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Title
Does microprocessor controlled knee movement influence common activities of daily living when using a knee-ankle-foot orthosis?

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None

Summary
Activities of daily living are physically demanding tasks for KAFO users. MPKAFO use increased knee power absorption and net negative work during stair descent and altered task execution time and reduced inter-limb loading asymmetry during sitting.

Introduction
For people that use a knee-ankle-foot orthoses (KAFO), completing activities of daily living (ADLs) such as stair negotiation and seat transfers can be challenging. Assistive technologies aid the user in performing such ADLs and address functional deficits associated with joint pain, muscle weakness or limb absence. For example, microprocessor-controlled knee-ankle-foot orthoses (MPKAFO) have been shown to improve mobility and patient perceptions of safety [1,2]. However, it is not yet clear how MPKAFOs influence limb loading when standing from and sitting into a chair nor when descending stairs. Therefore, the current study aimed to investigate how MP-control, applied to the knee joint of a KAFO, influences limb loading symmetry during sit-to-stand (SIT-STA)/stand-to-sit (STA-SIT) and joint kinetics during stair descent.

Methods
One participant (male; 28 years; height 1.60m, mass 80.9kg) completed SIT-STA, STA-SIT and stair descent trials at a self-selected speed wearing a KAFO (Chas A Blatchford and Sons, Basingstoke, UK) on their right leg. The KAFO operated with no resistance to knee flexion/extension (FREE) and with microprocessor controlled knee articulation (STS-MP) during sitting trials; and with MP controlled knee flexion resistance (STAIR) or with the knee joint locked in full extension (LOCK) during stair descent. A 13-camera motion capture system (Qualisys AB, Gothenburg, SE) and four force platforms (AMTI, Watertown, US and Kistler, Winterthur,

CH) captured whole body kinematics and ground reaction forces (GRF) at 100Hz and 500Hz respectively. Task execution time and loading (impulse) were calculated for STA-SIT and SIT-STA. Affected limb hip, knee and ankle power and net mechanical work were calculated during stair descent.

Results

The participant performed SIT-STA movements more quickly when using the KAFO in the STS-MP mode (Table 1). The impulse produced under the non-affected limb was always higher than that under the affected limb during SIT-STA movements. However, this asymmetry was reduced when using the STS-MP mode, where the affected limb produced a greater percentage impulse. The participant completed STA-SIT movements more quickly when using the KAFO in the FREE mode. Again, the impulse produced under the non-affected limb was always higher than that under the affected limb during STA-SIT movements. Similarly, inter-limb impulse asymmetry was reduced when using the STS-MP mode, where the affected limb produced a greater percentage impulse. (Table 1) The participant generally performed stair descent with a step-over-step approach during the STAIR condition and favoured a step-to or skipping approach during the LOCK condition. Knee joint power absorption was considerably increased during the STAIR condition when compared to the LOCK condition (Figure 1). This also resulted in greater net negative work done by the knee joint during stance phase in the STAIR condition. During the LOCK condition, net negative work done by the hip was greater when compared to the STAIR condition (Figure 1). There was little difference in ankle work between conditions.

Conclusion

Preliminary analyses from this case study suggest that microprocessor control applied to the knee joint of a KAFO does influences limb loading symmetry and task execution time during sitting. This may reflect an increased ability of the affected limb to perform positive and negative work during these ADLs, reducing the burden on the non-affected limb. Whilst decreased tasks execution time during SIT-STA in STS-MP mode may reflect improved performance, it is not clear whether increased execution time during STA-SIT tasks reflects improved control or decreased performance. During stair descent, the MPKAFO increased knee joint power absorption and thus net negative work. This may be due to the knee flexion present when engaging the STAIR mode, alongside altered ground reaction forces. The fixed nature of the knee articulation in the LOCK condition seemed to shift the requirement to perform negative work to the hip joint, in order to lower the centre of mass during stance.

References

[1] Probsting E et al. Pros Orth Int 2017; 41(1);65-77.

[2] Schmalz T et al. Pros Orth Int 2016; 40(2); 277-286.

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Table 1. Limb specific impulse (absolute and %) and execution times from sit-to-stand (SIT-STA) and stand-to-sit (STA-SIT) movements.

		FREE		STS-MP	
SIT-STA	Non-Affected Limb Impulse (N.s)	529.1	80%	460.1	76%
	Affected Limb Impulse (N.s)	134.9	20%	149.0	24%
	Execution Time (s)	0.97		0.94	
STA-SIT	Non-Affected Limb Impulse (N.s)	461.2	69%	496.6	66%
	Affected Limb Impulse (N.s)	205.0	31%	261.2	34%
	Execution Time (s)	1.01		1.21	

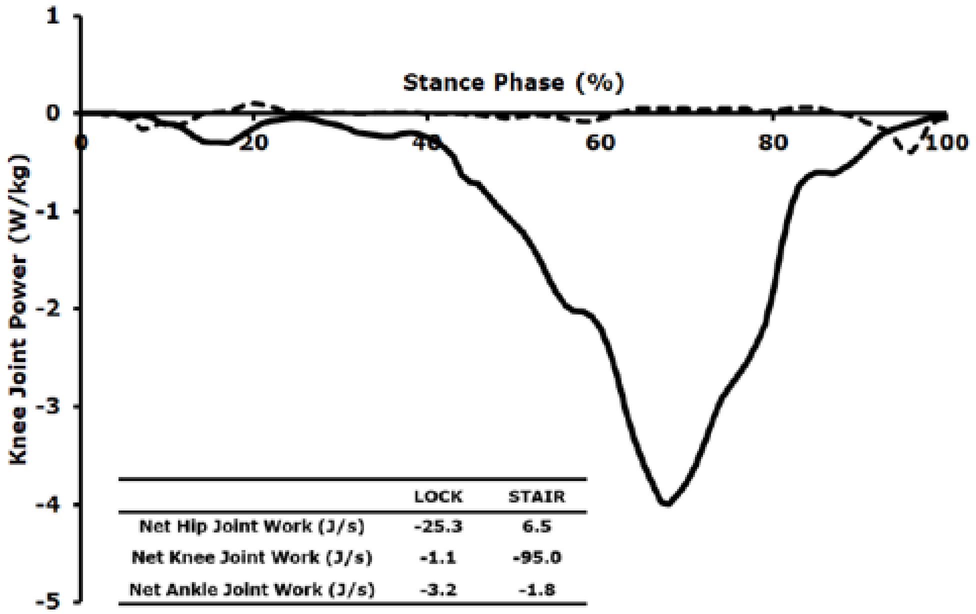

Figure 1. Mean knee joint power during STAIR (solid) and LOCK (DASH) conditions. Inset table shows net joint work.