Modifying the ground reaction

The idea of this exercise is quite simple. We want to see if you can work out how to walk in ways that alter the ground reaction forces.

Walking at different speeds

Schwartz et al. (2008) asked a group of children to walk at a variety of speeds and measured the joint kinematics, kinetics and the ground reaction at those various speeds. In figure 6 of that publication (reproduced below) you can see that when children walked at different speeds the shape of the anterior-posterior curve remained fairly similar but the magnitude changed quite markedly.

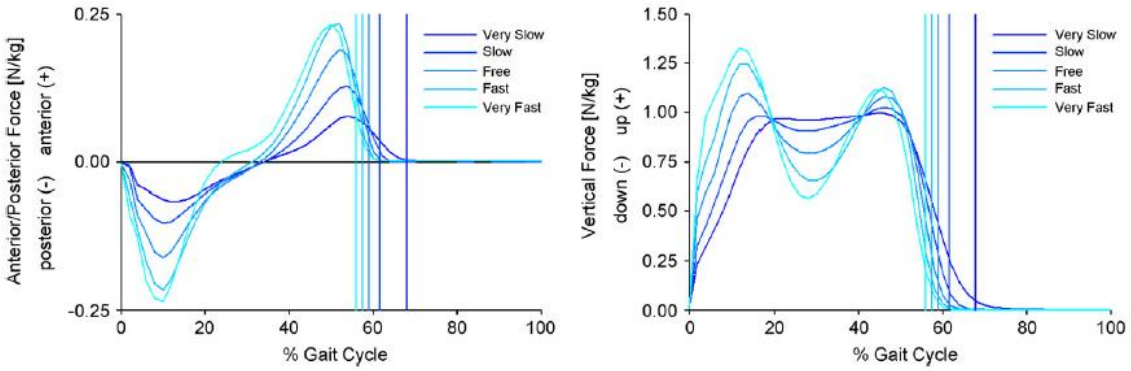


Fig. 6. Ground reaction forces. Anterior/posterior and vertical components of the ground reaction force are shown. Each line represents the average of trials within the corresponding group.

In contrast the shape of the vertical component of the ground reaction changed quite markedly. At normal walking speeds the early and late peaks are of roughly equal height with a pronounced trough in between. When walking more slowly the peaks remain a similar height but the trough in between flattens out. When walking faster the first peak increased in magnitude more than the second peak.

The first exercise is to see if you can generate a family of curves like this from your own walking. Walk up and down at different speeds and then examine the data you have recorded to see if it gives the same patterns.

Ben Lomonding

Barry Meadows is a Scottish Bioengineer who has spotted that, in a lot of patients with a range of different conditions, the first peak of the ground reaction is much higher than the second. He calls it Ben Lomonding after a famous Scottish mountain that has two peaks, one of which is considerably higher than the other. He attributes this to a failure of the legs to support bodyweight in late stance that has to be compensated for by increased forces early in stance.

Fig. 1. Ben Lomond adapted from original image (www.livefortheoutdoors.com/Hill-Guide/Search-Results/7885/7910/Ben-Lomond/). Accessed on 19/7/2010.

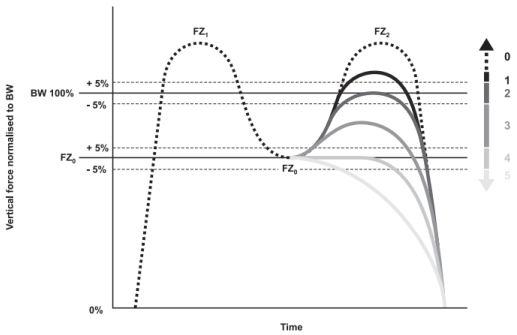


Fig. 3. Classification of 'Ben Lomonding' into types.

In a paper in 2011 (Williams, Gibbs, Meadows, & Abboud, 2011) he and co-workers introduced a proposal for classifying gait patterns of children with cerebral palsy on the basis of this phenomenon.

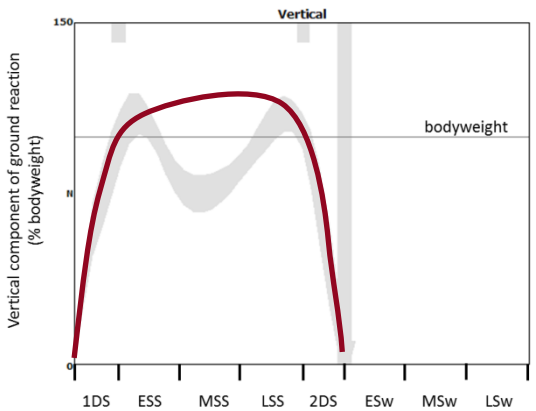
The second exercise is thus to see if you can replicate this pattern walking at normal or slow speeds (the data form Schwartz et al. plotted in the figure above suggest that it is a natural consequence of walking quickly). As well as plotting the ground reaction to show whether you've achieved this or not plot out the joint angles and moments (and maybe record some video) and use these to describe how you have modified your gait to achieve this. For example, you might have allowed your knee to flex excessively in late stance to reduce the vertical load on the force plate, in which case you should see this in the gait graphs.

You'll have to experiment for this with a combination of thinking what you want to achieve and then trying it out. Remember that Barry attributes this to the leg "giving way" in late stance so you might think about how you can mimic this.

