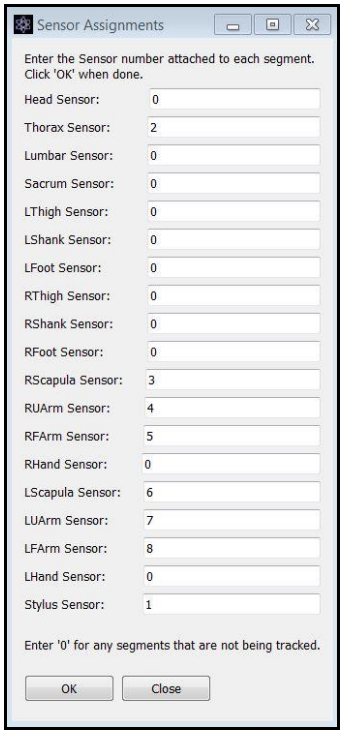
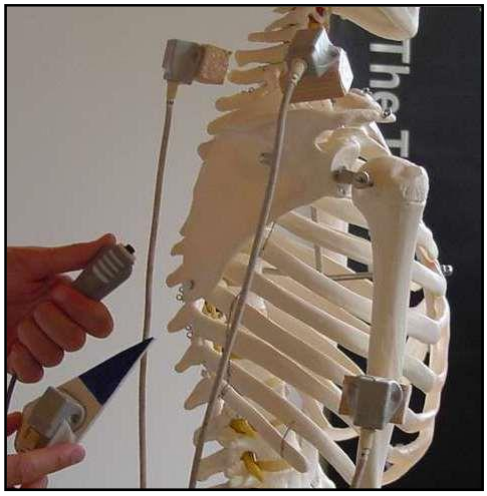
The MotionMonitor xGen Software Guide: ISB Shoulder Procedure

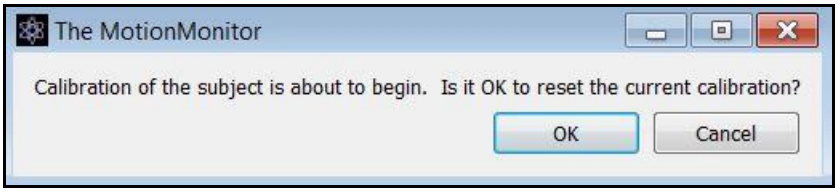
The ISB proposal for a standardized shoulder protocol was published in the *Journal of Biomechanics* in 2005. The following is a step-by-step procedure for calibrating your subject using this protocol in *The MotionMonitor* xGen. If you haven't already been provided with this workspace, please contact your Client Support Engineer to request it. The Segment Joint definitions and ISG axes definitions have already been configured within the workspace. All joint center locations except for the shoulder joint are located using the digitization method. The shoulder joint center is located using a functional-rotation method:

1. Click the "ActivateHardware" icon (lightning bolt) to activate your hardware.
2. Next click on the "SensorAssignment" icon Sensors. Enter the number for the sensor being attached to each segment. A "0" should be entered for any segments that are not being tracked. A sensor must be placed on the thorax, scapula(s) and upper arm(s). Another sensor will be defined as the Stylus sensor for digitizing purposes.
3. The stylus will need to be calibrated, using the "Stylus Calibration" icon , before proceeding to the Setup Subject procedure. Depending on your hardware, the motion tracking system may need to be added as a hardware component and then aligned to the recommended World Axes layout. The picture below illustrates the placement of sensors on the subject. Click "OK" to proceed.
4. Click the "SetupSubject" icon (person) to begin the Subject Calibration procedure.

