Reference

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Transitioning to a microprocessor-controlled prosthetic knee: Executive functioning during single and dual-task gait

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Products

Microprocessor-controlled prosthetic knee joints (MPK)[a] vs. Non-microprocessor-controlled prosthetics knee joints (non-MPK)[b]

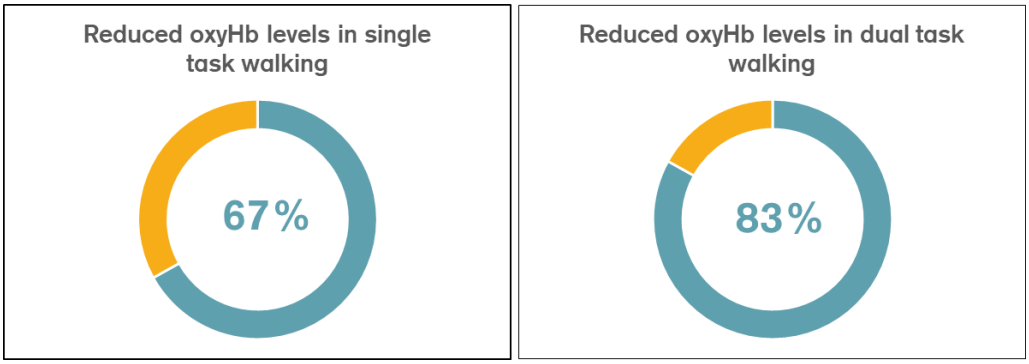
[a] C-Leg (Ottobock), Genium (Ottobock), Rheo Knee (Ossur)

[b] 3R-80 (Ottobock), Mauch (Ossur), Total Knee (Ossur)

Major Findings

→ Reduced oxyHb levels in the prefrontal cortex for 4 out of 6 participants (67%) in the single-task walking condition with the MPK

→ Reduced oxyHb levels in the prefrontal cortex for 5 out of 6 participants (83%) in the dual-task walking condition with the MPK



→ Time taken to complete a 10 meter walk test was reduced for 4 out of 6 (67%) participants when completing a single or dual task walking condition and walking with an MPK

→ Time taken to complete an obstacle course was reduced for 5 out of 6 (83%) participants when walking with an MPK

Population

Subjects:	6 participants (4 male, 2 female)
Previous prosthesis:	Non-MPK (3x 3R80, 2x Mauch, 1x Total knee)
MPK fitted during study:	MPK (4x Rheo Knee, 1x C-Leg, 1x Genium)
Amputation causes:	not reported
Mean age:	44.3 ± 16.8 years
Mean time since amputation:	10.8 ± 12.3 years
Accommodation period MPK:	7.8 ± 2.4 months

Study Design

Multiple case-study design:

