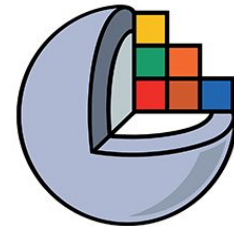
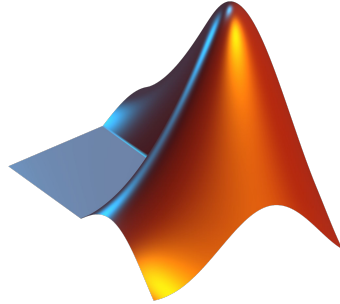


Morphologies Measurement Protocol Notes

O'Connell Biomechanics Lab
Yousuf + Sylvi
Winter 2025



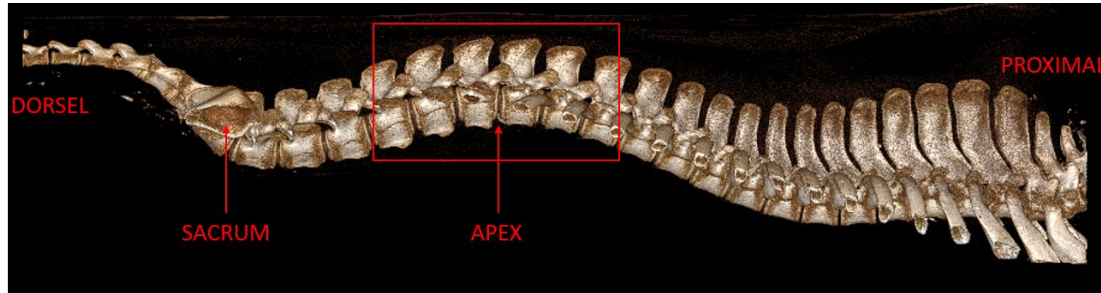
3D Slicer



Berkeley
UNIVERSITY OF CALIFORNIA

Measurement Protocol Overview

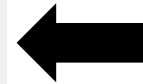
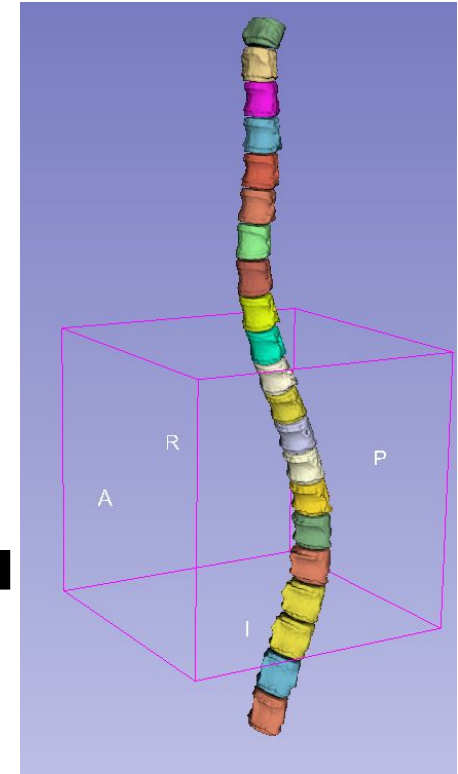
Raw imaging data



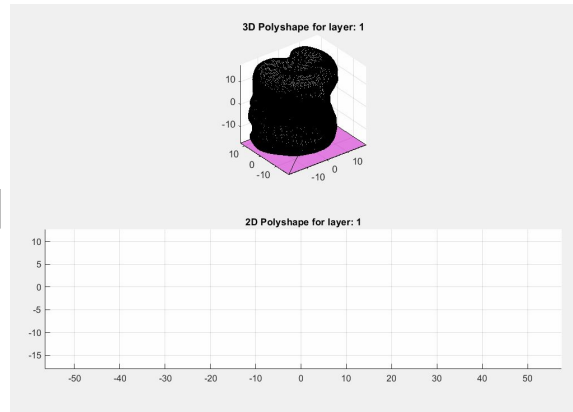
Assumes: 15
thoracic + 6
lumbar levels



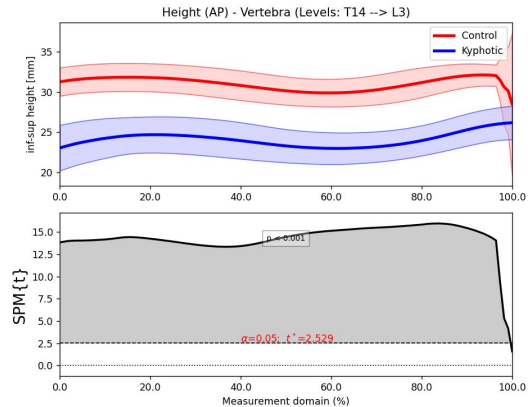
Full spine segmentation^[1]



(Automated) MATLAB measurements



Statistical Analysis



[1] Manual segmentation protocols [here](#)

Programing Overview

Morphologies Github [here](#)^[1], general pipeline:

