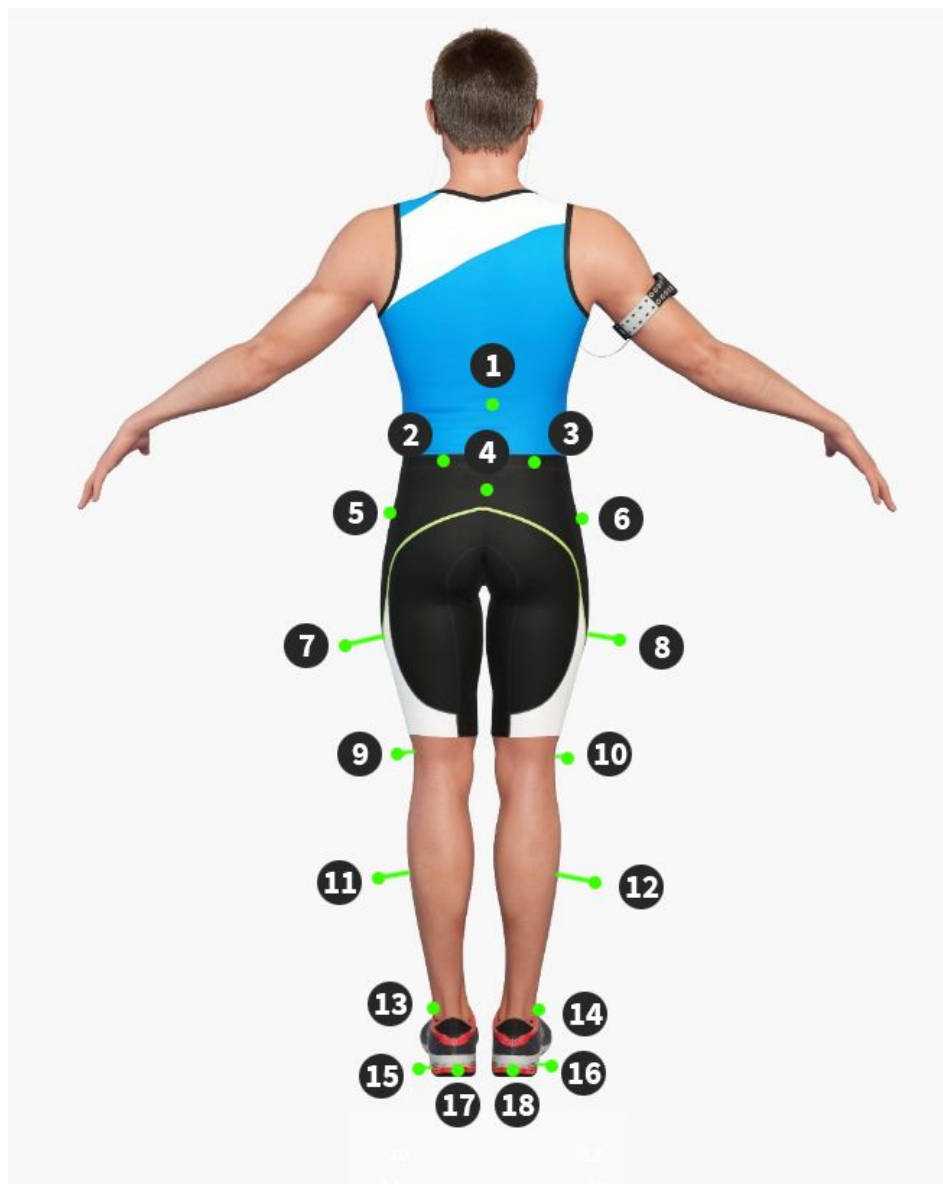


ACE 3D Motion Monitor

Marker placement - overview

A total of 18 markers are used. Among them, 12 are fixed directly on the body and the remaining 6 are mounted on light, plastic extenders (markers 7, 8, 11, 12, 15, and 16 use extenders).



