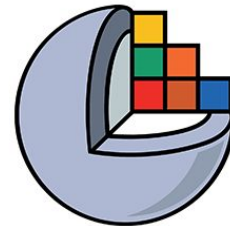
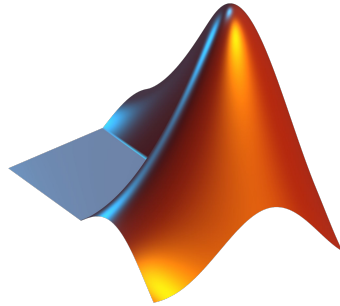


# *Morphologies* Measurement Protocol Notes

*O'Connell Biomechanics Lab*

Yousuf + Sylvi

Winter 2025



3D Slicer

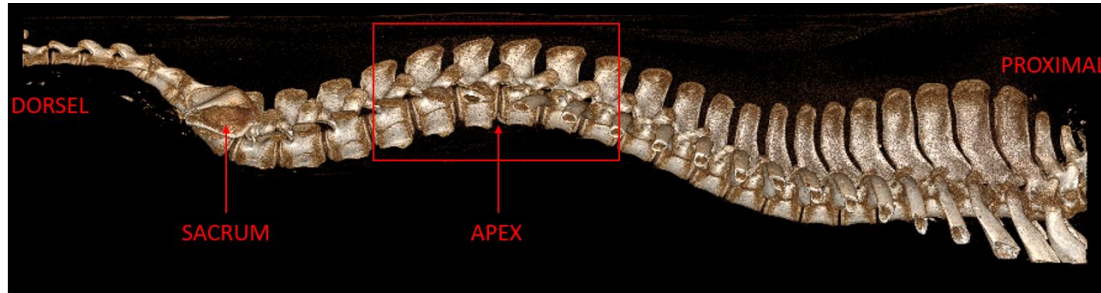


BERKELEY  
BioMechanics

Berkeley  
UNIVERSITY OF CALIFORNIA

# Measurement Protocol Overview

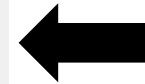
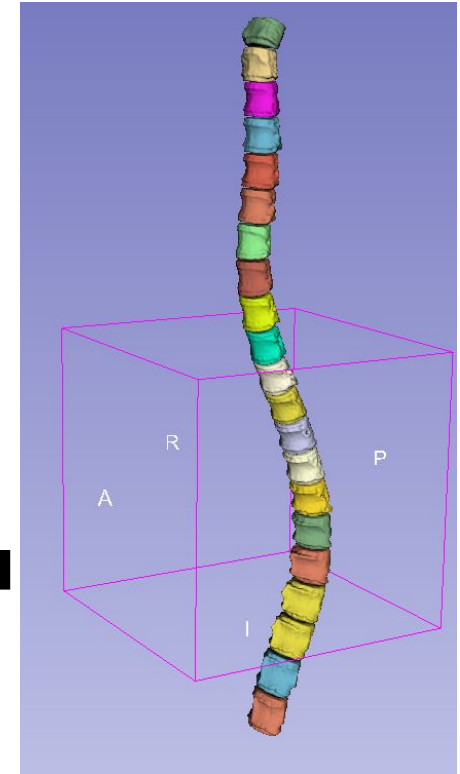
Raw imaging data



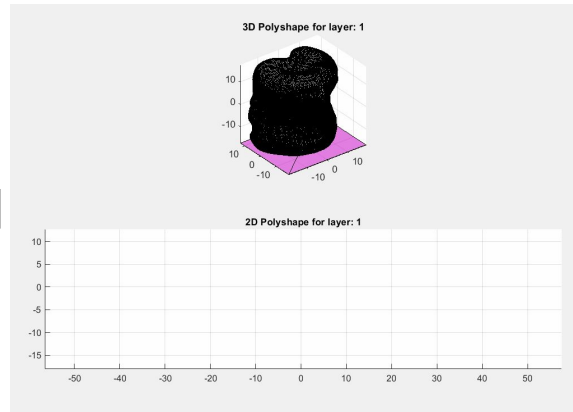
Assumes: 15  
thoracic + 6  
lumbar levels