Loading all vertebrae geometry files → disc construction → geometry alignment → slicer, height, and volume measurements → analysis

Morphologies

Author: Yousuf Abubakr (yousufabubakr123@berkeley.edu)

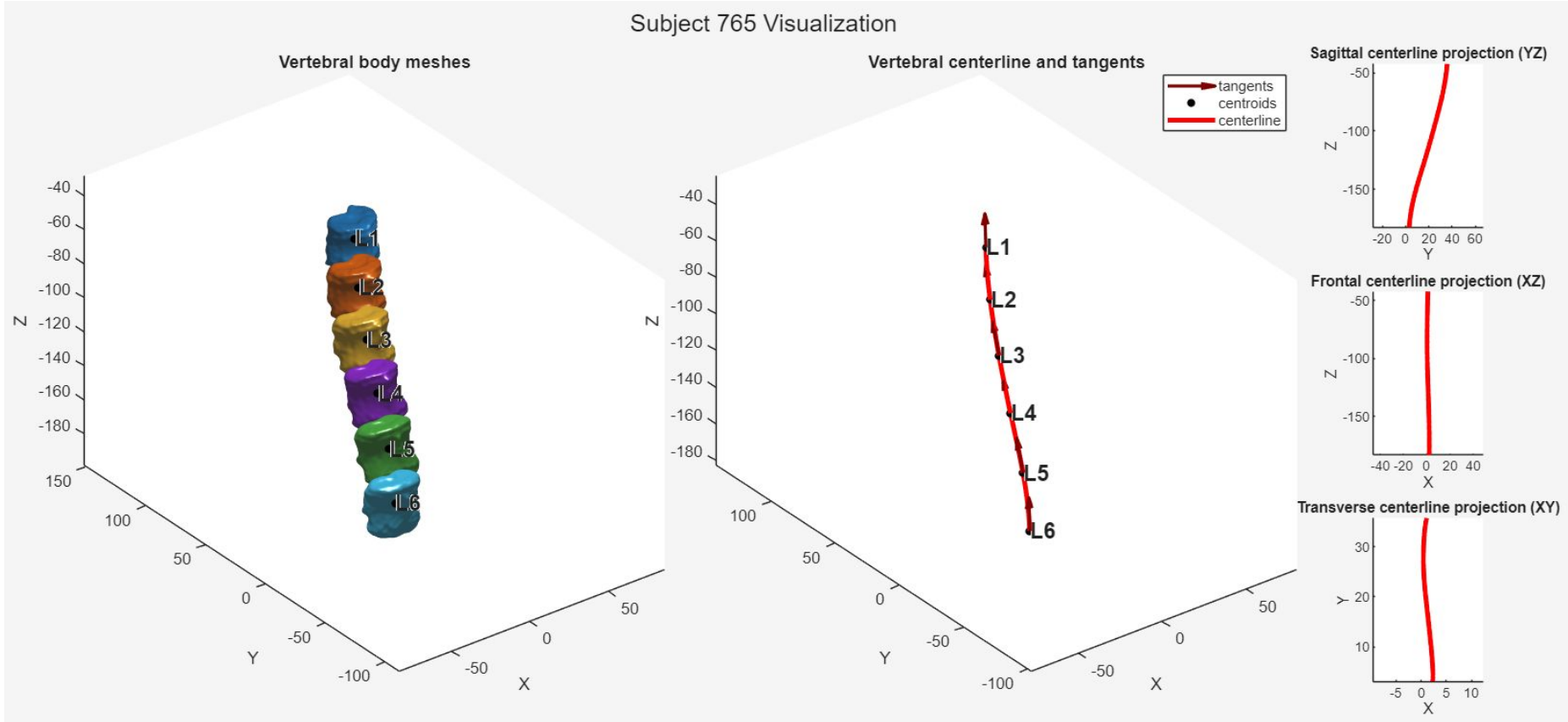
Lab: Grace O'Connell Biomechanics Lab (<https://oconnell.berkeley.edu/>)

Description: A toolkit for processing, analyzing, and visualizing morphological data from medical imaging datasets (e.g., STL meshes, MATLAB measurement files).

[1] Github stats (as of 1/22/2026): total # lines of code = 5,802, total # of words = 25,239, total # of characters = 225,008, total # of MATLAB .m files = 72

MATLAB Program Overview

1.) Loading geometry: *loads vertebral body geometries & computes centerline path and tangents*



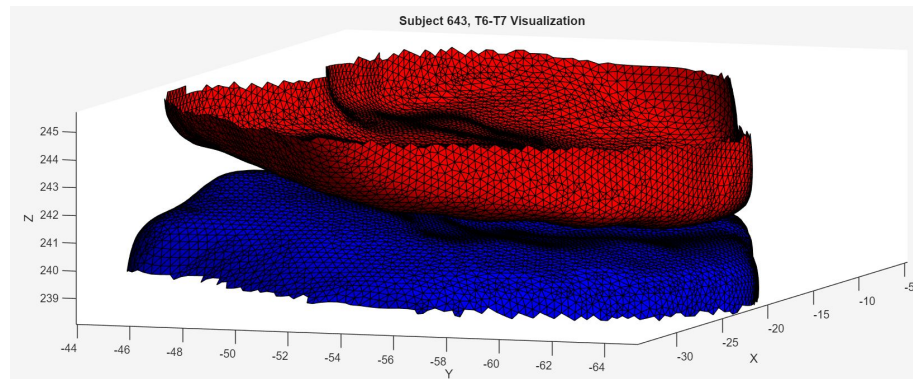
MATLAB Program Overview

2.) Disc construction: *interpolating across vertebral endplates to define and export disc volumes*

