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Comparative Gait Analysis of Transtibial Amputees versus

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Comparative Gait Analysis of Transtibial Amputees versus Healthy, Able-Bodied Individuals
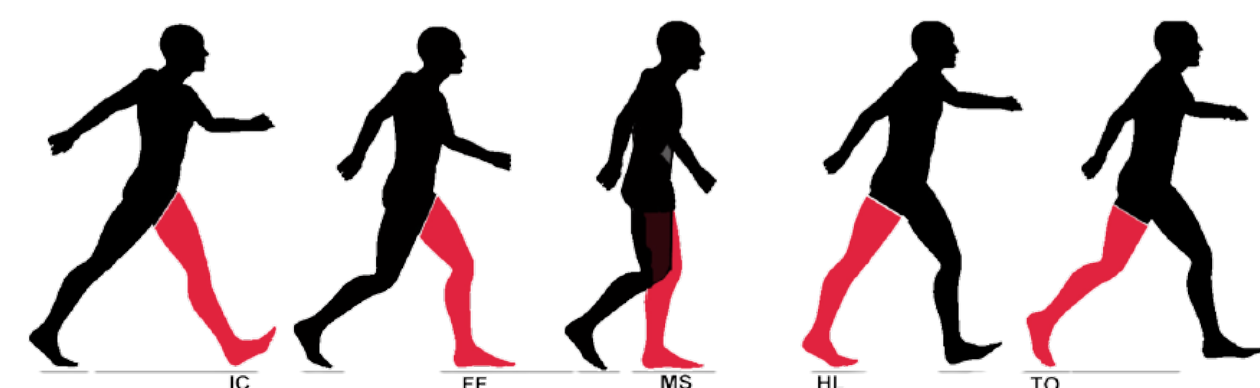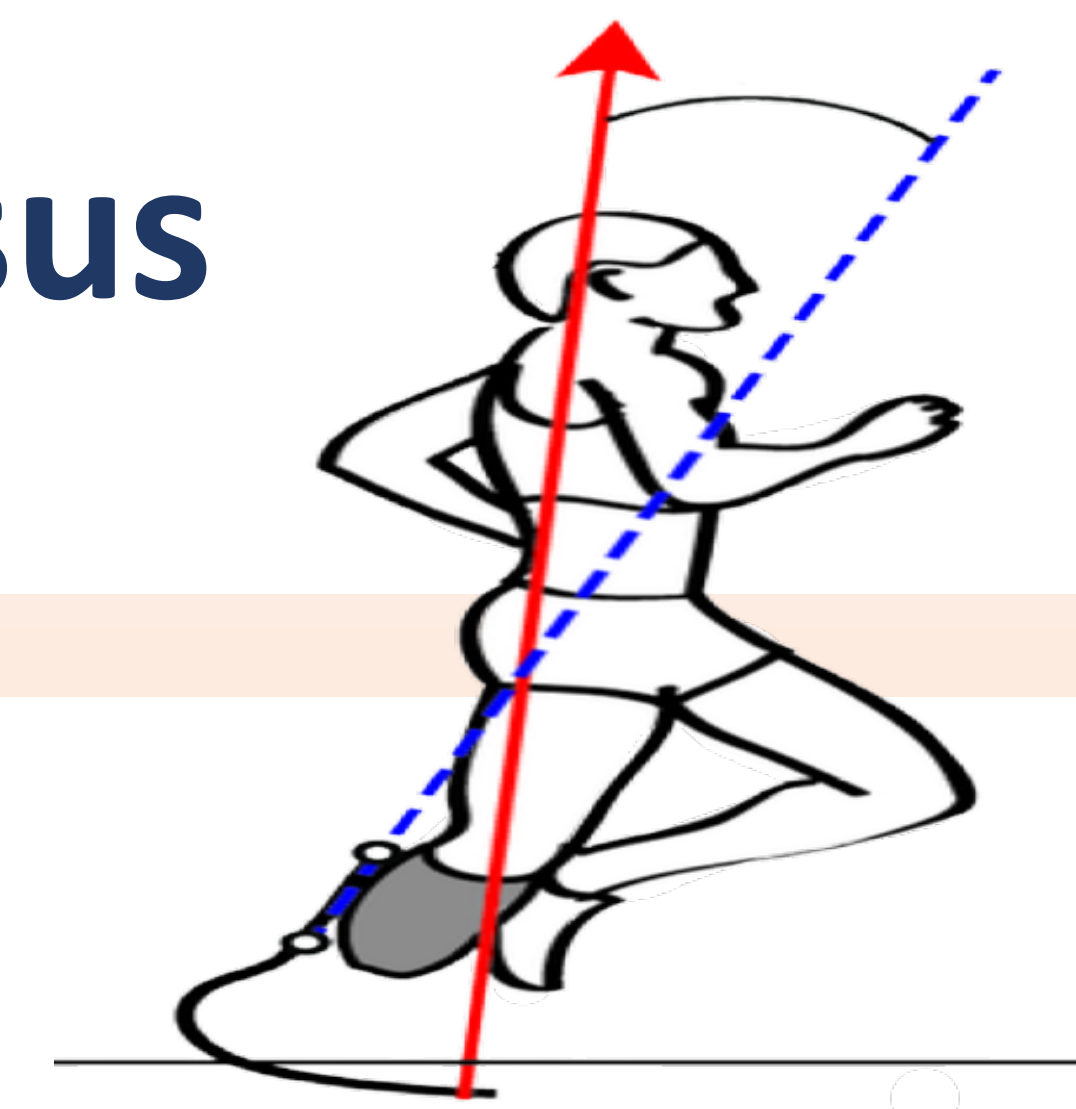
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Introduction

