Q: Is there any way to use a combination of marker 3D positions and joint coordinates (i.e. joint angles from either direct kinematics or inertial measurement units) to further improve model scaling procedure?

A: Yes, the scale tool allows you to input values for coordinates that can be used in pose generation. Scale tool uses the Inverse Kinematics (IK) tool to pose the model, and the tool can take values for coordinates as part of the pose generation. You will need to weight the coordinate value, similarly to the marker weights. If you have a coordinate value that you want the posed model to respect (without any deviation), then you should update the coordinate value in the model directly and lock it thereby stopping the IK tool from changing the coordinate during pose generation.

Q: Do you suggest to weight markers only on your confidence in the experimental acquisition? What are considerations to keep in mind when choosing the number of markers to place on a given body?

A: If you weigh all markers on a model equally, but have a disproportionate number of markers on a single segment, then IK will more closely track the segment with more markers on it, given how IK formulates its optimization. Choosing marker weights is difficult because your research question will determine the trade-offs that are acceptable to you. In practice, you should put more markers on the bodies that you are interested in.

Q: How do you suggest to scale contact points, such as in the scapulothoracic joint, as they are not scaled with the scale tool

A: The Scapulothoracic joint is scaled like much like any other Joint in OpenSim. Based on the dimensions of the parent and child body scale factors the parent frame (and the Ellipsoid on the Thorax) and the child frame are scaled. The [Scapulothoracic joint paper](#) reduced the number of parameters by scaling the width and height radii (depth being the same as width) and optimized the tilt of the ellipsoid in the parent frame, since the frame orientation is not affected by scaling. All other values came from regular mark-based scaling.

Q: Could you comment on trunk scaling (especially scaling each vertebral body)? Has this been done by your group?

A: The models that we distribute consider the trunk to be a single segment and any scaling will be applied equally to all geometry objects that are contained in the trunk body. More detailed models of the spine, with individual segments at each vertebra, could still use the same method, applying a single scale factor to all the bodies in the trunk. If you have detailed data on the size of each vertebra, you could use that information in scaling, as well.

Q: Have you used 3d scans to record marker positions?

A: Our group has not. The technology has promise for both scaling and registration, but the equipment is expensive and it hasn't made itself into typical motion capture yet.

Q: What do you use as subjective values for acceptable tolerance for scaling and IK? Or does this vary per study?

A: This varies for each study and each modeling choice you make, and depends on an understanding of the system of interest. I would recommend reading [this paper](#) on modeling choices and validation.

Q: How do you rotate axes by 90 degrees in Opensim?

A: The most common way of transforming your data to an OpenSim coordinate system is to use packages and utilities provided by the community. There are some Matlab packages that can be found here (link).

You can also transform your data in the OpenSim GUI. Open the experimental data (.trc or .mot) in the GUI (*File > Preview Experimental Data*), right click on the data file name in the Navigator and click on *Transform*. A new pane will open that allows you to rotate the data along each x,y,z axis and save the results to file.

Q: I was informed that Cmotion Visual3D software can help generate files used for running an OpeSsim simulation. Would you be able to provide more details regarding this and/or comment on whether the use of this 3rd party software may simplify the process?

A: We don't have experience using the c-motion software directly, so we recommend you consult their documentation, found here or reach out to the company directly. When using third-party software that does any pre-processing of data or OpenSim models, care should be taken to fully understand any transformations, filtering, or other processing that is happening, so that you understand exactly what models and data you are working with in OpenSim.

Q: On the IK weightings tab, it looked like there were non-zero weights assigned for markers that were not checked as "Enabled." Does the "Enabled" box have the same function as setting <fixed> to true or false in the .osim file? Is it for registration?

A: Unchecking "Enabled" does not have the same effect as setting a model marker's fixed property to true. In general, we do not recommend disabling the markers. When markers are disabled, they are not included in the IK weighting and are not copied when the registered model is generated. Setting the marker weighting to zero is preferred as the markers are not included in the IK pose generation but are included in the new registered model).

Checking 'fixed' on a marker only affects the step between the pose generating and the markers being moved. Fixed markers will not be moved to match their experimental position.

Q: Is there a template for how plug-in-gait markers can be converted into maker pairs for OpenSim full body model scaling?

A: We don't provide a scale setup file for any specific marker set, please see the documentation for creating a setup file here.

Q: Does constraining the knee as a hinge joint (vs. using 3 DOF) affect inverse kinematic results and how can you discern these effects?

A: This is a modeling choice. The OpenSim knee joint is a single rotational coordinate with a coupled translation where the translation splines have been calculated from experimental data. This was an intentional design choice stemming from the unreliability of non-sagittal rotations from motion capture data; the signal error is greater than the signal itself. Since there are real non-sagittal rotations at the knee, you would expect to see the difference between the experimental and model marker positions during IK. If you change the knee to a ball joint (3 rotations, no translations), you would expect to see a reduction in RMS error between experimental and model markers, but you are moving the error from the markers to the coordinates. It is the Modeler's choice to make these decisions; I would recommend reading this paper on model validation.

Q: Is it possible to scale differently two parts of one segment? E.g., to prolong the posterior part of the foot (calcaneus) independently of the anterior part of the foot (midfoot and forefoot)?

A: In the case of the foot, it is already treated as three separate segments. We typically scale all three segments as the foot the same since foot marker sets only represent the foot as a single rigid segment, but if you had markers (or any data) for each individual part of the foot, you can use that to scale each segment separately.

Q: Can you suggest a marker set that matches OpenSim the best? (e.g. plug-in-gait, Helen-Hayes, etc.)

A: There is no single best marker set. We would suggest looking at previous OpenSim research studies of walking and running that have used OpenSim, The choice of marker set depends on your study (e.g., what motions you are measuring and the characteristics of your subject) and how you expect to scale the model.

Q: Is it possible to add degrees of freedom to joints such as the knee?

A: Yes. There are a number of different joint types. You will need to edit the .osim file in a text editor (we recommend notepad++). Please see the opensim documentation for joints and an example for model editing.