at swing phase initiation are smallest with C-Leg</b> → most easy swing phase initiation	<b>++</b>
		C-Leg, Orion and Rel-K are using a servo-hydraulic valve that allows variation of the flexion resistance. Plié2.0 allows switching between a lower manual adjustable and a higher manually adjustable	n.a.

Category	Outcomes	Results for C-Leg	Sig.*
		flexion resistance.	

\* no difference (0), positive trend (+), negative trend (-), significant (++/--), not applicable (n.a.)

### Author's Conclusion

'With the microprocessor-controlled knee joints compared in this study (C-Leg, Plié 2.0, Orion, and Rel-K), differences in the quality of functions required for level walking could be identified. The technical analyses of the functional principles showed that the differences in joint design and control corroborate those differences. The stance phase control is one of the central functions of prosthetic knee joints. While walking with stance flexion, the gait pattern appears more natural and the full ground contact of the foot is reached faster. The analysis of the knee angular acceleration showed that damping of the extension movement after stance phase flexion is significantly smoother with the C-Leg and the Orion joints than with the Plié 2.0 and the Rel-K joints. ... Owing to the low hip flexion moment that had to be provided by the hip musculature, the swing phase could be initiated most easily at all walking velocities with C-Leg in comparison to all other tested joints. During swing phase flexion, significant differences in the maximum knee flexion angle were identified at the different walking velocities. C-Leg shows the least variation of the maximum knee flexion angle with increasing walking velocity, thus meeting the demand for optimal swing phase flexion control. ... Reaching of the extension stop during the end of the swing phase allows reproducible positioning of the prosthetic foot. The extension stop was reached reliably with Plié 2.0 and C-Leg. The Orion and Rel-K joints more seldom reached the extension stop, especially at mid velocity. ... The significant differences in function found in this study suggest that patients' benefits may also vary remarkably between the devices tested. If there are significant differences between the MPKs in level walking, even more pronounced differences may be expected on more challenging terrains and in safety-relevant situations. ..., (Thiele et al. 2014)

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