Aging and Task-Specific Training to Reduce Falls

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LIST OF ABBREVIATIONS

COI	Conflict of Interest
DHHS	Department of Health and Human Services
DMC	Data Monitoring Committee
DSMB	Data and Safety Monitoring Board
DSMP	Data and Safety Monitoring Plan
FERPA	Family Educational Rights and Privacy Act
FDA	Food and Drug Administration
GCP	Good Clinical Practice
HIPAA	Health Insurance Portability and Accountability Act
IBC	Institutional Biosafety Committee
ICD	Informed Consent Document
ICH	International Conference of Harmonization
IDE	Investigational Device Exemption
IDS	Investigational Drug Service
IND	Investigational New Drug
IRB	Institutional Review Board
LAR	Legally Authorized Representative
OHRP	Office of Human Research Protections
OPRS	Office for the Protection of Research Subjects
PHI	Protected Health Information
PI	Principal Investigator
PPRA	Protection of Pupil Rights Amendment
QA/QI	Quality Assurance/Quality Improvement
SAE	Serious Adverse Event
SOP	Standard Operating Procedure

1.0 Project Summary/Abstract

The proposed study employs a randomized, controlled design to assess the immediate and long-term effects of task-specific balance training for reducing environmental falls in at-risk community-dwelling older adults. >33% of older adults fall at least once each year[1-5], leading to serious injuries (e.g., hip fractures, head injuries) and comorbidities (e.g., Alzheimer's disease and related Dementias)[5-9]. Most falls occur due to environmental disturbances which cause a loss of balance while walking (i.e., slips, trips)[10,11]. Overground perturbation training (repeated exposure to unpredicted perturbations) improves both volitional/anticipatory and reactive balance control and reduces real-life falls among older adults[12-16]. However, overground perturbation training is not suitable for routine clinical application due to its complex design, space, and technology requirements. An alternative method for delivering perturbation training is commercial treadmill systems, which not only can enhance fall-resisting skills but are more feasible for community-translation[17,18]. However, the equipment is costly and the translational effectiveness of treadmill perturbation training for reducing falls in community ambulatory older adults is lesser than overground training, probably as it mainly only entrains reactive balance control. Falls may also occur due to deficits in volitional balance control which affect gait stability during daily living. Training paradigms focused on improving volitional balance control have primarily comprised of conventional balance exercises delivered as a part of physical rehabilitation; however, conventional balance exercises generally do not translate to improvements in reactive balance control when exposed to an unpredicted external perturbation and have limited effects on reducing real-life falls[19,20]. A fall prevention intervention that targets both volitional and reactive balance domains could more effectively reduce falls than existing paradigms which only train a single domain (e.g., treadmill perturbation training: reactive-dominant, or conventional balance: volitional-dominant). We have developed a novel task-specific balance program that includes exercises specific to slips and trips and requires little set-up and equipment, making it a cost-effective, feasible and accessible fall prevention intervention. We will compare the effects of 8 weeks (16 sessions) of task-specific balance training with established fall prevention paradigms including treadmill perturbation training and conventional balance training. We will examine the immediate effects of task-specific balance training on reactive balance (**Aim 1**) and volitional balance (**Aim 2**). Additionally, we will evaluate the longer-term retention (18 months) of task-specific balance training and effects on real-life falls and balance confidence (**Aim 3**). In an exploratory aim, will also examine the neuromuscular adaptations induced through training using simulation techniques (**Aim 4**). If successful, our novel intervention can be implemented as a feasible, safe, and effective fall-prevention intervention and has large potential for direct dissemination to clinical settings.

2.0 BACKGROUND/SCIENTIFIC RATIONALE

Falls occur in ≥30% of older adults each year[1-5], leading to ~2.8 million hospital admissions[5-9], 32,000 deaths, and $50 billion in medical costs[21]. Further, older adults with fall history are 3x as likely to experience another fall within the same year[22]. >60% falls occur due to environmental disturbances which cause loss of balance while walking (i.e., slips, trips)[10,11]. We have developed an innovative overground perturbation-based training paradigm which delivers repeated slip-like disturbances and conducted systematic theoretical and empirical studies which establish its positive effects on volitional/anticipatory and reactive balance control[12-16]. Slip training improves the ability to restore center of mass stability (influenced by protective stepping) and limb support (influenced by net extensor torque)[23-25]; these adaptations can be retained for at least one year, and reduce long-term real-life falls in older adults[16]. Our recent study *(R01AG050672)* showed that mixed training (slip and trip training) resulted in greater retention of stability control and lower overall real-life fall rates[26]. Despite its robustness for acquiring fall-resisting skills, overground perturbation training is not suitable for routine clinical application due to its complex design, space, and technology requirements.

An alternative method for perturbation training delivery is via commercial treadmill systems, which not only enhance fall-resisting skills but are more feasible for community-translation. However, the equipment is costly and the translational effectiveness of treadmill perturbation training is lesser than overground training for reducing falls in community ambulatory older adults[17,18], probably as it mainly only entrains reactive balance control. But falls are heterogeneous in nature and may also be caused by decrements in volitional balance control which affect gait stability during daily living, especially for at-risk older adults. Training paradigms focused on improving volitional balance have primarily comprised of conventional balance exercises; however, such training does not translate to improvements in reactive balance and thus has limited effects on reducing falls during daily living[19,20]. A fall-risk intervention that targets both volitional and reactive balance domains could more effectively reduce falls than existing paradigms which only train a single domain (i.e., treadmill-perturbation training (reactive-dominant), or conventional balance training (volitional-dominant)). Further a fall prevention intervention which addresses other barriers of perturbation-based training (i.e., fear of facing falls and chances of adverse effects) would be safer and more acceptable for clinical translation.

3.0 Objectives/Aims

For this project, we have developed a novel task-specific balance training program that includes functional exercises specific to slips and trips and requires little set-up and equipment, making it a cost-effective, feasible and accessible fall prevention intervention[27]. The purpose of this study is to determine efficacy of this program in older adults who are 'at-risk' of falling, compared to treadmill-perturbation and conventional balance interventions. Our specific aims are listed below:

Aim 1: To examine immediate effects of 8 weeks of task-specific balance training on reactive balance in at-risk community-dwelling older adults.

Hypothesis 1: Task-specific balance training will induce greater improvements in reactive center of mass stability and limb support than treadmill-perturbation and conventional balance training, resulting in fewer laboratory falls on novel overground slips and trips immediately post-training.

