

Reference

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Analysis of locomotor adaptations in young children with limb loss in an early prosthetic knee prescription protocol

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Products

3R38, 3R66

Major Findings

With 3R38 (free posterior-offset single-axis knee hinge with manual lock and adjustable knee extension assist), 3R66 (4-bar knee with swing extension assist) and Pediatric Total Knee in unlocked and locked state:

→ **An articulating (unlocked) knee as the first prosthesis in children can reduce toe clearance adaptations (circumduction^a, vaulting^b, hip hiking^c) while walking is developing**

- Less swing phase toe-clearance adaptations with an articulating knee in unlocked state compared to a locked knee
- Significant increase in circumduction ($p = 0.038$) in locked state
- No statistically significant increase in vaulting (highly variable results, $p = 0.64$) or hip hiking (but a trend to increase for most subjects, $p = 0.85$) in the locked state

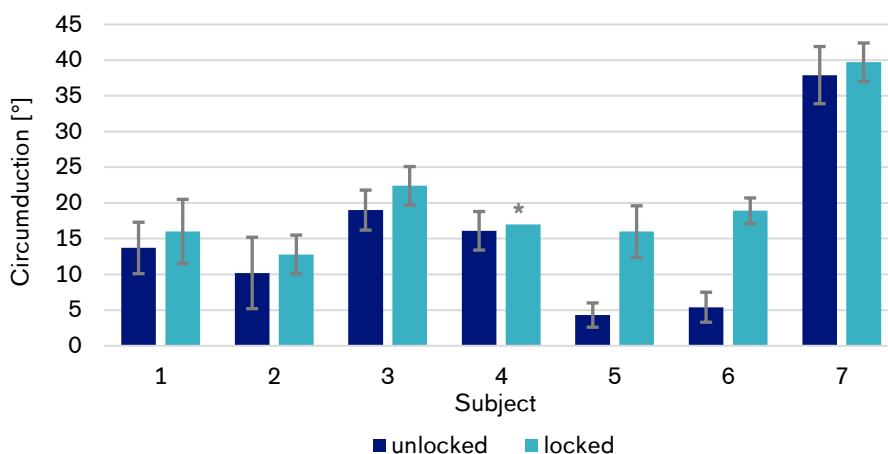


Figure 1. Circumduction angle of each subject for locked and unlocked state (angle of ipsilateral femur segment in frontal plane from vertical). *Subject 4 had only one useful trial → no standard deviation

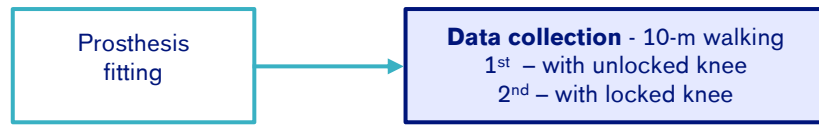
Population

Subjects: 7 subjects (3 male, 4 female)
 Amputation level: knee disarticulation (4), transfemoral (3)
 Current prosthesis: - 3R38, TRS Inc. infant foot, TES belt (4)
 - 3R66, College Park Truper foot, TES belt (1)
 - Pediatric Total Knee, College Park Truper foot, Spirit liner (1)
 - 3R38, Seattle child’s play foot, TES belt (1)
 Amputation causes: Tibia deficiency (2)
 Amniotic banding (2)
 Trauma (1)
 Embryonal rhabdomyosarcoma (1)
 Knee disarticulation (1)
 Age: 52 months (18-92 months; ≤7 years)
 Time since amputation (range): 30.2 months (range: 7-60 months)

MFCL: n.a.

Study Design

Before-and-after experimental design:



Children who had been provided prostheses following the early knee protocol, walked along a 10-m walkway while gait data was measured. First, they completed 3 trials with their knee in an unlocked state and then 3 trials with the knee mechanically locked into full extension.