	#	NAME IN SOTWARE	ANATOMICAL POSITION
LMB	1	<i>lumbar</i>	This marker is placed on the L1 vertebra .
PELVIS	2	<i>left_posterior_superior_iliac_spine</i>	The iliac crest can be found easily. Follow the left crest back to the rearmost point. That is the left posterior superior iliac spine .
	3	<i>right_posterior_superior_iliac_spine</i>	Likewise, follow the right crest back to the rearmost point. That is the right posterior superior iliac spine .
	4	<i>lower_sacrum</i>	Place the marker in the center of the Sacrum , around 2-3cm below the imaginary line formed by markers #2 and #3.
FEMURS	5	<i>left_greater_trochanter</i>	Left greater trochanter . Hint: find the imaginary spot that works as the rotation axis for the femur head.
	6	<i>right_greater_trochanter</i>	Right greater trochanter . Hint: find the imaginary spot that works as the rotation axis for the femur head.
	7	<i>left_lateral_thigh</i>	<i>(This marker requires a long extender, which is provided).</i> On the left thigh , just below the swing of the hand, the extender forms an axis that crosses the Longitudinal thigh axis and is parallel to the flexo-extension axis of the knee.
	8	<i>right_lateral_thigh</i>	<i>(This marker requires a long extender, which is provided).</i> On the right thigh , just below the swing of the hand, the extender forms an axis that crosses the Longitudinal thigh axis and is parallel to the flexo-extension axis of the knee.
	9	<i>left_knee</i>	Lateral epicondyle of the left femur . Hint: find the imaginary lateral spot that works as the rotation axis for the knee.
	10	<i>right_knee</i>	Lateral epicondyle of the right femur . Hint: find the imaginary lateral spot that works as the rotation axis for the knee.
TIBIAS	11	<i>left_calf</i>	<i>(This marker requires a long extender, which is provided).</i> On the left calf , the wand forms an axis that crosses the Longitudinal calf axis and is parallel to the flexo-extension axis of the ankle.
	12	<i>right_calf</i>	<i>(This marker requires a long extender, which is provided).</i> On the right calf , the wand forms an axis that crosses the Longitudinal calf axis and is parallel to the flexo-extension axis of the ankle.
	13	<i>left_ankle</i>	<i>(This marker is small)</i> On the left lateral malleolus along an imaginary line that passes through the transmalleolar axis.
	14	<i>right_ankle</i>	<i>(This marker is small)</i> On the right lateral malleolus along an imaginary line that passes through the transmalleolar axis

FEET	15 <i>left_lateral_heel</i>	(This marker requires a short extender, which is provided). Forms 90° with left ankle and left heel markers (see drawings).
	16 <i>right_lateral_heel</i>	(This marker requires a short extender, which is provided). Forms 90° with right ankle and right heel markers (see drawings).
	17 <i>left_heel</i>	(This marker is small) Placed on the left calcaneus at the same height as the lateral heel marker.
	18 <i>right_heel</i>	(This marker is small) Placed on the right calcaneus at the same height as the lateral heel marker.



LONG EXTENDER



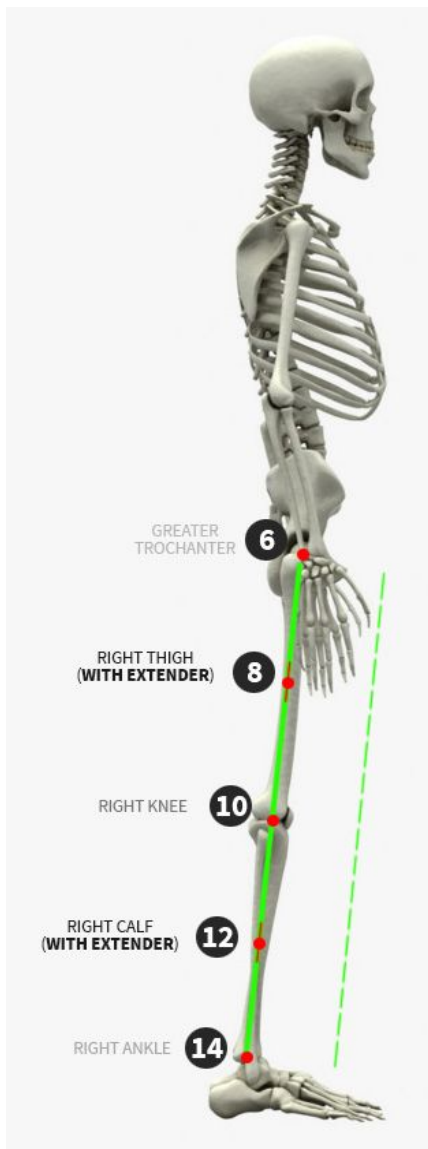
SHORT EXTENDER

General recommendations for marker placement

- Generally speaking, markers should be placed on the skin in order to avoid or minimize the relative motion between the marker and its target anatomical position. In many cases this is not possible, so the practitioner / Sports scientist will just try to place it as close as possible. It is a good idea to recommend wearing **tight clothes** if possible. Loose pants will introduce some error.
- The antero-posterior placement of the markers is critical for correct alignment of the knee flexion axis. Pay a special attention to the markers on the legs (showing only the right side – check the left side likewise):

✓ Markers #6, #8 and #10 should be aligned in the plane that contains the hip and knee joint centers and the knee flexion/extension axis.