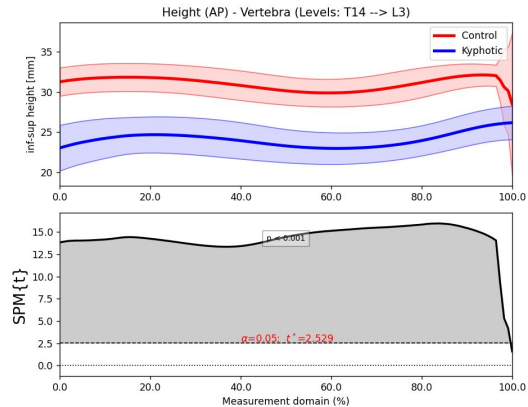
Full spine segmentation<sup>[1]</sup>



(Automated) MATLAB measurements



Statistical Analysis



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

# Programing Overview

**Morphologies** Github [here](#)<sup>[1-2]</sup>, general pipeline:

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

## Morphologies

**Author:** Yousuf Abubakr ([yousufabubakr123@berkeley.edu](mailto:yousufabubakr123@berkeley.edu))

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

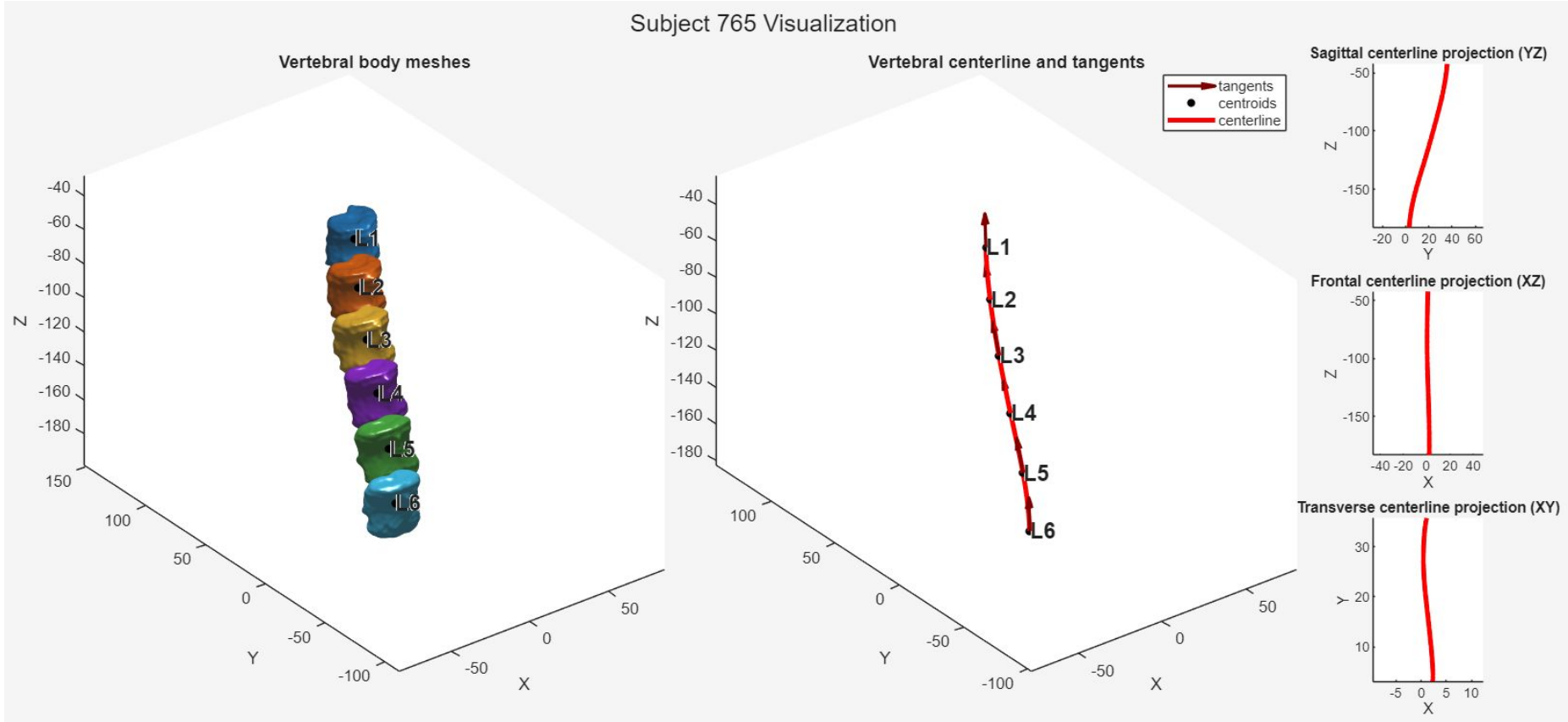
**Description:** A toolkit for processing, analyzing, and visualizing morphological data from medical imaging datasets (e.g., STL meshes, MATLAB measurement files).