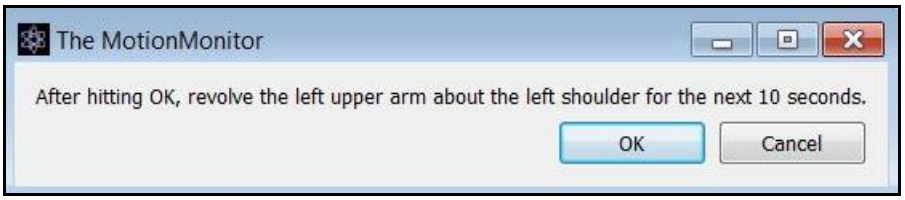


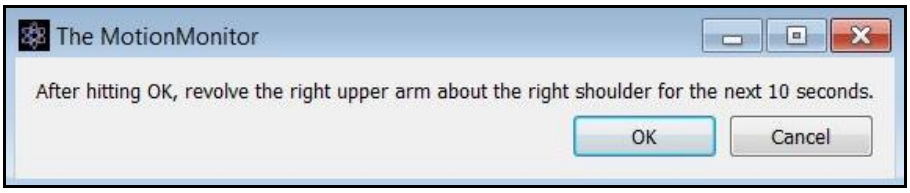


5. A message indicating that the calibration of the subject is about to begin will appear. Click "OK" to proceed or "Cancel" to quit the process.



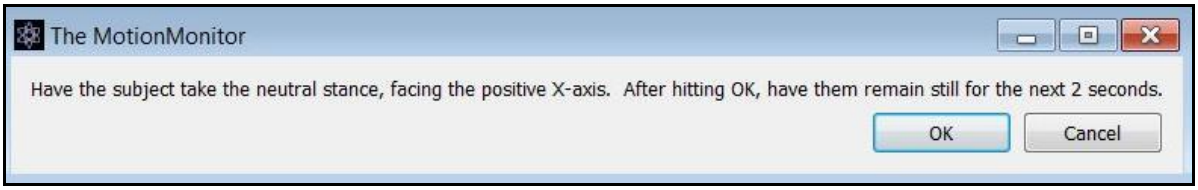
6. The subject's left and right shoulder joints will be the first item defined using the functional-rotation method. When completed, feedback will be provideded for determining whether the joint center calculation should be accepted or to retry the functional method.





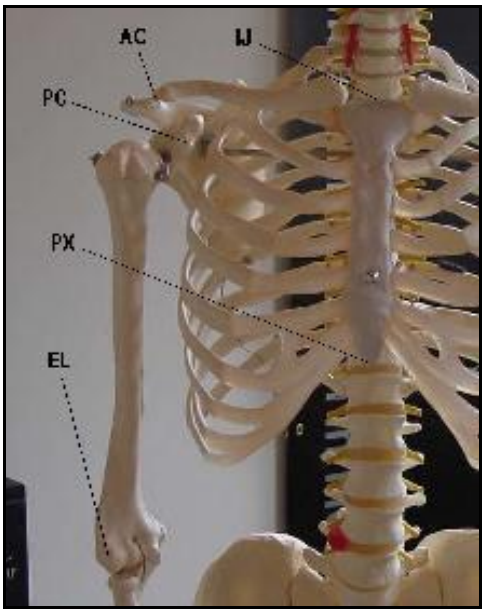
During the 10 second calibration period, the upper arm should be dynamically rotated through positions below 90 degrees in all orientations and the subject should otherwise try to remain as motionless as possible.

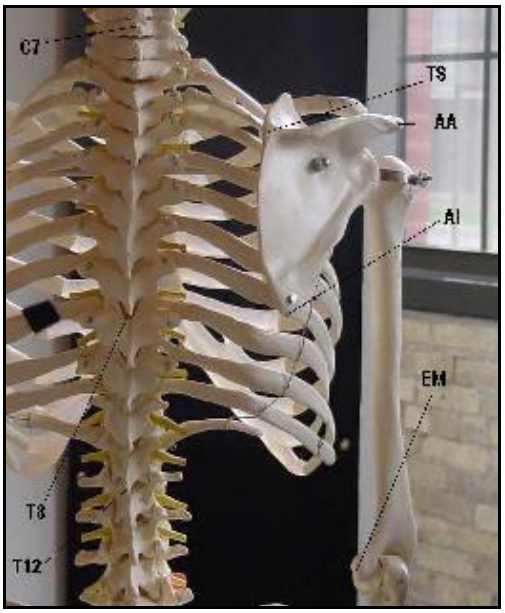
7. Next, the subject will be asked to take the neutral stance, facing the positive X-axis.



