INTRODUCTION

A dynamic model to determine biomechanical parameters such as ground reaction forces and intersegmental joint moments during normal level walking was developed using Adams Figure Modeller. Limited published information on the methodology and the computed biomechanical data is currently available. The biomechanical model consists of 15 rigid body segments and is driven by torques produced by proportional-derivative (PD) controllers at each joints and interactions between the foot segments and the ground. Some of the key modelling parameters includes the controllers’ gains and contact properties such as friction and stiffness. The paper reports on the methodology adopted and the results obtained from the simulation.

METHODS

Motion Data: The kinematics and kinetics data of human locomotion were obtained using a 5-camera Vicon gait analysis system and 2 Kristler force plates.

The human model: A full body human model, which composed of 15 segments and 16 joints, was built using the Adams FIGURE Modeller software, based on the weight (59 kg) and height (1.69 m) of the subject. These segments are connected by standard triaxis hinge joints and only the degree of freedom in the sagittal plane is allowed at each joint location. When the joints are implemented, each joint angle is adjusted so that the human model is posed as the initial position of the motion data.

Inverse Dynamics Simulation: The purpose of inverse dynamics is to drive the motion of the human model under the influence of motion agents. Twenty-one motion agents, located at human segments, are created after the human model is posed and attached properly. The motion agents are attached to the human segments with springs and dampers, rather than rigidly connected to the parts. This set up will allow some separation between the motion agents and the attached parts. It can be witnessed during the animation of the inverse dynamics. Red balls are attached to the parts and yellow balls track the exact positions of the motion data. The discrepancies between the red and yellow balls are used to account for errors in the motion data measurement.

Forward Dynamics Simulation: After running the inverse dynamics simulation, the time histories of the joint motions are recorded. The motion agents are removed from the model and motion splines are created for the joint angle histories and PD-servo controllers replace the passive joint torque functions. In the forward dynamics simulation, proportional-derivative (PD) controllers are generated to produce torques that track the motion splines and contacts between the foot segments and the ground are defined. To keep the balance of human body during the motion, a single motion agent is created at the lower torso segment to account for the torques from the missing upper torso and segments. The control and contact parameters are refined by comparing simulated results against the reference data.

RESULTS AND DISCUSSION

A complete single gait cycle was developed and simulated. The plot below depicts the ground reaction forces and the intersegmental joint forces at the ankle and the hip obtained from the model as compared with the experimental findings.

Figure 1 shows the ground reaction force and the intersegmental joint moments of the left foot and the right foot obtained through simulation (dotted) and that obtained experimentally (solid).

Intersegmental joint moments and accurate tracking of joint angle trajectories for simulation of a complete gait cycle is dependent on various parameters such as the proportional and differential control gains and contact parameters such as friction and contact stiffness.

SUMMARY

This study reports on the methodology adopted in developing a dynamic walking model using Adams Figure Modeller. Several modelling and contact parameters are important in obtaining desired joint trajectories and joint moments values in the physiological range. Future work would be conducted to further refine the model and to extend its application in load carriage studies.

REFERENCES