Table 1
Summary of results.

	N_{TF}	N_{TT}	GDI_{ave}	ΔGDI_{ave}*	nSL_{ave}*	ΔnSL	nSSWS (1/s)	TUG (s)
Asymmetrical $GDI_{pro} \neq GDI_{intact}$	6	6	79.6 (15.5)	13.1 (8.6)	0.35 (0.06)	0.03 (0.02)	0.59 (0.15)	12.9 (3.8)
Symmetrical $GDI_{pro} = GDI_{intact}$	1	2	88.1 (3.9)	2.0 (1.4)	0.45 (0.06)	0.03 (0.02)	0.76 (0.21)	9.4 (1.8)

Abbreviations: ave, average; TF, transfemoral; TT, transtibial.
* $p \leq 0.05$ for asymmetrical vs. symmetrical.

compensation required by the intact limb for amputee gait in these subjects. The GDI was unable to detect differences between levels of amputation, largely because functional ability was not dictated by level of amputation in this study. The moderate to strong correlation between the GDI and functional measures further supports this finding and enhances previous research which demonstrated a relationship between the GDI and functional ability [1].

References

[1] Schwartz, Rozumalski. Gait Posture 2008;28(3):351–7.
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O60

Using the movement analysis profile with lower limb amputees

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Summary

The Movement Analysis Profile (MAP) and the Gait Profile Score (GPS) have been used to summarise overall gait pathology in children with cerebral palsy. This study investigated the use of the MAP/GPS with unilateral lower limb amputees. Fifteen unilateral lower limb amputees underwent three-dimensional gait analysis (3DGA). The MAP demonstrated increased deviations from normal values for all subjects. Pelvic obliquity, hip adduction/abduction and knee flexion/extension differentiated levels of amputation. Asymmetries were detected in all variables, except pelvic tilt and pelvic rotation.

Conclusions

Elements of the MAP differentiated between levels of amputation and detected asymmetries, which suggests this summary measure has potential for use with unilateral lower limb amputees.

Introduction

Several unidimensional measures have been developed to summarise overall gait pathology. While efficient, these measures do not expose the source of gait deviation, which is often of most interest. The MAP/GPS has been proposed to overcome this restriction [1]. It is composed of several kinematic variables and includes an overall summary score, the GPS. The MAP has been shown to correlate strongly with levels of disability in children with cerebral palsy, but its use with other disability groups has been limited. This study considered the suitability of the MAP/GPS for use with lower limb amputees. Suitability was defined as an ability to detect asymmetries and differentiate between levels of amputation.

Patients/materials and methods

Seven unilateral transfemoral and eight unilateral transtibial amputees underwent 3DGA while wearing their regular prosthesis. Kinematic and temporospatial data were collected from a minimum of six trials per subject. The MAP was calculated for the pelvis, hip, knee and ankle in the sagittal plane, pelvis and hip in the frontal plane and pelvis and foot in the transverse plane. Normal data were sourced from the laboratory's database comprised of able-bodied males in their twenties [2].

Results

The mean MAP scores for each variable are summarised in Table 1. Larger values of the MAP represent larger deviations from normal. The largest deviations were seen at the pelvis, hip and knee in the sagittal plane. Asymmetries were detected for all variables, except pelvic tilt and pelvic obliquity. Ankle dorsi/plantar flexion and foot progression scores detected asymmetries in the majority of subjects. There were significant differences between transfemoral and transtibial amputees for pelvic obliquity on the prosthetic side, knee flexion/extension on the intact side and hip adduction/abduction on both sides.

Discussion

While deviations from normal were seen for all aspects of the MAP, the sagittal plane kinematics showed the greatest deviations. Magnitudes of deviations were similar in both the transtibial and transfemoral amputee groups (except for knee flexion/extension on the intact side) which suggest that compensations strategies are substantial, but similar, in the sagittal plane for both levels of amputation. Several compensation strategies adopted by trans-

Table 1
The movement analysis profile.