Results

Functions and 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 locked versus unlocked knees	Sig. *
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Level Walking **Hip hiking ° [mm]** Subjects did not demonstrate a significant increase in hip hiking in the locked state ($p = 0.85$), but 6 out of 7 showed a trend towards increased values in the locked knee state (exception subject 3).

Subject	Unlocked knee (Mean ± SD)	Locked knee (Mean ± SD)	
1	39 ± 1 mm	56 ± 7 mm	+
2	74 ± 17 mm	80 ± 28 mm	+
3	89 ± 28 mm	45 ± 14 mm	-
4	75 ± 17 mm	92 ± n.a. mm	+
5	53 ± 25 mm	58 ± 13 mm	+
6	86 ± 16 mm	91 ± 22 mm	+
7	12 ± 3 mm	14 ± 11 mm	+
All	59 mm	63 mm	0

Hip hiking, measured by the mean increase of ASIS marker height was overall lower in the unlocked state than in the locked.

Circumduction ^a [°] Overall circumduction angle increased significantly in the locked state compared to unlocked state ($p = 0.038$). Individually, all subjects showed an increased circumduction angle in the locked state.

Subject	Unlocked knee (Mean ± SD)	Locked knee (Mean ± SD)	
1	13.7 ± 3.6°	16 ± 4.5°	+
2	10.2 ± 5.0°	12.8 ± 2.7°	+

Category	Outcomes	Results for locked versus unlocked knees		Sig. *	
		3	19.0 ± 2.8°	22.4 ± 2.7°	+
		4	16.1 ± 2.7°	17.0 ± n.a.°	+
		5	4.3 ± 1.7°	16.0 ± 3.6°	+
		6	5.4 ± 2.1°	18.9 ± 1.8°	+
		7	37.9 ± 4.0°	39.7 ± 2.7°	++
		All	n.a. ± n.a.	n.a. ± n.a.	++

Vaulting ^b [°]

Vaulting results were highly variable and the differences across subjects not significant ($p = 0.641$).

Subject	Unlocked knee (Mean ± SD)	Locked knee (Mean ± SD)	
1	4.0 ± 0.1°	3.5 ± 6.0°	-
2	0.0 ± 0.0°	1.0 ± 1.4°	+
3	3.3 ± 6.7°	0.0 ± 0.0°	-
4	3.2 ± 0.7°	2.5 ± 0.2°	-
5	1.7 ± 1.9°	6.6 ± 4.3°	+
6	4.8 ± 1.9°	6.8 ± 6.8°	+
7	0.0 ± 0.0°	0.0 ± 0.0°	0
All	n.a. ± n.a.	n.a. ± n.a.	0

Three subjects increased vaulting when the knee was locked, one was unchanged, and three decreased vaulting when the knee was locked.

Toe-clearance adaptation strategies with locked knee

Subject 1&5: increased all three clearance adaptations	n.a.
Subject 7: increased hip hiking & circumduction, no change in vaulting	n.a.
Subject 2,3,6: increased two adaptations, decreased one	n.a.
Subject 3: increased circumduction while hip hiking decreased by more than 50%, the vaulting strategy was eliminated (was present in the unlocked condition)	n.a.

Peak knee flexion

In the unlocked state, children make use of the possible knee flexion. Peak knee flexion on average was 70.4° (range: 27.0°-90.0°)

* no difference (0), positive trend (+), negative trend (-), significant (++/--), not applicable (n.a.); significance set at $p < 0.05$;

^a Circumduction: ipsilateral hip abduction during flexion

^b Vaulting: contralateral ankle plantarflexion

^c Hip hiking: ipsilateral upward pelvic obliquity

Author's Conclusion

"All subjects in the study adopted one or more clearance adaptations when their prosthetic knee was locked into full extension. Subjects who had a clearance adaptation with a flexing knee reduced that adaptation when the knee was permitted to flex and extend. These results, combined with favorable results during crawling [...], suggest that an Early Knee prescription protocol might encourage more typical motor development that reduces clearance adaptations." (Geil and Coulter, 2014)

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