[1] Github stats (as of 1/29/2026): total # lines of code = 5,861, total # of words = 25,572, total # of characters = 228,566, total # of MATLAB .m files = 72

[2] Necessary MATLAB packages: Curve Fitting Toolbox

# MATLAB Program Overview

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



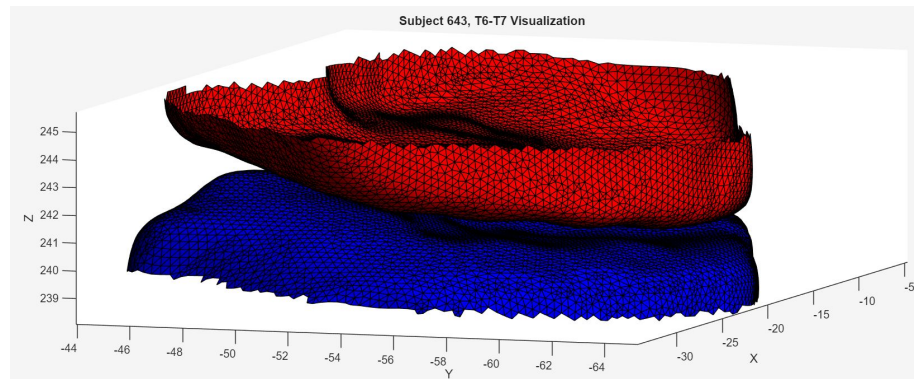
# MATLAB Program Overview

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

### Step 1:

*Extract triangulation representations of superior + inferior surfaces*

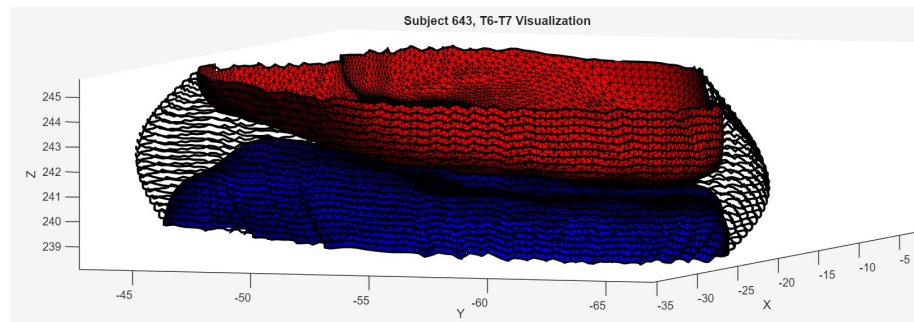
- Red = superior surface of disc
- Blue = inferior surface of disc



### Step 2:

*Obtain inferior → superior loft curves (pictured in black)*

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



# MATLAB Program Overview

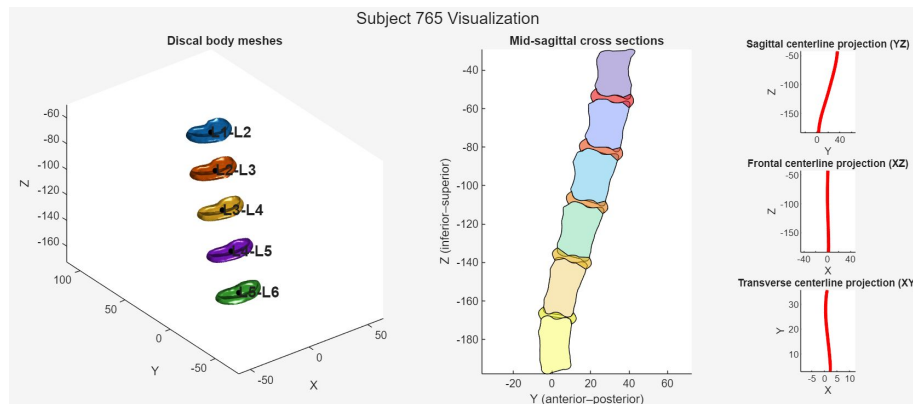
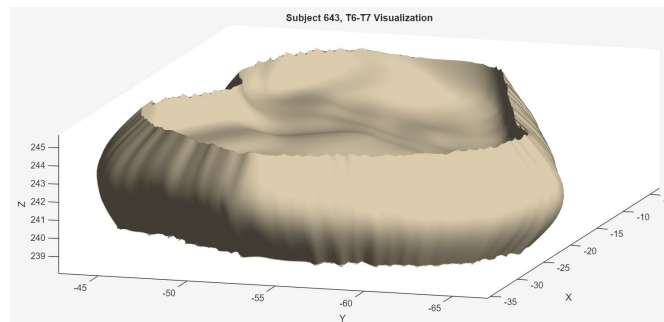
## 2.) Disc construction: *interpolating across vertebral endplates to define and export disc volumes*

