Better Long Cane Design and Biomechanics for Blind Cane Users: Mobility for People with Visual Impairments

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Orientation and Mobility (O&M)

- **Orientation**: knowing where you are and which direction you are facing
- **Mobility**: getting from one place to another safely and independently
Component of a comprehensive rehabilitation training designed for individuals with vision loss

Aim of the training is to help the individuals travel more safely and independently in their desired environment, often using a long cane or a dog guide

O&M training often covers topics such as:

- How to stay oriented using non-visual landmarks and clues
- How to use a long cane
- How to cross streets safely and independently
- How to use public transit systems
Cane Techniques

- Two-point touch technique
- Constant contact technique
Drop-off Detection

- Critical for blind travelers to detect drop-offs reliably
  - Curb
  - Uneven surfaces
    - Pothole, sunken slab
Obstacle Detection

- Critical for blind travelers to detect obstacles reliably
  - Trip over obstacles (construction cones, bricks, etc.)
  - Collision with obstacles (sign posts, etc.)
Factors Related to Drop-off Detection

- Cane-use Biomechanics Factors
  - Type of Cane Technique
  - Cane-swing-arc width

- User Characteristics
  - Age of Cane User
  - Age at Onset of Visual Impairment
  - Cane Use Experience

- Cane Design Factors
  - Type of Cane Tip
  - Cane Length
  - Cane Weight

- Environmental Factors
Factors Related to Obstacle Detection

Obstacle Detection

Cane-use Biomechanics Factors
- Type of Cane Technique
- Cane–wing-arc width

User Characteristics

Cane Design Factors
- Cane Tip Shape
- Cane Length

Environmental Factors
Methods
(Drop-off Detection Studies)
Recruitment Criteria

- Legal blindness with no other disabilities
- Familiarity with both techniques
- At least one month of cane training
- 13-16 cane users participated in individual studies
Drop-off Detection Experiment

- Test site
  - 8-foot-wide concrete hallway in CHHS building basement
- Sleep-shades and headphone set
Apparatus

Participant Approaching the Drop-off on the 32-foot-long Walkway Used in the Study
Experiment Procedure

- Starting point randomization
- 64-96 trials per participant
- Block randomization to prevent order effect
- Block randomization to randomly select drop-off depth for each trial
Key Findings
(Drop-off Detection)
Key Findings

- Drop-off detection performance (Significant factors)
  - Constant contact (CC) better than two-point touch (TT)
  - CC’s advantage is larger for less experienced
  - Younger cane users were better
  - Individuals with earlier-onset VI were better
  - Heavier cane was better
  - Standard length was better than extended length (16” longer)
  - Standard cane-swing arc width was better than extended swing arc width (a foot wider on each side)
Key Findings

- Drop-off detection performance (Factors that were NOT significant)
  - Cane shaft rigidity
  - Cane tip (marshmallow tip vs. marshmallow roller tip)
Methods
(Obstacle Detection Studies)
Recruitment Criteria

- The same as drop-off detection studies
Obstacle Detection Experiment

- Test site
  - WMU’s CHHS building 4F hallway
- Sleep-shades and headphone set
Apparatus

- Cylindrical objects of different sizes (diameters of 2”, 6”, 10”, and 14”) and heights (1”, 3”, 5”, and 7”) were created with Styrofoam and linoleum.
Apparatus

- Objects presented either at the midline of the walking path or slightly off to the side following a randomized schedule.
- A 20-foot-long rail (3 feet high), built with PVC pipes, was placed beside the walking path for participants to trail with the free hand.
Experiment Procedure

- Starting point randomization
- 128-192 trials per participant
- Block randomization to randomly select obstacle size and height for each trial
Key Findings
(Obstacle Detection)
Key Findings

- Obstacle detection performance
  - CC better than TT for short obstacles
  - Bundu basher tip was better than marshmallow tip
  - Cane length and cane swing arc width didn’t have a significant effect
DISCUSSION
Discussion

- One of the most significant and prevailing findings
  - Presence of CC’s advantage over TT in drop-off detection
- Particularly noteworthy is large effect size
  - 50% threshold: half as large
  - Large drop-offs
    - TT: missed 1 in 15
    - CC: missed less than 1 in 100
Discussion

- Surprising finding
  - Failure to detect even tall obstacles at least 1 in 3 times
  - Consistent with Uslan (1978)’s finding (68.9% path coverage rate)
  - Bundu basher tip somewhat improves the obstacle detection rate (from 35% to 25% misses)
  - Raises a question of whether we should modify the current cane techniques
Current/Future Studies

- Ecological validity (real-world testing)
- Surface texture discrimination
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Published Articles


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