One action many take for granted is their ability to walk with ease. Most individuals do not consider the intricacy of this motion unless they are working in a field in which rehabilitation of gait patterns is a focus. For instance, lower limb amputees strive to achieve normal walking biomechanics through rehabilitative practices. The most effective way to successfully analyze these deviations of stride patterns is to understand the baseline kinematics of a healthy, able-bodied (i.e. no injuries or deformities) individual. In the following study, gait kinematics of transtibial amputees will be compared to that of able-bodied individuals in attempts to answer the following research question: *How do lower limb gait biomechanics of normal, healthy individuals compare to that of transtibial amputees, specifically looking at joint angles of the hip and knee?*

Methods

- Two platforms of research used
- Literature analysis for unilateral transtibial data collection [online]
- Research limited to transtibial amputees and sagittal plane movements (flexion and extension) of the hip and knee joints
- Able-bodied participant data collected using the University of Rhode Island's Gait Analysis Lab
  - Recruited 7 healthy, able-bodied students
  - Participants instructed to walk on bilateral force plates located beneath controlled treadmill at comfortable pace (~1 mph)
  - Tracked gait cycles using 16-camera motion capture system (Qualysis) and placement of 34 reflective sensors on the lower limbs
  - Computerized joint angles, forces, and moments in processing system (Visual 3D) to establish models used for implementation of normal walking data in future database creation

Discussion

- *Ranges of motion collected from literature review of unilateral transtibial amputee gait*
  - Average <u>peak</u> ranges of motion for hip: *~20º flexion*
  - ***Decreased hip extension in late stance (first 60%) of gait cycle***
  - ***Greater hip flexion of affected side through entire gait compared to unaffected side***
  - Average <u>peak</u> ranges of motion for knee: *~60º flexion*
  - ***Delayed peak knee flexion in swing phase of affected side***
  - ***Loss of knee flexion during loading***
- *Ranges of motion collected from compilation of 14 able-bodied participants*
  - Average <u>peak</u> ranges of motion for hip: *~40º flexion, ~10-20º [hyper]extension*
  - Average <u>peak</u> ranges of motion for knee: *~70º flexion, 0º (complete) extension*
  - ***Joint angles varies slightly between participants, but were compiled to create one database for average gait kinematics of all involved individuals***
- Amputee hip angles of affected side showed significantly limited range of motion compared to able-bodied participants (max knee flexion of amputees ~20º; max knee flexion of able-bodied ~40º)
- Gait deviations in amputees used to compensate for abnormal limb abilities
  - Limited ranges of motion due to prosthetic design, material stiffness or pain/improper adjustments of residual limb attachment site
- Limited data collection for in-person gait study due to COVID-19 restrictions

