Correlation of Kinetic and Musculoskeletal Asymmetries in Individuals with Transtibial Amputation

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INTRODUCTION

Many data collection and analysis tools in biomechanics rely on cadaveric data as the gold standard, so musculoskeletal asymmetries (MAs) in cadavers with lower limb amputation should be consistent with kinetic asymmetries observed in living individuals with lower limb amputation.

The study aimed to examine kinetic interlimb asymmetries and correlate results to a recent anatomical study by the first author examining MAs from long-term prosthesis use. This study found lower bone mineral density (BMD) and content (BMC), more tissue fat, wider knee joint space (KJS), and smaller biceps femoris long head physiological cross-sectional area (BF PCSA), indicating reduced prosthetic side (PS) loading.

We expected reduced PS kinetics in each participant with >10% differences compared to the sound limb, and strong positive correlations between kinetic and MAs.

METHODS

Five participants with unilateral transtibial amputation ambulated on a split belt treadmill. All participants were a K3 functional level, indicating ability to walk at a variable cadence and traverse environmental barriers in the community. Cortex motion analysis files were processed through Visual 3D software. Discrete magnitudes on the graph below (Fig. 1) were chosen based on previous points of comparison by Winter and Sienko.[1] Percent differences were calculated to assess interlimb asymmetry. Correlations between kinetic asymmetries and MAs (Table 1) were found in three male participants closest in age (51-67), height (5'8-6'0), and weight (140-240lbs) from both studies. A <10% difference in moments between the left and right limb has been found in healthy populations[2], therefore, a 10% difference in interlimb asymmetry was chosen as a clinically relevant threshold in this study.

RESULTS AND DISCUSSION

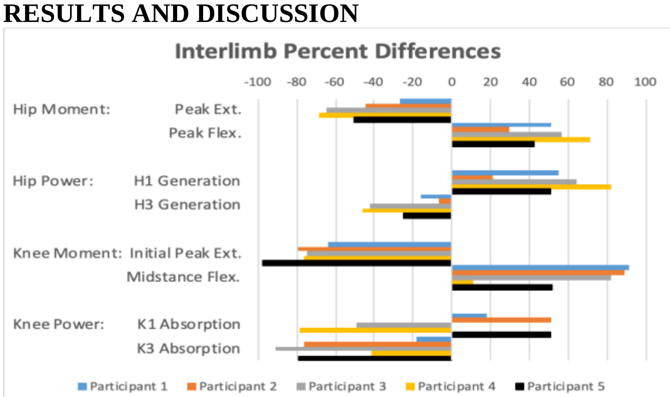

Fig. 1: Negative percent differences indicate lower values on the PS. H1, H3= hip power generation; K1, K3= knee power absorption

Each participant had interlimb percent differences >10%. Most kinetics analyzed were reduced on each participant's PS. However, peak hip and knee flexion moments and initial hip power burst (H1) were greater on the PS- potentially from lack of anatomical plantarflexion.[3]

Trends of interlimb asymmetry were consistent except in initial knee power absorption (K1), potentially indicating eccentric knee extensor activity during loading response can be a variable compensatory strategy.

CORRELATION		BMD	BMC	Fat	KJS	PCSA
Hip Moment	*Initial Ext*	-0.973	0.792	-0.404	0.997	-0.635
	Peak Flex	0.908	-0.897	0.214	-0.963	0.776
Hip Power	*H1*	0.931	-0.87	0.271	-0.977	0.737
	H3	-0.984	0.757	-0.454	0.999	-0.591
Knee Moment	*Initial Ext*	0.961	-0.388	0.802	-0.904	0.171
	MS Flex	-0.499	0.988	0.389	0.631	-0.998
Knee Power	*K1*	-0.955	0.831	-0.342	0.991	-0.684
	K3	0.157	-0.866	-0.692	-0.311	0.956

Table 1: Weak (0-.3), moderate (.3-.7), and strong (.7-1) correlations between kinetic and MAs.

Correlations varied between positive and negative within each MA measure, which may indicate high variability between participants. BMD and BMC were most strongly correlated with kinetic data, while tissue fat was least correlated with kinetic data.

Peak hip flexion moment and H1 power generation were most strongly correlated to MAs except tissue fat (Table 1), and were also consistently greater on the PS (Fig.1). Greater hip kinetic asymmetry was strongly correlated to greater asymmetry in BMD and BF PCSA, and less asymmetry in BMC and KJS. This agrees with previous research that found gait asymmetry correlated most with muscle torque in hip joint extensors of individuals with unilateral transfemoral amputations.[4]

SIGNIFICANCE

Asymmetries in hip kinetics were most strongly correlated to MAs, while BMC was most strongly correlated to kinetic data. This knowledge can inform analysis of kinetic data and improve biomechanical models to better reflect MAs in individuals with lower limb amputations.

ACKNOWLEDGEMENTS

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