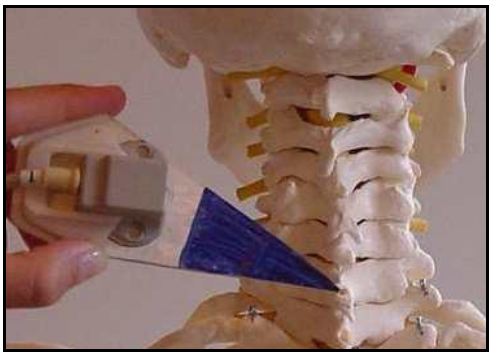
8. The process of digitizing **segment endpoints** will now begin. The following steps are outlined for the thorax, right scapula and right upper arm.

Please use the following two diagrams below as a guide for locating points (left side is mirrored):



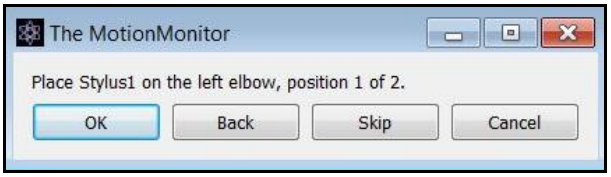


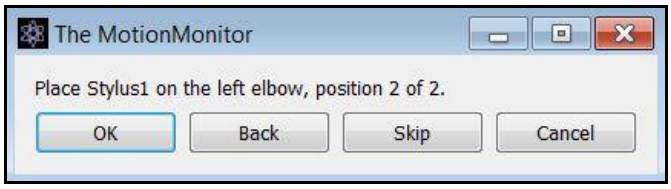
a) The first landmark to be digitized is the distal segment endpoint for the thorax. Perform a single reading at C7/T1.

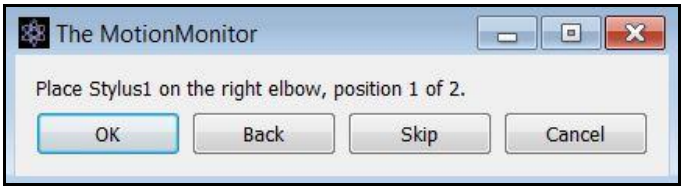


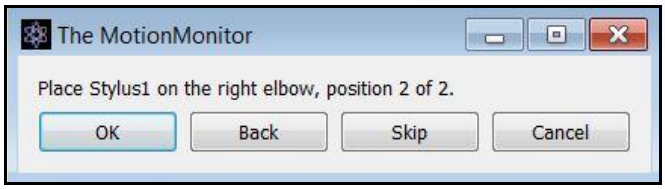
b) The next landmark to be digitized is the proximal segment endpoint for the thorax. Perform a single reading at T12/L1.

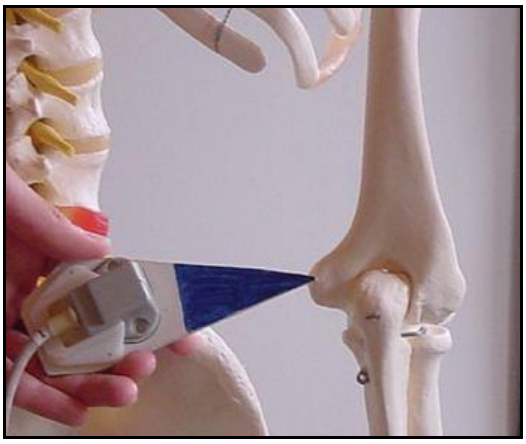
c) Next, the upper arm's distal segment endpoint is determined by the centroid method by taking a reading at the EL (Lateral Epicondyle) and then a reading at the EM (Medial Epicondyle).




The MotionMonitor
Place Stylus1 on the left elbow, position 2 of 2.
OK
Back
Skip
Cancel

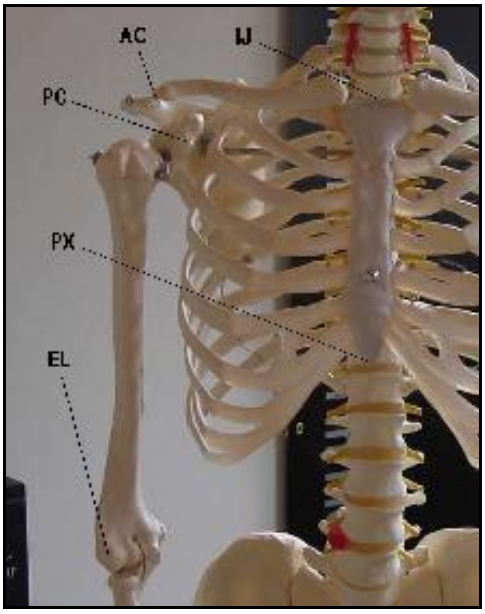

The MotionMonitor
Place Stylus1 on the right elbow, position 1 of 2.
OK
Back
Skip
Cancel