Step 1:

Extract triangulation representations of superior + inferior surfaces

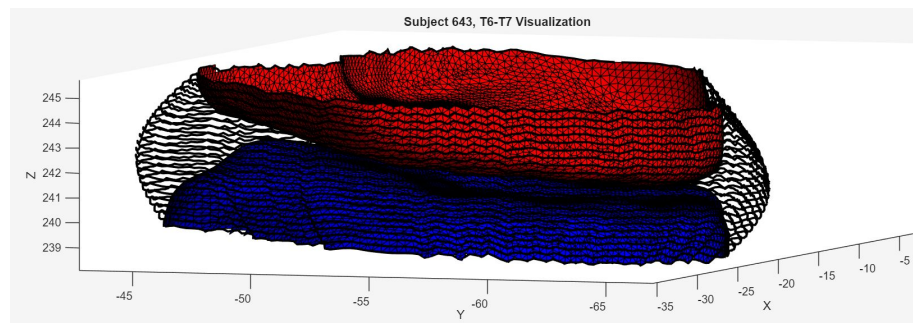
- Red = superior surface of disc
- Blue = inferior surface of disc



Step 2:

Obtain inferior → superior loft curves (pictured in black)

- Associated parameters:
 - # of rings
 - bulge amplitude (default: 2 mm)



MATLAB Program Overview

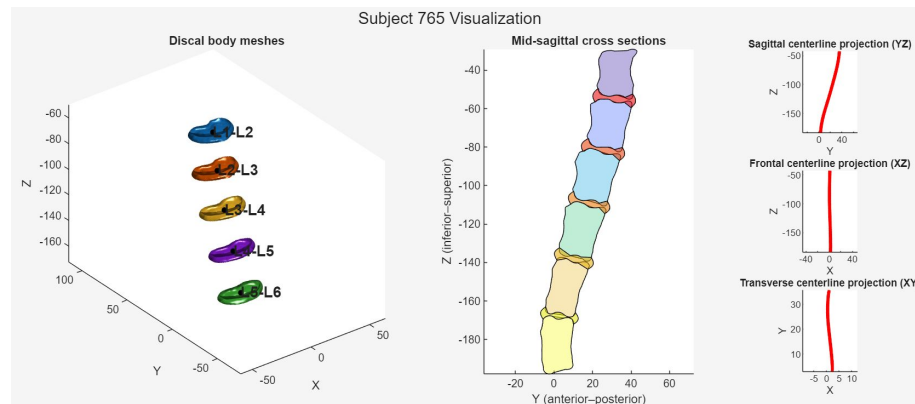
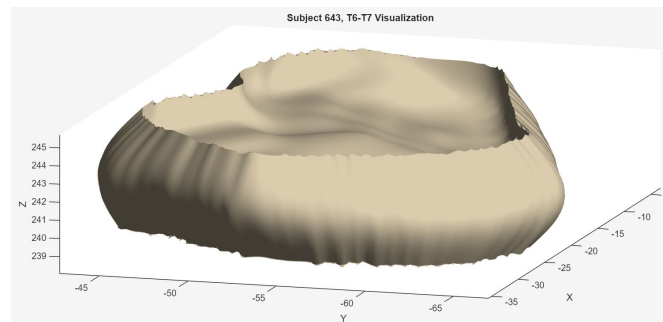
2.) Disc construction: *interpolating across vertebral endplates to define and export disc volumes*

Step 3:

Stitch endplate surfaces to one another to create a full disc triangulation and export to .stl file

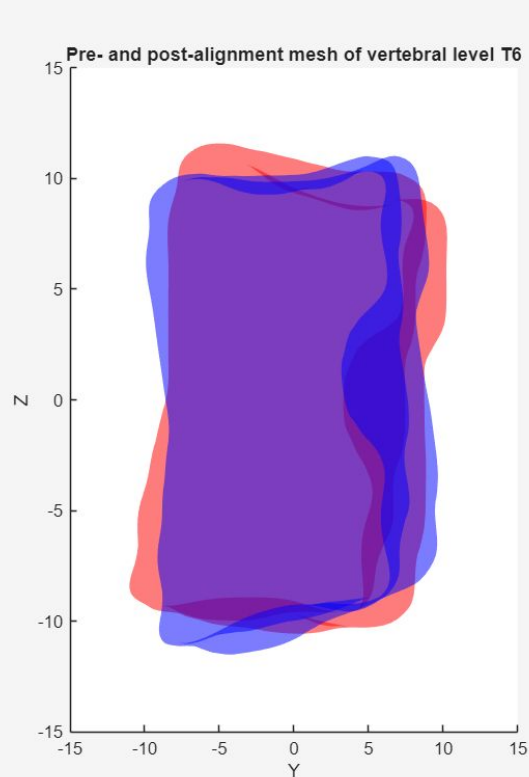
NOTES:

- **Water-tightness is NOT guaranteed**
- Any further geometry processing and measurement processes are generalized for both vertebra and disc structures

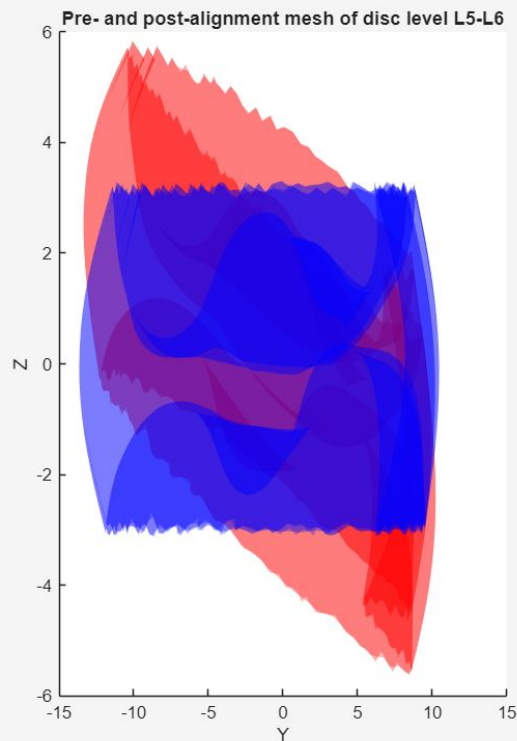


MATLAB Program Overview

3.) Geometry alignment: *centerline-based geometry alignment to standard coordinate reference frame*



Subject 665 Visualization



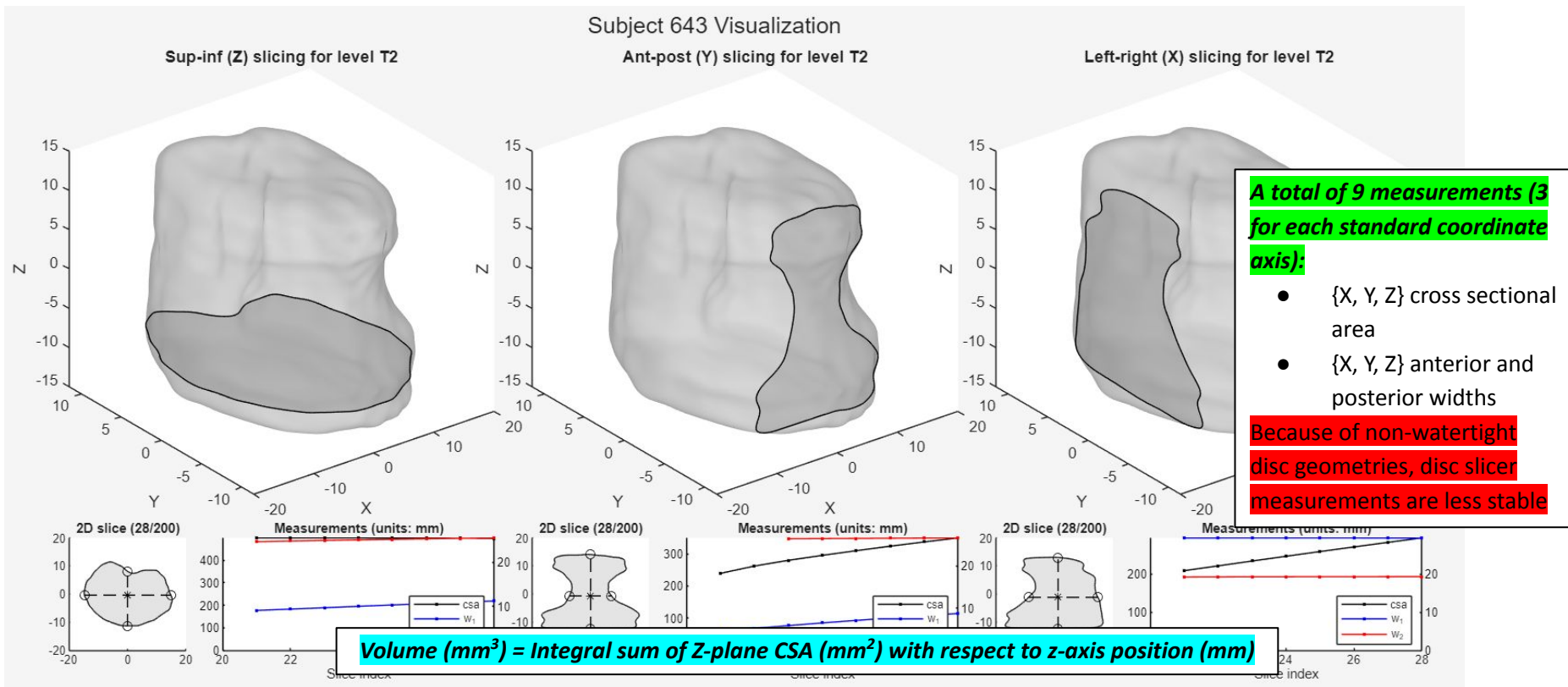
Rotation alignment matrix is found from centerline geometry:

