

Let's rock

Classification of Balance Recovery Steps in the Wild Application to Punk Rock Concerts.

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How to label and study recovery steps following physical interactions
in an ecological crowded environment ?

Context

- ◆ Physical interactions are common in crowded situation (e.g., mass gatherings, evacuations...). [1]
- ◆ Physical interactions can lead to a loss of standing balance. [2]
- ◆ Multiple balance recovery strategies are used to avoid falling in this context. [3]



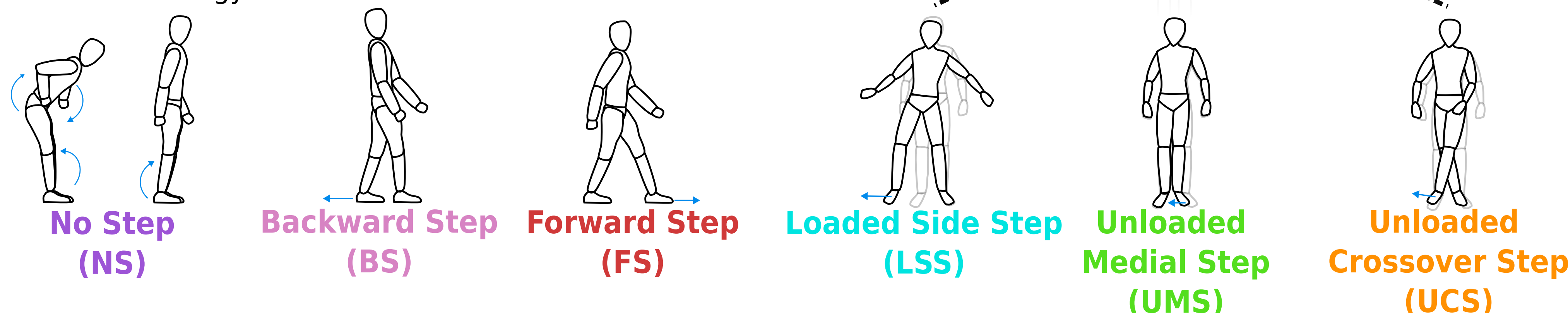
Figure 1: Aerial view of the concert venue where the experiment took place.

Method

Unified classification method for first recovery steps after quiet standing.

Labelling of recovery steps based solely on body kinematics. [4]