Aim 2: To examine immediate effects of 8 weeks of task-specific balance training on volitional balance in at-risk community-dwelling older adults.
Hypothesis 2: Task-specific balance training will induce greater improvements in volitional balance control than treadmill-perturbation and conventional balance training, resulting in higher scores on the Functional Gait Assessment immediately post-training.

Aim 3: To examine longer-term effects of 8 weeks of task-specific balance training on real-life fall reduction and falls efficacy in at-risk community-dwelling older adults.
Hypothesis 3: Long-term retention of improvements in reactive and volitional balance control induced by task-specific balance training will result in fewer real-life falls and higher falls efficacy than treadmill-perturbation and conventional balance training 18-months post-training.

Exploratory Aim 4: To validate whether task-specific balance training induces neuromuscular adaptations to muscle synergies during unperturbed and perturbed walking that may serve as causative factors to reduce environmental falls.

4.0 Eligibility

Participant recruitment. Potential participants will be recruited by posting flyers, sending e-mails and presenting at local health forums, community senior centers, retirement communities, independent living facilities, and wellness centers. Potential participants will also be recruited by posting study flyers on the Cognitive, Motor, and Balance Rehabilitation lab website (*https://cmbrl.ahs.uic.edu*), or on the lab Facebook and/or Instagram accounts. The Research Match Registry supported by the Center of Clinical and Translational Research and the Center for Research on Healthy Aging at UIC will also be used. Direct referrals by geriatricians and other health-care practitioners will also be included for screening. Newspaper, radio, television, and internet advertising will be done. Participants from previous studies will not be included.

Potential participants will make contact with the research team if they are interested in participating in the study, at which point we will initially screen them over the phone using the telephone screening form. If participants are initially eligible to participate in the study via phone screening, we will then schedule them for an in-person screening visit. (See details of specific inclusion and exclusion criteria for the telephone and in-person screening visits under participant screening).

Participant screening (inclusion and exclusion criteria). This study will enroll older adults (ages 60-90 yrs) who are identified as 'at-risk' of falling. Participant eligibility will initially be assessed over the phone, which will take approximately 10 minutes. Upon passing the phone screening, the remaining eligibility criteria will be assessed in-person

on the participant's first visit to the laboratory after they sign the consent. The in-person screening will take about 1 hour. The specific inclusion/exclusion criteria assessed at each level of screening are listed below.

4.1 Telephone Screening Inclusion Criteria

- *Age: 60-90 years.*
- *Absence of any acute or chronic neurological (Stroke, Parkinson's disease, Alzheimer's disease), cardiopulmonary, musculoskeletal, or systemic diagnosis.*
- *No recent major surgery (< 6 months) or hospitalization (< 3 months).*
- *Not on any sedative drugs.*
- *Can understand and communicate in English.*
- *Can walk without an assistive device for at least 1 block to ensure independent functioning.*

4.2 Telephone Screening Exclusion Criteria

- *Complaints of shortness of breath or uncontrolled pain (>3/10 on visual analogue scale (VAS)) at rest to avoid complications/injuries during testing/training.*
- *Uncontrolled (not under any medications) hypertension to avoid cardiovascular complications during testing/training.*
- *Self-reported history of bone fracture in the last six months to avoid complications/injuries during testing/training.*
- *Self-reported disability (with or without assistive device) to ensure independent functioning.*
- *Weight >220 lbs (harness weight threshold).*

4.3 In-Person Screening Inclusion Criteria

- ***Identification of 'at-risk' older adults**: We will only include older adults who are identified as 'at-risk' of falling based on two criteria. First, participants will be identified as 'at-risk' if they self-report experiencing at least one or more fall in the past 12 months. We will ask participants if they have experienced a fall in the past year during their telephone screening, and confirm this information when they come for their in-person screening. Secondly, participants will be identified as 'at-risk' using fall risk prediction models which our lab has developed (called the Fall Risk Assessment and Testing Technology (FRATT). Using these models, we can predict the risk of falls in the laboratory (when exposed to slip-like or trip-like perturbations) and in real-life based only on a video of a participant walking for about 10 seconds. We have published papers in which we tested the accuracy of these models, and found that they can predict fall risk with greater than 80% accuracy[28] [29]. We will ask participants to walk for about 10 seconds while we take a video of them on a tablet, and the FRATT system will immediately output their fall risk score. If participants receive a fall risk score of >50% using these models,*

then they will be identified as 'at risk.' Note: To be considered 'at-risk' of falling and included in the study, participants only need to meet ONE of the above listed criteria (i.e., either report ≥1 fall in the past 12 months OR receive a fall risk prediction score of >50% using our models).

- *Visual acuity greater than or equal to 20/40 with or without corrective lenses[30] to ensure intact vision.*

4.4 In-Person Screening Exclusion Criteria

- *Participants will not proceed with the study if any of the following occurs at baseline measurement: 1) Heart Rate >85% of age-predicted maximal heart rate (HRmax) (HRmax = 220 – age), 2) systolic blood pressure (SBP) > 165 mmHg and/or diastolic blood pressure (DBP) > 110 mmHg during resting). If participants have a blood pressure outside of the cutoff ranges, we will immediately provide them with a copy of their blood pressure reading and discuss with them why they were excluded from the study. Participants will be encouraged to follow up with their physician regarding their blood pressure.*
- *Participants will be excluded from the study if they are not independent community ambulators. We are aiming to include older adults who have higher fall risk but are still independent community ambulators, as these individuals are at the greatest risk of falling from external perturbations (e.g., slips, trips) in the community. We will determine ambulatory status using the following three criteria:*
    - *Participants will be excluded if they are not able to stand for 5 minutes and walk for 10 m without an assistive device. Each trial of testing/training requires independent standing and walking for at least 10 meters.*
    - *Participants will be excluded if they receive a score of <40/56 on the Berg Balance Scale. Older adults who receive a score less than 40 on the Berg Balance Scale would be at extreme risk of falling even just while standing and would likely not be able to perform training exercises without falling. These individuals are likely to rely on an assistive device and be only home-ambulators rather than community-ambulators.*
    - *Participants will be excluded if they score <4 on the Functional Ambulation Category (FAC). The FAC is a 6-point functional walking test (possible scores 0-5) that evaluates ambulation ability. A score of less than 4 would indicate that participants cannot ambulate independently without physical assistance or supervision.*
- *Complaints of shortness of breath, or uncontrolled pain (more than 3 out of 10 on Visual Analogue Scale), or if pulse oxygen drops less than 92% on the six- minute walk test (for endurance) to ensure that the participant can effectively participate without discomfort or injury during testing and training. If participants have low pulse oxygen at screening, we will not proceed with screening/testing, we will advise them to follow up with their physician, and they will be excluded from the study.*

