UNEXPECTED PERTURBATIONS TRAINING IMPROVES BALANCE CONTROL AND VOLUNTARY STEPPING TIMES IN OLDER ADULTS – A DOUBLE BLIND RANDOMIZED CONTROL TRIAL

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Background: Falls are common among elderly, most of them occur while slipping or tripping during walking. We aimed to explore whether a training program that incorporates unexpected loss of balance during walking able to improve risk factors for falls.

Methods: In a double-blind randomized controlled trial 53 community dwelling older adults (age 80.1±5.6 years), were recruited and randomly allocated to an intervention group (n = 27) or a control group (n = 26). The intervention group received 24 training sessions over 3 months that included unexpected perturbation of balance exercises during treadmill walking. The control group performed treadmill walking with no perturbations. The primary outcome measures were the voluntary step execution times, traditional postural sway parameters and Stabilogram-Diffusion Analysis. The secondary outcome measures were the fall efficacy Scale (FES), self-reported late life function (LLFDI), and Performance-Oriented Mobility Assessment (POMA).

Results: Compared to control, participation in intervention program that includes unexpected loss of balance during walking led to faster Voluntary Step Execution Times under single (p = 0.002; effect size [ES] =0.75) and dual task (p = 0.003; [ES] = 0.89) conditions; intervention group subjects showed improvement in Short-term Effective diffusion coefficients in the mediolateral direction of the Stabilogram-Diffusion Analysis under eyes closed conditions (p = 0.012, [ES] = 0.92). Compared to control there were no significant changes in FES, LLFDI, and POMA.

Conclusions: An intervention program that includes unexpected loss of balance during walking can improve voluntary stepping times and balance control, both previously reported as risk factors for falls. This however, did not transferred to a change self-reported function and FES.

Trial registration: ClinicalTrials.gov

Registration number: NCT01439451.

AGE INFLUENCES THE OUTCOME OF A SLIPPING PERTURBATION DURING INITIAL BUT NOT REPEATED EXPOSURES

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Background: Fall incidence in older adults might be reduced through learning to better recover from or adjust to perturbations. Extents of age-related declines and limitations in the ability to recover are not well established.

Methods: Slips were induced, using bilateral low-friction platforms, during a sit-to-stand task in 60 young and 41 older, healthy, safety-harnessed adults. Subjects underwent five slips, a block of non-slipping trials, then two re-exposures to the slip. The first slip was novel and unexpected. Age-group and trial effects on fall incidence (evidenced by excessive hip descent) and on the direction of the initial protective step were examined.

Results: More older than young adults fell upon the first slip (73% vs 28%;$p < .001$). With repeated exposure, fall incidence decreased at similar exponential rates in both age groups. All but one subject eventually learned to slip without falling, and two-thirds of fallers fell only once. Repeat fallers fell without stepping in 63% of falls. Upon later slip re-exposure, more older than young adults fell (20% vs 2%), but fewer falls occurred than did originally ($p = .001$). Likelihoods of forward and backward stepping during successful recovery changed with repeated slip exposure and upon re-exposure, but did not differ between age groups.

Conclusions: Older adults are more likely to fall upon initial, unexpected perturbation exposure, but, upon repeated exposure, healthy young and older adults rapidly learn to avoid falling at a similar rate. Healthy older adults appear fully capable of learning to better recover from or adjust to a perturbation through repeated exposure.

EFFECT OF A PERTURBATION-BASED BALANCE TRAINING PROGRAM ON COMPENSATORY STEPPING AND GRASPING REACTIONS IN OLDER ADULTS: A RANDOMIZED CONTROLLED TRIAL

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Background: Compensatory stepping and grasping reactions are prevalent responses to sudden loss of balance and play a critical role in preventing falls. The ability to execute these reactions effectively is impaired in older adults.

Objective: The purpose of this study was to evaluate a perturbation-based balance training program designed to target specific age-related impairments in compensatory stepping and grasping balance recovery reactions.