Hip or Ankle Strategy



Classification of first recovery steps after quiet standing following external perturbation from different directions [4]
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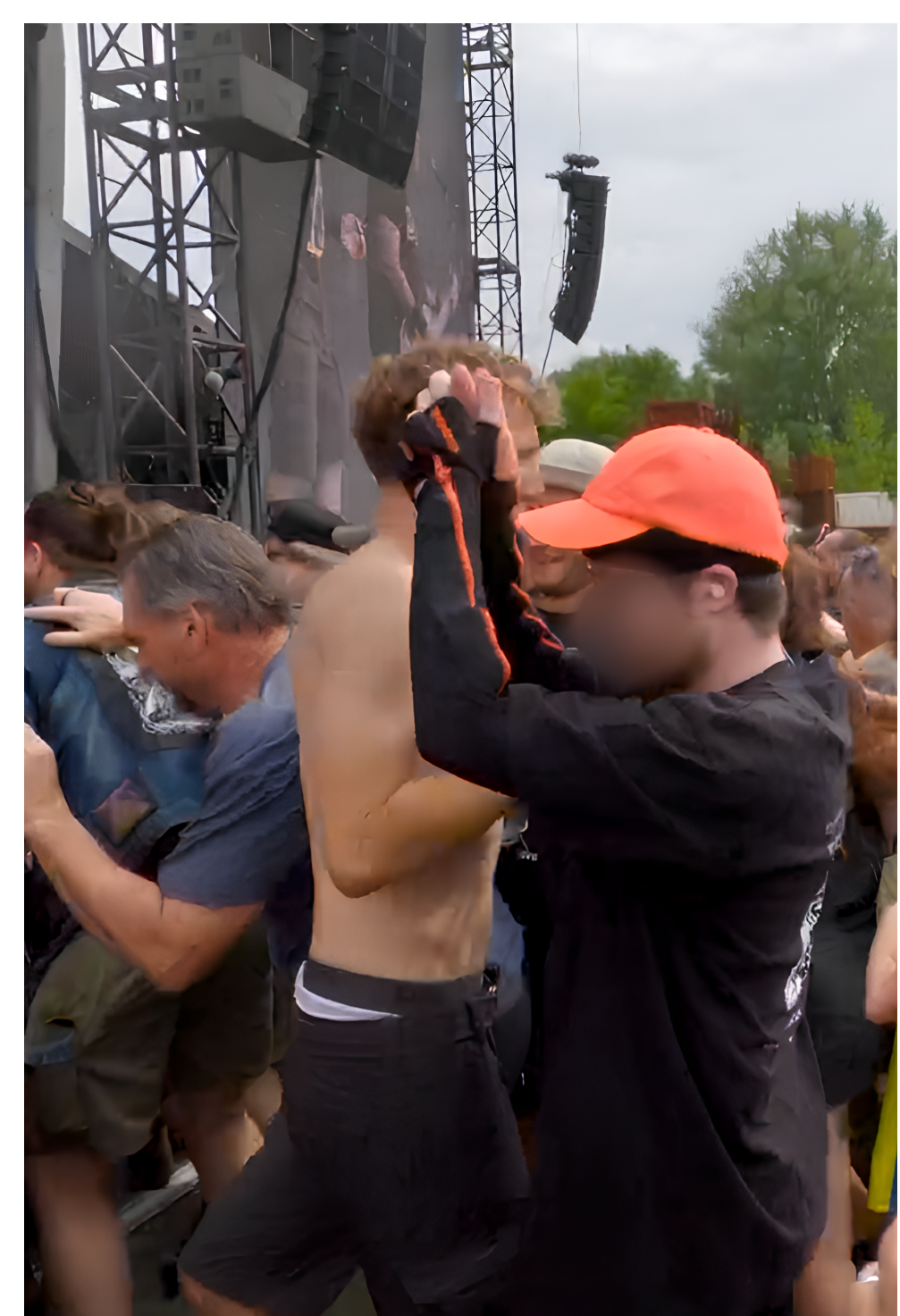


Figure 2: Participant clapping to indicate they stood in a balance, quiet position.

Proof of Concept - Studying Balance recovery in the wild.

- ◆ **3 Participants** (2M, 1F, 22-37yo).
- ◆ **Social Context:** Punk Rock concert (physical interactions socially accepted).
- ◆ **Terrain:** Flat dry paved ground - Figure 1.

Protocol

- 1) Stand in a balanced position with feet no larger than the hips.
- 2) Clap hands (to indicate that step one was completed) - Figure 2.
- 3) Recover from a random physical interaction - Figure 3.
- 3 bis) Clap hands twice to indicate voluntary steps.

Data Processing

- ◆ Motion capture: Xsens (240Hz).
- ◆ Biomechanical Model (44 DoF, 18 segments). [5]
- ◆ Labelling of first recovery step using a Unified classification method.



Figure 3: Participant recovering balance after receiving a perturbation by a concert-goer.

Results

Classification method

- ◆ Labeling of the first recovery steps without prior information about perturbations.
- ◆ Allows comparison between laboratory and in-situ balance recovery experiments.

