SKIN MOVEMENT ARTIFACT DURING GAIT AND CUTTING MOVEMENTS MEASURED IN VIVO

Daniel L Benoit [1,2,*], Dan K. Ramsey [3,4], Mario Lamontagne [5,6], Lanyi Xu [6], Per Wretenberg [2,4], Per Renström [1, 2]
[1]Institution for Surgical Sciences, Section of Sports Medicine, Karolinska Institute, Stockholm, Sweden; [2]Department of Orthopaedics, Karolinska Hospital, Stockholm, Sweden; [3]Department of Physical Therapy, University of Delaware; [4]Institution for Surgical Sciences, Section of Orthopaedics, Karolinska Institute, Stockholm, Sweden; [5]School of Human Kinetics, University of Ottawa, Ottawa, Canada; [6]Department of Mechanical Engineering, University of Ottawa, Ottawa, Canada; dbenoit@magma.ca

INTRODUCTION

Skin movement artifact limits the ability to accurately 3D tibio-femoral kinematics using non-invasive techniques. Previous investigations into the error associated with skin movement artifact have had few subjects and/or been measured under conditions that may not represent healthy populations. The purpose of this study is to measure the effect of skin movement artifact on the reporting of knee joint kinematics in a healthy population during gait and cutting, a movement believed to illicit non-sagittal plane rotations and translations.

METHODS

Eight healthy male subjects participated in this study. Intra-cortical bone pins were transcutaneously implanted under local anaesthetic into the proximal tibia and distal femur. Three reflective markers were attached to each bone pin and four reflective markers were mounted on the skin of the tibia and thigh respectively. Roentgen-stereophotogrammetric analysis was used to determine the anatomical reference frame of the tibia and femur. Knee joint motion was recorded during walking and cutting using infra-red cameras at 120 Hz.

RESULTS AND DISCUSSION

The kinematics derived from the bone-pin markers was compared with that of the skin markers. Rotational errors of up to 4.4 and 13.1 degrees and translation errors of up to 13.0 and 16.1 mm were noted for the walk and cut respectively (table 1).
Although the data was repeatable within subject the direction and magnitude of the error was not repeatable across subjects (figure 1). This suggests that repeatability of motion analysis data can not be used as an indication of accurate data.

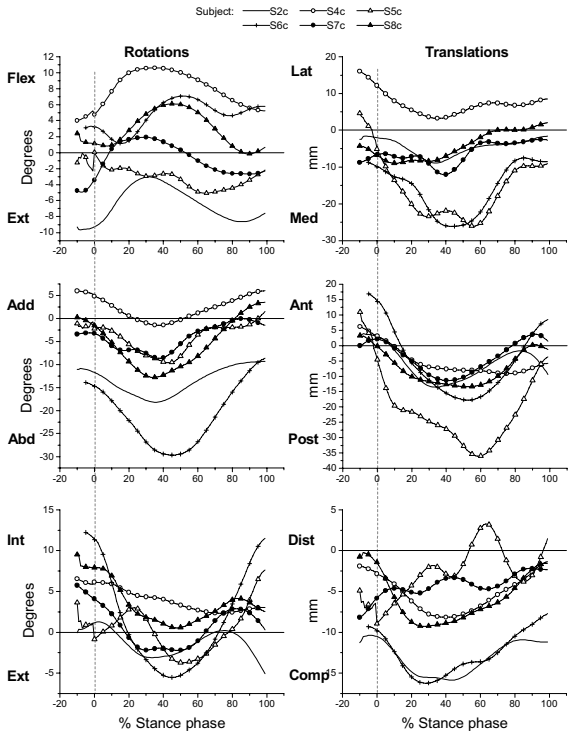
CONCLUSION

It was noted that although the skin marker derived kinematics could provide repeatable results this was not representative of the motion of the underlying bones. A standard error of measurement is proposed for the reporting of 3D knee joint kinematics.

Table 1: Absolute error values of skin-marker derived kinematics at three time points during walking and cutting of knee rotations and translations: flexion extension (Flex/ext), adduction-abduction (Add/abd), internal-external rotation (Int/ext); medio-lateral (Med/lat), anterior-posterior (Ant/post) and distraction-compression (Dist/comp). Note: † denotes significant difference between skin and pin-marker data (2 tailed paired Students T-test, $p<0.05$)

		Rotations (degrees +/- StDev)			Translations (mm +/- StDev)		
		Flex/ext	Add/abd	Int/ext	Med/lat	Ant/post	Dist/comp
Walk	Foot-strike	2.8 (2.6)†	2.5 (2.7)	2.8 (2.0)†	5.0 (2.6)	7.7 (4.4)†	5.0 (2.9)†
	Mid-stance	2.4 (2.0)†	3.1 (3.3)	2.4 (1.1)	5.5 (3.1)†	6.2 (5.4)	3.3 (2.4)†
	Toe-off	2.7 (2.4)	4.4 (3.2)†	2.2 (2.1)	8.0 (5.7)	13.0 (5.0)†	5.0 (2.5)†
Cut	Foot-strike	3.9 (2.9)	6.7 (5.4)†	5.4 (4.2)†	7.3 (4.4)	5.6 (5.1)†	6.3 (4.0)†
	Mid-stance	4.0 (2.5)	5.9 (3.1)†	5.4 (4.0)†	5.9 (4.5)†	6.7 (4.4)†	5.6 (3.8)†
	Toe-off	4.2 (2.7)	13.1 (9.8)	3.3 (1.8)†	13.9 (10.1)	16.1 (8.9)	8.3 (6.2)†

Figure2: Progression of error due to skin movement during cutting for all subjects. Figure shows average difference between skin-marker and pin-marker data as it progressive during stance. A positive value describes an over-estimation; zero describes perfect agreement and negative values describe an under-estimation of the skin marker derived knee joint rotations and translations.



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