### Step 3:

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

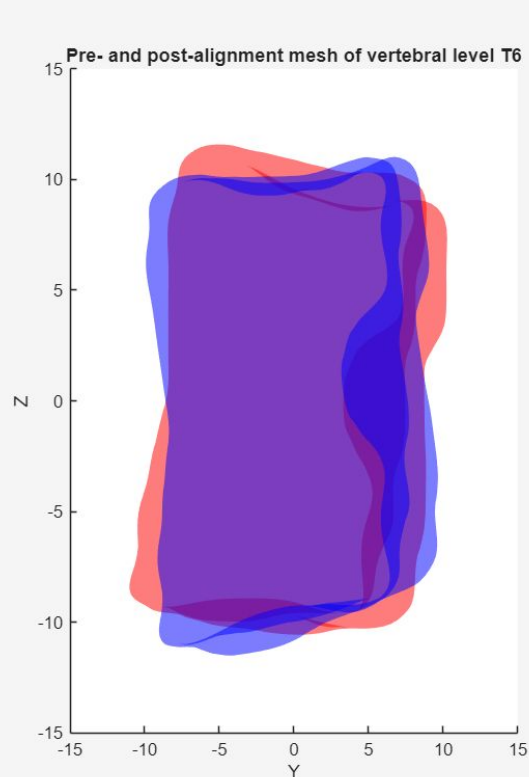
### NOTES:

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

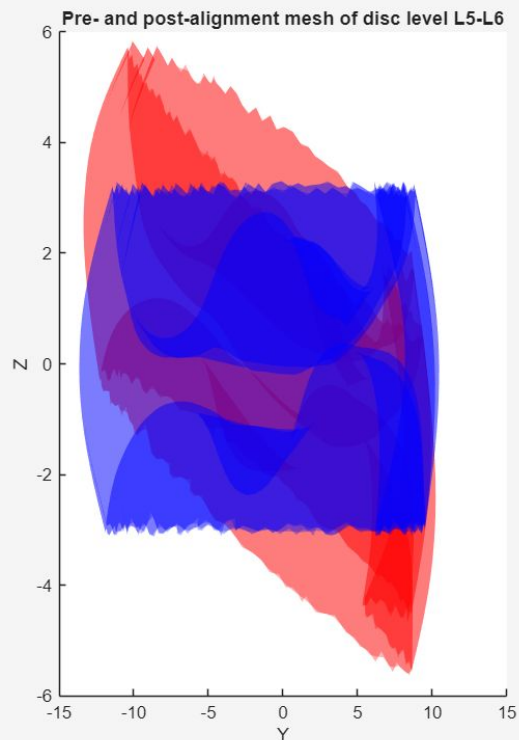


# MATLAB Program Overview

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



Subject 665 Visualization



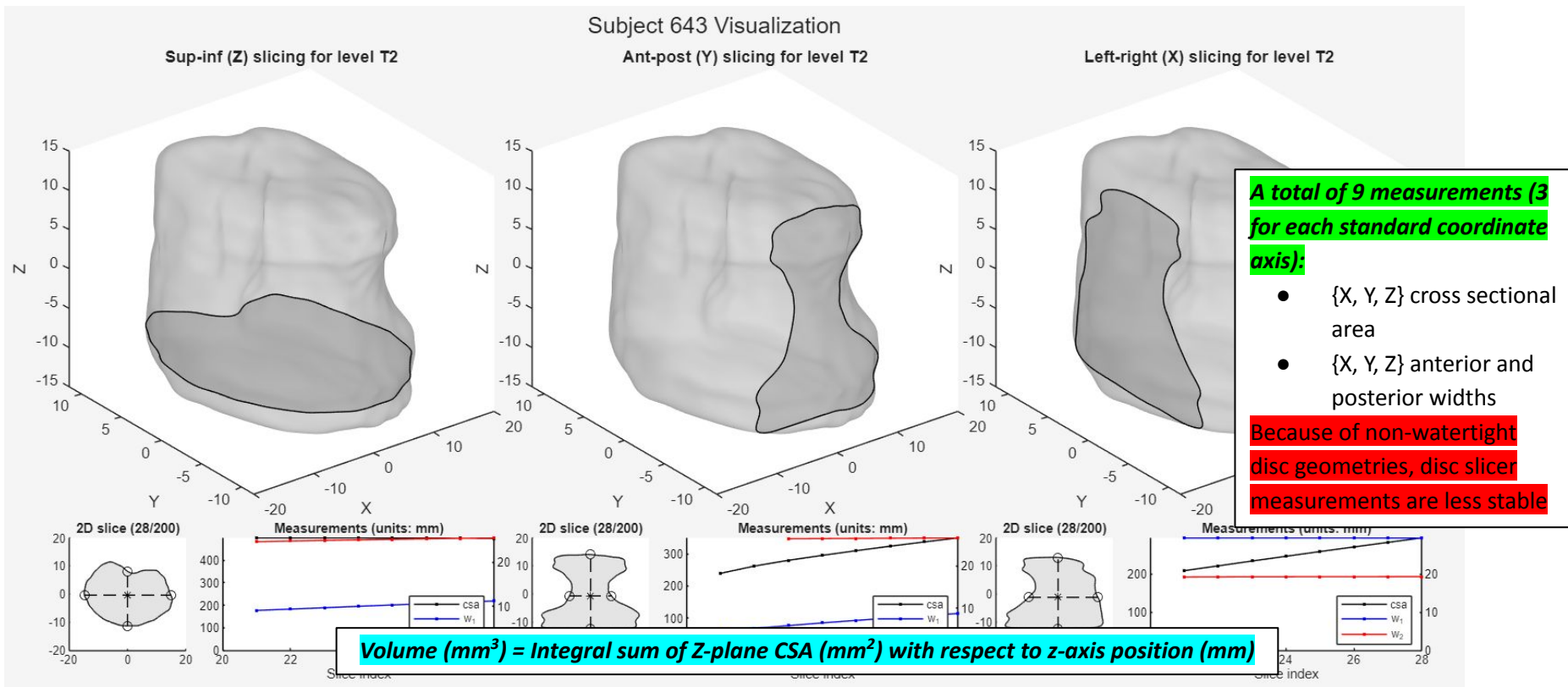
**Rotation alignment matrix is found from centerline geometry:**