Level	Limb	Pel Tilt	Pel Obl*	Pel Rot	Hip Flex	Hip Add*,†	Knee Flex†	Ank Dors	Foot Prog	GPS
TF, $n=7$	Prosthetic	14.1	5.2	7.4	14.3	8.7	15.0	9.3	9.4	11.6
	Intact	14.4	4.9	7.4	17.0	6.9	13.7	9.5	7.8	11.4
	Asymmetry	0/7	2/7	0/7	5/7	6/7	5/7	5/7	6/7	3/7
TT, $n=8$	Prosthetic	17.8	3.3	5.3	20.9	4.8	11.7	10.9	8.3	12.3
	Intact	17.7	3.4	5.5	20.0	4.7	9.0	8.5	7.2	11.4
	Asymmetry	0/8	0/8	0/8	3/8	4/8	5/8	8/8	7/8	3/8

Abbreviations: TF, transfemoral; TT, transtibial; pro, prosthetic.
Notes: Prosthetic and intact values were measured in degrees. See [1] for details.
* $p \leq 0.05$ for TF_{pro} vs. TT_{pro}.
† $p \leq 0.05$ for TF_{intact} vs. TT_{intact}.

femoral amputees to enable adequate prosthetic foot clearance were exposed by the MAP-hitching was summarised by the significantly larger value for pelvic obliquity, and circumduction by the significantly larger values for hip abduction. The significantly larger value for knee flexion/extension represented increased intact knee extension during stance. Vaulting – an additional compensation strategy – was evident in several transfemoral amputees, but was not revealed by the MAP. The MAP detected asymmetries at the ankle and foot for the majority of subjects, which is most likely attributable to the relatively immobile prosthetic ankle joint.

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O61

Strength deficits in trans-tibial amputees

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Summary

With a new technique isometric strength testing of trans-tibial amputees (TTA) and controls was performed at the hip and the knee. Maximum joint moments for hip flexion and abduction and knee flexion and extension in TTA were significantly smaller than those in controls.

Conclusions

The relations between isometric joint moments and joint moments during gait in the two subject groups indicate that the strength deficit in TTA plays an important role in their gait deficiency.

Introduction

The decrease in strength and muscle volume of the residual limp is a common finding in TTA [1,2]. The aim of this study was to evaluate to which extent isometric strength deficit induces compensatory mechanisms in gait. A new measurement device for testing isometric joint moments was established by combining optical 3D motion capture with static dynamometry.

Patients/materials and methods

7 unilateral trauma induced TTA and 12 healthy controls underwent a conventional 3D gait analysis and were tested for maximum isometric moments of the hip and the knee. The isometric strength was recorded using the new device "OpTIMo" (Optical Testing of Isometric Moments) developed in the laboratory (Fig. 1). The subjects stood supported at the trunk inside a rigid frame. The measured segment was connected to a dynamometer with a cuff and a non-elastic strap. Analogue force data and optical data were simultaneously captured by a Vicon system (12 cameras, 120 Hz). Lever arm and force direction were recorded by markers on the cuff and strap. Joint moments were calculated via cross products accordingly. To check repeatability, all controls were tested twice.

Results

A good reproducibility between sessions was verified with an ICC of 0.765. Isometric joint moments for hip flexion and abduction and knee flexion and extension in TTA were significantly smaller than those in controls ($p < 0.01$). In controls, the maximum isometric moments always exceeded by far the maximum joint moments during gait whereas in TTA this was not the case.

Fig. 1. Isometric strength testing device.

Discussion

According to Fosang et al. [3] 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 TTA 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.

References

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Day 2 – 18 September 2009,
Session 8: Normal and Perturbed Gait, 14:00–15:40, Lecture Theatre

O62

Effect of boot shaft stiffness on stability, joint energy and muscular cocontraction during walking on uneven surface

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Summary

3D gait analysis was performed, walking with two different boots on uneven surface. Boot-shaft stiffness reduced significantly the ankle range of motion and caused compensatory changes at the knee joint: it increased the cocontraction and the amount of absorbed energy in the knee. Parameters of stability remained unaffected by shaft stiffness.