Title: Mechanisms of Fall Resistance to Diverse Slipping Conditions

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Study Protocol

For all gait collections, participants will arrive at the Biomechanics Research Building on the University of Nebraska at Omaha campus. All participants will be consented and screened prior to gait testing. During the consent process, participants will be asked if they can be contacted again for future research studies. During the screening, participants will undergo a short medical history.

Participants will be asked to put on a form fitting suit for data collection. Body weight, height and extremity anthropometry will be collected (length of arm and leg segments). Retroreflective markers will be placed on the legs, arms, torso and head to obtain whole-body kinematic data. A ceiling-mounted safety harness will also be fitted to each participant. Prior to performing any walking trials, the participants will be allowed to "sit" in the harness to experience how it feels when it catches them.

Aim 1 Specific Methods

Young healthy participants will undergo overground gait and stabilization movement analysis sessions that will last approximately 210 minutes. All participants will be fitted with a form-fitting singlet, ceiling mounted safety harness, lab-provided shoes, and a full-body retroreflective marker set. A load cell placed in line with the safety harness will allow for the quantification of forces exerted on the harness at 80 Hz. A 17 camera 3D motion capture system will be used to collect kinematic data at 120 Hz throughout each trial. Data will be collected at a comfortable walking speed of 1.3 m/s53. Walking speed will be monitored using timing gait plates placed along the path. Participants will be coached to maintain prescribed walking speed. A repeated measures design will have participants slip both feet at 3 different times in the gait cycle for each of 3 path curvatures for a total of 18 slip episodes. Slips will be delivered while walking along a straight path (infinite radius), or curved paths with radii of 2 or 1 meters. A path consisting of multiple turns will be marked on the floor of the lab, including turning radii of 2 and 1 meters.

Only right turns will be examined, as previous research has found no difference between the kinematics of left and right turns. Participants will follow the path for a randomly selected amount of time between 1 and 3 minutes. After this time has elapsed, the investigator will initiate a slip during a randomized turn on the path in early, middle, or late stance. Participants will be given a seated rest period of 5 minutes between each trial.

Aim 2 Specific Methods

Young healthy participants will undergo treadmill gait and stabilization movement analysis sessions that will last approximately 270 minutes. All participants will be fitted with a form-fitting singlet, a safety harness mounted to the rigging of the CAREN system, lab-provided shoes, and a full- body retroreflective marker set. A load cell placed in line with the safety harness will allow for the quantification of forces exerted on the harness at 80 Hz. Data will be collected with the treadmill set at a comfortable walking speed of 1.3 m/s53. A repeated measures design will have participants slip at 3 different times in the gait cycle for each of 5 different uphill/downhill slopes and at 3 times to both feet for 2 cross-slopes for a total of 27 slip episodes (3 phases x 5 slopes that foot doesn't matter + 3 phases x 2 feet x 2 slopes that foot matters).

Specifically, slips will be delivered over sloped ground surface of no slope, ±5.0 and ±10.0 degrees slopes in the direction of walking, and 5.0 and 10.0 degrees perpendicular to the direction of walking.

Sloped surfaces will be generated with the CAREN system treadmill, which is capable of pitch and roll ±16 degrees.55Slip onset will be triggered by the experimenter in a randomized order at early, mid, or late stance. Participants will walk on the prescribed slope and a slip will be triggered on after a randomly predetermined amount of time between 1 and 3 minutes at either early, middle, or late stance. Participants will be given a seated rest period of 5 minutes between each trial. To quantify the effects of the slip perturbation, whole body angular momentum, COM characteristics, arm movements, and slip characteristics will be derived from the kinematic data.

Statistical Analysis Plan

For each variable, investigators will test for normality and employ the appropriate parametric or non-parametric descriptive statistics. Histograms and plots for each variable will be made and examined. Statistical hypothesis testing will be done using custom software written in R statistical computing language (R Core Team). General linear mixed-effects model will be used to determine the effects of diverse slip conditions on reactive movements and slip severity measures for all aims. This mixed-effects model will be used to include participants and order as random factors while testing for differences between conditions. For example, even though these data will have repeated measures from the same subject, a linear mixed effect model can resolve those non-independencies by including participants as a random factor and accounting for changes from baseline participant variation. Aim 1: independent variables will be a) turn radius (4 levels: no turn, 2m, 1m, 1/2m), b) slip timing (3 levels: early, mid, and late stance). Aim 2: independent variables will be a) slope (7 levels: no slope, ±5.3 degrees AP, ±10.6 degrees AP, ±5.3 degrees ML, ±10.6 degrees ML).