

Gait Adaptability in People with Unilateral Trans-tibial Amputations in Response to Variable Walking Speed and Body Weight Support

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INTRODUCTION

Lower limb amputations reduce the number of muscle receptors, proprioceptors and plantar sensory receptors (Dietz, 2002). Visual cues combined with modified somatosensory information revise the motor output thus influencing gait adaptability and safety (Kavounoudias et al, 2005). Residual sensory receptors may be further compromised by dysvascular conditions.

Changes in walking speed challenge individuals with amputations to utilize residual sensory input to efficiently maneuver the prosthesis during gait (Dingwell et al, 1996). Body weight support (BWS) combined with treadmill gait at selected speeds allows the assessment of multiple strides while varying sensory input from the periphery (Threlkeld et al, 2003)

Our purpose was to assess motor adaptability of people with trans-tibial amputations by evaluating kinematic responses to changes in walking speed and body weight support vs. matched controls. We also compared a small subset of people with unilateral trans-tibial dysvascular amputations vs. traumatic amputations.

METHODS

All volunteers read, understood and signed an IRB approved informed consent. Six people with unilateral trans-tibial

amputations (3 dysvascular amputations, 3 traumatic amputations; \bar{x} age 57.1 yrs, \bar{x} ht. 176.3 cm, \bar{x} wt. 83.3 kg) and eight group matched controls participated in the study.

Subjects walked on a treadmill at three speeds (0.36, 0.8, and 1.07 m/s) at each of three BWS levels (0%, 30%, and 50%) while wearing a harness attached to a commercial BWS system (NeuroVigor II). Joint kinematics were captured at 60 Hz. with a MotionAnalysis system and normalized to percentage of gait cycle (%GC) using OrthoTrak software.

Temporal (cadence, initial double support, total support, total swing) and kinematic (knee and ankle) variables were compared using Repeated Measures ANOVA ($p \leq 0.05$): controls vs. both the intact and the amputated limb; dysvascular vs. traumatic.

RESULTS AND DISCUSSION

Changing walking speeds and BWS caused significant gait changes in all subjects ($p < 0.001$). **Tab. 1**

As walking speed decreased and as BWS levels decreased, all subjects increased the %GC spent in double limb support and total support. Compared to controls, people with amputations devoted a larger %GC on the prosthetized limb to initial double support ($p < 0.001$) and total support ($p = 0.038$) at all speeds and BWS levels. **Tab. 1**

Average knee flexion during the early swing (first 1/3) was significantly greater in controls compared to the amputated limb of people with prosthetics (p=0.012) but controls were the same as the intact limb of people with amputations (p=0.589). **Tab. 1**

Subjects with dysvascular amputations had markedly less average knee flexion of the intact limb during early swing compared to subjects with amputations from trauma (p<0.016). Differences ranged from 27.5° at 0.36m/s @ 0%BWS to 17.7° at 1.07m/s @ 50%BWS but there were no differences when comparing the prosthetized sides.

CONCLUSIONS

All subjects displayed temporal and kinematic adaptability to changing walking speed and BWS level. The increased %GC in initial double support and total support on the prosthetized limb of people with amputations allows greater time to transfer weight from the intact to the amputated limb; a compensation that increases gait

stability and is consistent with compromised somatosensory feedback mechanisms. In normal gait, early swing knee flexion with ankle dorsiflexion ensures foot clearance and avoids tripping. Increased mean early swing knee flexion on the prosthetized side of subjects with trans-tibial amputations was likely a compensation for the prosthetic ankle. There was a marked reduction in mean early swing knee flexion in the intact limb of people with dysvascular amputations versus subjects with traumatic amputations possibly reflecting diminished compensatory adaptability in people with dysvascular amputations.

REFERENCES

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Table 1: Measures of Interest from Control (**Ctrl**) Subjects and the Prosthetized Limb of Subjects with Unilateral Trans-tibial Amputations (**Amp Prost**).

Speed (m/s)		0.36			0.8			1.07		
		0	30	50	0	30	50	0	30	50
BWS (%BW)		\bar{x} (s.d.)	\bar{x} (s.d.)	\bar{x} (s.d.)	\bar{x} (s.d.)	\bar{x} (s.d.)	\bar{x} (s.d.)	\bar{x} (s.d.)	\bar{x} (s.d.)	
Initial Double Limb Support (%GC)	Ctrl	21.4(1.4)	20.2(1.0)	16.0(1.6)	14.6(2.5)	14.4(2.7)	13.5(2.4)	12.9(1.3)	13.5(1.1)	12.2(0.9)
	Amp Prost	25.2(2.2)	25.1(1.4)	23.3(4.5)	18.2(2.3)	18.0(2.0)	17.5(2.1)	15.0(1.9)	15.3(1.8)	15.0(1.4)
Total Support (%GC)	Ctrl	72.0(1.1)	71.1(1.6)	65.9(2.1)	65.3(2.7)	64.9(3.0)	64.1(2.4)	63.9(1.4)	63.7(1.3)	62.7(1.0)
	Amp Prost	73.9(1.4)	72.5(3.7)	72.1(3.1)	66.6(2.2)	66.2(1.8)	65.7(1.9)	64.5(2.5)	63.9(2.2)	63.6(1.8)
Early Swing (%GC)	Ctrl	43.3(2.6)	42.1(3.5)	43.5(3.5)	46.6(4.4)	46.8(4.9)	45.4(4.3)	51.3(3.0)	49.0(3.5)	46.9(3.6)
	Amp Prost	26.5(11.6)	34.5(12.1)	33.5(10.2)	38.1(11.3)	34.1(7.9)	37.3(11.5)	43.4(9.5)	42.9(9.6)	43.2(9.7)