MODEL HEALTH

Cutting Analysis Report

Subject	Session	Trial	Type
Demo Subject	demo-overground	90_right	90° (88.1°) right

Cut metrics

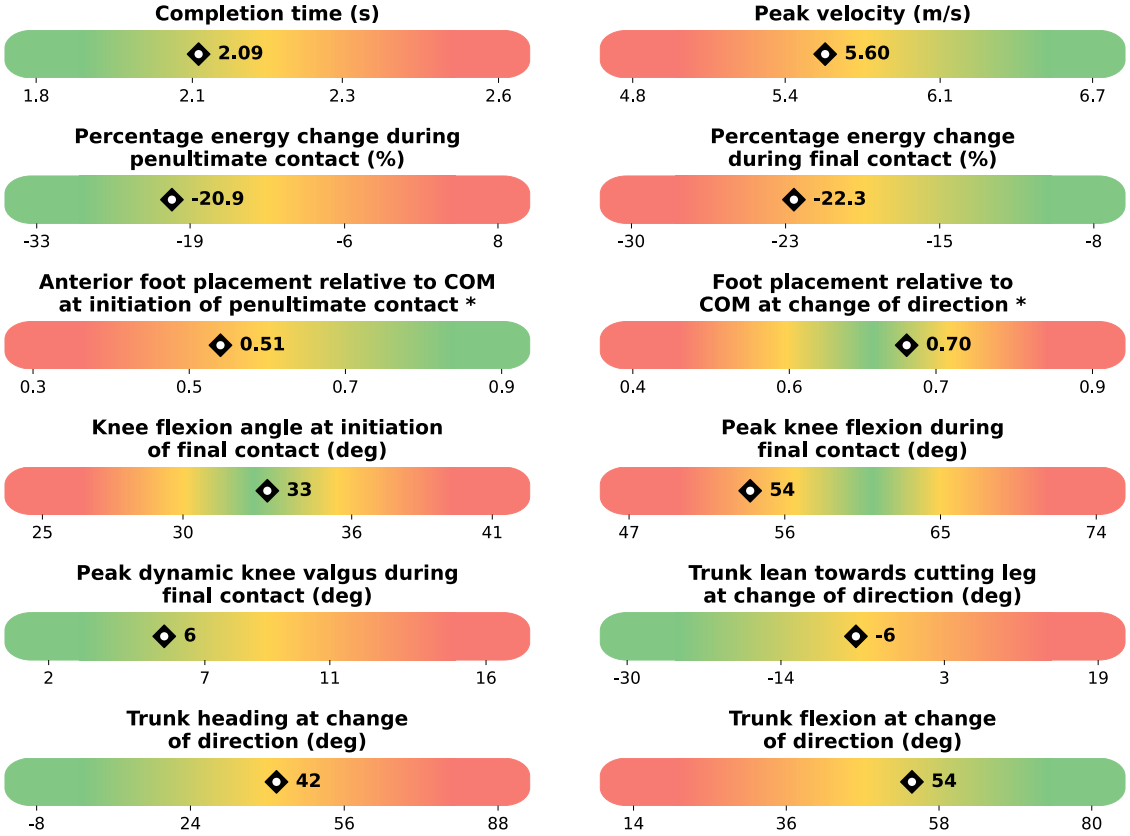

Figure 1: COM = center of mass. Colors indicate how results compare to normative data from healthy adult populations, comprising both males and females. For directional metrics (where higher or lower is universally better), the top 25% is green, the middle 50% yellow, and the bottom 25% red. For centered metrics (where both extremes are unfavorable), green represents the middle 40% (30th-70th percentile), red the outer extremes (below the 10th or above the 90th percentile), and yellow the transition zones in between. Key events and phases are detected with a mean absolute error of <18 ms. *Normalized by leg length.

