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Title
Comparison of Maximum Isometric Hip and Knee Joint Moments in Trans-tibial and Trans-Femoral Amputees with Moments During Gait

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Summary
Maximum isometric moments of transtibial (TT) and transfemoral (TF) amputees were tested at the residual limb hip and knee. Compared to controls, TF showed hip strength deficits in all motion directions while TT had knee and hip strength deficits in all directions but in hip adduction and extension.

Introduction
The decrease in muscle strength, volume and allocation of the different fibre-types of the residual limp is a common finding in TF [1] [2] and TT [3]. This weakening can be explained by the loss of muscle insertions due to amputation, changed activation-pattern and contraction-amplitude of muscles and an unsymmetrical loading-distribution on both limbs during ambulation. The aim of this study was to evaluate to which extent isometric strength deficit induces compensatory mechanisms in gait of amputees. These mechanisms could be e.g. enhanced lateral-trunk-tilt in TF by means of weak abductors [4] or co-contraction of quadriceps and hamstrings in TT in order to stabilize the knee joint [5]. A new measurement device for testing maximum isometric joint moment (MIJM) was established by combining optical 3D motion capture with a static force measurement. The intention of this method is to get information of segment orientation and force direction next to the force magnitude.

Methods
10 TF, 7 TT (trauma caused, unilateral amputation), and 12 healthy controls (NORM) underwent a conventional 3D gait analysis (12 camera Vicon system; 120 Hz; kistler force plates) and were tested for MIJM of the hip and the knee (TT, NORM only). The isometric strength was recorded using the new device “OpTIMo” (Optical Testing of Isometric Moments)

developed in the laboratory. During hip MIJM measurement the subjects stood supported at the trunk inside a rigid frame equipped with skin mounted markers (PlugInGait markerset, Fig. 1). The measured segment was connected to a force transducer fixed to the frame through a cuff and a rope. For measurement of knee MIJM, the thigh was also supported. Analogue force data and optical data were simultaneously captured by the Vicon system. Lever arm and force direction were obtained using additional markers placed on the cuff and rope. Joint moments were calculated via cross products. To check repeatability, all controls were tested twice.

Results

A good reproducibility between sessions was verified with an ICC of 0.765. MIJM for hip flexion, abduction and knee flexion, extension in TT and for all four movement directions of the hip in TF were significantly smaller than those in controls (Fig. 2).Comparing MIJM with the according maximum moments during gait the MIJM should be higher in order to assure stability. In controls, the maximum isometric moments always exceeded by far their maximum joint moments during gait whereas in TT and TF this was not always the case. Comparing MIJM of TT and TF with physiological maximum joint moments during gait the isometric/gait moment ratio is even smaller. In this assessment only one of the TT could exceed physiological knee extension moment with isometric performance. TF didn’t reach physiological joint moments during gait with their in MIJM in hip abduction and flexion. For hip extension 7 out of 10 TF reached the physiological extension moments during gait with their MIJM.

Conclusion

According to Fosang et al. [6] maximum isometric hip and knee joint moments in controls are larger than maximum joint moments during gait which is supported by our findings. The fact that TT and TF develop joint moments in gait which are closer to their maximum isometric joint moments compared to controls suggests that compensatory mechanism during gait are induced at least partially by strength deficits besides other parameters like e.g. prosthetic alignment [7] socket design and prosthetic components. These results suggest that the standard rehabilitation protocol of lower limb amputees should include strength training of the involved limb. Further investigation of strength in TT and TF after strength training should

be performed to prove the theory that an enhanced isometric/gait moment ratio can reduce compensatory mechanisms of amputees and improve stability.

References

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Image: Abb.Comparison of maximum isometric ...._351.png

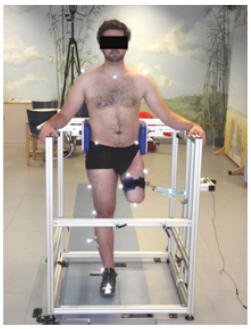

Fig.1

	extension			flexion			abduction			adduction		
group	TF°	TT	NORM	TF°	TT	NORM	TF°	TT	NORM	TF°	TT	NORM
hip moment [Nm/kg]	1.0 **	1.3	1.5	0.8 ***	1.3 ***	2.1	0.7 ***	1.3 *	1.7	0.8 ***	1.2	1.4
	(±0.3)	(± 0.4)	(± 0.3)	(±0.3)	(± 0.3)	(± 0.3)	(±0.2)	(± 0.3)	(± 0.2)	(±0.2)	(± 0.3)	(± 0.3)
knee moment [Nm/kg]	-	0.4 ***	1.6	-	0.4 ***	1.6						
	-	(±0.1)	(±0.4)	-	(±0.1)	(±0.3)						

Mann-Whitney non parametric test / compared to NORM ° Günther, M. [2] (TF results) * p<0.05 ; ** p<0.01 ; *** p<0.001; (± SD)

Fig.2