- *Subjects with severe osteoporosis (Tscore < –2) [31] measured via Achilles heel bone density scan (Lunar Achilles Tendon (EXPII)). This is to prevent potential risk of fractures, musculoskeletal injuries and to ensure patient safety. If we observe a T score indicating osteoporosis, participants will be provided with a copy of screening results describing why they were excluded from the study and will also be encouraged to follow-up with their physician.*
- *Presence of cognitive impairment, identified by a score of less than 25 on the Mini Mental State Exam[32]. If participants receive a score indicative of cognitive impairment, we will provide them with a copy of their score and discuss with them why they were excluded from the study. Participants will be encouraged to follow up with their physician regarding their score.*

4.5 Excluded or Vulnerable Populations

- *Participants will be excluded if they are unable to understand or communicate in English as the entire training and testing protocol will be provided in English.*

The inclusion and exclusion criteria assessed during telephone screening and in-person screening are summarized in the tables below.

Telephone Screening
Inclusion Criteria
Age 60-90 years
Self-reported medical conditions
• No acute/ chronic disease
• No recent major surgery (< 6 months)
• No recent hospitalization (< 3 months)
• Not on sedative drugs
Can understand and communicate in English
Can walk without an assistive device for at least 1 block
Exclusion criteria
Complaints of shortness of breath or uncontrolled pain (>3/10 on visual analogue scale)
Uncontrolled (not under any medications) hypertension
Self-reported history of bone fracture (in the past 6 months)
Self-reported disability (with or without assistive device)
Body weight > 220 lbs

In-Person Screening
Inclusion Criteria

'At-risk' Older Adults
• Self-report of at least 1 or more falls in the past 12 months OR
• Fall risk score >50% using our fall risk prediction models
Visual acuity ≥20/40 with or without corrective lenses
Exclusion criteria
Heart rate >85% age-predicted maximal heart rate (220-age)
Systolic blood pressure >165 mmHg and/or diastolic blood pressure >110 mmHg during rest
Not an independent community ambulator
• Cannot stand for 5 minutes and walk for 10 m without an assistive device
• Score <40/56 on the Berg Balance Scale
• Score <4 on the Functional Ambulation Category
Shortness of breath or uncontrolled pain (>3/10) or if pulse oxygen drops below 92% on the six-minute walk test
Severe osteoporosis (T-score <-2 on Achilles heel bone density scan)
Presence of cognitive impairment (<25 on the Mini Mental State Exam)

5.0 Subject Enrollment

We plan to screen up to **n=523** participants, and we expect that up to 40% of participants will not meet the inclusion criteria. Potential participants who are interested in participating in the study will make contact with the research, and will then be screened over the phone to see if they meet the telephone screening inclusion/exclusion criteria. Participants who pass the in-person screening would then be scheduled for an in-person laboratory visit to complete the in-person screening protocol at Room 415, B56 or 725 of the College of Applied Health Sciences building.
We plan to enroll a total of **n=315** participants who will complete a baseline assessment and be randomly (through random number generator using excel) assigned into one of three groups. Group A will complete task-specific balance training (**n=105**), Group B will complete treadmill perturbation training (**n=105**), and Group C will complete conventional balance training (**n=105**). All groups will complete their respective trainings for 8 weeks (2x per week for a total of 16 sessions). *Detailed descriptions of each type of training are provided in section 6, "Study Design and Procedures."*

All participants' information will be recorded in a database in the form of an excel sheet that will include the information of the participants eligible and those not eligible for study. For participants not eligible for the study, the reason for withdrawal or exclusion from the study participation as per the telephone screening will be recorded. An excel file would be maintained to document the results of participants' initial telephone screening.

6.0 Study Design and Procedures

Session 1: Subject Screening & Baseline Assessment (All Groups) (3 hours):
Once included (as per inclusion criteria detailed above), all groups (A, B, and C) will undergo several clinical measures to assess their baseline function. We will measure

basic demographics such as height, weight, years of education, current medications, and race/ethnicity. We will also assess peripheral sensation, range of motion, and lower limb strength. We will also assess participant's balance control using the functional gait assessment (FGA) and the mini–Balance Evaluations Systems Test (mini-BEStest), and we will assess participant's balance confidence using the Activities-Specific Balance Confidence Scale (ABC). The in-person screening and baseline assessment will take a total of 3 hours. Details of each baseline assessment are provided below:

1) **Peripheral Sensation:** Application of 5.07 monofilament with 10g force to 10 sites on the plantar surface of foot[33,34].
2) **Range of motion**: Assessed bilaterally via electronic goniometer for lower extremity (hip, knee, ankle).
3) **Strength**: Participants asked to sit and stand from a chair as many times as possible in 30 seconds (Chair Stand Test)[35].
4) **Functional Gait Assessment (FGA):** The Functional Gait Assessment (FGA) is a clinical tool used to evaluate an individual's ability to perform various walking tasks, assessing gait stability and balance. It consists of 10 tasks that measure different aspects of gait, including walking on different surfaces, changing speed, and negotiating obstacles, with a maximum score of 30.
5) **Mini Balance Evaluation Systems Test (Mini-BESTest):** The Mini BESTest consists of 36 tasks which assess different domains of balance control such as self-initiated movements, reactive balance control, and gait. The research scores the participant on each task ranging from 0 (severe impairment) to 3 (no impairment), resulting in a percentage score out of 108 points. Higher scores indicate better performance.
6) **Activities-Specific Balance Confidence Scale (ABC):** The Activities-specific Balance Confidence (ABC) Scale is a self-reported questionnaire that assesses an individual's confidence in maintaining balance while performing various daily activities. It consists of 16 items, where respondents rate their confidence on a scale from 0% (no confidence) to 100% (complete confidence).

Sessions 2-17: Training (All Groups) (1 hour per session, 2 sessions/wk, 8 wks)

All participants will complete 8 weeks (2x/week, 16 sessions total) of an exercise intervention designed to improve their balance control, consisting of either task-specific balance training (**Group A**), treadmill perturbation-based training (**Group B**), or conventional balance training (**Group C**)**.** Each group will have 105 older adults, and participants will be randomized into groups using a random number generator (0-2) in excel. The specific components of each type of training are described below.

