

Helen Hayes Marker Set Overview

The **Helen Hayes** marker set is a relatively simple set of external markers developed for time efficient video analysis of lower extremity kinematics. The original configuration of 13 markers was developed by M.P. Kadaba, et. al. at the Orthopaedic Engineering and Research Center, Helen Hayes Hospital, West Haverstraw, N.Y. and is more thoroughly described in their publication “Measurement of Lower Extremity Kinematics During Level Walking,” *Journal of Orthopaedic Research*, 1990. (See [Appendix I, Measurement of Lower Extremity Kinematics During Level Walking](#))

This marker configuration minimizes the patient preparation and data acquisition time and reduces the number of trajectories that must be tracked or edited. The markers are secured to the body at anatomically significant locations that determine embedded axes for segments under consideration. Lower body motion analysis with this marker set does not require a static “standing, right leg and left leg” data capture for the calculation of lower body segment motion. This reduces patient involvement time at the clinic. However, the use of “optional” static trials greatly improves the accuracy in determining the knee and ankle joint centers and coordinate systems and is highly recommended.

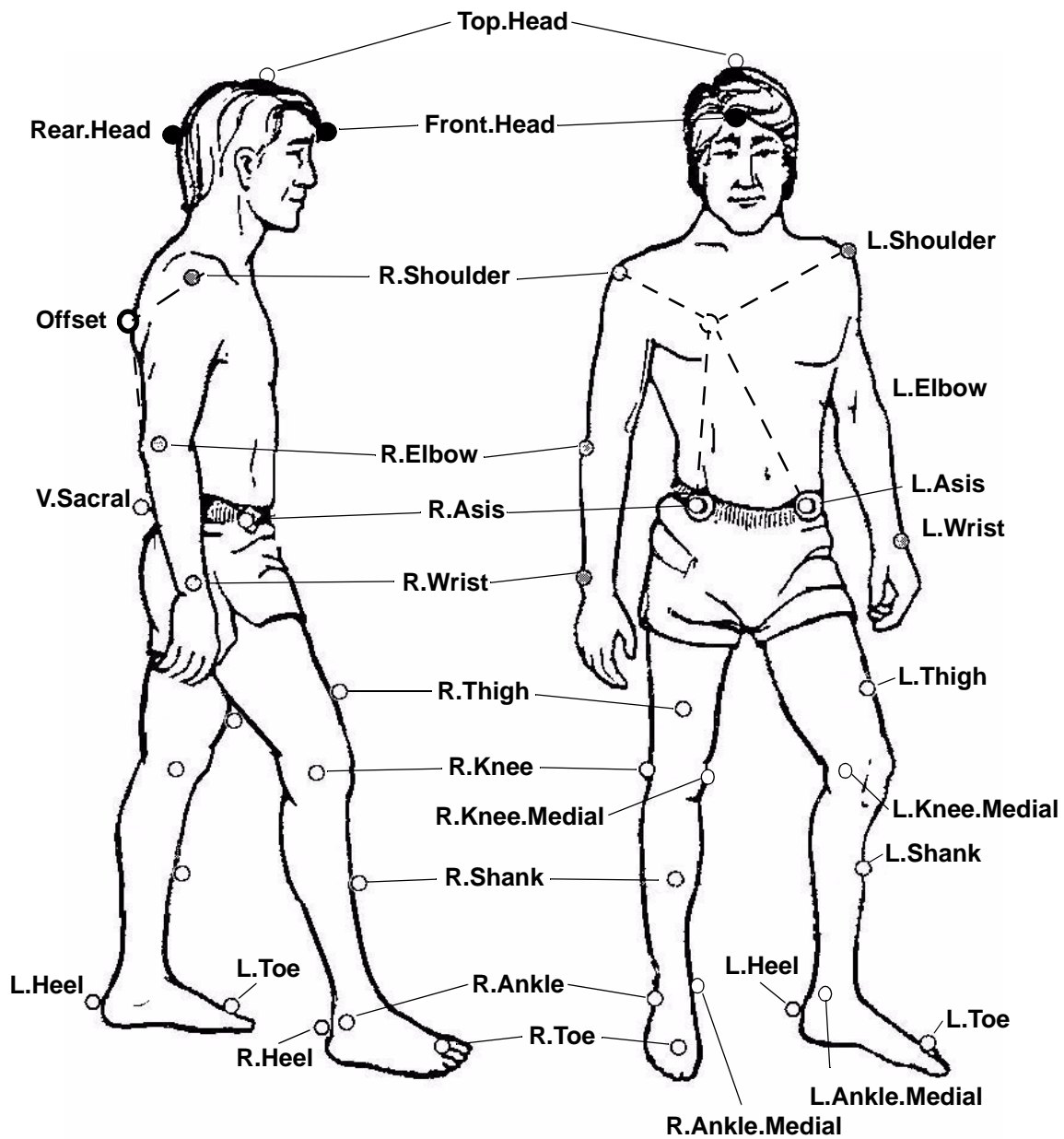
The basic **Helen Hayes** marker set has evolved to consists of 15 lower body markers. The markers are retro-reflective spheres approximately 0.75 inch in diameter. The markers are secured to the body at anatomical significant locations that determine embedded axes for segments under consideration.

