

# Hip\_Joint\_Landmarks

**Estimates for the Right and Left Hip Joint Center are represented as Landmarks relative to the CODA and V3D\_Composite pelvis segment coordinate systems.**

**You should notice the following for all equations:**

1. The left and right side landmarks are defined exactly the same, except the ML direction for one side is negated.
2. The only difference between the equations for the CODA and V3D\_Composite pelvis segments is that there is an offset ( $0.5 \times \text{RPV\_Depth} - \text{Target\_Radius\_ASIS}$ ). This is because the origin of the V3D\_Composite pelvis is 50% of pelvis depth compared to the CODA pelvis origin.

## Model Metrics

You will see the following model metrics used in the equations below. These model metrics are automatically created when you create the CODA or V3D\_Composite pelvis.

|                           |                                                                                 |
|---------------------------|---------------------------------------------------------------------------------|
| <b>ASIS_Distance</b>      | The 3D distance between the Right and Left ASIS                                 |
| <b>RPV_Depth</b>          | The 3D distance between the Mid-Point of the ASIS and the Mid-Point of the PSIS |
| <b>Target_Radius_ASIS</b> | The radius of the marker placed on the ASIS landmark                            |

**NOTE:** RPV\_Depth is included in the subject metrics starting in Version 5 and the Target\_Radius\_ASIS is included in the subject metrics starting in Version 6. In previous versions, these metrics must be added manually

## Bell and Brand Hip Joint

When you create the CODA or V3D\_Composite pelvis, the hip joint landmarks are automatically created using the Bell and Brand regression equations.

- Since the pelvis depth is defined differently between the CODA and V3D\_Composite pelvis, use the set of equations which corresponds to the pelvis type you are using.

| Bell & Brand           |                                      |                                                                                                     |
|------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------|
| CODA Coordinate System |                                      | V3D_Composite Coordinate System                                                                     |
| RHJC                   |                                      |                                                                                                     |
| ML                     | $0.36 \times \text{ASIS\_Distance}$  | $0.36 \times \text{ASIS\_Distance}$                                                                 |
| AP                     | $-0.19 \times \text{ASIS\_Distance}$ | $-0.19 \times \text{ASIS\_Distance} + (0.5 \times \text{RPV\_Depth} - \text{Target\_Radius\_ASIS})$ |
| Axial                  | $-0.3 \times \text{ASIS\_Distance}$  | $-0.3 \times \text{ASIS\_Distance}$                                                                 |
| LHJC                   |                                      |                                                                                                     |
| ML                     | $-0.36 \times \text{ASIS\_Distance}$ | $-0.36 \times \text{ASIS\_Distance}$                                                                |

|       |                                     |                                                                                                   |
|-------|-------------------------------------|---------------------------------------------------------------------------------------------------|
| AP    | $-0.19 \cdot \text{ASIS\_Distance}$ | $-0.19 \cdot \text{ASIS\_Distance} + (0.5 \cdot \text{RPV\_Depth} - \text{Target\_Radius\_ASIS})$ |
| Axial | $-0.3 \cdot \text{ASIS\_Distance}$  | $-0.3 \cdot \text{ASIS\_Distance}$                                                                |

**Bell AL, Pederson DR, and Brand RA (1989)** Prediction of hip joint center location from external landmarks. Human Movement Science. 8:3-16: **Bell AL, Pedersen DR, Brand RA (1990)** A Comparison of the Accuracy of Several hip Center Location Prediction Methods. J Biomech. 23, 617-621. **Note that if the ASIS markers have been placed medial or lateral to the palpated landmark because the subject is overweight or because the markers can not be placed at these locations, it is important to measure the inter-ASIS distance and enter this value into the Subject Properties TAB.**

**Note that in the 1990 article the ML distance is listed as 0.14 instead of 0.36 as used by Visual3D. The confusion lies in the location of the origin of the pelvis used in the article. Visual3D uses the mid-point of the ASIS, the article uses the Right ASIS location.**