Task-Specific Balance Training (Group A): Participants in Group A will complete some exercises task-specific to slipping or tripping. Each session will begin with 10 minutes of warm-up/stretching exercises to prevent injury and strengthen postural muscles. Following this, participants will practice moving/controlling a slider plate with their foot on both sides, similar to how the plate will move when a slip is administered. These exercises will be completed with or without added weight on the slider plate as resistance. Additionally, participants will complete exercises where they have to stand/walk and step over an obstacle (similar to an object which they might trip over in daily life). During task-specific balance training, participants will be secured in a safety harness

attached to an overhead I-bar out of precaution to prevent the hands and knees from contacting the floor should they lose their balance. Additionally, at least one research member will be present in close proximity to the participant during training to provide assistance if needed. However, we expect that most if not all of the exercises can be performed independently. Each session of task-specific balance training will last approximately 1 hour. At least one day of rest will be required in between weekly training sessions.

Training Progression: The rate and magnitude of progression of task-specific balance training will be determined bi-weekly via the Mini Balance Evaluation System Test (Mini-BESTest), which will be completed at the baseline session to determine baseline performance and repeated biweekly. If a participant demonstrates ≥5% (≥1 point) improvement, the exercises will be progressed by dosage (repetitions) and difficulty (complexity, intensity). These progression criteria align with the established MCID for the mini-BESTest (4 points)[36].

Treadmill Perturbation-Based Training (Group B): Participants in Group B will complete reactive balance training consisting of repeated exposure to slip-like and trip-like perturbations delivered via ActiveStep treadmill (Simbex). Each session will begin with 10 minutes of warm-up/stretching exercises to prevent injury and strengthen postural muscles. During treadmill perturbation-based training, participants will be secured in a safety harness attached to an overhead I-bar out of precaution to prevent the hands and knees from contacting the floor should they lose their balance. Additionally, at least one research member will be present in close proximity to the participant during training to provide assistance if needed. Participants will be instructed about the possible occurrence of a slip or trip without being informed about their timing or nature. Participants will first receive a familiarization perturbation while walking in both the forward (slip-like) and backward (trip-like) directions, to minimize fear and the startle response. During each trial (unperturbed/perturbed, 10 seconds long), the treadmill belt will first ramp up to match the participants' self-selected gait speed. For slip/trip trials, after 8-10 regular steps, the belt will accelerate in the forward (reverse) direction (for slips) or backward direction (for trips) causing a displacement of the base of support relative to the participant's center of mass. Each participant will experience three levels (L1-L3) of perturbations (acceleration=6 m/s^2; displacement=27-91 cm) over 16 sessions (24 slips and 24 trips per session) in a progressive, ascending way to increase the likelihood of successful adaptation. The protocol follows principles of motor learning to include block and random practice (wash-out walking trials) and overlearning (continued task practice after reaching a success criterion. Each session of treadmill perturbation-based training will last approximately 1 hour. At least one day of rest will be required in between weekly training sessions.

Training Progression: On week 1, participants will start with lowest perturbation displacement level and move up to the next level by week 2 if they have < 5 falls out of 8 perturbations. By week 5, participants are expected to move to level 5 and train at that for weeks 5 to 8. If participants fail to move to the next level, they will continue on the lower level. This protocol has been previously piloted among healthy older adults, inducing adaptations in reactive balance and fall reductions [17,18].

Conventional Balance Training (Group C): Participants in Group C will complete progressive conventional balance training focused on stretching, strengthening, balance and proprioception, and endurance. Each session will begin with 10 minutes of warm-up/stretching exercises to prevent injury and strengthen postural muscles. During all exercises, participants will wear a gait belt out of precaution and at least one research member will be present in close proximity to the participant during training to provide assistance if needed. Strengthening will last for 20 min and include upper and lower limb exercises with dumbbells and therabands. Balance and proprioception exercises (20 min) are comprised of sit-to-stands, foam or rocker bottom standing, and sideways walking. Exercises will be followed by treadmill walking for 10 minutes (for endurance). Each session of conventional balance training will last approximately 1 hour. At least one day of rest will be required in between weekly training sessions.

Training Progression: The rate and magnitude of progression during conventional balance training will be determined biweekly by the timed-up and go test (TUG) and four-square step test (FSST), which are used to assess functional mobility and fall risk. During the TUG, participants are timed as they are asked to stand quickly from a chair, walk 3 meters, and sit back in the chair. During the FSST, participants are timed as they step forward, sideways, and backwards over low obstacles as quickly as they can. If a participant demonstrates ≥2 second improvement on the TUG OR ≥1 second improvement on the FSST, then training will be progressed by dosage (repetitions) and difficulty (complexity, intensity). These progression criteria were selected based on the established MCIDs for the TUG (8 seconds) and FSST (4 seconds)[37,38].

Vital monitoring (All groups): During training for all groups, we will monitor heart rate and heart rate variability using a Polar ProTrainer 5 RS 800CX GPS monitor. Rated Perceived Exertion (Borg Scale) will be used to determine the exertion and fatigue level at least every 10 minutes, and we will also monitor blood pressure at least every 10 minutes during training.

Workload: NASA TLX visual analog scale will be used to determine the perceived physical and mental load during training, about every 10 minutes. This score will be collected on an ipad/iphone and the data will be exported in the form of a .csv file.

Session 18: Immediate Post-Training Assessment (All Groups) (2 hours)

Within one week after completing their final session of training (session 17), all participants will return to the laboratory to complete a post-training assessment of their volitional and reactive balance control. The immediate post-training assessment will take about 2 hours.

Volitional Balance Assessment: Immediately post-training, all groups will repeat the Functional Gait Assessment (FGA) (details of this test listed under session 1) to assess their volitional balance control. We will also assess participant's balance confidence using the activities-specific balance confidence scale (ABC) (details of this test also listed under session 1).

Reactive Balance Assessment: Immediately post-training, all groups will complete an overground slip and trip test to assess their reactive balance control.

- ***Prep-up:*** During the reactive balance assessment, participants will be set-up with a body harness and reflective marker set. Electromyography (EMG) sensors will be placed on 8 locations (Tibialis Anterior, Medial Gastrocnemius, Quadriceps, and Hamstrings of both legs). This will measure the muscle responses to perturbations.
- ***Overground Slip and Trip Test:*** Participants will be asked to walk on an overground walkway (mounted on force platforms). After at least three regular walking trials, an unannounced slip will randomly be induced under either limb (to increase unpredictability) by electro-mechanical release of a moveable low-friction platform (for slips, slides 90 cm), and an unannounced trip will be delivered by unexpected release of a horizontal plate into upright position (8 cm height). These trigger devices are camouflaged and embedded in the walking path[39]. The order of the slip and the trip will be randomized for each participant. Participants will be informed that a slip or trip may or may not occur on any trial, but will not be informed when/how the slip/trip will occur or on which side. All participants will wear a safety harness during the overground slip test which prevents their arms, knees, head, and trunk from contacting the ground should they experience a fall.
- Vitals (heart rate, blood pressure, rating of perceived exertion – see details under training) and perceived workload (also see details under training) will also be collected at least every 5-8 trials during the reactive balance assessment.