Figure 1 Reference
Bateni, H., & Olney, S. J. (2002). Kinematic and Kinetic Variations OF Below-Knee Amputee Gait. *JPO Journal of Prosthetics and Orthotics*, *14*(1), 2–10. https://doi.org/10.1097/00008526-200203000-00003
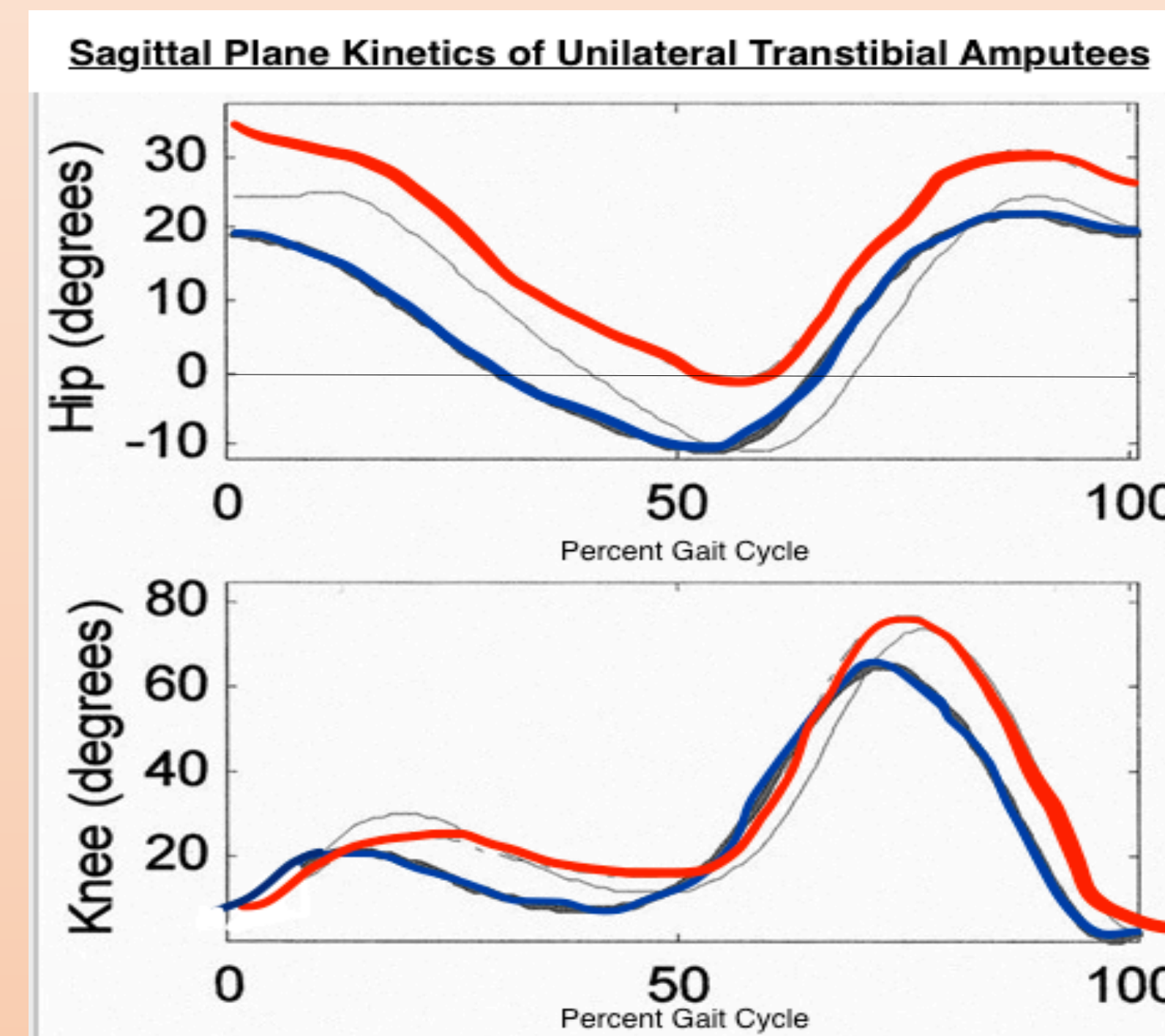
Results