Proof of concept

- ◆ **Perturbations coming from all possible directions** - Figure 4.
- ◆ Smaller and faster recovery steps than in laboratory experiments - Figure 5. [6, 7]
- ◆ **Predictive model** based on classic push recovery paradigm performed with more than **76% accuracy, except for LSS** - Figure 6. [4, 7]

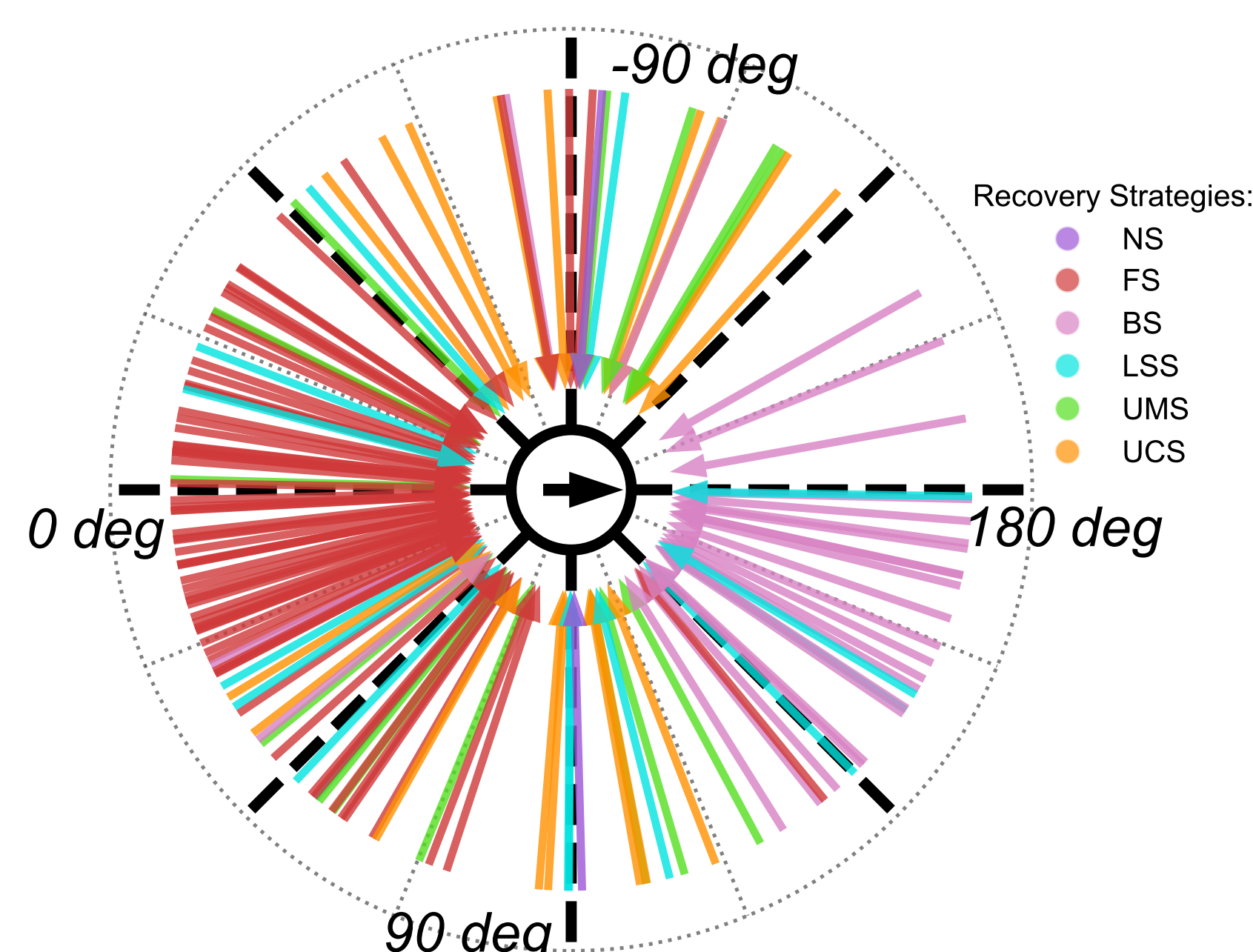


Figure 4: Representation of the estimated perturbation directions (i.e., direction of the CoM velocity before step initiation). Arrows are coloured by recovery strategies.