- 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:

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

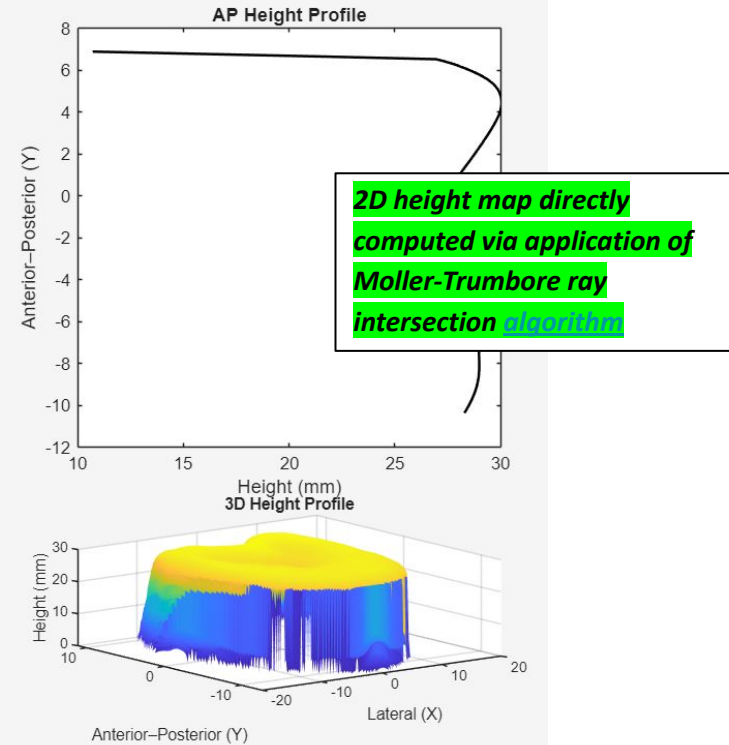
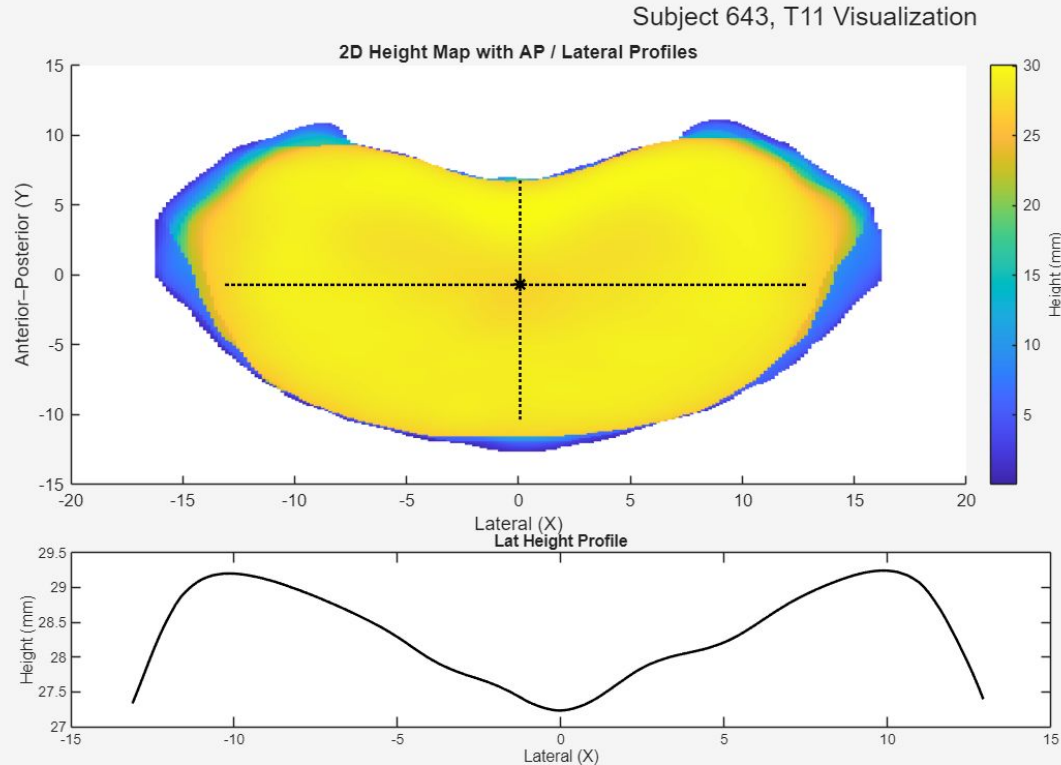
# MATLAB Program Overview