The **Helen Hayes** marker set determines ankle and knee joint centers and segment coordinate systems by means of a marker on the lateral aspect of the thigh and shank, bilaterally. The subject is asked to walk across the room while the clinicians observe the subject's gait in order to determine the best location for the thigh and shank markers. The markers are secured on the lateral aspect of each thigh and shank and should be located to give the greatest visibility from the various camera views. It is important that the markers do not move with respect to their original position on the patient's legs during data capture. If the markers move, the knee and or ankle coordinate systems will move with them. This sometimes, undetectable movement, can cause large degrees of inaccuracy in joint kinematics and kinetics.

Important

For locating joint centers, the placement of the lateral thigh and shank markers are critical if “static” trials are not used.

Figure 7-3. Helen Hayes Marker Set Marker Placement



Patient Preparation—Helen Hayes Marker Sets

Marker Placement

When not using “static” trials, care must be taken in placing the lateral thigh and shank markers. With the patient standing in normal position, laterally align the cuffs with the long axis of the bones so that they reflect the neutral rotation angle. It is sometimes easier to align the wand with the flexion-extension axis when the patient is sitting.

The location of the hip joint center from the ASIS marker is computed as a function of the distance between the ASIS markers. The knee center is assumed to be half-way between the femoral condyle in the plane defined by the knee marker, thigh-wand marker, and the hip joint center. The ankle center is assumed to be half-way between the malleoli in a plane defined by the ankle marker, the knee center, and the shank-wand marker.

Gait Acquisition— Walking Trials

Note—The subject must start walking far enough outside of the video field so that a normal gait velocity has been attained prior to entering the video field.

As the subject enters the video field, a photocell or push-button triggers the video, forceplate, and EMG data collection. Data are saved if all of the above collections appear good. Several trials are recorded for later comparison.

Note: Without the wand markers, it is important that the lateral thigh and shank markers be placed on the anterior or posterior surface of the limb so that the lateral knee/tibia/lateral ankle markers don't become too linear. The same holds true for the thigh markers. A short pedestal may not provide enough offset to prevent collinearity problems, and they generally manifest themselves as adduction/torsion errors.