- 3D coordinate frame is determined at every disc/vertebra centroid-centerline position
- 3D coordinate frame \rightarrow basis of rotation matrix
- Every disc/vertebrae geometry is transformed via the formula:

$$\circ \quad V_I = (V_0 + t) * R$$

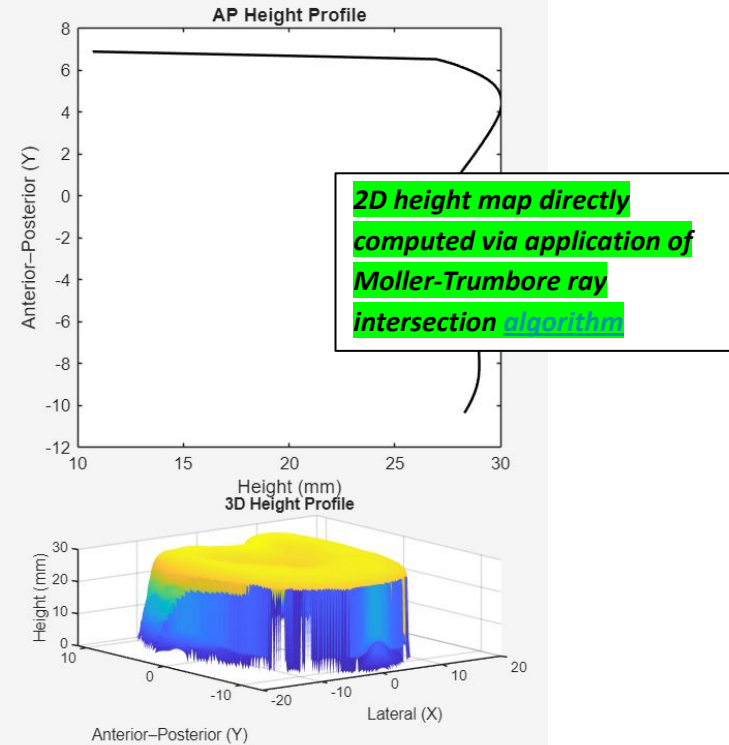
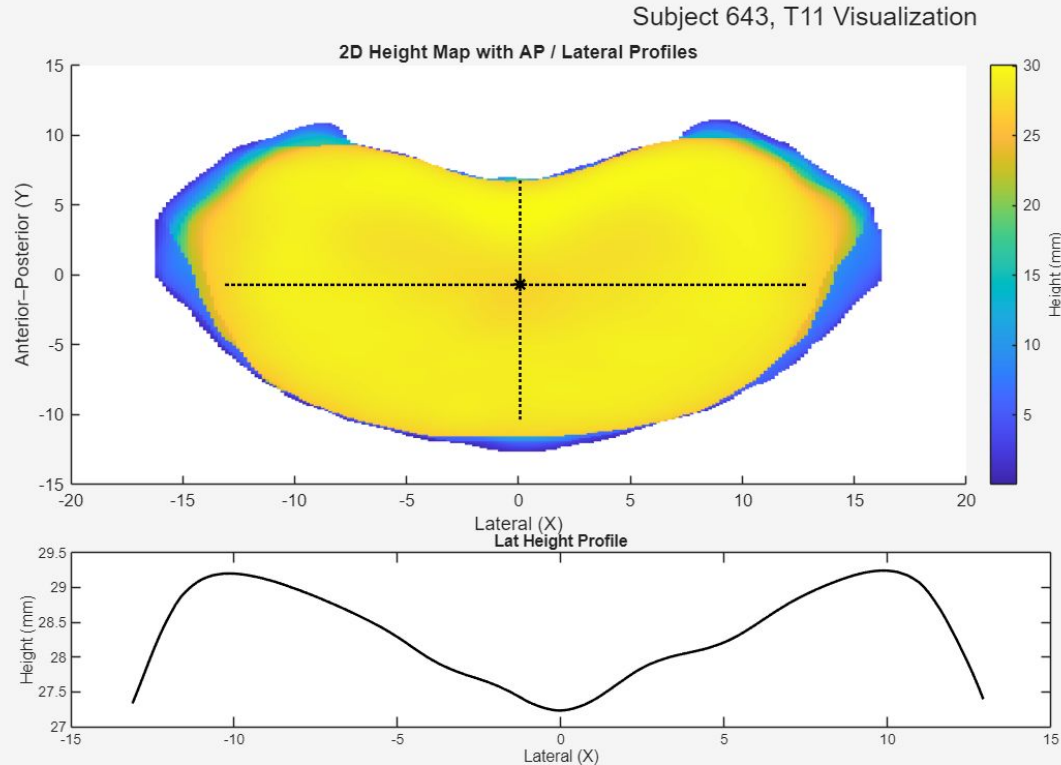
MATLAB Program Overview