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



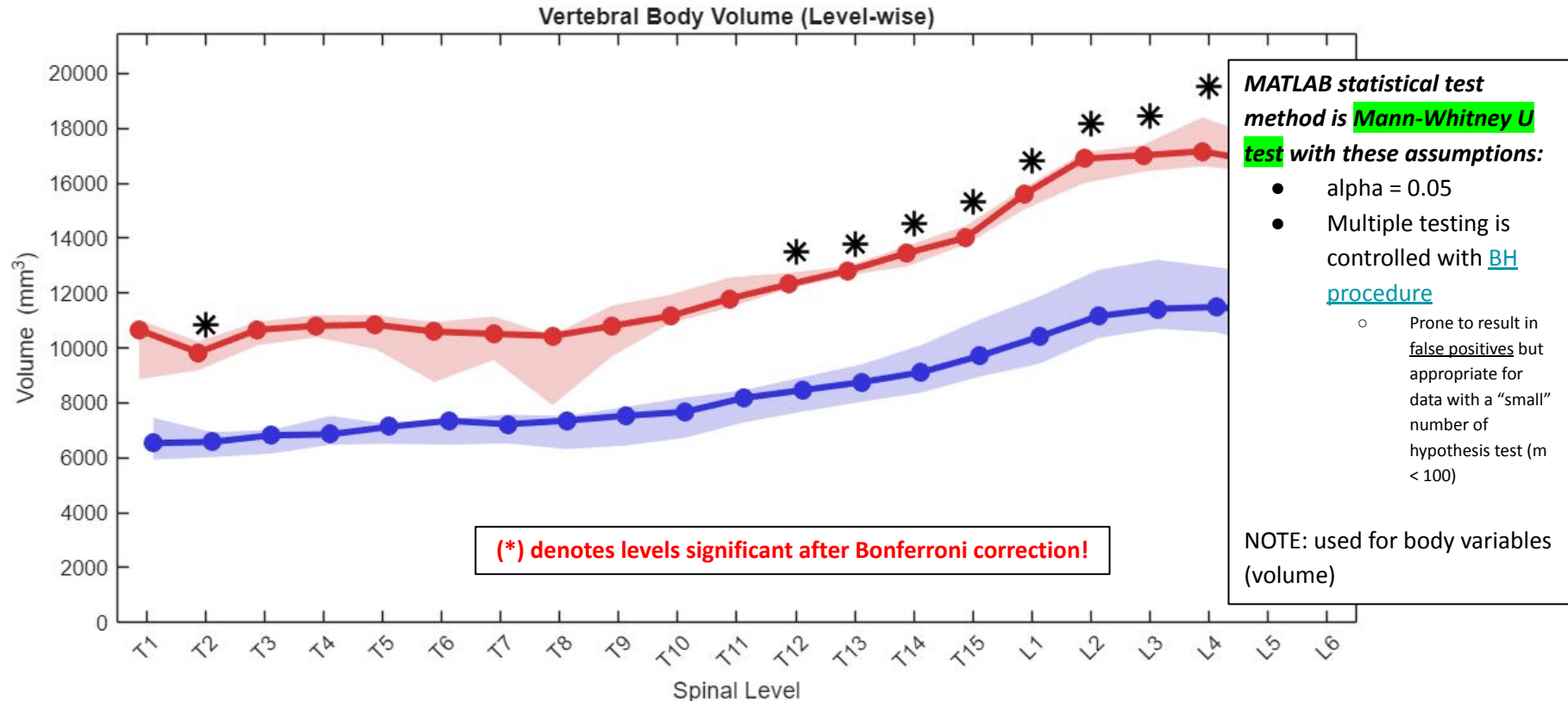
# MATLAB Program Overview

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



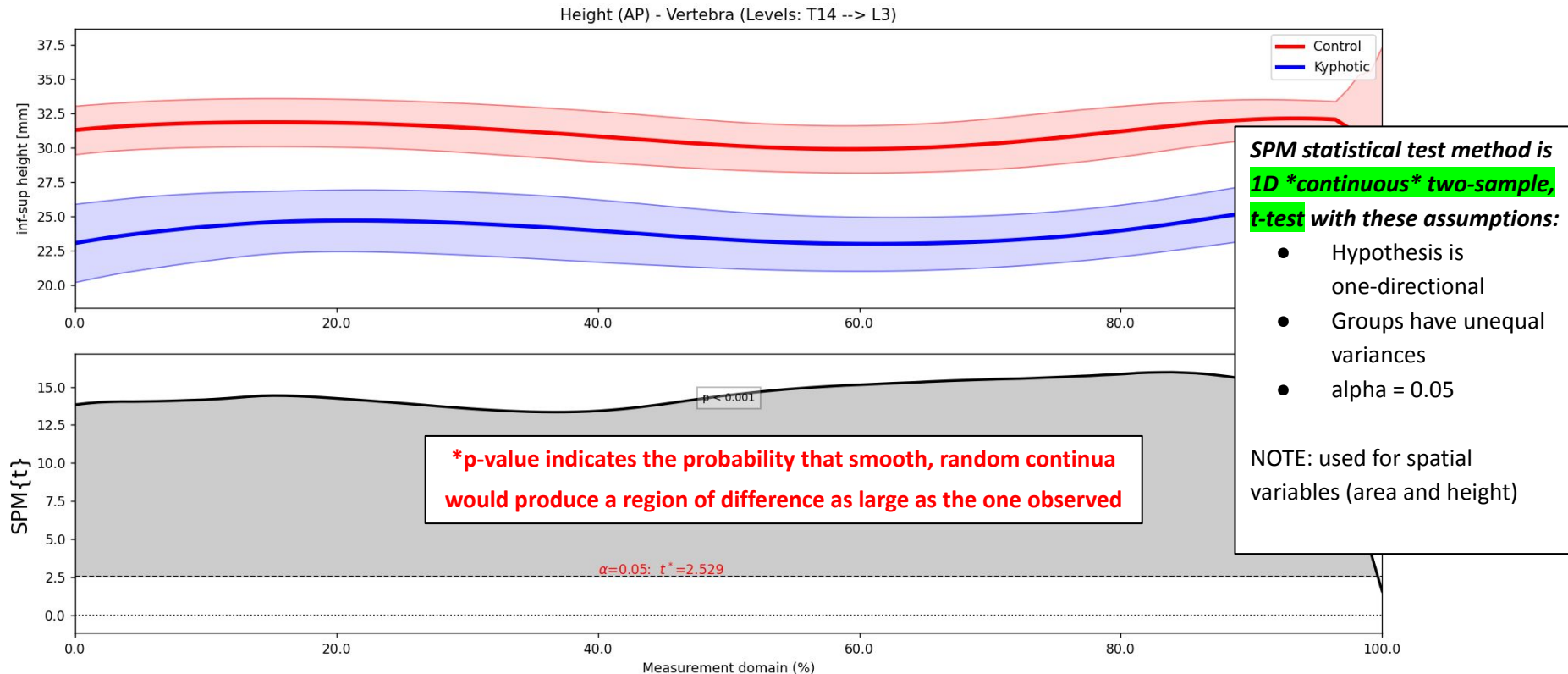
# MATLAB Program Overview

## 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)
<b>Primary routine files (executed in main.m)</b>		
	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)