Session 19: Booster Training Session (All Groups) (1 hour)

6 months after the completion of the final session of training (session 17), all groups will receive a **single-session booster dose** of their respective training (Group A: task-specific balance training; Group B: treadmill perturbation-based training; Group C: conventional balance training). The booster dose will consist of one, 1 hour session which is a repeat of their final (16^{th}) training session. Previous studies have indicated that the addition of a booster session can significantly aid in long-term retention and prevention of motor decay of fall-resisting skills, particularly in older adults [13,15]. *The booster training session is optional, and participants can opt-out of receiving the booster training session on the consent form if they wish.*

Session 20: 18-month Post-Training Assessment (All Groups) (2 hours)

18-months post-completion of the final training session (session 17), all groups will return to the laboratory to reassess their volitional and reactive balance control. The 18-month post-training assessment will consist of the same protocols/assessments as the immediate post-training session (*refer to session 18 protocol*), including the volitional balance assessment (FGA) and reactive balance assessment (overground slip and trip test). We will also re-assess participants' balance confidence using the ABC. The 18-month post-training assessment will take about 2 hours. *The 18-month post-training assessment is optional, and participants can opt-out of returning to the lab for this session on the consent form if they wish.*

18 Months Prospective falls tracking and ActiGraph monitoring (All Groups)

Self-reported falls (All Groups): Per Prevention of Falls Network Europe (ProFane) recommendations[40], falls will be recorded using prospective weekly recording via an electronic fall diary set up using REDCap (Research Electronic Data Capture) system. Participants will get a weekly text on their phone asking them if they had a fall or not in the past 7 days. A fall will be defined using lay terminology. The text will read "have you had any falls in the past 7 days including a slip or trip in which you lost your balance and landed on the ground or floor? If you wish to stop receiving these text messages, please reply STOP". If participants respond "No", the entry will be recorded in the REDCap database along with the date and time. If they respond "Yes", they will receive a phone call within 72 hours from the research team to document fall circumstances via a survey. The fall survey includes questions about the circumstances surrounding a fall, including environmental factors, type of fall, perceived cause, and injury description. If participants reply STOP and wish to stop receiving text messages, we will stop sending them weekly texts and will follow up within 72 hours via phone call to inquire if they wish to continue participating in the study or change their method of contact.

Participants who do not have a phone that can receive text messages can still be included in the study, and we will instead give them paper copies of fall logs for prospective falls tracking. Specifically, participants will be given paper copies of the fall logs and survey, with pre-stamped and pre-addressed envelopes to mail in to the lab monthly. If participants do not send the falls questionnaires back 2 consecutive times, we will call them to follow up. Even participants who have text messaging may also choose to use mail-in fall logs instead of texting if they prefer. Thus, participants will be given an option on the consent form to indiciate whether they wish to complete prospective falls monitoring via text message or via mail in logs.

The 18 months prospective falls tracking is optional, and participants may opt-out of receiving both text messages and mail-in fall logs on the consent form if they wish.

ActiGraph Monitoring (All Groups): The ActiGraph sensor allows prospective (18 months) physical activity data (# of steps, gait speed, and distance) and fall data collection. For participants who opt-in to wear the ActiGraph for 18-month monitoring, self-fall recording will be supplemented with ActiGraph. We will provide the ActiGraph again to participants on their last training session (session 17) along with the reminder about how to wear the sensor and charge it[41-46]. For those who opt-in to upload their own data from the ActiGraph at home, we will provide them with an additional educational session about how to sync data to the cloud-based system. The research personnel will download the centerpoint mobile application on the participant's phone (for participants with smartphones) and help them create a profile with the required personal information. The ActiGraph watch will be connected to their phone via Bluetooth. The participant will be asked to ensure that their Bluetooth is on for the real-time data to sync to the cloud system. The website *https://actigraphcorp.com/cpiw/* shows how the watch can be connected to the mobile phone. Participants who do not have a smartphone or request for us to upload their data for them will be requested to

visit the lab for data upload once every month. If they do not want to continue wearing the ActiGraph, they would be requested to return the watch to the research team.

All Actigraph data will be uploaded to our secured server for further analysis. Consistent with best practices, telephone interviews (biweekly) will be used to rectify missing data and details regarding fall circumstances[40,47]. A sooner phone follow-u*p will occur for non-compliant subjects (no response to the weekly fall question texts on >2 weeks)*.

The ActiGraph company will have access to the raw data generated by their wearable sensor (e.g., number of steps, wear time, sleep time) while the study is active. This data will not contain any identifying information, as we will keep track of participants using only their subject number in the Centerpoint mobile application. After the study is closed in ActiGraph, the data will be moved to their archives, where it will no longer be accessible.

Wearing the ActiGraph sensor for 18-months is optional, and participants may opt-out of wearing the ActiGraph sensor on the consent form if they wish.

Compensation

Participants will be compensated at the end of every study visit in cash in a pro-rated amount, even if they do not complete the entire study. For the initial screening and baseline clinical assessment, all groups (A,B,C) will receive $30. Participants will receive this compensation even if they are not eligible for the study after the initial screening. During training, participants will receive $10 per training session, for a total of $160 if they complete all 16 training sessions. Participants will also receive $10 for completing the booster training session. Participants will receive $20 each for the immediate post-training assessment and 18-month post-training assessment. Participants in all groups will also have the opportunity to upload their physical activity data (obtained via Actigraph) for $10 per monthly upload, up to 18 months of uploads ($180 total). Participants will receive the compensation for monthly physical activity uploads when they come to the lab for their booster training dosage (after 6 months) and for their 18-month post training assessment. All groups will have the possibility of receiving up to $420 if they complete all aspects of the study. A summary of study compensation is provided in the table below.

