

# Tutorial: Human gait analysis

## Answer sheet

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First, it should be noted that there is not a finite answer to most of the questions! The tutorial should have made you look at the data, and come to your own findings and conclusions. However, some answers and example solutions are given below.

### Assignment 1. 'Passive dynamic' walking

**1b.** In swing, muscle activity is generally low, only the tibialis muscle is active to lift the foot. In stance, the calf (GAM and SOL) muscles are active to generate the necessary ankle moment.

**1c.** The main differences are in the calf muscles. These muscles have somewhat high activity (double hump) in mid stance. This brings the heel to rise somewhat early in stance (early heel rise).

The gastrocnemius activity in swing is an artefact, this can be seen when closely studying the raw EMG signal.

All EMG signals appear to be somewhat delayed compared to the reference. This is mainly due to a difference in the low pass filter that was used to get the EMG envelopes (3Hz in reference data (derived from Winter et al) and 2Hz low pass in lab data).

**1d.** All EMG amplitudes decrease with speed. Peak amplitude in GAM and SOL show a relatively small decrease with speed. These muscles also have a shorter active phase: they turn on later in stance at slower speeds (other differences may be present as well). The main difference in ground reaction force is in the amplitudes of peaks and the valley in between.

**1e.** Semitendinosus: braking hip flexion and knee extension in terminal swing  
Rectus femoris: assisting in knee extension moment in loading response (early stance).  
Sometimes active in (pre)swing to guide knee flexion/hip flexion  
Gastrocnemius: necessary for push-off, helps in knee flexion.  
NB the role of bi-articular muscles is still an object of study, and their role can be counter-intuitive (see Neptune 2001), especially in pathological gait.

## Assignment 2. Push-off

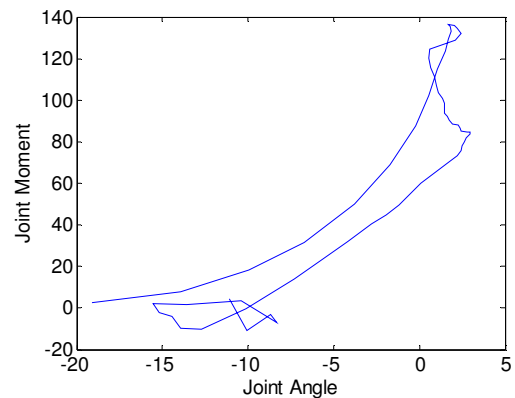
**2b.** The perpendicular distance from ground reaction force to joint centre gives a quick estimate of the joint moments. Mass and inertia are neglected, but for slow tasks such as walking the estimates are quite good, esp. for the ankle and knee (Hof 1990).

### 2d.

```
%% Plot springlike behavior
IC=BODY.CONTEXT.EVENTS.InitialContact.ICRight_100hz(1);
TO=BODY.CONTEXT.EVENTS.ToeOff.TORight_100hz(1);

figure(1);
plot(BODY.JOINT(4).PostureRefKinematics.RotationAngles(1,IC:TO),...
      BODY.JOINT(4).Kinetics.NetMoment(3,IC:TO))
set(gca,'fontsize',15)
xlabel('Joint Angle'); ylabel('Joint Moment')
```

The ankle is quite spring-like, with an extra energy input when the 'spring' is fully stretched.



### 2e/f

```
%% Plot power at very very slow and fast speed

loadbodyfile          % load vvslow
BODYVVSLOW=BODY;

loadbodyfile          % load fast
BODYFAST=BODY;

ICS=BODYVVSLOW.CONTEXT.EVENTS.InitialContact.ICRight_100hz(1);
TOS=BODYVVSLOW.CONTEXT.EVENTS.ToeOff.TORight_100hz(1);
ICF=BODYFAST.CONTEXT.EVENTS.InitialContact.ICRight_100hz(1);
TOF=BODYFAST.CONTEXT.EVENTS.ToeOff.TORight_100hz(1);

figure(2);
plot([0:100],normalizetimebase(BODYVVSLOW.JOINT(4).Kinetics.NetPower(1,ICS:TOS)));
hold on
plot([0:100],normalizetimebase(BODYFAST.JOINT(4).Kinetics.NetPower(1,ICF:TOF)),':');
plot([0 100],[0 0],'color',[.5 .5 .5])

set(gca,'fontsize',15)
ylabel('Ankle Power (J/s)'); xlabel('% stance phase');
legend('VERY VERY SLOW', 'FAST')
```

Ankle power is negative in first part of stance and positive in last part of stance. Positive power increases rapidly with speed, Net power (summed power over stance phase) is negative at slow speeds and positive at fast speeds.