Description of the metrics

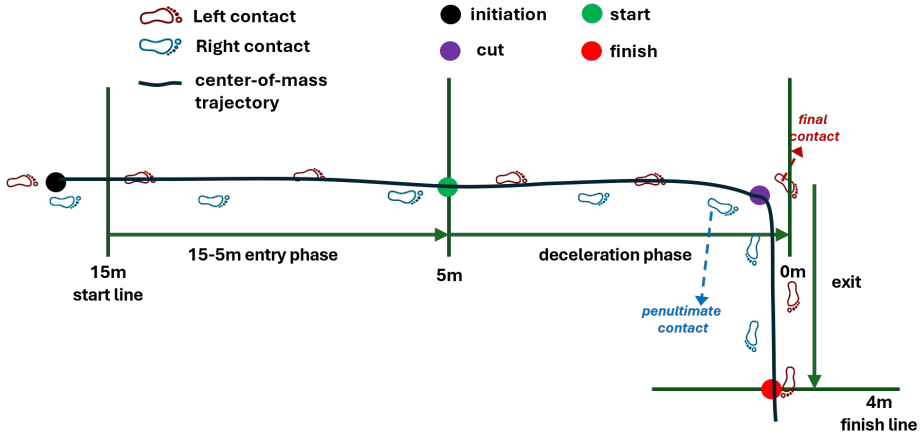

Figure 2: The 90 cutting test involves sprinting from the 15 m line to the cutting location, turning 90 in the intended direction and sprinting 4 m further towards the finish. Timing is based on the athlete's center of mass (COM) crossing the distance lines and computed relative to the cutting contact foot location. Four key events are defined: **initiation**, **start** (5 m before the cutting contact), **cut** (most prominent orientation change from initial to intended direction), and **finish** (4 m after the cutting contact).

- **Completion time** is the time taken to complete the timed section, from cut contact position -5 m along the initial direction to cut contact position +4 m along the intended direction. This metric measures the efficiency of the cutting movement throughout the critical section.
- **Peak velocity** is the maximum horizontal speed of the center of mass during the movement.
- **Percentage energy change during penultimate contact** is the change in kinetic energy during the penultimate foot contact, normalized by peak kinetic energy. Positive values indicate acceleration, negative values indicate braking. For change-of-direction movements with large angles, effective penultimate contact deceleration reduces braking requirements during final contact, lowering knee joint loads and improving acceleration efficiency.
- **Percentage energy change during final contact** is the change in kinetic energy during the final contact phase, normalized by peak kinetic energy. Positive values indicate acceleration, negative values indicate braking. During shallow cutting movements, minimal braking is desired for efficient redirection with minimal joint loads.
- **Anterior foot placement relative to center of mass (COM) at initiation of penultimate contact** is the anterior (forward) foot placement relative to the center of mass at the initiation of the penultimate contact, normalized by leg length. A more anterior placement is an effective braking strategy to reduce approach speed before the final contact. CMAS item 1: Clear penultimate contact braking strategy (Dos Santos et al. 2021).
- **Foot placement relative to center of mass (COM) at change of direction** is the horizontal distance between the ankle and the COM, normalized by leg length, at the change-of-direction moment. Higher values correlate with better performance, but might result in increased knee abduction moment, a contributor to ACL loading. CMAS item 2: Lateral leg plant distance (Dos Santos et al. 2021).
- **Knee flexion angle at initiation of final contact** is the knee angle when the foot makes final contact. During deceleration movements, adequate knee flexion at initial contact is important for shock absorption and reducing joint loads. Shallow cutting movements require a more stiff final contact for aggressive redirection.
- **Peak knee flexion during final contact** is the maximum knee angle during the final foot contact phase. A balanced value is desirable to balance optimal shock absorption with force generation. CMAS item 8: Limited knee flexion during final contact (Dos Santos et al. 2021).

- **Peak dynamic knee valgus during final contact** is the maximum frontal-plane knee angle during the final foot contact phase. A lower value is desirable to reduce injury risk (e.g., iliotibial band and patellofemoral pain syndromes). CMAS item 9: Excessive knee valgus motion (Dos Santos et al. 2021).
- **Trunk lean towards cutting leg at change of direction (CoD)** is the angle of the trunk toward the cutting leg at the CoD. Lower values indicate the trunk leans more toward the intended travel direction, reducing joint loads and improving re-acceleration.
- **Trunk heading at change of direction** is the trunk's orientation relative to the intended travel direction at the change-of-direction moment. Lower values indicate better trunk alignment with the intended direction. Part of CMAS item 6: Transverse plane trunk position relative to intended direction of travel (Dos Santos et al. 2021).
- **Trunk flexion at change of direction** is the angle of the trunk versus the vertical axis through the COM in the sagittal plane (original direction), at the change-of-direction moment. Positive values indicate forward lean, negative values indicate backward lean. A forward lean is desirable to absorb loads. Additionally, backward lean inhibits coordination patterns protecting the knee. On the other hand, high-intensity cutting movements are reactive and require an upright posture. CMAS item 7: Trunk upright or leaning back throughout contact (Dos Santos et al. 2021).