Session Type	Frequency	Compensation	Total
Initial Screening & Baseline Assessment	1	$30	$30
Training	16	$10	$160
Immediate Post-Training Assessment	1	$20	$20
Booster Training Dose	1	$10	$10
18-month Post-Training Assessment	1	$20	$20
Physical Activity Data Uploads	18	$10	$180
		Total Compensation Possible = $420	

Outcome Measures

The primary outcomes for Aim 1 will be laboratory falls, reactive stability, and limb support on the overground slip and trip test. Laboratory falls induced on overground slips and trips will be quantified from the load cell data and verified by video recording[48]. Falls will be identified if the peak loadcell force is ≥ 30% of body weight[48]; otherwise, the trial will be classified as a recovery[48]. Reactive stability: Reactive stability at post-perturbation recovery foot touchdown will be computed as the shortest distance of the COM state (relative BOS) to the extensively validated computational thresholds of stability limits for backward (slips) and forward balance loss (trips)[39,49-53]. Values < 0 (slips) or > 1.2 (trips) indicate instability and between 0 and 1.2 indicate greater stability against both slips and trips [54]. Limb Support: Limb support will be quantified by hip height (Z_{hip}) obtained as the vertical distance of the bilateral hip midpoint to the surface of the platform, and then normalized to body height [25,55,56]. Minimum hip height and its change from pre- to post-perturbation will be extracted. We will compare differences in Aim 1 outcomes between Groups A, B, and C immediately post-training (to examine immediate improvements) and 18-months post-training (to examine 18-month retention).

The primary outcome for Aim 2 will be the functional gait assessment (FGA). We will compare performance on the FGA between Groups A, B, and C immediately post-training (to examine immediate improvements) and 18-months post-training (to examine 18-month retention). We will also examine within-group improvements by comparing performance pre- and post-training.

The primary outcome for Aim 3 *will be the 18-month retention of outcomes from Aim 1 (laboratory falls, reactive stability, limb support) and Aim 2 (FGA)* ***and real-life falls***. The secondary outcome for Aim 3 will be balance confidence via the Activities-Specific Balance Confidence Scale (ABC). We will compare rates of real life falls between Groups A, B, and C over 18 months post-training, and compare immediate and retained improvements in ABC scores.

Aim 4 will be an exploratory aim to determine if task-specific training results in neuromuscular adaptation that produces optimal muscle synergies during both unperturbed and perturbed walking for fall prevention. Using data from Dr. Bhatt's previous clinical trial (R01AG050672), we will select overground slip trials in which older adults demonstrate successful adaptation to overground perturbation training, and examine if task specific training can produce similar synergies post-training. **The primary outcome for Aim 4** ***will be the correlation (r value) between reconstructed optimal muscle synergies and the post-training experimental muscle synergies from Groups A-C.***

7.0 Expected Risks/Benefits

Potential Risks:

Overground Slip and Trip Tests (All Groups), Treadmill Slips and Trips (Group B – Treadmill Perturbation-based Training): During the overground and the treadmill perturbations, there is a slight risk of falls and injury (e.g., a muscle pull at shoulder, leg,

or back). To prevent falls, all the participants will wear a full-body protected harness to prevent any part of the body other than the feet contacting the ground. The harness has adjustable shoulder and leg straps, and will be attached to an overhead trolley that will allow the participants to perform movements freely having neither the knees nor hands touching the treadmill belt/force platform. During the past several years, in more than 500 experimental sessions for both young and older adults conducted by the research team, similar harness systems have successfully protected subjects from injury following induced slips and trips during standing or walking tasks. The harness system incorporates a number of safety features designed to limit the peak forces applied to the body, thereby minimizing the risk of injury upon a fall into the harness. The full-body harness is padded and provides support over a large contact area (>1500 cm^2), primarily in regions that are able to withstand larger forces without injury (*i.e.* the pelvis and buttocks). Shoulder suspension of the harness provides protection against both forward and backward falls, with negligible risk of straps entanglement. Finally, the extent of body descent before harness assistance begins is limited (15 cm on average) and very carefully calibrated and controlled. Our calculations indicate that, during a worst-case fall into the harness, an individual who weighs 1000 N would be subjected to a peak pressure of < 0.3 MPa, well below the stress threshold for even a moderate muscle contusion (1.9 MPa), requiring no medical treatment. Participants in Group A will also wear the safety harness during task-specific training out of caution, even though most exercises can be performed independently.

Training sessions (All Groups): The initial training sessions may cause some muscle soreness and discomfort in the lower limbs which may result in increased pain during the first week of training, which will then be settled once the training sessions progress.

Preventing injury during slip and trip tests/treadmill-perturbation training: All participants will undergo a series of stretching and warm-up exercises at the start of the sessions. A physical therapist or an exercise specialist on the team will conduct these procedures. Stretches will encompass all major muscle groups of the lower limbs and trunk. Warm-ups include activities such as walking, lunges, squats, high stepping and chair rise. To protect the safety of all participants during the overground and treadmill slips and trips, all participants will wear a full-body safety harness at all times to prevent their arms or knees from contacting the ground should they experience a fall. There will also be at least one research assistant standing by the participant during all slip and trip trials to guard them and provide assistance should they experience a fall. Additionally, we will have participants wear a heart rate monitor which will constantly monitor their heart rate (Polar ProTrainer 5 RS 800CX GPS). If heart rate ever exceeds the normal limits (i.e., 85% of age-predicted maximal heart rate), the session will immediately be terminated and the participant will be asked to sit down until their heart rate returns to normal limits. Additionally, we will use a blood pressure monitor to monitor blood pressure after every slip and trip trial, and after every 5-8 walking trials. If systolic blood pressure exceeds 20 mmHg of the resting state or diastolic blood pressure exceeds 15 mmHg of the resting state, the session will immediately be terminated and the participant will be asked to sit down until their blood pressure returns to normal limits. We will also ask participants to provide their rating of perceived exertion on the Borg Scale after every slip and trip trial,

and after every 5-8 walking trials. If participants feel extremely tired (i.e., ≥15 on the Borg Scale), it would indicate that the intensity of the physical activity was high and the participant would need to sit down and rest. Additionally, participants will be asked to inform the experimenter about any symptoms including marked breathlessness, excessive sweating, pain in chest, or fatigue. The research personnel will observe for any changes in participant's facial expression indicating anxiety or discomfort. In case of any discomfort, the session will be terminated, and the time of the training session will be noted. All participants will additionally receive a rest break after 30 minutes and given a chair to sit down in. Additionally, participants will be called 2 days after their testing sessions to determine if there were any symptoms or discomfort due to the testing session. At this time, they would be asked to confirm that no outside injury/ accident/falls have taken place in the event they report any pain or soft tissue injury/ sprain/strain. These precautionary features have evolved through a decade of research to prevent falls and injuries.

All participants, regardless of group, will follow the same safety procedures during the slip and trip tests. These safety procedures are designed to provide the highest level of safety to all participants, regardless of their group classification and prior training.