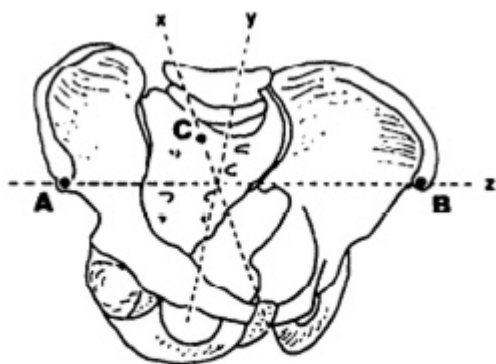


Fig. 1. Pelvic marker reference frame. Defined by markers over the right ASIS (Point A), the left ASIS (point B), and the midpoint between the PSISs (point C). The mid-PSIS marker is behind the sacrum, and would not normally be visible in this view.

Table 3. Hip joint center location from ASIS as a percentage of inter-ASIS distance (with estimated x direction marker/soft tissue correction of 2-3 cm)

| Subject               | X (%)      | Y (%)      | Z (%)      |
|-----------------------|------------|------------|------------|
| 1                     | -24.7      | -29.0      | -15.4      |
| 2                     | -30.7      | -33.3      | -9.7       |
| 3                     | -20.0      | -32.2      | -13.3      |
| 4                     | -25.0      | -29.8      | -11.9      |
| 5                     | -9.4       | -31.1      | -16.9      |
| 6                     | -10.9      | -25.9      | -18.8      |
| 7                     | -14.2      | -31.2      | -13.0      |
| Ave. (2 sig. figures) | -19        | -30        | -14        |
|                       | S.D. - 8.0 | S.D. - 2.4 | S.D. - 3.1 |

## Harrington Hip Joint

Harrington provided two regression equations for the hip joint landmark

- The second set of equations requires the user to manually measure leg length. If you do not plan to manually measure leg length, use the first set.
- Since the pelvis depth is defined differently between the CODA and V3D\_Composite pelvis, use

the set of equations which corresponds to the pelvis type you are using.

### Harrington 1

|                        |                                 |                                                                           |
|------------------------|---------------------------------|---------------------------------------------------------------------------|
| Harrington Equation 1  |                                 |                                                                           |
| CODA Coordinate System |                                 | V3D_Composite Coordinate System                                           |
| RHJC                   |                                 |                                                                           |
| ML                     | $0.33*ASIS\_Distance + 0.0073$  | $0.33*ASIS\_Distance + 0.0073$                                            |
| AP                     | $-0.24*RPV\_Depth - 0.0099$     | $-0.24*RPV\_Depth - 0.0099 + ( 0.5 * RPV\_Depth - Target\_Radius\_ASIS )$ |
| Axial                  | $-0.30*ASIS\_Distance - 0.0109$ | $-0.30*ASIS\_Distance - 0.0109$                                           |
| LHJC                   |                                 |                                                                           |
| ML                     | $-0.33*ASIS\_Distance - 0.0073$ | $-0.33*ASIS\_Distance - 0.0073$                                           |
| AP                     | $-0.24*RPV\_Depth - 0.0099$     | $-0.24*RPV\_Depth - 0.0099 + ( 0.5 * RPV\_Depth - Target\_Radius\_ASIS )$ |
| Axial                  | $-0.30*ASIS\_Distance - 0.0109$ | $-0.30*ASIS\_Distance - 0.0109$                                           |

### Harrington 2

|                        |                                                    |                                                                           |
|------------------------|----------------------------------------------------|---------------------------------------------------------------------------|
| Harrington Equation 2  |                                                    |                                                                           |
| CODA Coordinate System |                                                    | V3D_Composite Coordinate System                                           |
| RHJC                   |                                                    |                                                                           |
| ML                     | $0.28*RPV\_Depth + 0.16*ASIS\_Distance + 0.0079$   | $0.28*RPV\_Depth + 0.16*ASIS\_Distance + 0.0079$                          |
| AP                     | $-0.24*RPV\_Depth - 0.0099$                        | $-0.24*RPV\_Depth - 0.0099 + ( 0.5 * RPV\_Depth - Target\_Radius\_ASIS )$ |
| Axial                  | $-0.16*ASIS\_Distance - 0.04*Leg\_Length - 0.0071$ | $-0.16*ASIS\_Distance - 0.04*Leg\_Length - 0.0071$                        |
| LHJC                   |                                                    |                                                                           |
| ML                     | $-0.28*RPV\_Depth - 0.16*ASIS\_Distance - 0.0079$  | $-0.28*RPV\_Depth - 0.16*ASIS\_Distance - 0.0079$                         |
| AP                     | $-0.24*RPV\_Depth - 0.0099$                        | $-0.24*RPV\_Depth - 0.0099 + ( 0.5 * RPV\_Depth - Target\_Radius\_ASIS )$ |
| Axial                  | $-0.16*ASIS\_Distance - 0.04*Leg\_Length - 0.0071$ | $-0.16*ASIS\_Distance - 0.04*Leg\_Length - 0.0071$                        |