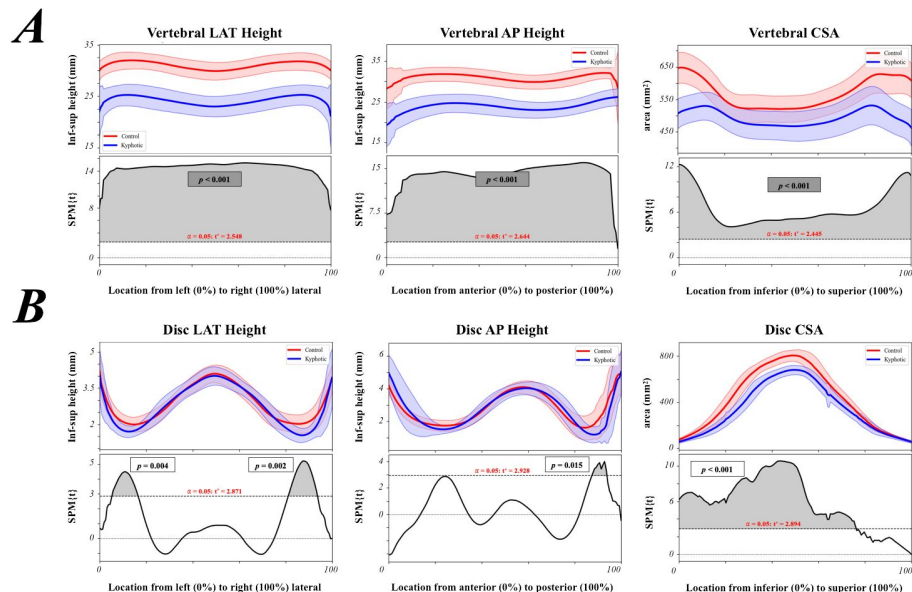
## How to use source code:

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*

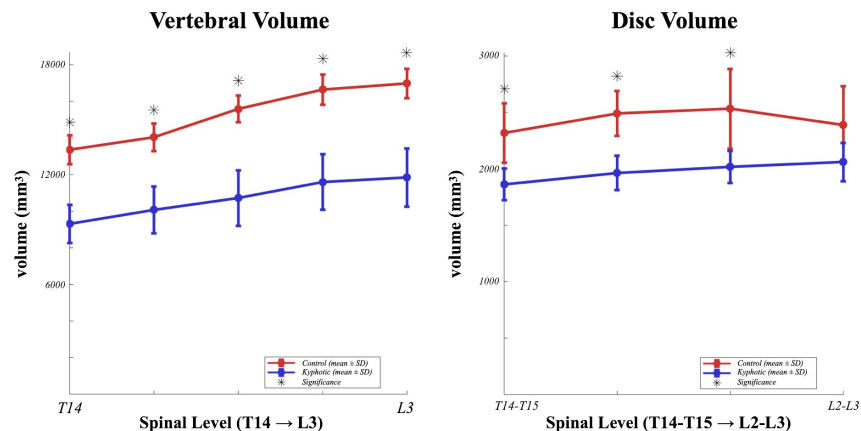
# Summary of Results from *Morphologies*

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

## Spatially-varying measurements



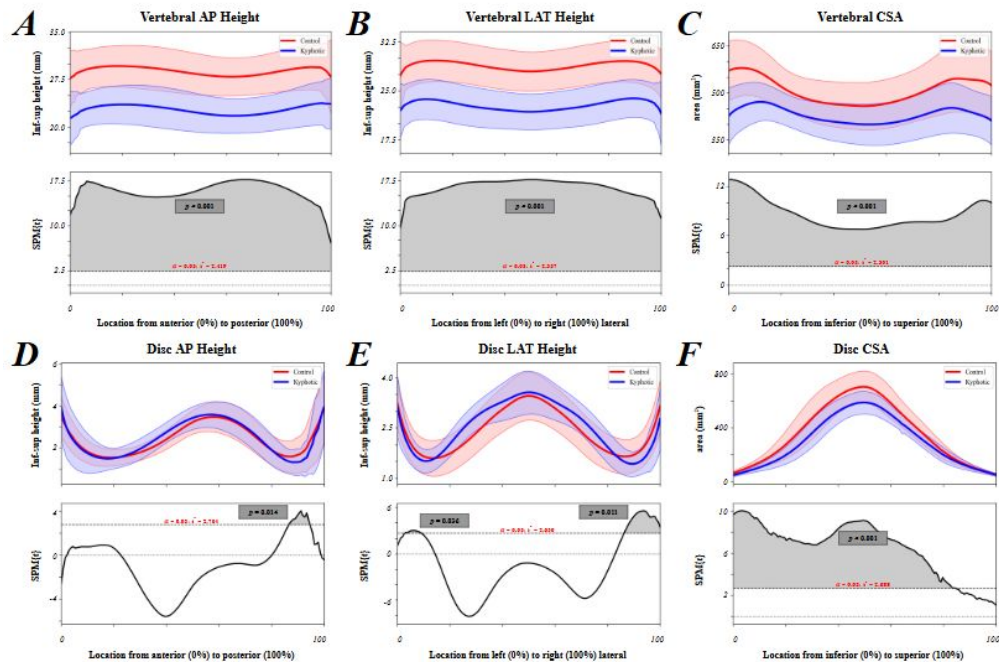
## Spine-level scalar measurements



# 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

