Step-to-step changes in foot-shank coordination during initial sprint acceleration

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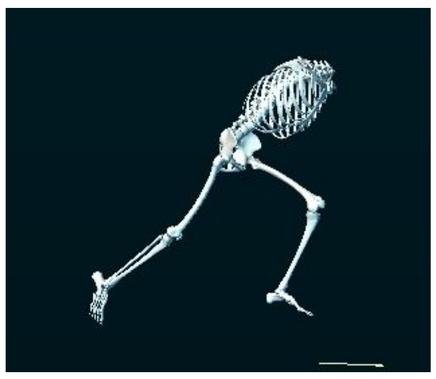
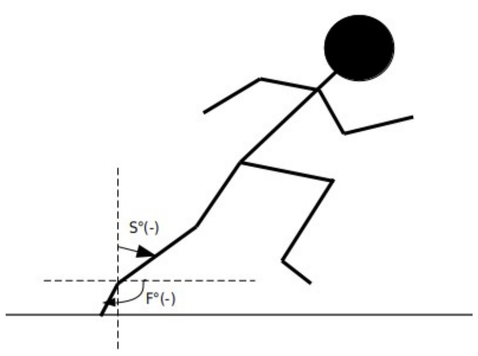
Introduction:

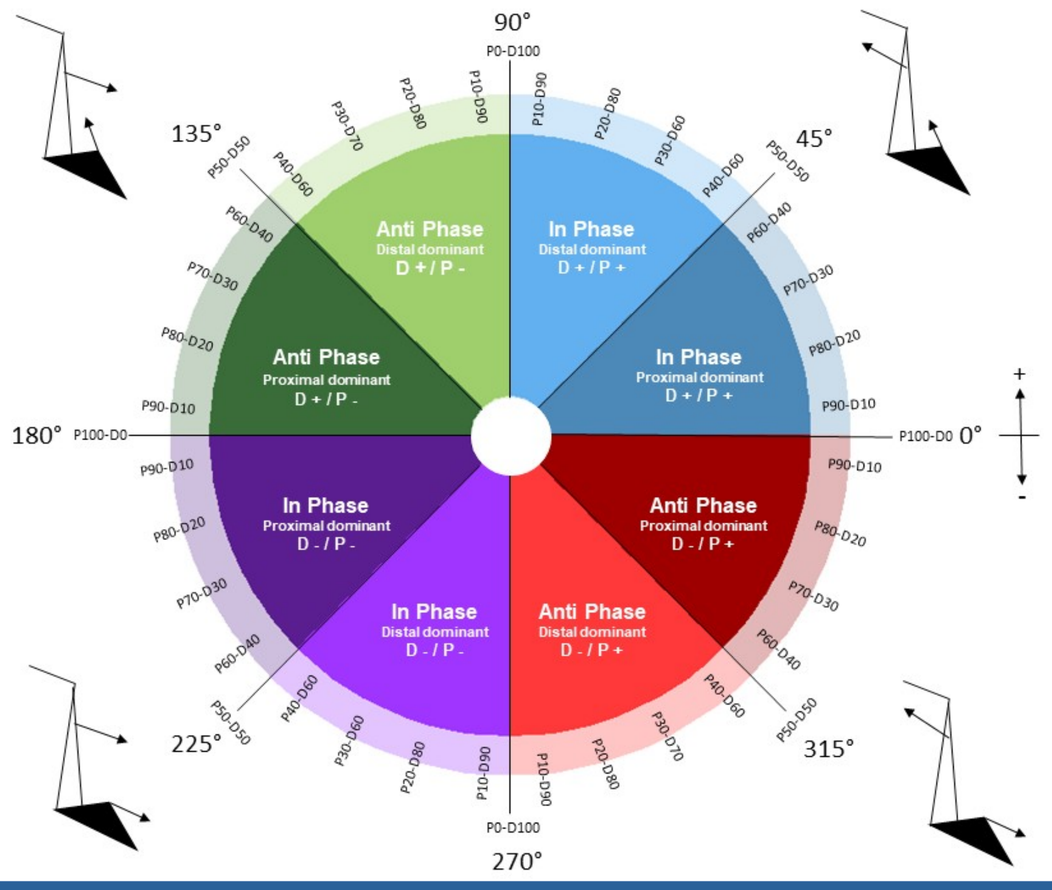
- Initial sprint acceleration is characterised by step-to-step changes in kinematics as the sprinter moves from a stationary, crouched position in the blocks to an upright, vertical position during later phases of the movement.
- First steps after block exit see changes in the shank angle at touchdown and during stance as well as changes in the foot position and orientation.
- Coaches focus on ankle mechanics during acceleration, which is directly influenced by the motion of foot and shank segments.
- Understanding the relative coordination between the shank and foot during this transition can improve our understanding of how athletes solve the challenges of initial acceleration and the relative contribution of these segments to motion of the ankle.

Methods:

- Twenty-one sprinters (15 M, 100 m PB 10.47 ± 0.42 s; 6 F, 100 m PB 11.70 ± 0.24 s)
- Sprinters performed three ≥20 m starts from blocks, the fastest trial over the respective distance used.
- Sagittal plane kinematics were captured using video (Ninox-250, 100 Hz) and inertial measurement units (IMUs) (200 Hz; MyoMotion, Noraxon, USA).
- Each step was time-normalised from toe off (0%) to subsequent toe off (100%) .
- Foot-shank coordination profiles for each of the first four steps were determined using vector coding and binning analysis (below) with group means determined using circular statistics (1).