Preventing injury during testing and training sessions: Blood pressure and heart rate will be monitored prior to and throughout the testing and training sessions. Participants will be given a chair to sit back after approximately 30 minutes or if he/she feels tired (i.e., ≥ 15 on Borg scale for perceived exertion) or if the blood pressure is beyond normal limits (i.e. > 85% of age-predicted maximal heart rate). More than or equal to 15 on the Borg scale of perceived exertion indicates that the intensity of the physical activity performed was high and that it gives an idea to the research personnel that the participant would need to slow his movements down. Additionally, if at any point the heart rate or blood pressure drops or rises above the pre-determined acceptable limits, the session will be terminated. Participants will be asked to inform the experimenter about any of the symptoms including marked breathlessness, excessive sweating, pain in chest, or fatigue. The research personnel will observe for any changes in participant's facial expression indicating anxiety or discomfort. In case of any discomfort, the session will be terminated, and the time of the training session will be noted. The proposed setup incorporates several precautionary features, evolved through a decade of research, against such injuries. To further reduce the risk of injury, all subjects will undergo a series of stretching and warm-up exercises at the start of the experiment and training. A physical therapist or an exercise specialist on the team will conduct these procedures. Stretches will encompass all major muscle groups of the lower limbs and trunk. Warm-ups include activities such as walking, lunges, squats, high stepping and chair rise.

Abnormal Findings: There is a possibility that we will find significant cognitive decline, high blood pressure, or osteoporosis in participants. If we observe any clinically significant findings regarding cognitive decline, blood pressure, or osteoporosis (or any other life-threatening findings), we will immediately inform participants, provide them with a copy of their cognitive scores/blood pressure/osteoporosis screening, and advise them to follow up with their physician to have appropriate medical evaluation. If any of

these was cause for exclusion, we will inform them and discuss why they have been excluded from the study. The measures in this study will only be considered for research purposes and are not used for treating or diagnosing any medical condition.

Emergency Contact/Physician Information: While signing the consent form, participants will have the opportunity to provide the contact information for their emergency contact or primary physician, and can opt in or out of us contacting their emergency contact or physician in the case of an unexpected event or emergency. We will not directly share the scores of clinical tests (cognitive, blood pressure, osteoporosis) with the participant's emergency contact or physician unless directly relevant in the emergency situation. However, participants will be encouraged to share their test scores with their physician if anything abnormal is noticed by the research team.

Potential Benefits:
We expect no direct benefits from participating in this study. If participants demonstrate no gains, the testing and intervention sessions offered will maintain their optimal physical functioning and not result in any deterioration.

8.0 Data Collection and Management Procedures

The overall goals of data management are to ensure: 1) that the collected data is properly documented and accurately entered; 2) the confidentiality of the subject data is maintained giving access to the primary investigators for retrieving data and exporting to statistical packages. Prior to data collection and entry, a codebook will be created which will contain the variable names, descriptions, and value codes of each variable/item collected during the study. Following development of the codebook, a database will be created in Microsoft Excel to facilitate data entry. The program permits logic checks on input and checks for invalid entries. One research staff member will enter all data separately, and another researcher will verify the data entry to identify any mismatching data values, variable names, or observation numbers thus, to eliminate data entry errors. Several data quality checks will also be conducted, including descriptive statistics and graphic plots to detect outliers and influential observations. All computer data will be stored in a password-protected network server with back-up scheduled every midnight. The network server is managed by UIC Applied Health Sciences (*\\uicfs.server.uic.edu\AHS-PT1 or AHS-PT2*). Data coding keys will be stored in a separate file from the data. The original raw data will be stored in a locked cabinet accessed only by key project personnel. Only the Principal Investigator and one research team member have the access key, and there are no duplicate keys. The motion analysis data will also be backed up on a portable hard drive and stored in a locked cabinet accessed only by key project personnel.

Each laboratory session will be recorded with a video camera system for further analysis of body responses. The 3D motion cameras will detect small ball-shaped markers that is placed on different parts of the body, including the feet,

ankles, knees, hips, shoulders, elbows, and wrists to represent body movement. Only the investigators related to this project will have access to these files. The videotape or its reproduction may be used for research purposes such as publication in scientific journals or presentations at educational or scientific meetings and teaching purposes in the future. All of the videos are taken from the side and back, where no facial feature will be identifiable. Thus, the participant would not be recognizable by a stranger without other identification from the record.

All the files will be destroyed along with the videotape of the experiment 2 years after completion of the entire project, at which point all data will become de-identified.

Adverse Event and Serious Adverse Event Collection and Reporting

An adverse event is defined as an undesirable and unintended result of therapy, intervention or interaction experienced by a subject participating in a research study. We will monitor adverse events, reported by participants during the intervention and maintenance phases of the study and as reasons for drop out. All field staff who work directly with participants will be required to notify the PIs of any unanticipated problems/adverse events immediately upon discovery. If an adverse event is recorded during the intervention session the session will be concluded and the event reported to their physician and to the investigators.

Participants who report the event will notify the University IRB. The PIs will immediately notify the appointed Safety Officer (Radhika Sreedhar, MD, MS) and the University Institutional Review Board.

The relationship of the adverse event as not related, possibly related or definitely related will be determined using standard criteria for clinical trials and any additional guidelines used/ developed by the Safety Officer and the University Institutional Review Board.

<u>Possible - to qualify, the adverse event must meet 2 of the following conditions:</u>
1) Has a reasonable temporal relationship to the intervention,
2) Could not readily have been produced by the subject's clinical state,
3) Could not readily have been due to environmental or other interventions,
4) Follows a known pattern of response to intervention,
5) Disappears or decreases with reduction in cessation of intervention.

<u>Probable - to qualify, the adverse event must meet 3 of the following conditions:</u>
1) Has a reasonable temporal relationship to the intervention,
2) Could not readily have been produced by the subject's clinical state,
3) Could not readily have been due to environmental or other interventions,
4) Follows a known pattern of response to intervention
5) Disappears or decreases with reduction in cessation of intervention.

Definite - to qualify, the adverse event must meet at least 4 of the following conditions:
1) Has a reasonable temporal relationship to the intervention,
2) Could not readily have been produced by the subject's clinical state,
3) Could not readily have been due to environmental or other interventions,
4) Follows a known pattern of response to intervention,
5) Disappears or decreases with reduction in cessation of intervention

9.0 Data Analysis

All the data analysis will be performed at 1919 W Taylor St. Room 415 or B-56 using the SPSS Inc. (Armonk, NY). Also, see the section “Statistical Considerations”.