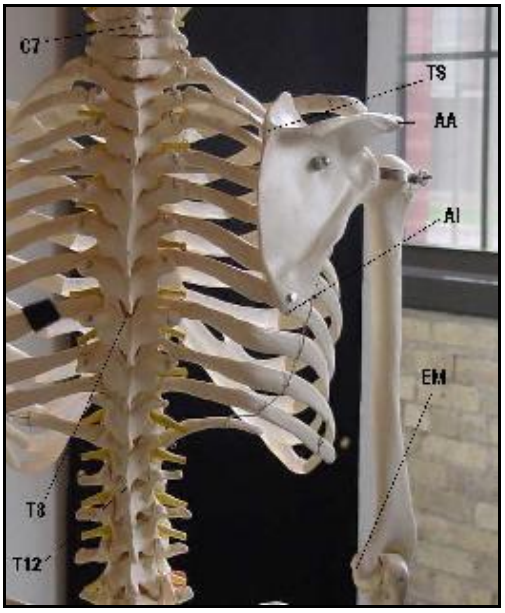




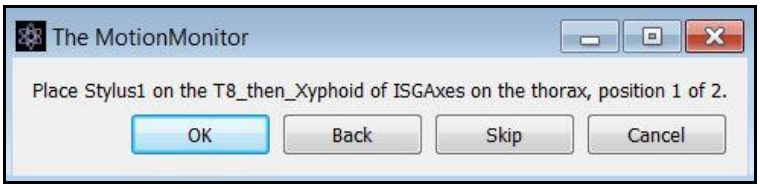
9. The process of digitizing **segment axes** will now begin. The following steps are outlined for the thorax, right scapula and right upper arm.

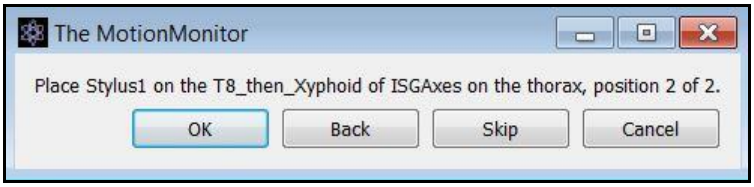
Please use the following two diagrams below as a guide for locating points:



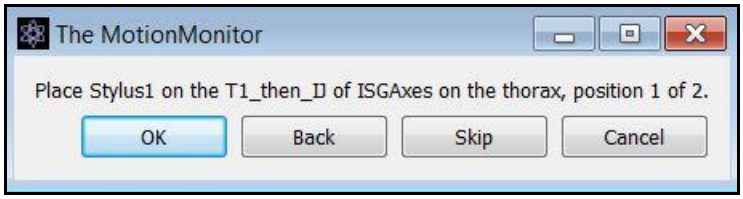


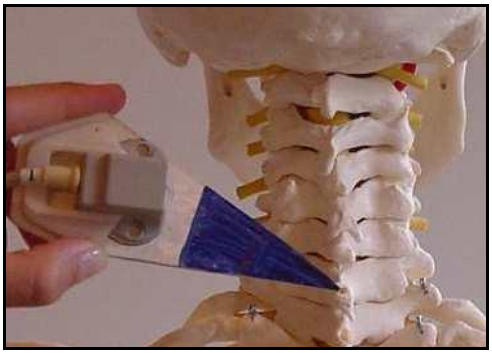
a) The segment axes for the thorax are digitized first. The proximal end of the longitudinal axis is determined first by the centroid method. Readings will be taken at T8 and then at the PX (Xyphoid Process).

