FORCE PLATE CONSIDERATIONS FOR STUDIES INVOLVING RAMPS WITH DIFFERENT INCLINE ANGLES

Andrew Post and D.G.E. Robertson

School of Human Kinetics, University of Ottawa, Ottawa, ON, Canada
E-mail: apost033@uottawa.ca and dger@uottawa.ca

INTRODUCTION

Much research has examined the biomechanical aspects of gait on level surfaces. Yet little information is available on the characteristics of gait on ramps. It has been shown for instance that gait on inclines has noticeably different ground reaction forces than those found during level gait (Kuster *et al*., 1995).

This project concerns itself with the ground reaction forces of gait on inclined surfaces. With ramp gait, there are unique considerations to permit inverse dynamics analysis. For example, the force vectors need to be adjusted so that they are compatible with a vertically oriented global reference system of the kinematics data collection system. This requires the use of a transformation of force platform's axes.

METHODS

Six subjects participated in the trials. Two force platforms (Kistler) were installed; one level and immediately in front of the ramp and another 90 cm up the ramp. The ramp was constructed of sheet metal and set to 10 degrees. Panels of plywood filled in the borders of the ramp so that the force plate and the ramp surfaces were even. The subjects walked across the laboratory stepping with the same foot on both platforms. The other foot landed on the incline first but did not land on a force platform.

The force data were collected with BioWare software. The force data were analyzed using the BioProc2 and Force Platform data analysis software (www.-health.uottawa.ca/biomech/software).

RESULTS AND DISCUSSION

The force curves for the ramp and level gait were noticeably different. They both had the typical double humps exhibited during level walking, however, the ramp curve had a higher push-off force (peak 2) than the ground level force platform. This is different from level gait where the first peak was usually marginally higher than the second (Winter, 1991).

Notice in Figure 1 that vibrations from the first step on the ramp were recorded by the second force platform. These vibrations will occur due to the relative elastic nature of the ramp. Between times 0.00 to 0.20 the ipsilateral foot made contact with the ramp and caused a vibration through the structure that was recorded by the force plate. Fourier analysis was used to discover the resonant frequency and select an appropriate cut-off frequency to remove these artifacts.
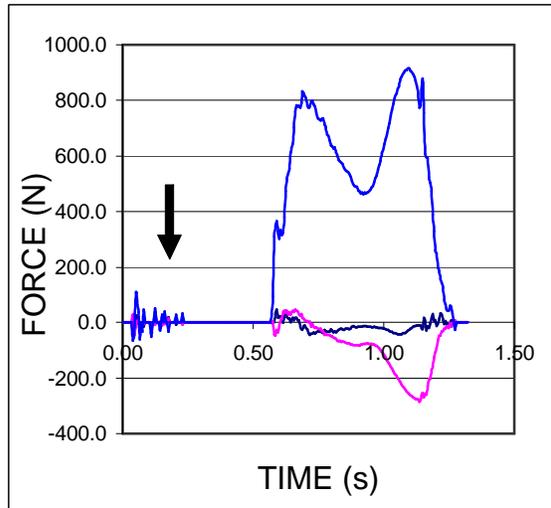
Figure 1: Force plate recording of a force plate inset into a 10-degree ramp. The initial vibrations are due to the transmission of forces through the metal ramp from the contralateral foot.

Another consideration shown by this study is in relation to the force vectors recorded. In Figure 2 it is shown how the computer interprets the force vectors from the force plate on a ramp. The vectors are noticeably off angle.
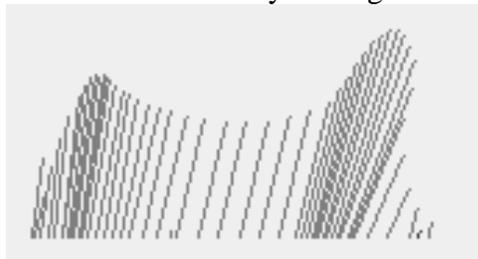

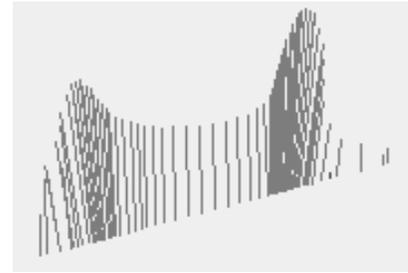**Figure 2:** Ramp force vectors without inclination adjustments.

Figure 3 shows the force and centre of pressure data rotated by 10 degrees using the following transformation:

$$x' = x \cos \theta - y \sin \theta$$
$$y' = x \sin \theta + y \cos \theta$$

where the (x, y) values represent the force or centre of pressure components. The vectors now show the properly angled push-off while on the ramp with

respect to vertically oriented frame of reference.

The transformation was validated by placing a 100 lbs. weight on the force plate and then examining the rotated data to show vertically oriented forces.

Figure 3: Ramp force vectors with inclination adjustments.

SUMMARY

The considerations that need to be made when designing a laboratory ramp are that the researcher must consider how to limit resonance that can interfere and cause noise in the data recorded (Post & Robertson, 2002). The angles of the force vectors also need to be adjusted in the data analysis phase of the research. Stiff surfaces will be preferable to limit the resonance and transfer of forces can be limited using damped surfaces. The angle of inclination is easily dealt with using a transformation.

REFERENCES
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