INERTIAL COMPENSATION IN MOVING FORCE PLATES

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INTRODUCTION

Instrumented force treadmills are capable of rotating and translating the walking surface. However, moving the treadmill platform introduces inertial artifacts in the ground reaction forces (GRF) detected by the load cell sensors of the force plate. Joint moment calculations from inverse kinematics are no longer accurate. Here, we present a linear, accelerometer-based compensation model that determines mass coefficients that are subtracted from force signals containing inertial errors.

METHODS

Our method was tested on an instrumented treadmill (VG005-A, Motek Medical, Amsterdam, Netherlands). An accelerometer was placed on each corner of the treadmill platform, assuming the moving surface as a rigid body. GRF and accelerometer signals were recorded during trials of an unloaded treadmill experiencing white noise perturbations in 2 degrees-of-freedom (DOF). An unloaded treadmill should produce zero measurements in the force signals.

Gravitational and inertial properties may be estimated utilizing Newton's second law. Linear least squares regression between 3D forces and moments ($\boldsymbol{G}$) and 3D accelerations ($\boldsymbol{S}$) from four accelerometers with an added constant term will produce an estimation of mass coefficients ($\boldsymbol{C}$).

$$\boldsymbol{G}_{6x1} = \boldsymbol{C}_{6x13} \times \boldsymbol{S}_{13x1} \quad (1)$$

The coefficients from one white noise movement trial were then subtracted from the force signals of a dissimilar white noise trial, differing by initial seed and variance.

RESULTS AND DISCUSSION

Preliminary results indicate an average reduction of 76.76% and 45.61% in the root-mean-square (RMS) of force and moment signals (Figure 1). Remaining errors may reside in the violation of the rigid body model assumption, as we are incapable of producing smooth treadmill movements. For the most successful compensation, mass coefficients should be determined from a trial containing similar treadmill movements.

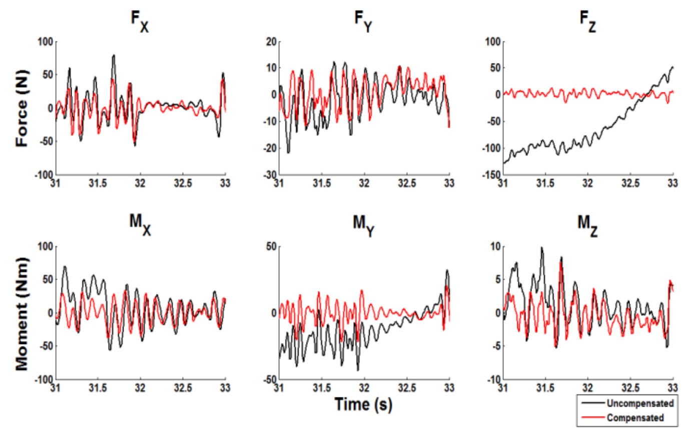

Figure 1: Uncompensated (black) and compensated (red) force signals obtained from calibration coefficients of a dissimilar white noise treadmill movements.

The described method is not limited to a 2-DOF system. Two accelerometers should be added for each additional DOF and placed on a rigid surface. Further investigation includes the compensation of errors in moment signals that are introduced from the torque of the treadmill belt rollers.

CONCLUSIONS

Our method is capable of reducing inertial artifacts in the GRF of moving force plates to a more acceptable level. Therefore, joint moments determined from traditional inverse kinematics can be calculated with greater accuracy.

REFERENCES

1. Pagnacco G, et al. Inertially compensated force plate: a means for quantifying subject's ground reaction forces in non-inertial conditions. *Biomed Sci Instrum*; 36: 397-402, 2000.