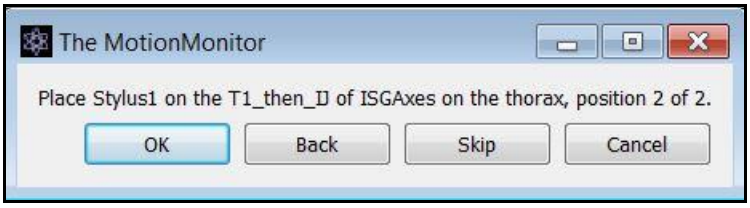




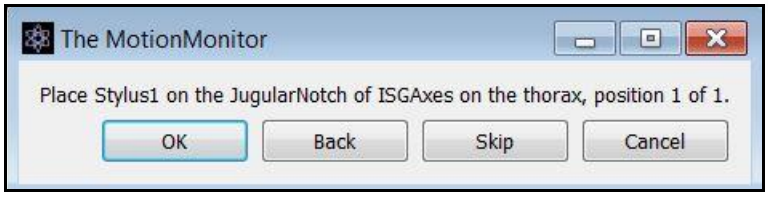
b) Then the distal end of the longitudinal axis for the thorax. The centroid method will be used again, with a reading taken at C7/T1 and then at IJ (Jugular Notch).





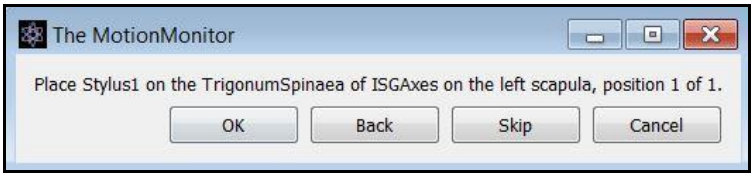


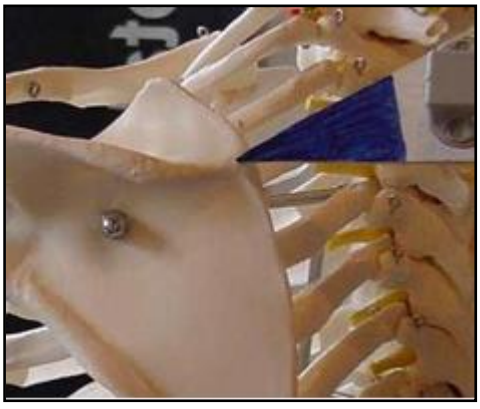
c) A single reading is taken at IJ (Jugular Notch) as the third point to form a plane from which the other two axes of the thorax are determined.



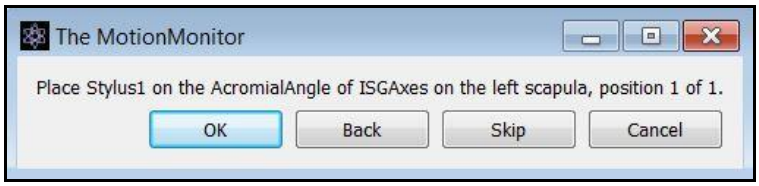
Note: The Thorax's origin is located at the IJ (Jugular Notch) and is assumed to the be the point taken for the IJ (Jugular Notch) as the third point for the thorax axes.

d) Next, the segment axes for the left scapula are digitized. Starting with the scapula's proximal longitudinal axis point, a single reading is taken at TS (Trigonum Spinae).

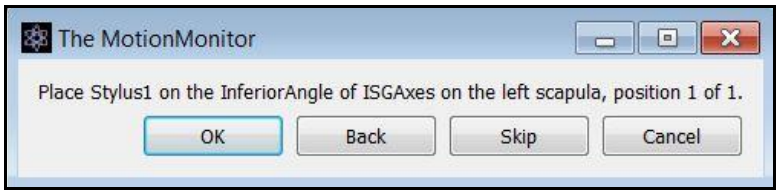




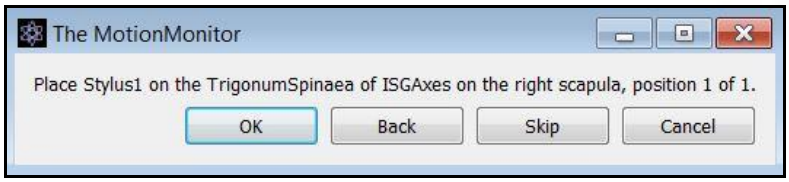
e) Then, for the left scapula's distal longitudinal axis point, a single reading is taken at AA (Acromial Angle).