**Harrington ME, Zavatsky AB, Lawson SE, Yuan Z, Theologis TN.**(2007) Prediction of the hip joint centre in adults, children, and patients with cerebral palsy based on magnetic resonance imaging. J Biomech. 2007;40(3):595-602. Epub 2006 Apr 3.

### Davis Hip Joint

If no clinical measurements are taken, the following values are calculated:

Estimates for the Right and Left Hip Joint Center are represented as Landmarks that are created automatically when the Helen Hayes pelvis segment is created. The location of the landmarks are defined in the Pelvis Segment Coordinate System as:

|                                        |                                                                                                                                            |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Davis                                  |                                                                                                                                            |
| CODA Coordinate System                 |                                                                                                                                            |
| RHJC                                   |                                                                                                                                            |
| ML                                     | $-(C * \sin(\theta) - 0.5 * ASIS\_distance)$                                                                                               |
| AP                                     | $(-Xdis-Rmarker) * \cos(\beta) + C * \cos(\theta) * \sin(\beta)$                                                                           |
| Axial                                  | $(-Xdis-Rmarker) * \sin(\beta) - C * \cos(\theta) * \cos(\beta)$                                                                           |
| LHJC                                   |                                                                                                                                            |
| ML                                     | $(C * \sin(\theta) - 0.5 * ASIS\_distance)$                                                                                                |
| AP                                     | $(-Xdis-Rmarker) * \cos(\beta) + C * \cos(\theta) * \sin(\beta)$                                                                           |
| Axial                                  | $(-Xdis-Rmarker) * \sin(\beta) - C * \cos(\theta) * \cos(\beta)$                                                                           |
| Davis - Metric Values                  |                                                                                                                                            |
| If LegLength is measured manually:     |                                                                                                                                            |
| LegLength                              | Measure leg length manually (must be updated for each subject)                                                                             |
| If LegLength is NOT measured manually: |                                                                                                                                            |
| RightLegLength                         | DISTANCE(RASIS,RLA)<br>[NOTE: LASIS and LLA should represent the name of your left ASIS and lateral ankle target names in your marker set] |
| LeftLegLength                          | DISTANCE(LASIS,LLA)<br>[NOTE: LASIS and LLA should represent the name of your left ASIS and lateral ankle target names in your marker set] |
| LegLength                              | $0.5 * (RightLegLength + LeftLegLength)$                                                                                                   |
| C                                      | $0.115 * LegLength - 0.0153$ (in meters)                                                                                                   |
| theta                                  | $28.4 * \pi / 180.0$                                                                                                                       |
| beta                                   | $18.0 * \pi / 180.0$                                                                                                                       |
| If Xdis is measured manually:          |                                                                                                                                            |
| Xdis                                   | anterior/posterior component of the ASIS/hip center distance in the sagittal plane of the pelvis and measured during the clinical exam     |
| If Xdis is NOT measured manually:      |                                                                                                                                            |
| Xdis                                   | $0.1288 * LegLength - 0.04856$                                                                                                             |
| Rmarker                                | marker Radius (in meters)                                                                                                                  |

These equations are adapted from the article:

**Davis RB, Ounpuu S, Tyburski D, Gage JR.** (1991) "A Gait Analysis Data Collection and Reduction Technique." Human Movement Science, 10: 575-587.

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