Figure 1. The above graph shows the gait cycle of an individual with a unilateral transtibial amputation. The angles of their knee and hip are represented on both the amputated (affected) side (red), unaffected side (grey), and mean normal angles (blue). The angles of the hip comparing the unaffected and affected sides differ greatly from one another, whereas the knee angles are less significant of a range from one limb to the other.
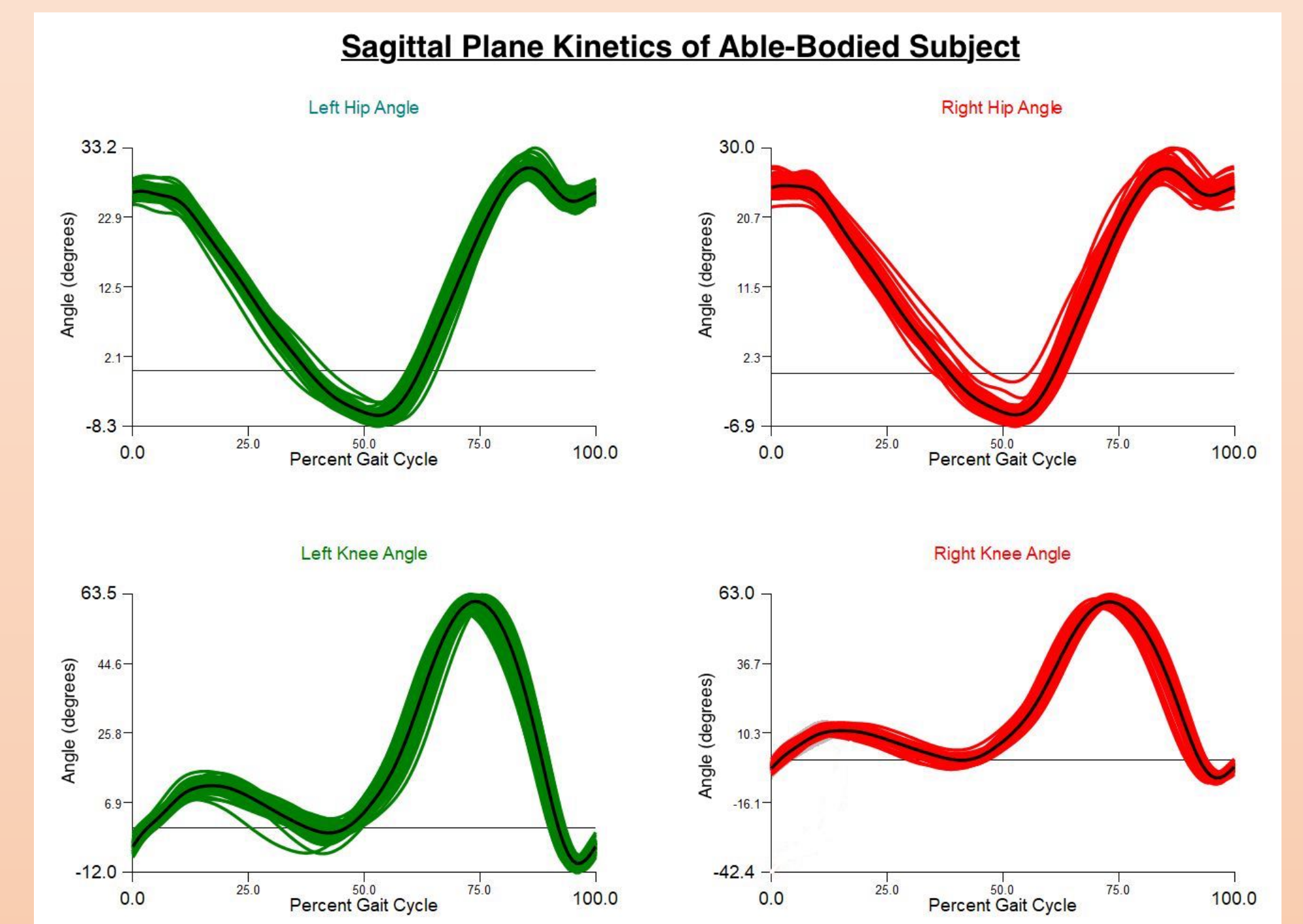