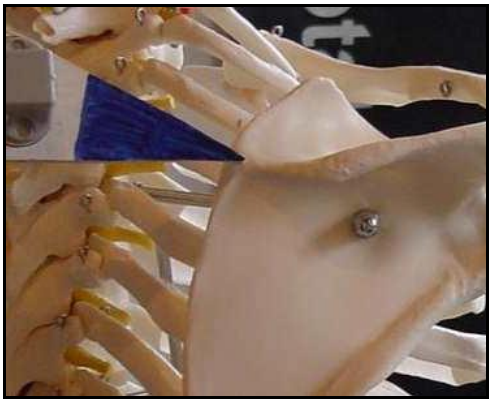


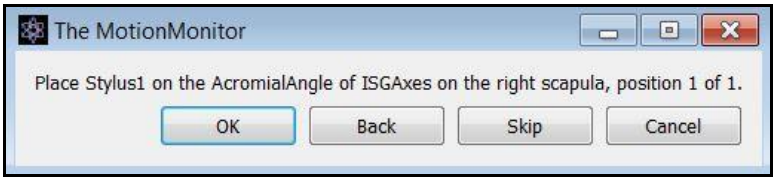
f) A single reading is taken at the left AI (Inferior Angle) for the third point to form a plane from which the other two axes of the scapula are determined.

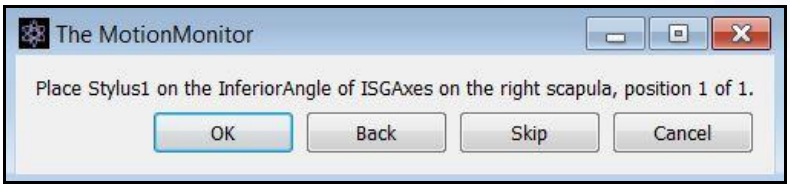


g) Now the digitization process is repeated for the right scapula to define its segment axes.



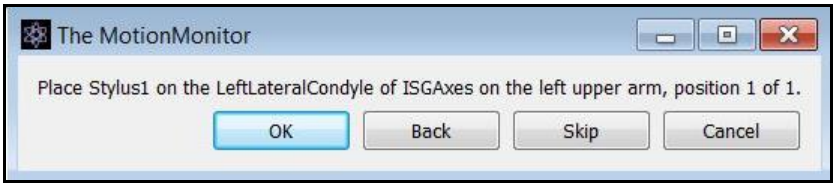


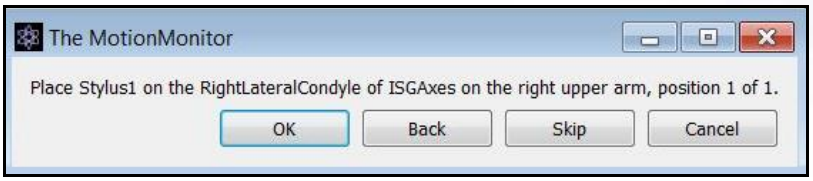




Note: The Scapula's origin is located at the AA (Acromial Angle) and is assumed to the be the point taken for the scapula's distal longitudinal axis point AA (Acromial Angle).

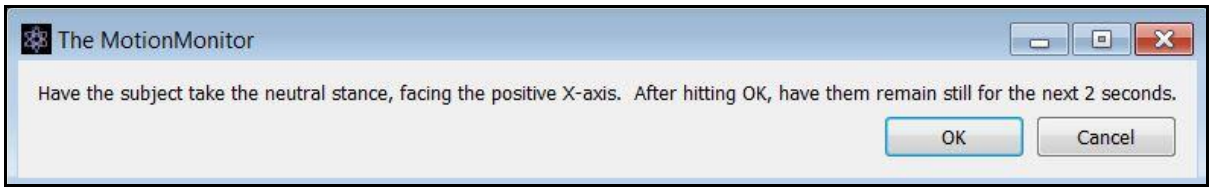
h) Next, a single reading is taken at the left and right EL (Lateral Epicondyle) for the third point to form a plane from which the other two axes of the upper arm are determined.