4.) Slicer/volume measurements: *slicing geometries and measuring CSAs, widths, and volumes*



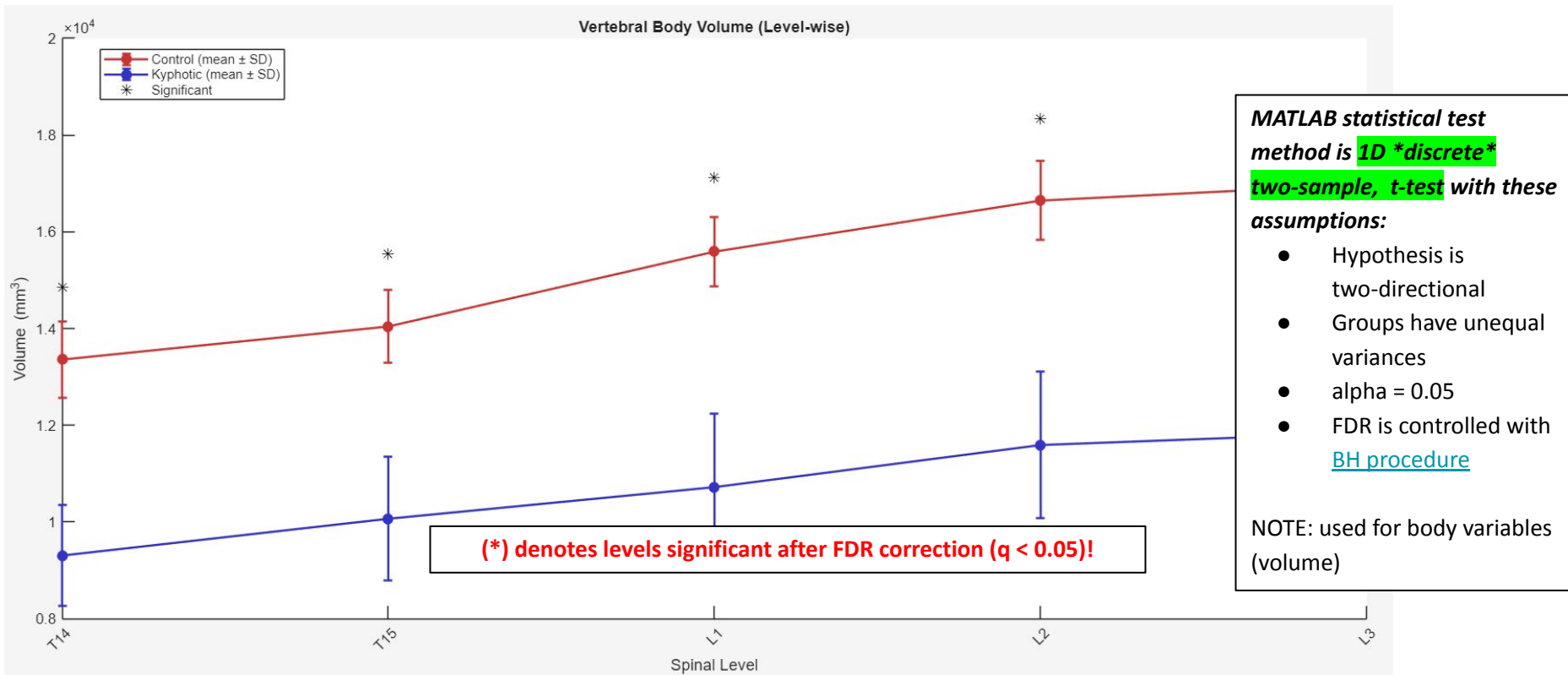
MATLAB Program Overview

4.) Height measurements: *measuring 2D height distribution and extracting AP and LAT heights*