Figure 2. The above graphs show an able-bodied subject with no previous history of lower limb injuries or deformities. Each cluster of lines is a compilation of the various strides from each walking trial. The image is broken up into left (green) and right (red) leg results, and further separated by hip or knee angle attention. This individual demonstrates average angle ranges in the extension and flexion phases of the gait cycle for both observed joints.
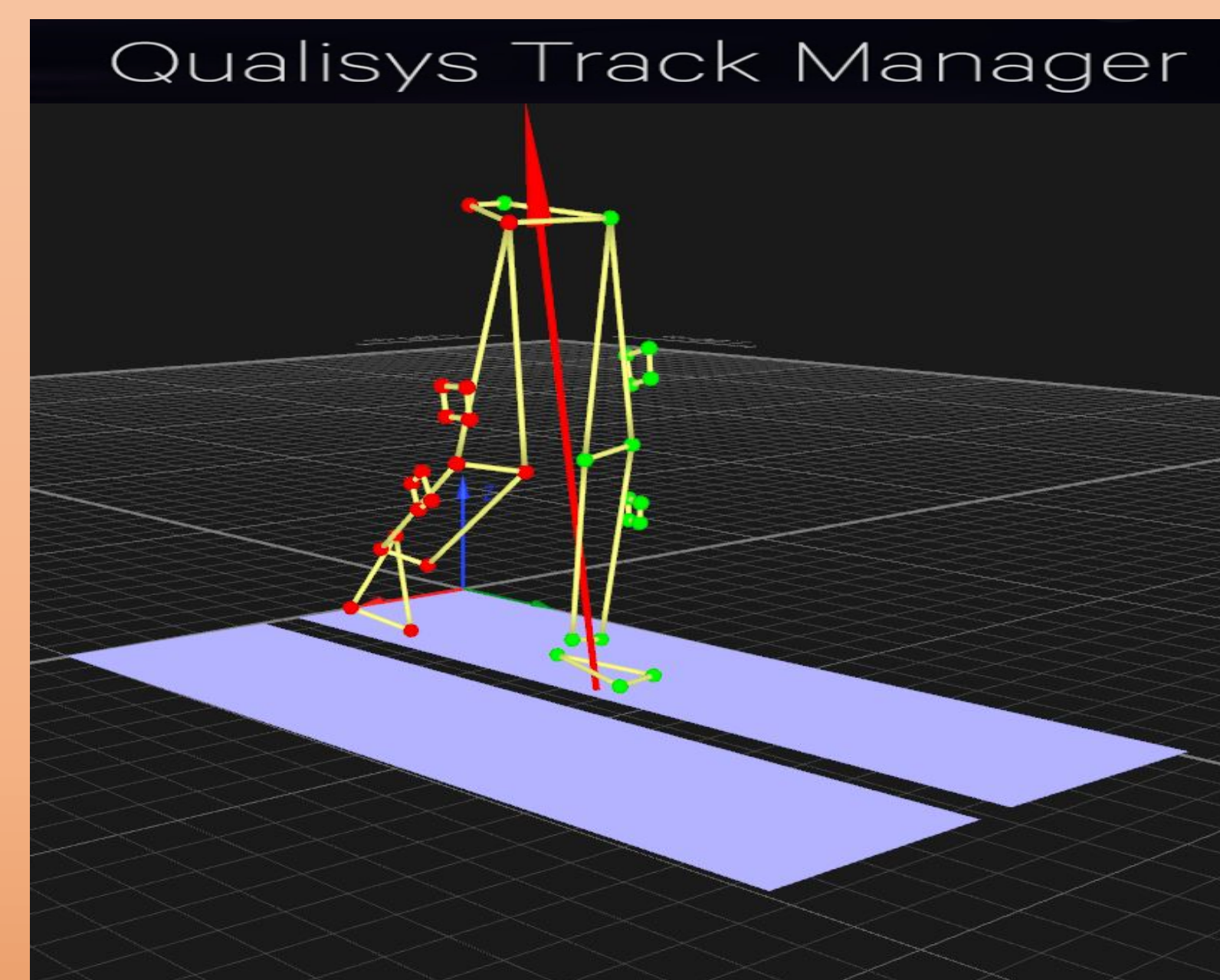