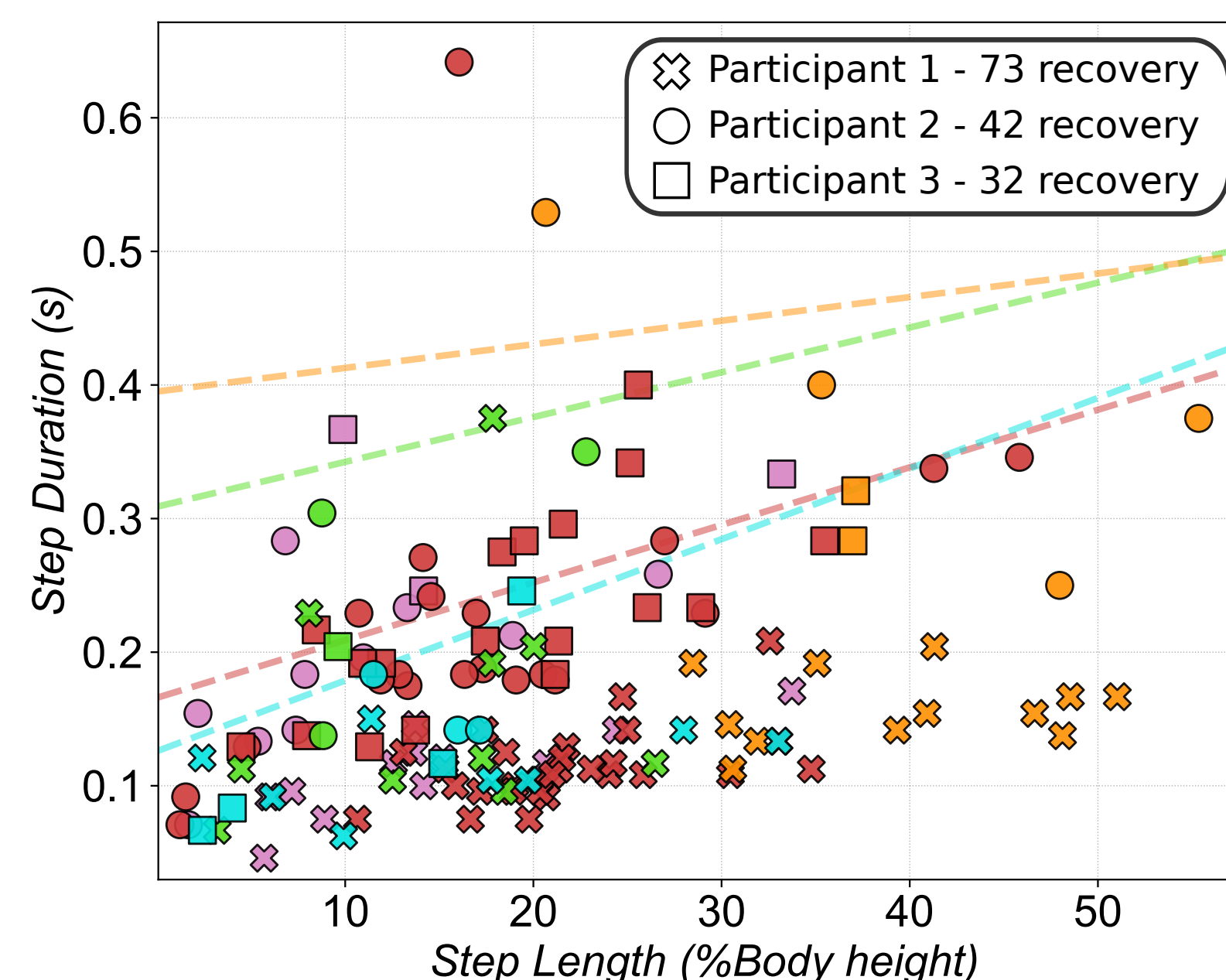


Figure 5: Duration of the first recovery step compared to the step length. The dashed lines correspond to regression obtained from single individuals in controlled laboratory environments. [7]