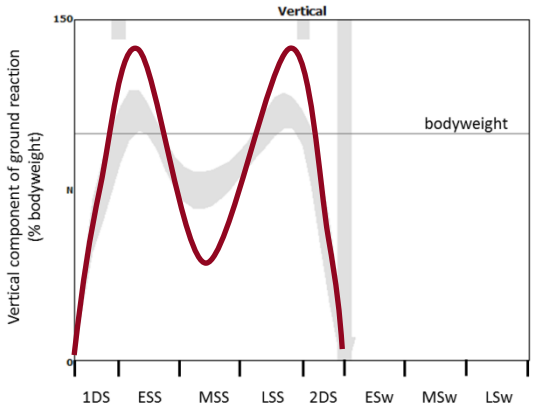
Is there only one way of doing this or are there several? If you think there is more than one then plot the different graphs out and use these to explain what the different patterns are.

Other patterns to try and create

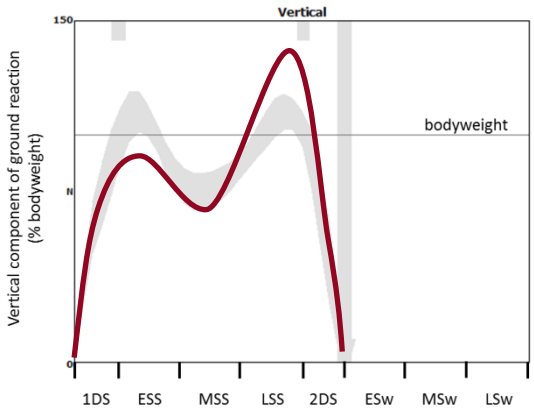
If you are successful in this are there other patterns you can mimic. Here are some examples.



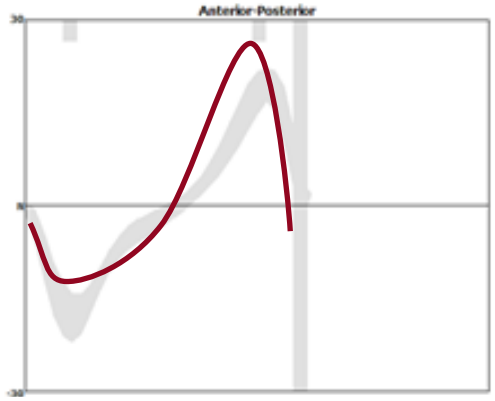
Can you walk in such a way that there is no trough in the ground reaction?



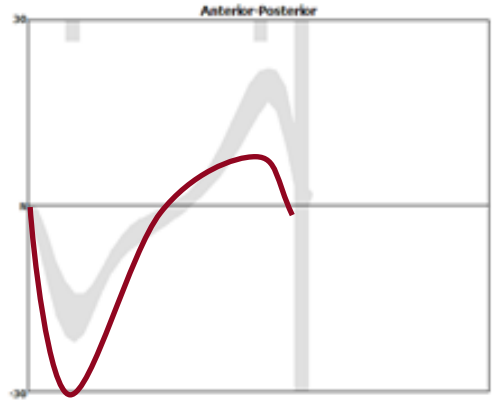
Can you walk in such a way that the trough and peaks in the ground reaction are exaggerated?



Can you walk in such a way that the first second peak is higher than the first?



Can you walk in such a way that the positive peak of the anterior-posterior component is bigger than the negative peak?



Can you walk in such a way that the negative peak of the anterior-posterior component is bigger than the positive peak?

If you are able to replicate these then plot out the ground reactions as proof and also plot the joint kinematics and kinetics and describe how these are changing to allow you to generate these forces. You might also want to record some video of how you have achieve this.

Warning

It should be obvious from what you know or have learnt this week that some of the ground reactions reproduced above are incompatible with symmetric cyclic walking. You will almost certainly have to walk asymmetrically or do something different on the particular step when you make contact with the force plate.

I'd be particularly interested to see how close you can get to these patterns from a fluent cyclic (though almost certainly asymmetric) walking pattern.

Report and discuss your results Warning

There is a lot to do here and it will be a challenge for anyone to complete all of it. Pick some aspect of what you have done and make a short presentation of the results either as a PowerPoint Presentation or a video that you can upload to YouTube. We will look at these together in the virtual classroom. They generally stimulate quite a lot of discussion so aim for the presentation itself to be between 4 and 8 minutes long.

When you've finished post the presentation or the link to the video on the Discussion Board.

Remember that with the Collaborate software that we use for the Virtual Classrooms it is almost impossible to view video embedded in PowerPoint. If you want to refer to videos it is much better to load them to YouTube so we can all see them streamed directly to our own computers (or you could mix and match …)

References

Schwartz, M. H., Rozumalski, A., & Trost, J. P. (2008). The effect of walking speed on the gait of typically developing children. *J Biomech, 41*(8), 1639-1650.

Williams, S. E., Gibbs, S., Meadows, C. B., & Abboud, R. J. (2011). Classification of the reduced vertical component of the ground reaction force in late stance in cerebral palsy gait. [Research Support, Non-U.S. Gov't]. *Gait Posture, 34*(3), 370-373. doi: 10.1016/j.gaitpost.2011.06.003