Figure 7-4. Helen Hayes Marker Set With Static Trials Marker List

Description	EVaRT/Cortex Marker Name	Static	Lower Body	Full Body	Full Body With Head	Placement
Top of the Head	Top.Head				+	On the center top of the head, in line with the back and front markers
Back of the Head Front of the Head	Rear.Head Front.Head				+	On the front and back of the head at the same height above the floor
Left Shoulder Right Shoulder	L.Shoulder R.Shoulder			+	+	Tip of the Acromion Process
Left Elbow Right Elbow	L.Elbow R.Elbow			+	+	Lateral Epicondyle of the Humerus
Left Wrist Right Wrist	L.Wrist R.Wrist			+	+	Centered between the Styloid Processes of the Radius and Ulna
Offset (not required but recommended for EVaRT)	Offset	+		+	+	See Figure 7-7 on page 7-13 .
Left ASIS Right ASIS	L.ASIS R.ASIS	+	+	+	+	Anterior Superior Iliac Spine
Sacrum	V.Sacral	+	+	+	+	Superior Aspect at the L5-sacral interface
Left Thigh Wand Right Thigh Wand	L.Thigh R.Thigh	+	+	+	+	On lower thigh below the mid-point, for greatest visibility by all cameras
Left Lateral Knee Right Lateral Knee	L.Knee R.Knee	+	+	+	+	Along the flexion/extension axis of rotation at lateral femoral condyle
Left Shank Wand Right Shank Wand	L.Shank R.Shank	+	+	+	+	On lower shank below the midpoint, for greatest visibility by all cameras
Left Lateral Ankle Right Lateral Ankle	L.Ankle R.Ankle	+	+	+	+	Along the flexion/extension axis of rotation at lateral malleolus
Left Heel Right Heel	L.Heel R.Heel	+	+	+	+	Posterior Calcaneus at same height from floor as toe marker
Left Toe Right Toe	L.Toe R.Toe	+	+	+	+	Center of the foot between the 2nd and 3rd metatarsals
Left Medial Ankle Right Medial Ankle	L.Ankle.Medial R.Ankle.Medial	+				Along the flexion/extension axis of rotation at medial malleolus
Left Medial Knee Right Medial Knee	L.Knee.Medial R.Knee.Medial	+				Along the flexion/extension axis of rotation at medial femoral condyle

Figure 7-5. Helen Hayes Marker Set Without Static Trials Marker List

Description	EVaRT/Cortex Marker Name	Lower Body	Full Body	Full Body With Head	Placement
Top of the Head	Top.Head			+	On the center top of the head, in line with the back and front markers
Back of the Head Front of the Head	Rear.Head Front.Head			+	On the front and back of the head at the same height above the floor
Left Wrist Right Wrist	L.Wrist R.Wrist		+	+	Centered between the Styloid Processes of the Radius and Ulna
Left Elbow Right Elbow	L.Elbow R.Elbow		+	+	Lateral Epicondyle of the Humerus
Left Shoulder Right Shoulder	L.Shoulder R.Shoulder		+	+	Tip of the Acromion Process
Offset (not required but recommended for EVaRT)	Offset		+	+	See Figure 7-7 on page 7-13 .
Left ASIS Right ASIS	L.ASIS R.ASIS	+	+	+	Anterior Superior Iliac Spine
Sacrum	V.Sacral	+	+	+	Superior Aspect at the L5-sacral interface
Left Thigh Wand Right Thigh Wand	L.Thigh R.Thigh	+	+	+	On lower thigh laterally aligned with the long axis of the thigh in line with the flexion/extension axis of the knee
Left Lateral Knee Right Lateral Knee	L.Knee R.Knee	+	+	+	Along the flexion/extension axis of rotation at lateral femoral condyle
Left Shank Wand Right Shank Wand	L.Shank R.Shank	+	+	+	On lower shank laterally aligned with the long axis of the shank in line with the flexion/extension axis of the ankle
Left Lateral Ankle Right Lateral Ankle	L.Ankle R.Ankle	+	+	+	Along the flexion/extension axis of rotation at lateral malleolus
Left Heel Right Heel	L.Heel R.Heel	+	+	+	Posterior Calcaneus at same height from floor as toe marker
Left Toe Right Toe	L.Toe R.Toe	+	+	+	Center of the foot between the 2nd and 3rd metatarsals