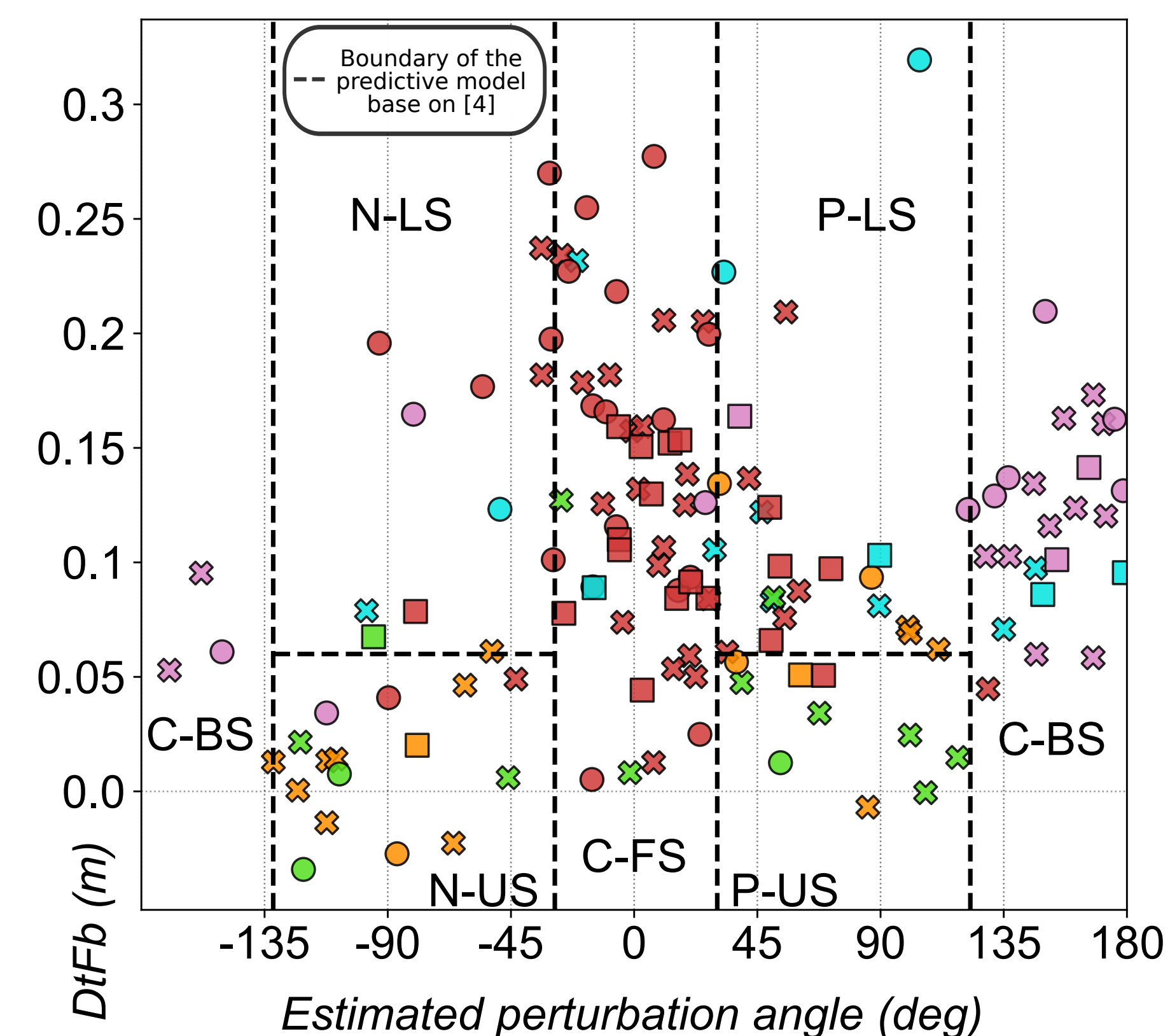


Figure 6: First recovery steps can be separated based on the perturbation angle and the distance between the CoM and the boundary non-stepping foot at step initiation (DtFB).

Perspectives

- ◆ Role of the upper body during recovery.
- ◆ Involve more participants.
- ◆ Repeat the protocol in different social contexts.