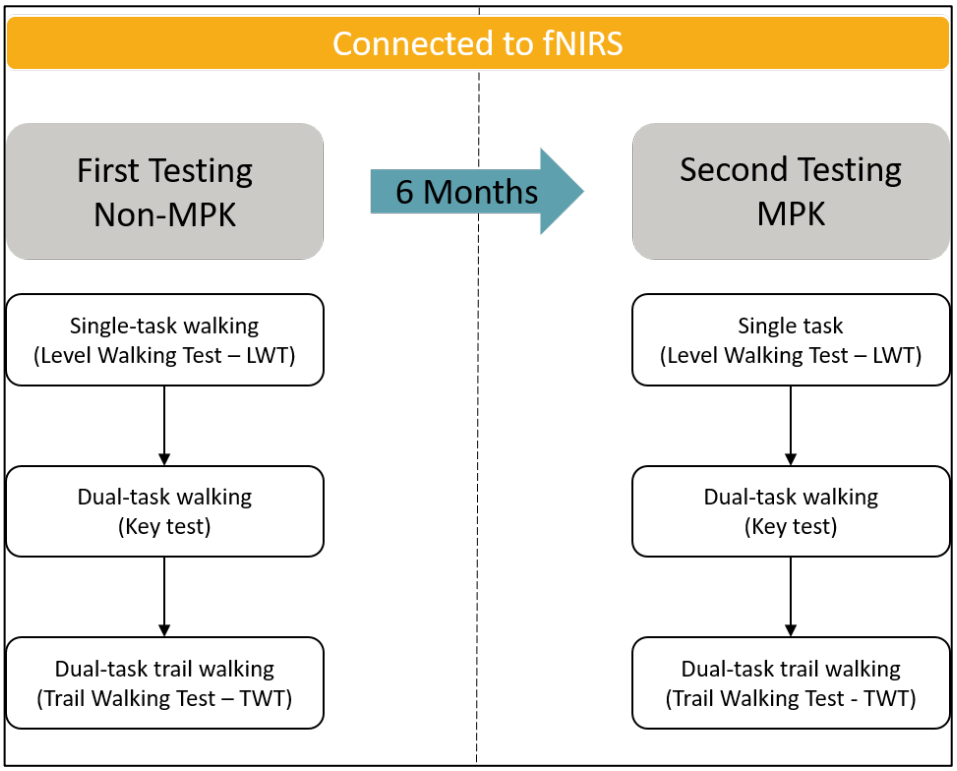


Figure 1, Experimental protocol

Participants were tested on two different occasions. The first set of tests was tested with the participant's current non-MPK, while the second set of tests was conducted after a minimum of 6 months after they had been fitted with an MPK. The experimental protocol was designed as followed:
Prior to testing, participants were fitted with the fNIRS system (functional near-infrared spectroscopy; a wireless, portable, continuous wave system to record haemodynamic responses). fNIRS systems record the relative changes in concentration of oxygenated (oxyHb) and deoxygenated (de-oxyHb) haemoglobin, which results from neural activation. An increase in oxyHb concentration and a simultaneous decrease in de-oxyHb concentration would typically be observed as a response to regional brain activation.
Prior to each walking condition, baseline signals were collected for 30 seconds with the participants sitting quietly, with closed eyes. Following the baseline measures, participants then stood for another 30 seconds to allow stabilization of fNIRS signals before given the signal to commence testing.

- Single-task walking:
Participants were instructed to walk at a self-selected velocity on a 15 meter walkway back and forth.

- Dual-task walking:
Participants were instructed to walk on the identical 15 meter walkway as in the single-task walking test, but they additionally had to find a specific key on a keyring, which consisted of 8 different keys. Just before they started walking they were informed what key they had to find, and handling was just allowed one-handed. When they identified the right key, they had to raise their arm in the air.

- Dual-task trail walking:
Six numbered cones were placed in a 1 meter x 4 meter area in a predetermined randomized order. Participants were instructed to circle the cones in consecutive order as fast as possible. The position of the numbered cones was altered for each walking trail. Participants could not see the numbers until they started walking.

Each condition was repeated 4 times for a total of 12 trials. For each condition the final three trials were analysed. The single-task walking and the dual-task walking was conducted on a 15 meter walkway, which participant had to walk back and forth. The time taken to walk the first 10 meters, along with the number of steps taken were recorded. For the dual-task trail walking, only the time taken to walk around the six cones was recorded.

Results

Functions and Activities						Participation			Environment
Level walking	**Stairs**	**Ramps, Hills**	**Uneven ground, Obstacles**	**Cognitive demand**	**Energy**	**Safety**	**Activity, Mobility, ADLs**	**Preference, Satisfaction, QoL**	**Health, Economics**

Category	**Outcomes**	**Results for MPKs**	**Sig.***
Level Walking	Time	Time taken to walk 10 meters was reduced for 4 out of 6 participants in both, the single-task walking condition and the dual-task walking condition, when fitted with an MPK.	n/a
	Steps	The number of steps taken to cover the 10 meters with an MPK were less for 2 out of 6 participants in the single-task walking condition, and for 3 out of 6 participants in the dual-task walking condition.	n/a
Uneven Ground, Obstacle Course	Time	When fitted with an MPK, time taken to complete the obstacle course was less for 5 out of 6 participants during the dual-task trail walking condition.	n/a
Cognitive Demand	Haemodynamic response in the prefrontal cortex	In the single-task walking condition, oxyHb levels were lower for the MPK condition for 4 out of 6 participants.	n/a
		In the dual-task walking condition, oxyHb concentration levels were lower for the MPK condition for 5 out of 6 participants.	n/a
		De-oxyHb concentration levels varied greatly between subjects among all three walking conditions.	n/a

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

Author's Conclusion

"Results of this study suggest that prescription of MPK prosthetic knee joints can reduce demand placed on executive functions during single-task walking and dual-task walking for some individuals. Our results support continued investigation into the role that assistive technology design can have on reducing cognitive loads." (Ramstrand et al, 2020)