Figure 7-6. Helen Hayes Marker Set Static Trial

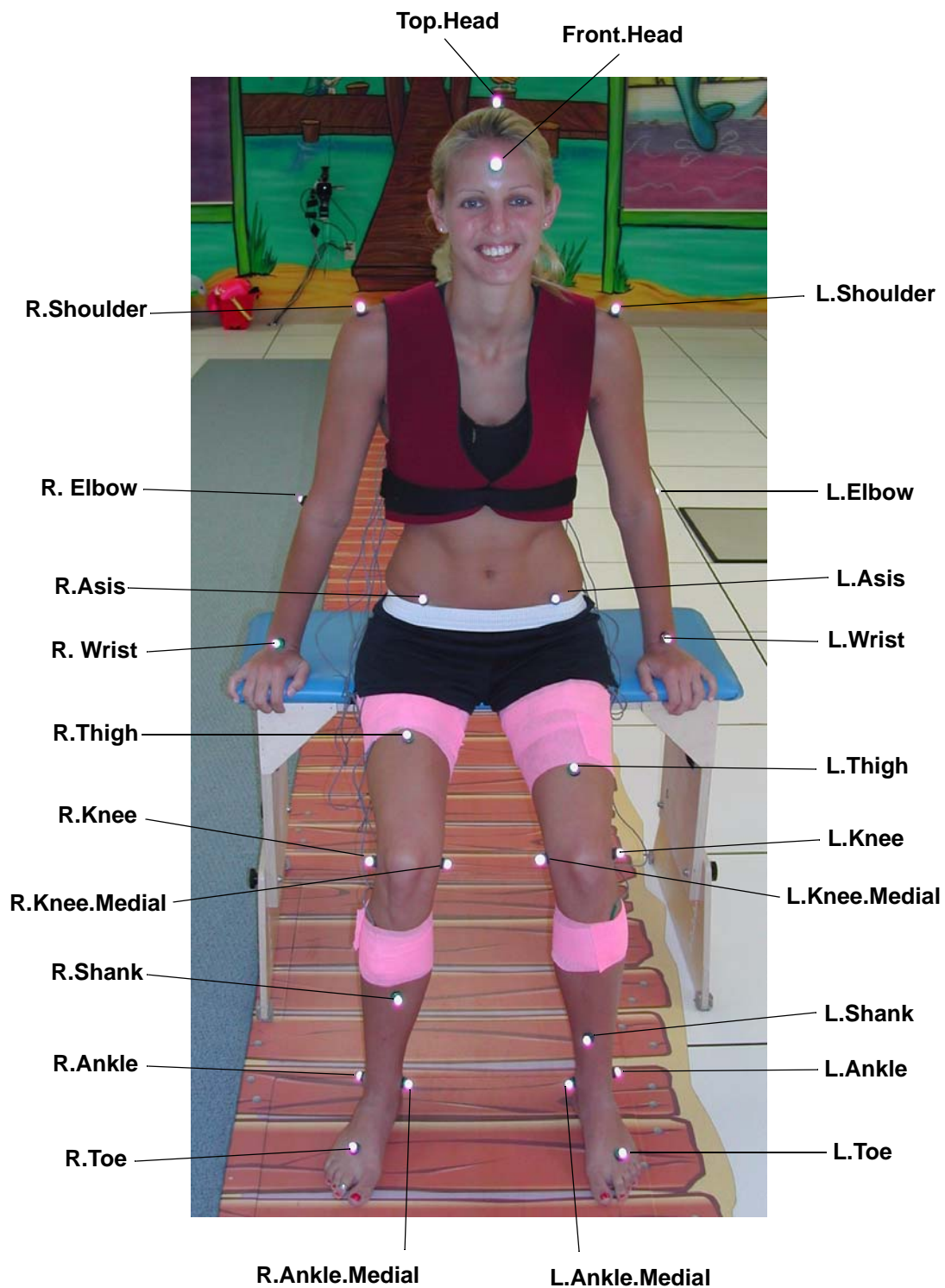
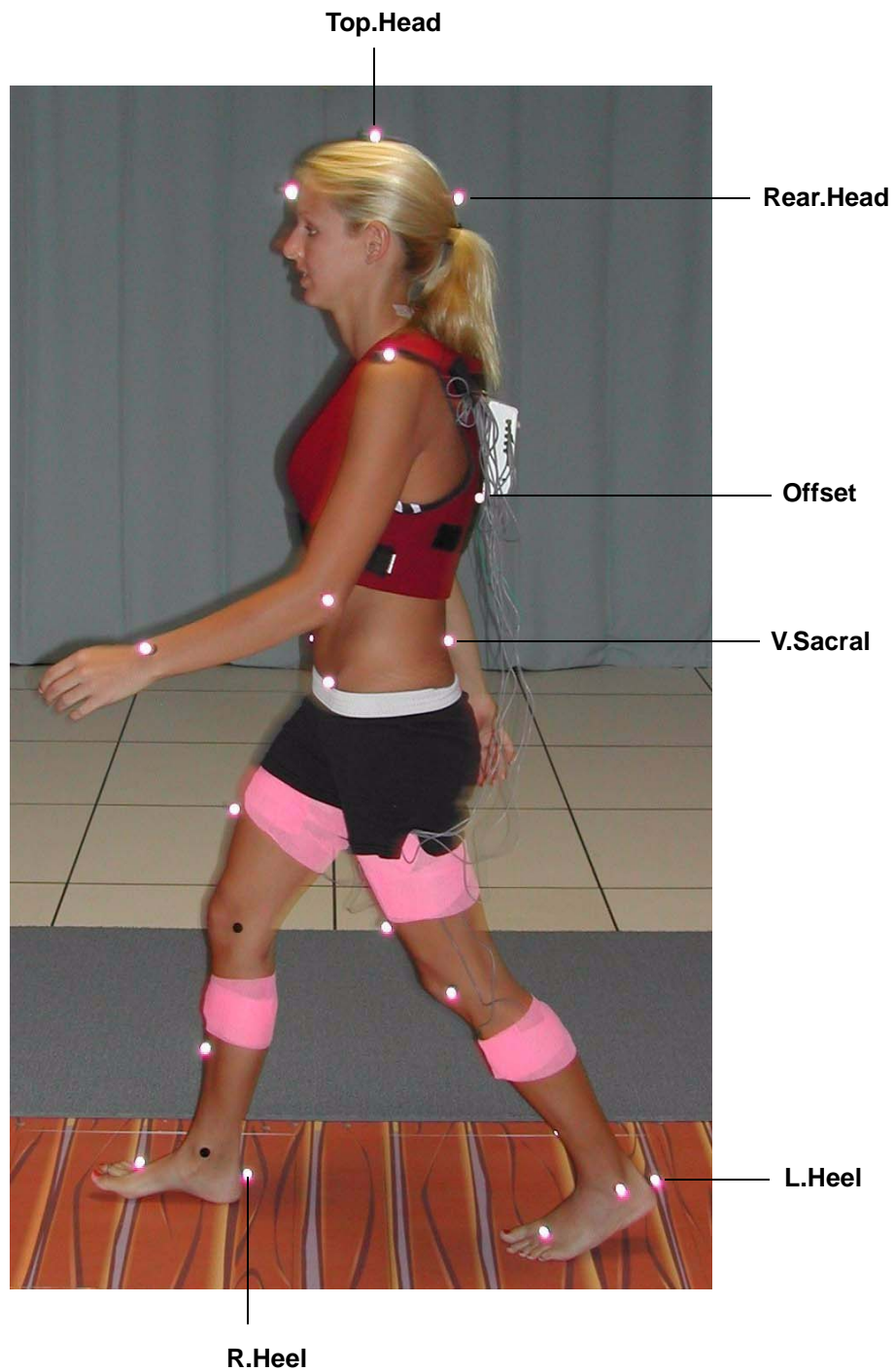


Figure 7-7. Helen Hayes Marker Walking Trial



Note: Medial markers from the static trial have been removed.