THE RELATIONSHIP BETWEEN SEAT HEIGHT, KNEE FLEXION AND TRUNK FLEXION ANGLES DURING CLOSED PLANAR MOTIONS OF THE LOWER LIMB

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INTRODUCTION

The quantitative assessment of trunk postures while driving is desired since trunk postures can be related to complaints of low-back pain. When aligned over the hip, a goniometer can be used to measure trunk flexion/extension angles. This approach requires the assumption that the lower limb is stationary. This may not be the case, with occasional leg movements by operators leading to erroneous results. It is possible to control for these movements by monitoring the operator's knee angles while the lower limb is constrained by the seat and the floor. In addition, goniometer misalignment and tissue displacement can result in inaccuracies in goniometer determined angles. The purpose of this study was to investigate the relationship between knee and trunk angles during planar motions of the lower limb while a seated operator's foot is on the floor, and to assess the accuracy of goniometer determined angles.

METHODS

Fifteen subjects had reflective markers placed over their ankle, knee, hip, and shoulder. Also, Biometrics™ SG150 goniometers were aligned over their hip and knee. While seated at a height of 29.5cm, 41.5cm and 56.5cm the subjects slid their foot along the floor in the sagittal plane. Marker positional data (using six M^2mcam cameras) and goniometer voltages were recorded with a VICON™ 460 motion capture system. Dot product calculations provided planar knee and trunk angles from the marker positional data, and goniometer voltages were converted to joint angles using a calibration equation. A step-wise multiple linear regression was then conducted with the variables found in Table 1. Finally, a comparison between the camera and goniometer determined angles was conducted.

RESULTS AND DISCUSSION

The step-wise regression analysis yielded a significant predictive model ($p<0.000$), explaining 96.6% of the variance in the motion capture determined trunk angles ($r^2=0.966$), and had a standard error of ±2.67˚. Equation 1 describes the model (variable definitions are provided in Table 1):

$$Y=0.224*X_1 + 0.974*X_2 - 0.134*X_3 - 2.399*X_4 - 0.0401*X_5 - 8.801 \quad \text{(Eq.1)}$$

Table 1: Variable labels, descriptions and significance

Label	Description	Significance (p<)
Y	Trunk angle (degrees)†	-
X_1	Knee angle (degrees)†	0.000
X_2	Initial trunk angle (degrees)†	0.000
X_3	Initial knee angle (degrees)†	0.000
X_4	Shank length/Seat height ratio	0.000
X_5	Individual's height (cm)	0.000

† Using the camera determined angles

With respect to the comparison of the goniometer and camera determined angles, an absolute percent error of 27.8 ± 12.5˚ was initially found for the trunk, and 7.7 ± 6.7˚ for the knee. This error was determined to be the result of a bias due to tissue displacements that occurred while the subjects sat down. Removal of the bias while the subjects adopt a known seated posture reduced the goniometer absolute percent errors to 3.2 ± 4.1˚ and 4.0 ± 3.8˚ for the trunk and knee respectively.