Method: This was a double-blind randomized controlled trial. The study was conducted at research laboratories in a large urban hospital. Thirty community-dwelling older adults (aged 64–80 years) with a recent history of falls or self-reported instability participated in the study. Participants were randomly assigned to receive either a 6-week perturbation-based (motion platform) balance training program or a 6-week control program involving flexibility and relaxation training.

Features of balance reactions targeted by the perturbation-based program were: (1) multi-step reactions, (2) extra lateral steps following anteroposterior perturbations, (3) foot collisions following lateral perturbations, and (4) time to complete grasping reactions. The reactions were evoked during testing by highly unpredictable surface translation and cable pull perturbations, both of which differed from the perturbations used during training.

Results Compared with the control program, the perturbation-based training led to greater reductions in frequency of multi-step reactions and foot collisions that were statistically significant for surface translations but not cable pulls. The perturbation group also showed significantly greater reduction in handrail contact time compared with the control group for cable pulls and a possible trend in this direction for surface translations.

Conclusion Perturbation-based training shows promise as an effective intervention to improve the ability of older adults to prevent them from falling when they lose their balance.

DOES PERTURBATION-BASED BALANCE TRAINING PREVENT FALLS? SYSTEMATIC REVIEW AND META-ANALYSIS OF PRELIMINARY RANDOMIZED CONTROLLED TRIALS

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Background: Older adults and individuals with neurological conditions are at an increased risk for falls. Although physical exercise can prevent falls, certain types of exercise may be more effective. Perturbation-based balance training is a novel intervention involving repeated postural perturbations aiming to improve control of rapid balance reactions.

Objective: The purpose of this study was to estimate the effect of perturbation-based balance training on falls in daily life.

Data Sources: MEDLINE (1946–July 2014), EMBASE (1974–July 2014), PEDro (all dates), CENTRAL (1991–July 2014), and Google Scholar (all dates) were the data sources used in this study.

Study Selection: Randomized controlled trials written in English were included if they focused on perturbation-based balance training among older adults or individuals with neurological conditions and collected falls data post-training.

Data Extraction: Two investigators extracted data independently. Study authors were contacted to obtain missing information. A PEDro score was obtained for each study. Primary outcomes were proportion of participants who reported one or more falls (ie, number of "fallers") and the total number of falls. The risk ratio (proportion of fallers) and rate ratio (number of falls) were entered into the analysis.

Data Synthesis: Eight studies involving 404 participants were included. Participants who completed perturbation-based balance training were less likely to report a fall (overall risk ratio=0.71; 95% confidence interval=0.52, 0.96; P=.02) and reported fewer falls than those in the control groups (overall rate ratio=0.54; 95% confidence interval=0.34, 0.85; P=.007).

Conclusions: Perturbation-based balance training appears to reduce fall risk among older adults and individuals with Parkinson disease.

IS IMPAIRED CONTROL OF REACTIVE STEPPING RELATED TO FALLS DURING INPATIENT STROKE
REHABILITATION?

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PhD. Neural Repair (2013); 27 (6) 526-533

Background: Individuals with stroke fall more often than age-matched controls. Although many focus on the
multifactorial nature of falls, the fundamental problem is likely the ability for an individual to generate
reactions to recover from a loss of balance. Stepping reactions to recover balance are particularly important
to balance recovery, and individuals with stroke have difficulty executing these responses to prevent a fall
following a loss of balance.

Objective: The purpose of this study is to determine if characteristics of balance recovery steps are related
to falls during inpatient stroke rehabilitation.

Methods: We conducted a retrospective review of individuals with stroke attending inpatient rehabilitation
(n = 136). Details of falls experienced during inpatient rehabilitation were obtained from incident reports,
nursing notes, and patient interviews. Stepping reactions were evoked using a "release-from-lean" postural
perturbation. Poisson regression was used to determine characteristics of stepping reactions that were
related to increased fall frequency relative to length of stay.