10.0 Quality Control and Quality Assurance

For quality control and assurance, all the study related procedures will be performed by trained and experienced personnel. All research personnel will take the CITI and HIPAA training courses along with regular training to ensure safety of the custom designed equipment. The raw data will be checked by the PI immediately after data collection.

11.0 Data and Safety Monitoring

There will be a data and safety monitoring plan in place monitored by the research team itself, as well as monitoring by the appointed safety officer (Radhika Sreedhar, MD, MS).

Monitoring by research team:
The goals of data management are: (a) to ensure that data collected during the study are properly and accurately entered and documented; (b) to ensure that data will be stored in an electronic format that will allow the primary investigators of the project to retrieve data easily and to export data to statistical packages; and (c) to ensure the confidentiality of subjects. **(*See details under Data Collection and Management Procedures)*.**

For monitoring subject safety during the assessment and training sessions: Subjects will be asked whether they are feeling any pain or any kind of distress at regular intervals. Subjects’ heart rate and blood pressure will be monitored every 5-8 trials, immediately after slip or trip exposure, and/or after ~10 minutes. The experiment will be stopped if HR >85% of age predicted maximum, systolic BP exceeds > 20 mmHg of the resting state, or if the diastolic BP exceeds > 15 mmHg from the resting state. There will always be two people in the experiment area to assist the subject if required. There is always a first aid kit available in the lab for use in case of any minor injury. We also have an AED for emergencies and at least one of the investigators during any experiment will be AHA-BLS (American Heart Association - Basic

Life Support) certified for health care providers. In addition, we do regular harness checks to ensure that it is not damaged. Also, the subjects will be called 2 days after each of their test sessions to determine if there were any symptoms or discomfort due to the test session.

Monitoring by the Safety Officer:

The appointed Safety Officer (Radhika Sreedhar, MD, MS) will monitor the implementation of the research protocol to ensure protection of subjects and data. The Safety Officer will meet with the PI quarterly to discuss issues related to recruitment, data collection and quality, and compliance of intervention(s). The Safety Officer will provide guidance and oversee study activities.

The Safety Officer will:

- Monitor the progress of trial and the safety of subjects
- Monitor and provide guidance for assuring data accuracy and protocol compliance
- Report unanticipated problems involving risks to subjects or others as well as adverse events, to the IRB, and NIH, if applicable
- Review on a regular basis the accumulated research data from the ongoing study
- Advise the sponsor and the PI regarding the continuing safety of study subjects and those yet to be recruited into the research trial
- Advise the sponsor and the PI as to the continuing validity and scientific merit of the trial.

12.0 Statistical Considerations

A between-groups analysis of covariance (ANCOVA), controlling for likely covariates and risk factors as well as demographic variables that are found imbalanced among the experimental groups in spite of randomization, will compare the difference in stability and limb support (on overground slip and trip tests) amongst Groups A, B & C. For laboratory falls, we will treat the fall outcome as a binary variable (fall: 1 and no-fall: 0). We will use chi-square test and multivariable logistic regression to compare slip and trip-specific falls, and total falls amongst Groups A, B & C. We will utilize Mixed-effects ANCOVA to assess the training effects on the FGA among Groups A, B, and C. The mixed-effects model is a combination of a between-groups ANCOVA (Groups A, B & C) and a within-groups ANCOVA (pre- and post-training). Mixed-effects ANCOVA model (for stability, limb support and FGA) and the generalized estimating equation (GEE) model (for lab falls incidence) accounting for within-subject covariance across time will be used to detect the retention effect 18 months after initial training. For real-life falls (which is not a repeated outcome), we will employ simple Chi-square test and multivariable logistic regression (if covariates control is needed) to determine if such training effect can be translated into everyday real-life setting. We will treat real-life falls during the 18 months as a binary outcome (yes or no). Pearson correlation coefficients (r) will be calculated to

analyze the similarities between optimal synergies and post-training synergies recruited in Groups A, B & C. Specifically, we will compare both the spatial structure and the time-varying temporal component of the muscle synergies between the optimal muscle synergies and experimental muscle synergies for each group.

13.0 Regulatory Requirements

13.1 Informed Consent

Participants will be invited to the laboratory on passing the phone screening. Those who are eligible and elect to participate will be provided with a written informed consent document (approved by the University of Illinois at Chicago IRB). Consent will then be obtained by trained research coordinators. The informed consent document and telephone screening document will be stored in a cabinet under lock and key located in AHS B-56, as they contain identifiable subject information. This locked cabinet will not contain any other data collection forms which have been collected using the subjects assigned alphanumerical code, to protect subject confidentiality and avoid linking the coded data to the identifiable information. Only the PI (Dr. Tanvi Bhatt) and one research team member will keep the key to this locked cabinet, and only active members of the research team will be able to access the completed informed consent forms and telephone screening forms upon PI approval.All study participant documents will be available in English. The consent form will explain all procedures, risks, and benefits of the study. The study subject will communicate their intention to leave the study clearly to any study staff personnel, and their confidentiality will not be breached. Subjects will receive a signed copy of the informed consent document upon request.

13.2 Subject Confidentiality

Subjects' confidentiality would be maintained as all data will be collected and stored using a subject specific, unique alpha-numeric code that is assigned at the time of enrollment. All study records will be kept confidential by using this numerical code. A participant will not be identified personally in any report of the results. We will keep the identifying information (screening documents, consent form) at a centralized single location which will be locked and it will be destroyed 2 years after the completion of the entire project, at which point all data will become deidentified. Only key research personnel of the research team will have access to the raw data. This research doesn't involve the use and disclosure of protected health information. Participants would be consented regarding usage of their videotapes in conference or for educational purposes.

We will also keep the screening documents for participants who have failed the screening and were not included in the study, in order to maintain accurate records of how many potential participants were excluded from the study, and for what reasons. These documents will be kept in the same locked cabinet as the

identifiable information for included participants (as mentioned above), and separated from any and all coded data, to protect subject confidentiality.

13.3 Unanticipated Problems

Any unanticipated problems will be reported to the IRB by submitting a “Prompt Report” form.

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APPENDICES

Trial Record Sheet		
Subject ID: **Subject Number:**		
Date:		
Trial	**Type**	**Notes**
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Demographics

1. Sex: ☐ M ☐ F

2. Weight: _____

3. Height: _____

4. Dominant leg:_____ Dominant hand: _____

5. ASIS Width: _____

6. Knee width (largest girth): _____

7. Ankle width (malleolus to malleolus): _____

8. Sacrum marker to L3/L4 Length: _____

9. BP: _____

10. HR: _____