Center-of-mass trajectory with foot contacts

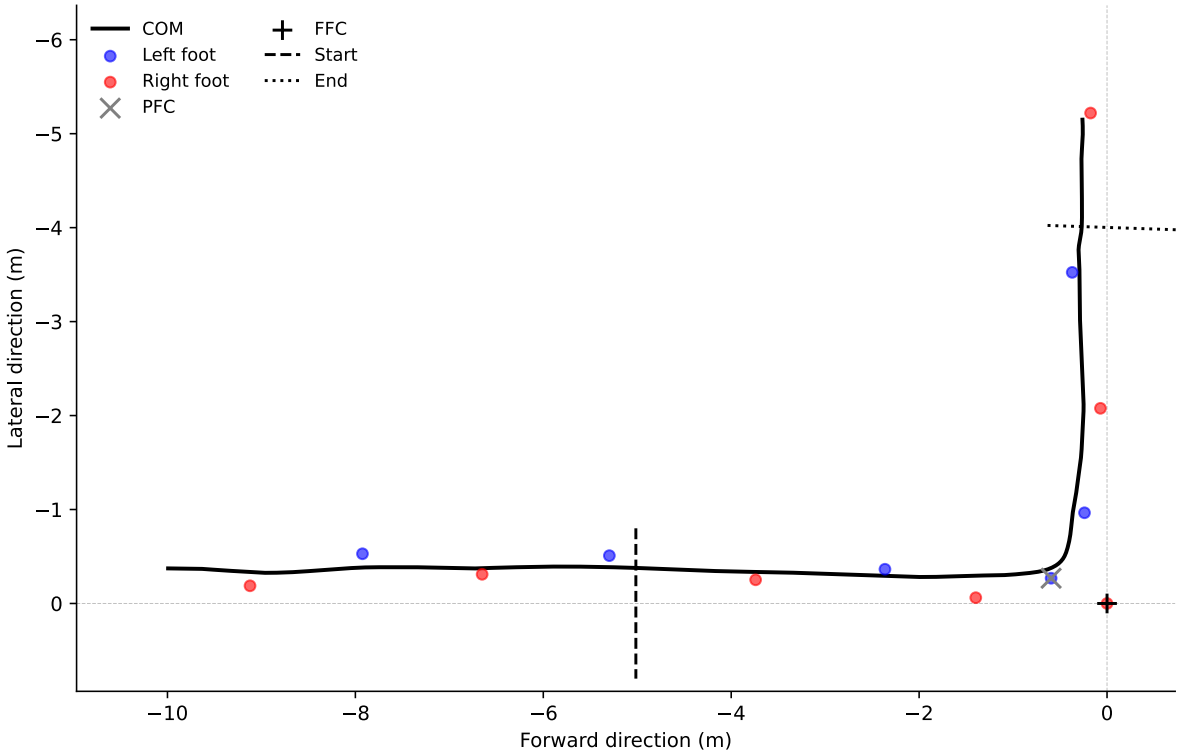

Figure 3: The timed interval extends from 5 m before the cut contact (forward direction; dashed line) to 4 m after the cut contact (lateral direction; dotted line). The penultimate foot contact (PFC) and final foot contact (FFC) are indicated by a cross and a plus sign, respectively.

