



# 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 crowed 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

No Step (NS)

**Backward Step** (BS)



**Loaded Side Step** (LSS)

Unloaded **Medial Step** (UMS)

**Unloaded Crossover Step** (UCS)

Lateral perturbation



Classification of first recovery steps after quiet standing following external perturbation from different directions [4] DOI: 10.1016/j.jbiomech.2025.112639

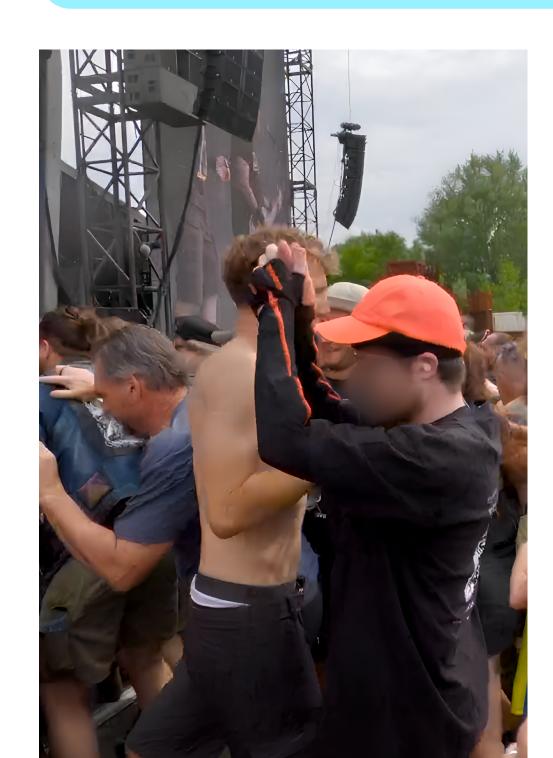


Figure 2: Participant clapping to indicate they stood in a balance, quiet position.

#### **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]

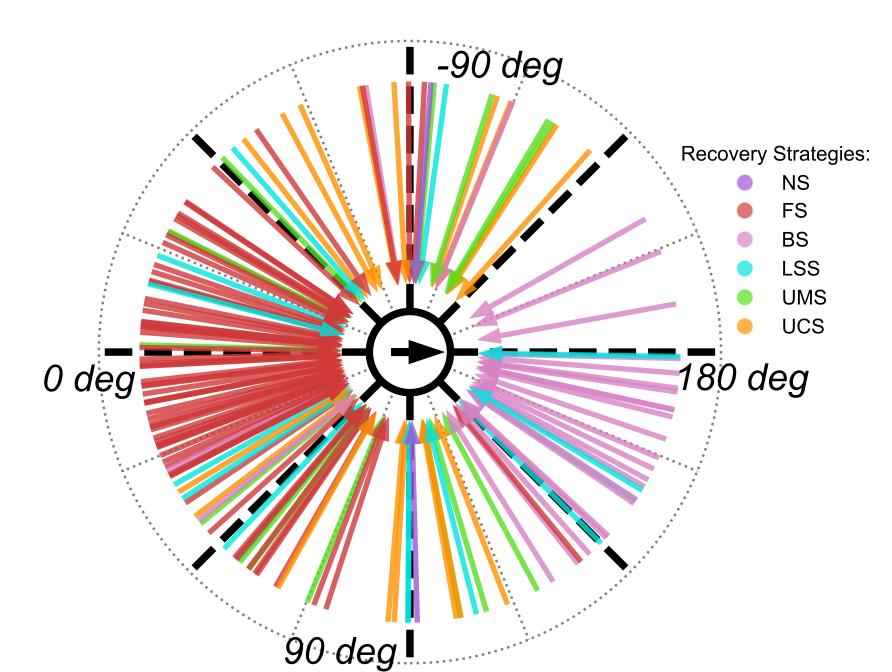


Figure 4: Representation of the estimated perturbation directions (i.e., direction of the CoM velocity before step initiation). Arrows are coloured by recovery strategies.