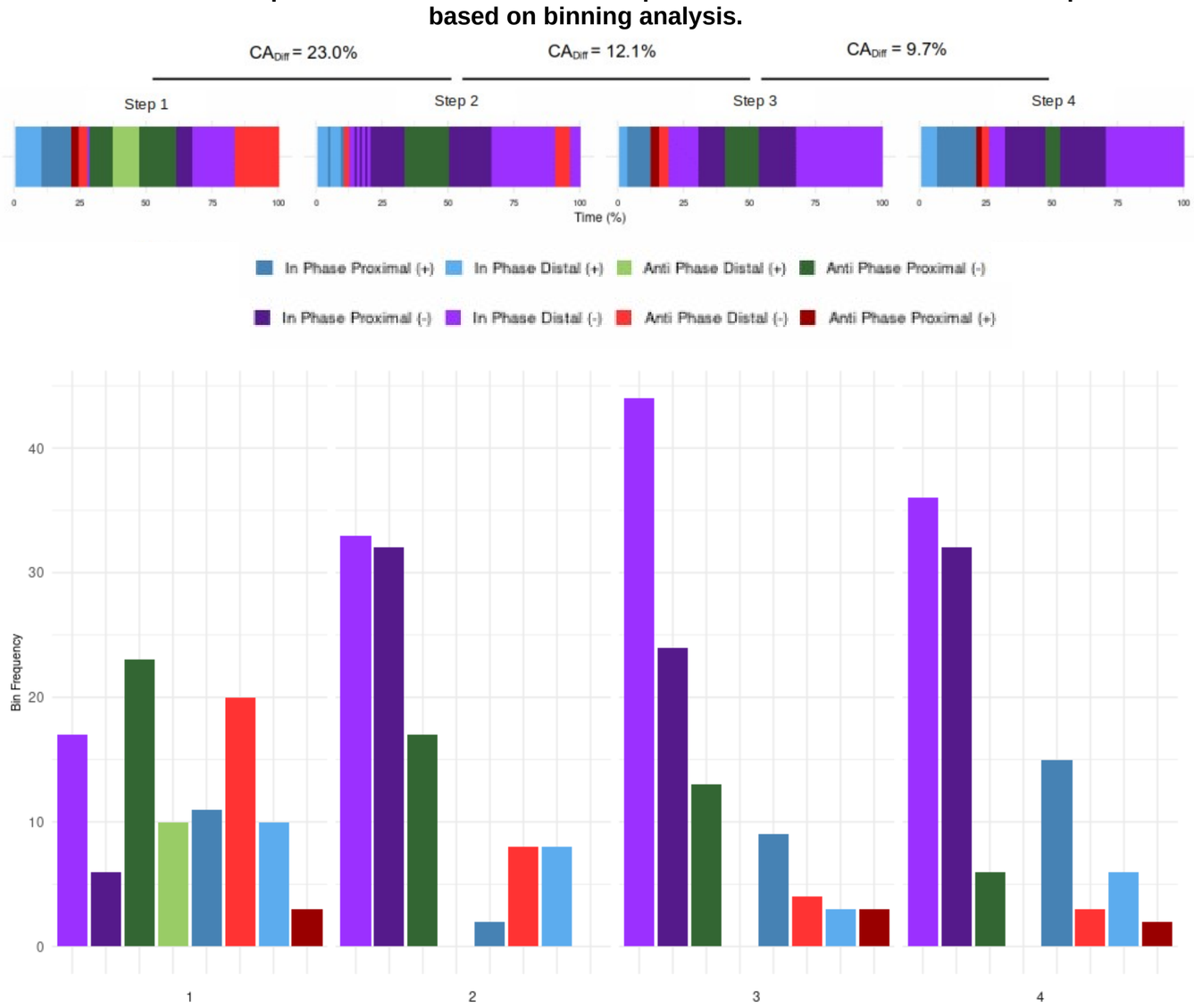


- Step-to-step changes were assessed based on the coordination bin frequency for each step and the coupling angle difference (CA_{Diff}) which represents the percentage of the maximal possible difference in coordination pattern between adjacent steps.

Results:

- Step-to-step coordination differences were largest between step 1 and step 2 (CA_{Diff} = 23.0%), with progressively smaller differences between steps 2-3 (CA_{Diff} = 12.1%) and 3-4 (CA_{Diff} = 9.7%).
- Coordination was dominated by anti-phase (AP) coordination - foot and shank rotate in opposite direction - (**AP foot (-)** 20%, **AP shank (-)** 23%) during the first step.
- Coordination became increasingly dominated by in-phase (IP) – foot and shank rotate in same direction – over step 2, 3 and 4, with **IP shank (-)** (32, 24 and 32% respectively) and **IP foot (-)** (33, 44, 36% respectively).
- Anti-phase coordination progressively decreased across the 4 steps.

Mean coordination profile and coordination bin frequencies for each of the first four steps and based on binning analysis.



Conclusion:

Sprinters appear to utilise a distinct foot-shank coordination strategy during the first step, dominated by anti-phase coordination where the foot and shank rotate in opposite directions, primarily after touchdown and at the end of the step. Coordination differences between subsequent steps become progressively smaller, utilising more in phase coordination with the two segments rotating in the same direction, alternately dominated by rotation of the shank or foot. These coordination patterns suggest ankle dorsiflexion driven primarily by shank rotation after touchdown and plantarflexion driven by foot rotation during stance and into toe off.

References:

1. Needham RA, Naemi R, Hamill J, Chockalingam N. Analysing patterns of coordination and patterns of control using novel data visualisation techniques in vector coding. The Foot. 2020 Mar;101678.

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