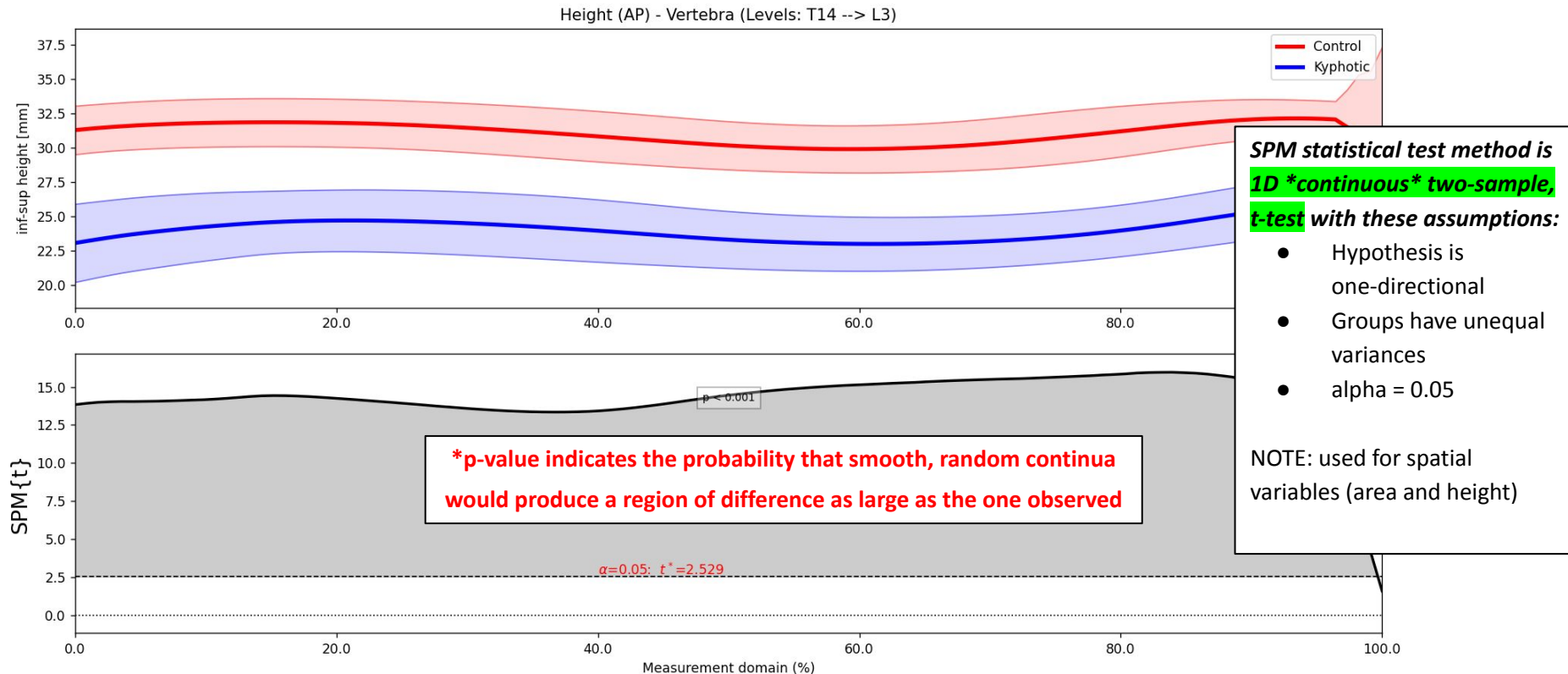
MATLAB Program Overview

5.) Analysis: *computing and visualizing summary statistics across control and kyphotic experimental groups*



MATLAB Program Overview

5.) Analysis: *computing and visualizing summary statistics across control and kyphotic experimental groups*



Morphologies Technical Overview

Morphologies source code [here](#), head files:

main.m	←-----	Execution hub of all programs and subprograms
makeConfig.m	←-----	Configuration file for pipeline (# of slices, height resolution, etc)
Primary routine files (executed in main.m)		setSubjectInformation.m ←----- initializes pipeline data structures
		loadGeometryMetadata.m ←----- loads geometry into data structure
		constructDiscs.m ←----- disc construction
		alignGometries.m ←----- aligns vertebrae and disc geometries
		makeSlicerMeasurements.m ←----- makes slicer measurements
		makeHeightMeasurements.m ←----- makes height measurements
		makeVolumeMeasurements.m ←----- makes volume measurements
		exportData.m ←----- writes data to file
		summarizeData.m ←----- visualizes and exports data

Morphologies Technical Overview

Morphologies source code [here](#), head files:

main.m	←-----	Execution hub of all programs and subprograms
makeConfig.m	←-----	Configuration file for pipeline (# of slices, height resolution, etc)

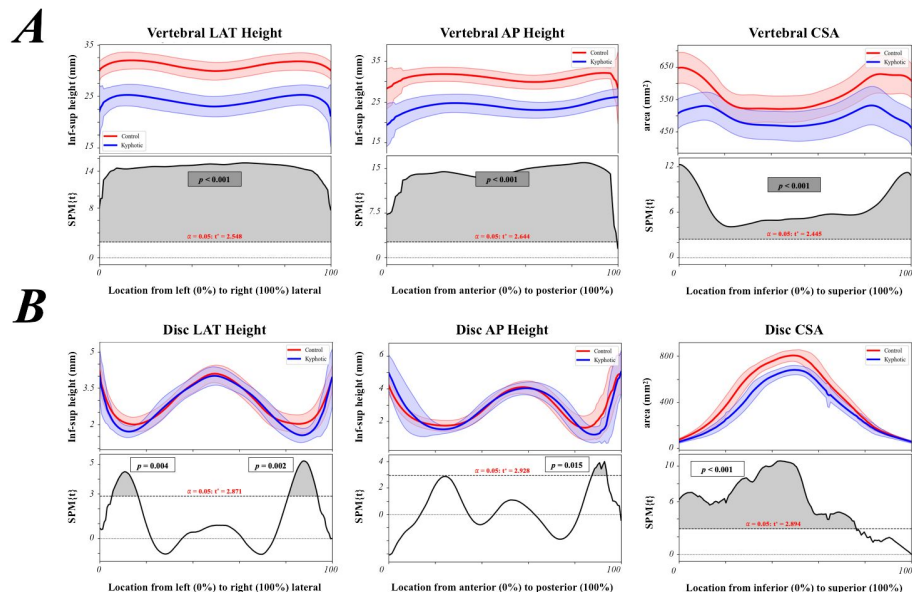
How to use source code:

1. *Set configuration settings in makeConfig.m*
 - a. **IMPORTANT PARAMETERS:**
 - i. **numSlices, heightResolution, slicerIgnorance, heightIgnorance**
 - ii. *If pipeline detects any of these config parameters are different from the saved config settings in 'data/raw', the measurements will be rewritten!*
 - b. *Options for visualization (note: some plots are graphics intensive)*
 - c. *Disc construction parameters*
 - d. *Range of levels to be exported for SPM analysis*
2. *Run main.m for MATLAB results and run '[analysis-utils/main.py](#)' for SPM results*

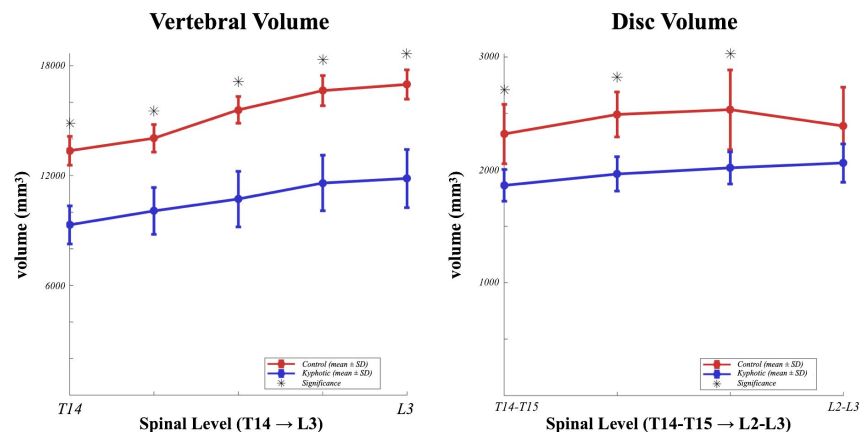
Summary of Results from *Morphologies*

Settings: # of slices = 200, height resolution = 200, slicer & height ignorance = 0.1, levels exported = T14 → L3

Spatially-varying measurements



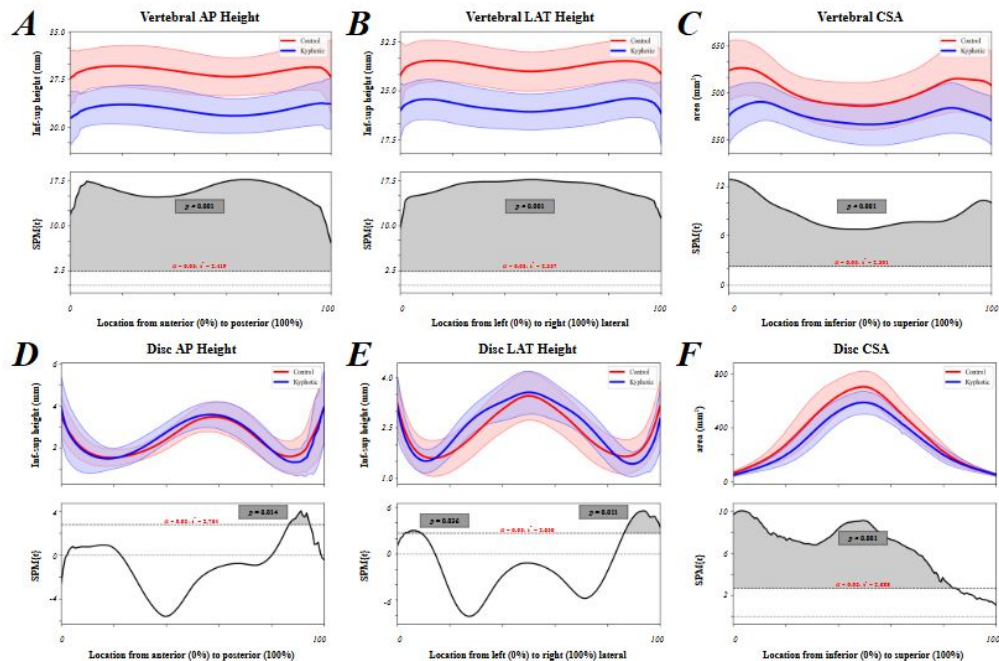
Spine-level scalar measurements



Summary of Results from *Morphologies*

Settings: # of slices = 200, height resolution = 200, slicer & height ignorance = 0.1, levels exported = T1 → L6

Spatially-varying measurements



Spine-level scalar measurements