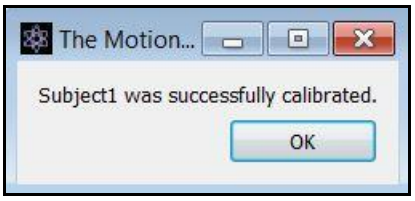


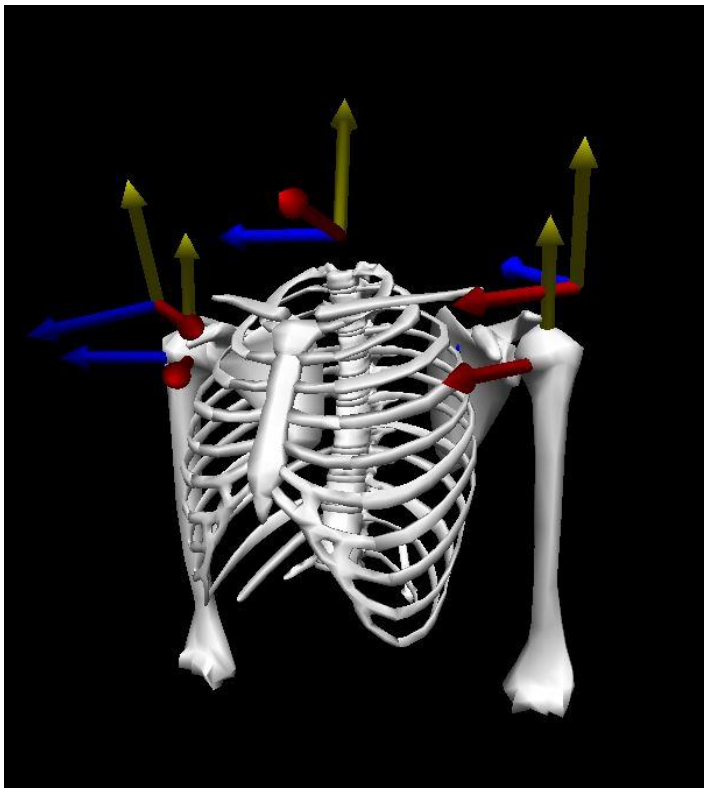
Note: The upper arm's proximal longitudinal axis point and origin are located at the shoulder joint center and is assumed to be the point taken during the Rotation method. The upper arm's distal longitudinal axis point is assumed to be the elbow joint center.

8. Finally, the subject will be asked to take the neutral stance, facing the positive X-axis again. This final reading is taken to account for any segment axes points that were not re-digitized.



9. The subject setup is now complete. The segments and segment axes are displayed in the animation window.





10. The Analysis toolbar provides icon shortcuts for enabling or disabling graphs, changing left vs right graph presentation, as well as exporting left, right, or bilateral kinematic data (in respective order below).

The images above show how these Analysis toolbars look when graphs are disabled (top) and enabled (bottom).

References

Euler or Carden Angles:
Euler sequence solutions are described in Introduction to Robotics, Mechanics and Control, Appendix B by John J. Craig. For sequences with multiple solutions, the solution where the sum of all the first angle magnitudes across the entire data series is the smallest is selected.

Shoulder Joint "Functional Method" (centre transformation technique (CTT)):
Ehrig, R.M, Taylor, W.R, Duda, G.N., Heller, M.O., 2006. A survey of formal methods for determining the centre of rotation of ball joints. Journal of Biomechanics 39(15), 2798-2809.

Shoulder Joint "Meskers' Method":
Meskers, C.G.M., Helm, F.C.T.v.d., Rozendaal, L.A., Rozing, P.M., 1998. In vivo estimation of the glenohumeral joint rotation center from scapular bony landmarks by linear regression. Journal of Biomechanics 31, 93-96.

ISB Shoulder Procedure:
Wu, G., van der Helm, F.C.T, Veeger, H.E.J., Makhsous, M, Van Roy, P., Anglin, C., Nagels, J., Karduna, A.R., McQuade, K., Wang, X., Werner, F.W., Buchholz, B., 2005. ISB recommendation on definitions of joint coordinate systems of various joints for the reporting of human joint motion-Part II: shoulder, elbow, wrist and hand. Journal of Biomechanics 38, 981-992.