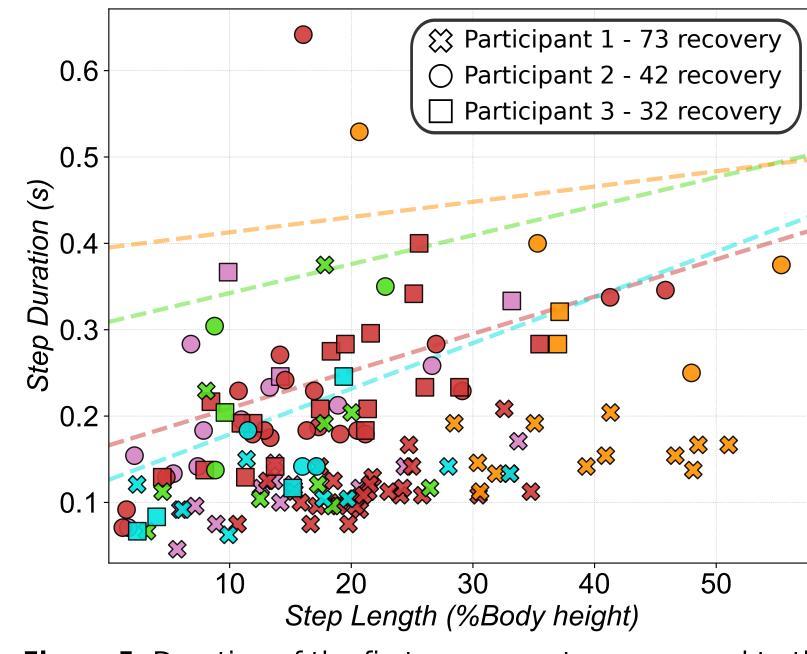


Figure 5: Duration of the first recovery step compared to the step length. The dashed lines correspond to regression obtained from single individuals in controlled laboratory environments. [7]

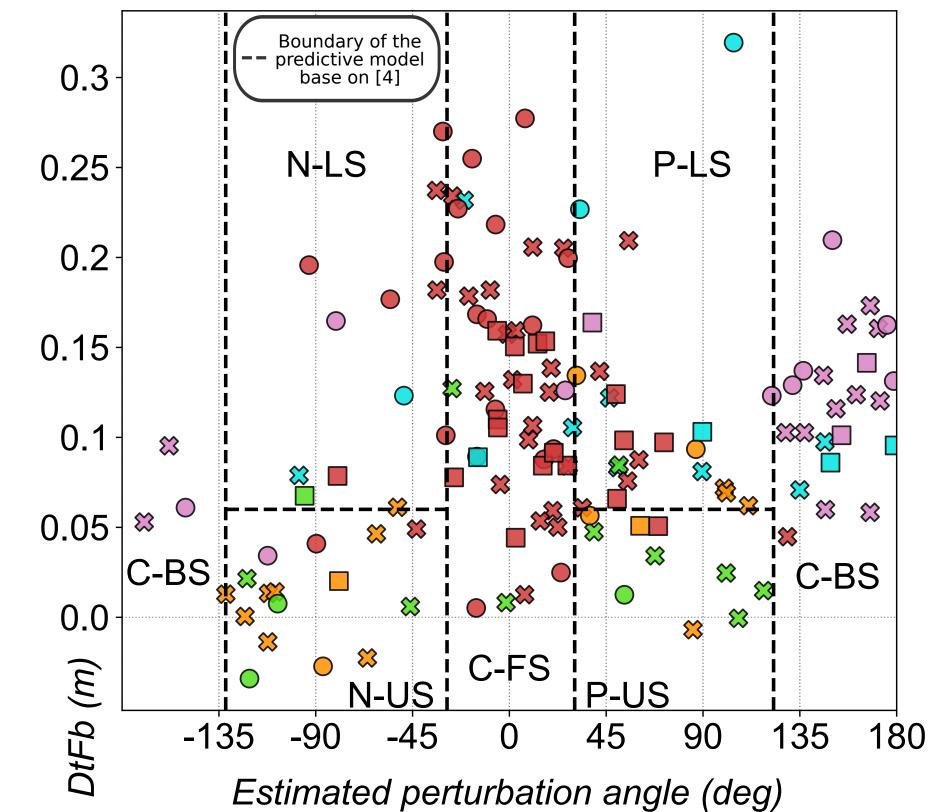


Figure 6: First recovery steps can be separated based on the perturbation angle and the distance between the CoM and the boundary non-stepping foot at step initiation (DtFB).

# Perspectives

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

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