Center-of-mass kinematics along the cutting direction

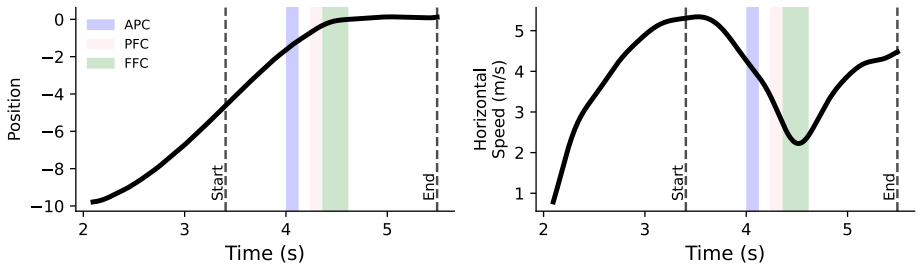

Figure 4: The last three foot contacts (AFC = antepenultimate foot contact, PFC = penultimate foot contact, FFC = final foot contact) are highlighted. The **start** and **end** of the timed interval are marked by vertical lines.

Joint kinematics

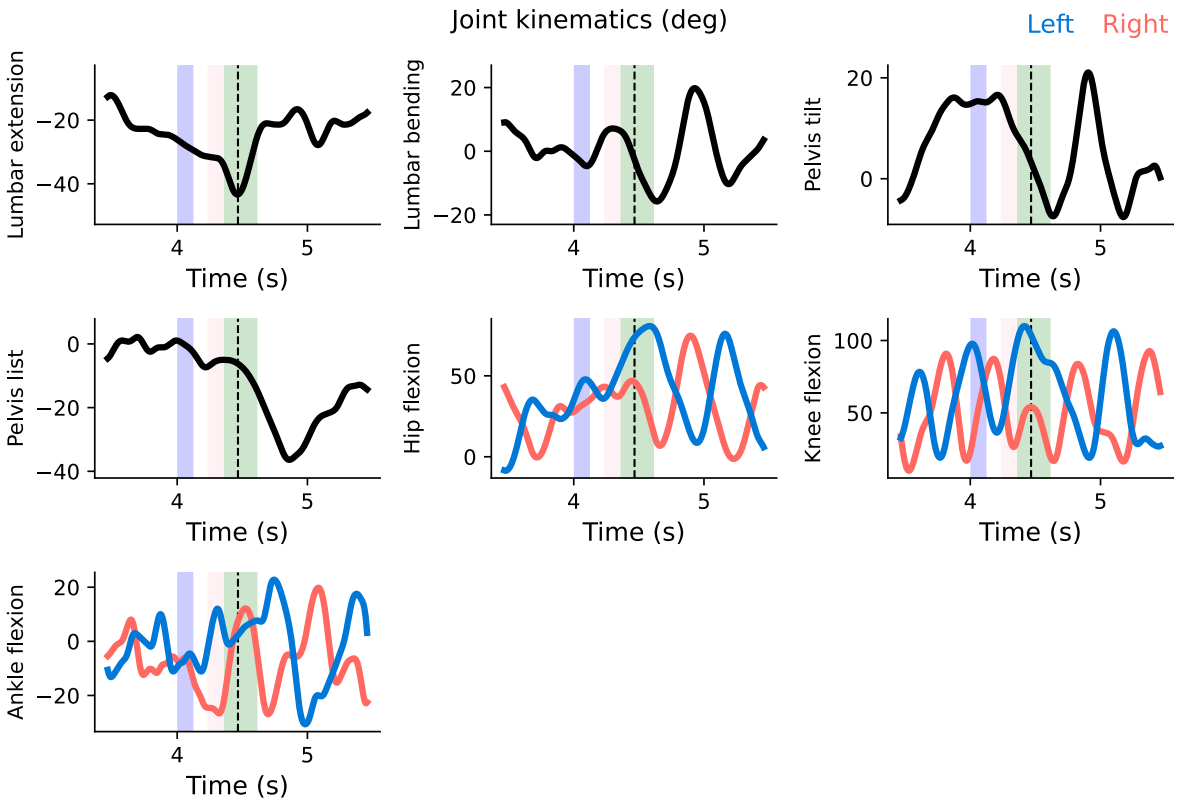

Figure 5: The shaded areas indicate the last three foot contact phases (AFC = antepenultimate foot contact, PFC = penultimate foot contact, FFC = final foot contact). The dashed vertical black line marks the change-of-direction (COD) moment, defined as the instant when the center of mass changes direction most prominently.