Kinematics of stair walking and inclined walking

The additional information provided in this document is valid for the two protocols kinematics of stair walking, and kinematics of inclined walking.

Introduction

This is the extended protocol that can be used to extract the performance indicators (PIs) for ramp and stair walking as developed by Roessingh Research and Development. The reference data was collected using an XSens MVN Link motion capture system. The procedure that is described below is therefore applicable when using this system. For more information as to how to use this system or when using a different XSens system, please see https://tutorial.xsens.com/.

The files extracting the PIs, however, also work with other gait analysis systems as long as the gait events (heel strike and toe off) and the sagittal joint angles of the anke, knee and hip are available (see exemplary input files). For the gaitEvents we need the timing of the left and right heel strikes and toe offs. For the jointAngles we need the joint angle per time stamp and per joint. As stated before, the sagittal joint angle of the ankle, knee and hip are required for the code to work. For the EMG we need the electrical activity of the muscle per time stamp per muscle. The EMG code is not limited to the use of the muscles stated in the exemplary file, nor is there a need for a specific order of muscle to be used in the input file.

For the code to work, we need separate runs. For stair walking, for instance, we need a separate run for ascending stairs and a separate run for descending stairs. The PIs are calculated for each run and can be aggregated afterwards.

Within the code, four different conditions are specified. These are:

- cond_3: stair ascent
- cond_4: stair descent
- cond_5: ramp ascent
- cond_6: ramp descent

The input should use this numbering and this numbering will also be visible in the output files.

Preparation

1. Perform the relevant body measurements
    a. Measure body height: from the floor to the top of the head.
    b. Measure the foot size: from the back of the heel to the tip of the toes
    c. Measure the shoulder height: from the floor to the left or right acromion
    d. Measure the shoulder width: from the top of the left to the top of the right acromion
    e. Measure the elbow span: from the left to the right olecranon in T-pose
    f. Measure the wrist span: from the left to the right ulnar styloid in T-pose
    g. Measure the arm span: from left to right finger tip
    h. Measure the hip height: from the floor to the greater trochantor
    i. Measure the hip width: from the left anterior superior iliac spine to the right anterior superior iliac spine

    j. Measure the knee height: from the floor to the lateral epicondyle
    k. Measure the ankle height: from the floor to the center of the ankle
2. Note the body measurements in the MVN Analyze software
3. Place the motion trackers on the body

Calibration

1. Before calibration is started, place the feet parallel pointing forward. Have the subject stand in an upright position ensuring that both arms and legs are in a straight line.
2. Start the calibration.
3. Ask the subject to hold the neutral pose for 4 seconds.
4. Let the subject walk forwards and backwards in a normal fashion.
5. Ask the subject to stand in the neutral pose.
6. Stop the calibration.
7. Check the feedback from the software and ensure that the calibration was performed successfully. If not, please repeat the calibration procedure.

Experiments ramp

1. Ask the subject to stand in front of the ramp in such a way that the first step will be made walking up or down the ramp.
2. Start the measurement.
3. Have the subject walk up or down the ramp in a normal fashion and at a normal walking speed.
4. Ask the subject to pause once the top or bottom of the ramp has been reached.
5. Stop the measurement.
6. Ask the subject to turn around and stand in such a way that the first step will be made walking up or down the ramp.
7. Start the measurement.
8. Have the subject walk up or down the ramp in a normal fashion and at a normal walking speed.
9. Ask the subject to pause once the top or bottom of the ramp has been reached.
10. Stop the measurement.
11. Repeat 8 times.

Experiments stairs

1. Ask the subject to stand in front of the stairs in such a way that the first step will be made walking up or down the stairs.
2. Start the measurement.
3. Have the subject walk up or down the stairs in a normal fashion and at a normal walking speed.
4. Ask the subject to pause once the top or bottom of the stairs has been reached.
5. Stop the measurement.
6. Ask the subject to turn around and stand in such a way that the first step will be made walking up or down the stairs.
7. Start the measurement.
8. Have the subject walk up or down the stairs in a normal fashion and at a normal walking speed.
9. Ask the subject to pause once the top or bottom of the ramp has been reached.
10. Stop the measurement.
11. Repeat 8 times.