
Reference

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Comparative biomechanical analysis of current microprocessor-controlled prosthetic knee joints

Archives of physical medicine and rehabilitation 2010; 91(4):644–652.

Products

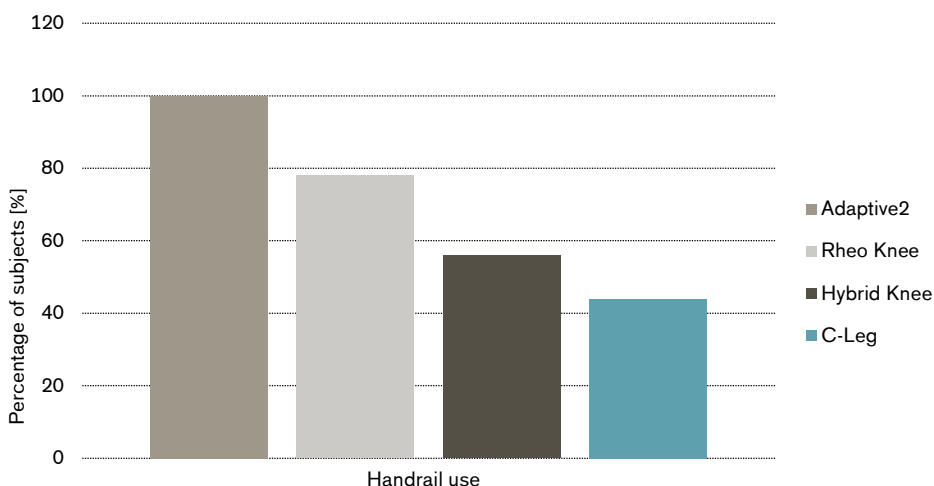
C-Leg vs Hybrid Knee, Adaptive2, Rheo Knee

Major Findings

With C-Leg compared to other MPCKs:

- **Increased safety potential**
- **Loading of the contralateral side decreased during stair and ramp descent**
- **Subjects are less dependent on handrails in stair or ramp descent**
- **Safe weight acceptance in stair descent**
- **Most suitable design for swing phase control through progressive flexion and extension damping**

Less use of handrail when descending stairs with C-Leg

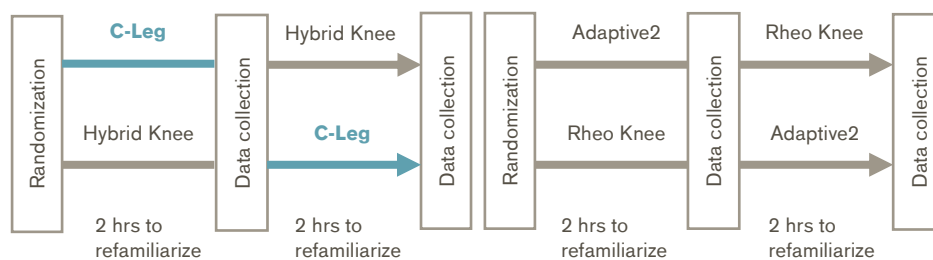


Population

Subjects:	9 unilateral, transfemoral amputees
Previous prosthesis:	C-Leg
Amputation causes:	78% trauma, 22% osteosarcoma
Mean age:	35.4 yrs (± 11 yrs)
Mean time since amputation:	17.4 yrs (± 9.2 yrs)
MFCL:	K3 - K4

Study Design

Interventional, randomized double-crossover design:



The study was conducted in two phases: First C-Leg and Hybrid Knee were investigated, followed by Adaptive2 and Rheo Knee a year later. The subjects used previously all prostheses successfully therefore 2 hours were sufficient to familiarize with the test prosthesis.

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	Motion analysis	Increased walking velocity at self-selected and fast walking speed compared to Hybrid Knee	++
		Most constant maximum knee flexion angle in swing phase when walking at varying gait speeds.	n.a.
		Knee angle velocity in swing phase extension movement slower compared to Hybrid Knee and faster compared to Rheo Knee.	++
Stairs	Motion analysis descending	Trend for lowest external sagittal hip moments during pre-swing phase on prosthetic side.	+
		Highest maximum knee flexion moments on prosthetic side.	++
		Only prosthesis which was not slightly flexed prior to stair contact.	n.a.
		Decreased thigh segment movement on prosthetic side compared to Rheo Knee and Adaptive2.	++
		Decreased maximum vertical ground reaction forces on contralateral side compared to Adaptive2.	++
		Lowest percentage of subjects using the hand-rail: 44% with C-Leg	n.a.

Category	Outcomes	Results for C-Leg	Sig.*
		56% with Hybrid Knee 78% with Rheo Knee 100% with Adaptive2.	
Ramps, Hills	Motion analysis descending	Increased maximum knee flexion moments on prosthetic side compared to Rheo Knee and Adaptive2. Trend for lowest maximum vertical ground reaction forces on contralateral side. Lowest percentage of subjects using the hand-rail: 22% with C-Leg 44% with Hybrid Knee 78% with Rheo Knee 100% with Adaptive2.	++ + n.a.
Metabolic energy consumption	Metabolic energy consumption	Energy consumption at self-selected walking velocity decreased by 5% compared to Rheo Knee.	++
Safety	Stopping	Without problems with C-Leg and Hybrid Knee. Increased compensatory movements with Rheo Knee. Incidental knee joint collapse with Adaptive2.	n.a.
	Sidestepping	Without problems with C-Leg and Hybrid Knee. Increased compensatory movements with Rheo Knee. Incidental knee joint collapse with Adaptive2.	n.a.
	Stepping onto an obstacle	Without problems with all MPCKs.	n.a.
	Stumbling	Interruption of swing extension movement at 10° and 35° knee angle: Without problems with C-Leg Increased compensatory movements or unavoidable falls with Hybrid Knee, Rheo Knee and Adaptive2. Stronger knee extension after interruption by stumbling: Permitted with C-Leg. Flexed prosthesis under weight-bearing load: C-Leg only collapsed at a knee flexion angle higher than 30°. Strong compensatory movements required or subject fell at less than 30° with Hybrid Knee, Rheo Knee and Adaptive2.	n.a.

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

Author's Conclusion

"The results from this study demonstrate that the clinical functions provided by the investigated electronic prosthetic knee joints differ considerably. The C-Leg with an integrated microprocessor-controlled linear hydraulic system in combination with its control algorithm appears to offer the subject with amputation greater functional and safety-related advantages than the other tested knee joints. Reduced loading of the contralateral side when using the C-Leg has been demonstrated during ramp and stair descent. Despite the documented functional differences, it should be noted that metabolic energy consumption does not vary significantly between the tested knees. Hence, this parameter seems not to be a suitable criterion for assessing microprocessor controlled knee components." (Bellmann et al. 2010)

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