

# THE THREE-DIMENSIONAL LUMBAR SPINE KINEMATICS OF TRANSFEMORAL AMPUTEES WITH AND WITHOUT BACK PAIN WHILE WALKING

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## INTRODUCTION

Low back pain (LBP) has long been recognized as a major health problem in the general population. Recent work suggests that it is an even greater problem for transfemoral amputees (TF). It is an important cause of secondary disability in as many as 71% of TF amputees (Edhe 2001, Smith 1999). Further, more than half of those TF amputees suffering from LBP rate it as either moderately or severely bothersome. Despite the magnitude of the problem, little is known about the kinematic alterations of the lumbar spine during amputee ambulation.

Increased lumbar lordosis (Steinberg 2003) and excessive and variable lumbar spine motion (Vogt 2001) are frequently cited causes of LBP in the general population. Each of these conditions is present to some degree in TF amputees as a result of prosthetic use, although their extent has yet to be fully documented. Because of their dual association with LBP in the general population and with prosthetic use in the TF population, we propose that these postural abnormalities underlie the development and continuation of LBP in the TF amputee. This study was carried out to determine the kinematic differences in lumbar spine motion between TF amputees and intact subjects, as well as to identify specific kinematic patterns that were associated with LBP in this population.

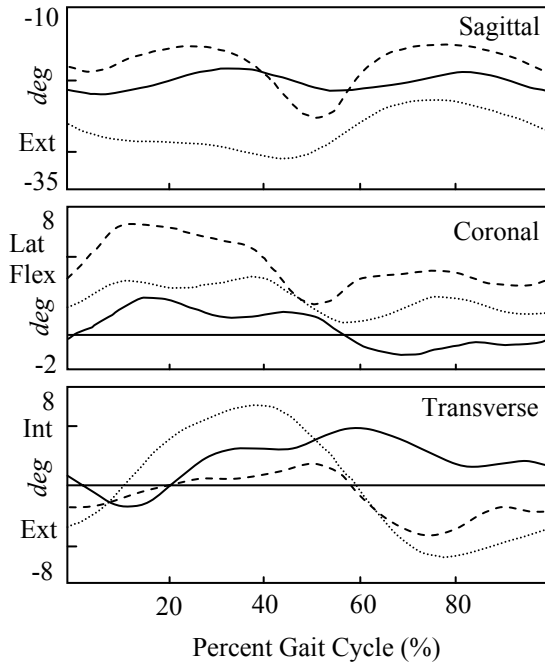
## METHODS

Five intact subjects free from any known gait pathology and LBP and ten TF amputees gave informed consent to participate in this IRB approved study. Five of the amputees experienced LBP of 5 or greater on a 10 point scale for at least 15 of the past 30 days and comprised the Amputee Pain (AP) group (n=5). The remaining five amputees were without pain and comprised the Amputee No Pain (ANP) group. Thirty-eight reflective markers were placed on each subject for full body gait analysis according to Vicon's Plug In Gait model (Oxford Metrics, England). Lumbar spine motion was defined by a triad of markers (2 placed at level T8 and 1 at T10). 3-D Euler angles were calculated relative to the pelvis defined by 4 markers (2 at the ASIS and 2 at the PSIS). Subjects walked at a controlled walking speed of  $1.0 \pm 0.1$  m/s and kinematic data were collected with a 10-camera Vicon 612 motion system at 120 Hz. Statistically significant differences in lumbar motion were detected with an ANOVA and Fishers tests post hoc ( $p < 0.05$ ).

## RESULTS AND DISCUSSION

The ranges of lumbar motion (deg) for the three subject groups across the gait cycle for each plane are compared in table 1. Ranges that were significantly different are denoted with an asterisk (\*) in bold italics ( $p < 0.05$ ). Intact subjects had significantly less sagittal

plane lumbar excursion during sound limb stance compared to TF amputees; no difference was detected between AP and ANP. However, AP demonstrated significantly less sagittal plane lumbar excursion during prosthetic limb stance as compared to ANP and intact subjects.



**Figure 1:** Three-dimensional lumbar angles during gait of intact subjects (—), TF amputees with LBP (.....) and TF amputees without LBP (----). Each graph begins at heel strike on the prosthetic limb and ends with the subsequent prosthetic heel strike.

In the coronal plane, ANP exhibited significantly larger lumbar range compared to both intact subjects and AP. In the transverse plane, AP had a two-fold increase in lumbar rotation compared to intact subjects and ANP. 3-D lumbar motion is shown across the gait cycle in figure 1. The lumbar spine kinematics of the intact

subjects was similar to previous research (Callaghan 1999, Vogt 2001). The TF amputees without LBP exhibited significantly different spinal kinematics in the sagittal and coronal planes, but not in the transverse plane compared to the intact subjects. These are likely the result of neuromuscular adaptations related to prosthetic replacement of the lower extremity. The greatest differences in spinal kinematics of AP were that they exhibited a nearly two-fold increase in transverse plane rotation with a significant decrease in sagittal plane motion compared to ANP.

## SUMMARY

TF amputees face significant physical challenges even without the additional burden of low back pain. Identifying differences in AP lumbar motion may lead to potential therapeutic interventions, which help to minimize these discrepancies and alleviate chronic back pain.

## REFERENCES

- Callaghan JP. et al. (1999) *Clinical Biomechanics*. 14, 203-16.  
 Ehde DM. et al. (2001) *Arch Phys Med Rehabil*. **82**, 731-4.  
 Smith DG. et al. (1999) *Clin Orthop*. 361, 29-38.  
 Steinberg EL. et al. (2003) *Clin Radiol*. **58**(12), 985-9.  
 Vogt L. et al. (2001) *Spine*. **26**, 1910-9.

## ACKNOWLEDGEMENTS

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**Table 1:** Lumbar spine kinematic ranges (deg ± standard deviation) in three planes of motion.

Subject	Sagittal (Prosthetic Limb)	Sagittal (Sound Limb)	Coronal	Transverse
Intact	4.1 ± 1.6	<b>4.1 ± 1.6*</b>	4.1 ± 1.4	7.9 ± 2.0
ANP	5.8 ± 4.0	11.7 ± 9.1	<b>9.0 ± 2.5*</b>	7.1 ± 3.1
AP	<b>0.7 ± 0.9*</b>	9.2 ± 5.2	4.8 ± 2.2	<b>14.5 ± 3.8*</b>