Figure 3. The figure above is to demonstrate the initial images computerized after physical data collection. The Qualysis software is used as a means to visualize the individual sensors according to camera location, and establish a baseline framework of the rigid sections of the body. The red arrow indicates the force intensity achieved from each step.
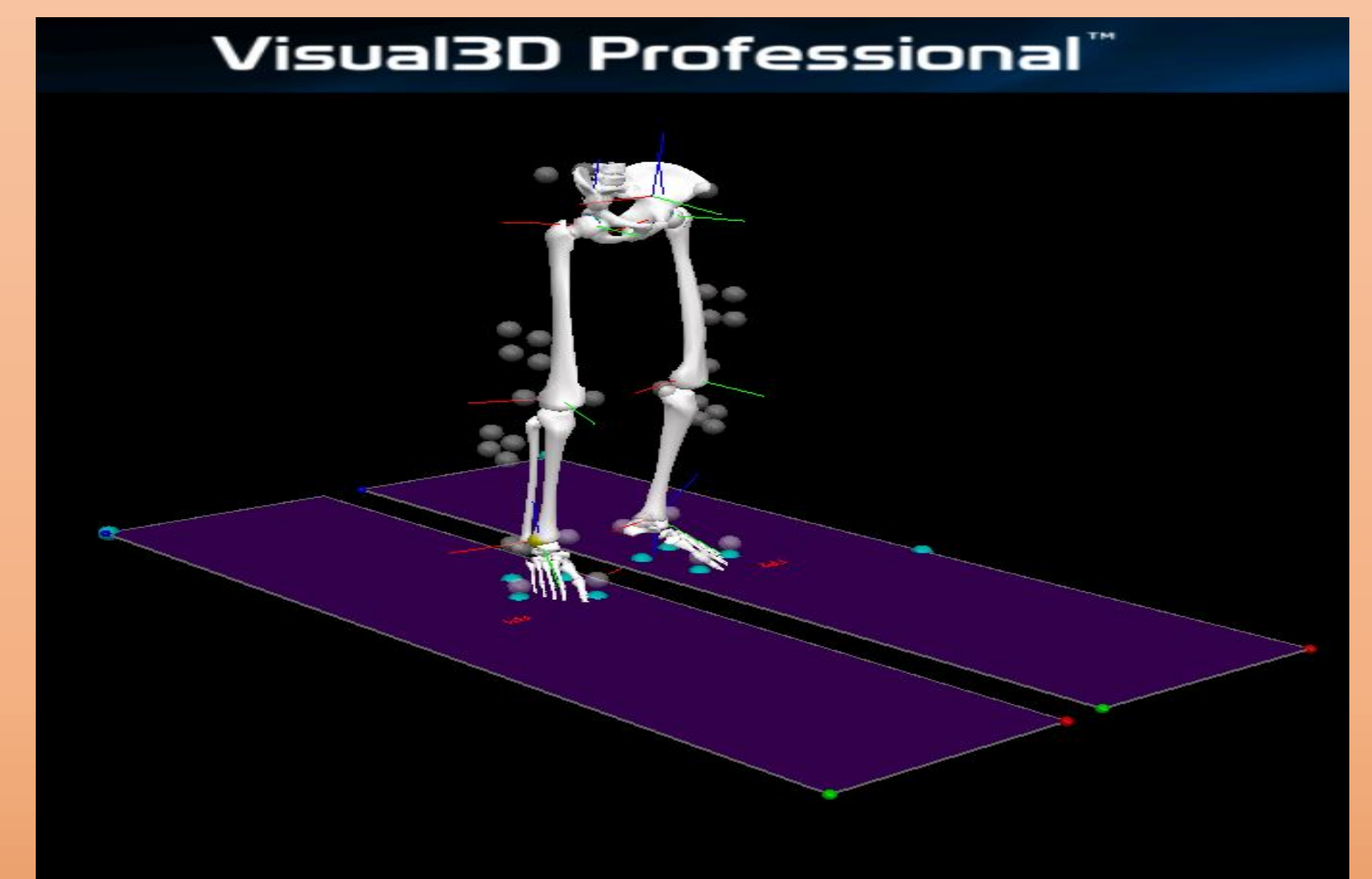

Figure 4. The figure above is the finalized model created after each sensor is tracked and identified to its specific anatomical location. Static image captures are applied to each walking trial to produce uniformity across all trials. Already engineered walking model is then applied, pipelines are executed to smooth and interpolate data, and final result is a locomotive skeletal model.