✓ The tibial marker #12 should lie in the plane that contains the knee (#10) and ankle joint (#14) centers and the ankle flexion/extension axis.



✓ In a normal subject the ankle joint axis, between the medial and lateral *malleoli*, is externally rotated by between 5 and 15 degrees with respect to the knee flexion axis. The placements of the shank markers should reflect this.

The foot markers need to be placed carefully so as to ensure the best data quality.

Marker 14 is placed right on the malleolus.

Marker 16 should be vertically aligned with marker 14 and leveled with marker 18.

Parameter description

Pelvis angles

- **Pelvis Tilt:** Angle between the vertical axis of the pelvis and the same axis at the calibration phase projected to the sagittal plane at calibration. Positive means that the Pelvis is tilting forward (Anterior Pelvic Tilt).
- **Pelvis Abduction/Adduction:** Angle between the vertical axis of the pelvis and the global vertical axis projected to the Frontal Plane at calibration. Positive means that the left hip is going up.

Hip Angles

- **Hip Flexion/Extension:** Angle between the vertical femur axis and the vertical pelvis axis projected to the sagittal pelvis plane. Positive means flexion.
- **Hip Abduction/Adduction:** Angle between the lateral axis of the femur and the lateral axis of the pelvis projected to the frontal pelvis plane. Positive means abduction.
- **Hip External/Internal Rotation:** Angle between the frontal femur axis and the frontal pelvis axis projected to the horizontal pelvis plane. Positive means external rotation.

Knee Angles

- **Knee Flexion/Extension:** Angle between the vertical tibia axis and the vertical femur axis projected to the sagittal femur plane. Positive means flexion.
- **Knee Abduction/Adduction:** Angle between the lateral tibia axis and the lateral femur axis projected to the frontal femur plane. Positive is valgus.
- **Knee External/Internal Rotation:** Angle between the frontal tibia axis and the frontal femur axis projected to the horizontal plane of the femur. Positive is external.

Ankle Angles

- **Ankle Plantar/Dorsal Flexion:** Angle between the vertical foot axis and vertical tibia axis projected to the sagittal tibia plane. Positive means plantar flexion.
- **Ankle Inversion/Eversion:** Angle between the lateral foot axis and the lateral tibia axis projected to the frontal tibia plane. Positive means pronation.
- **Ankle External/Internal Rotation:** Angle between the frontal foot axis and the frontal tibia axis projected to the tibia horizontal plane. Positive means external rotation.

Foot Angles

- **Foot Plantar/Dorsal Flexion:** Angle between the frontal foot axis and the horizontal plane projected to the tibia sagittal plane. Positive means plantar flexion.

Tibia Angles

- **Tibia Flexion/Extension:** Angle between the vertical tibia axis and the horizontal plane projected to the tibia sagittal plane. Positive means flexion.
Note that the tibia flexion and the knee flexion has contrary signus for the same movement.

Distances

- **Right Foot Crossover:** Distance in centimeters between the Sacrum marker and the ankle marker projected to the pelvis lateral axis of the calibration. Positive means exterior movement of the ankle (abduction).
- **Strike From COM:** Distance in centimeters between the L1 marker and the ankle marker projected to the pelvis frontal axis of the calibration. Positive means forward movement of the ankle.
- **Tibia distance to ankle:** Distance in millimeters between the ankle marker and the knee marker projected to the pelvis frontal axis of the calibration. Positive means forward movement of the knee.

Spine Angles

- **Spine Flexion:** Angle of the vector that connects the middle point of the ankles with the L1 marker and the horizontal plane projected to the pelvis sagittal plane, calibrated so that the value is zero for the calibration position. Positive means spine flexion (forward bending).

Other report parameters

Running gait characteristics

- **Speed:** This is the given treadmill speed in mph.
- **Cadence:** Number of steps per minute.
- **Vertical oscillation:** Difference in centimeters between the maximum and minimum height of the L1 marker.
- **Ground Contact Time:** Time in milliseconds that the foot is on the ground for each stride.
- **Step and Stride Length Asymmetry Score:** difference between the right and left step length in %.