Results: In all, 20 individuals experienced 29 falls during inpatient rehabilitation. The characteristics of
stepping reactions significantly related to increased fall rates were increased frequency of external
assistance to prevent a fall to the floor, increased frequency of no-step responses, increased frequency of
step responses with inadequate foot clearance, and delayed time to initiate stepping responses.

Conclusions: Impaired control of balance recovery steps is related to increased fall rates during inpatient
stroke rehabilitation. This study informs the specific features of stepping reactions that can be targeted with
physiotherapy intervention during inpatient rehabilitation to improve dynamic stability control and
potentially prevent falls.

PERTURBATION TRAINING WHILE WALKING IMPROVES BALANCE CONTROL AND VOLUNTARY STEPPING PARAMETERS IN COMMUNITY DWELLING ELDERS: A RANDOMIZED CONTROL TRIAL

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Introduction: Age-related deterioration of gait and balance increases the risk of falls. Fall related injuries are a serious public health problem in terms of the high costs to society and in terms of human suffering. To this date most fall prevention training programs did not include perturbation training while walking in their training protocol and, thus, ignored the important aspect of training postural recovery reactions during gait. We propose a novel training program using an innovative Balance Measure and Perturbation system (BaMPer system) that combines unexpected perturbation of balance during walking.

Aim: To evaluate the effect of perturbation training while walking on balance and voluntary step functions in independent older adults. We hypothesized that the novel training program can improve balance while standing as well as during voluntary stepping and decrease the fear of falling.

Method: In a randomized controlled trial of 57 elderly persons. The intervention group received 24 training sessions over three months that included unexpected perturbations during treadmill walking. The level of perturbations during the training was progressed according to the patient's abilities to cope with unexpected perturbation of balance during walking. The control group received similar intervention including dual task exercises while walking but with no perturbations. Postural stability in upright standing (e.g. ML sway, AP sway, sway velocity and sway area) and voluntary step during single and dual task conditions (e.g. step reaction and step times) were evaluated using a force plate (Kistler Ltd) before and after the intervention period.

Results: Forty volunteers completed the 12 week training program (twice a week for 20-30 minutes each workout) with seventeen drop outs (9 in the experimental and 8 in the controls). Results show significant improvement among both experimental and control group subjects. The experimental group showed significant improvement compare with the control group in: postural sway parameters especially in the eyes closed condition and voluntary step execution times in both single and dual task conditions. Compensatory stepping reactions during walking and during standing and fall rates in the following year are currently analyzed.

Conclusions: Current results are promising, suggesting that significant benefits can be achieved using a specific and personally tailored training program that includes unexpected perturbations of balance while walking. This training program can improve several markers of balance control, parameters previously found to be related to increased risk of falls and injury in older adults. Those benefits could not be attributed to walking alone and even to walking while preforming a secondary cognitive task. The importance of the specificity of a prevention training program is thus shown. Further work is needed to determine whether a maintenance training program would help retain the training effects and to assess whether these benefits reduce falls in daily life.

DO MEASURES OF REACTIVE BALANCE CONTROL PREDICT FALLS IN PEOPLE WITH STROKE RETURNING TO THE COMMUNITY

Objective: To determine if reactive balance control measures predict falls after discharge from stroke rehabilitation.

Setting: Rehabilitation hospital and community.Participants: Independently ambulatory individuals with stroke who were discharged home after inpatient rehabilitation (n = 95).

Main outcome measures: Balance and gait measures were obtained from a clinical assessment at discharge from inpatient stroke rehabilitation. Measures of reactive balance control were obtained: (1) during quiet standing; (2) when walking; and (3) in response to large postural perturbations. Participants reported falls and activity levels up to 6 months post-discharge. Logistic and Poisson regressions were used to identify measures of reactive balance control that were related to falls post-discharge.

Results: Decreased paretic limb contribution to standing balance control [rate ratio 0.8, 95% confidence interval (CI) 0.7 to 1.0; P = 0.011], reduced between-limb synchronization of quiet standing balance control (rate ratio 0.9, 95% CI 0.8 to 0.9; P < 0.0001), increased step length variability (rate ratio 1.4, 95% CI 1.2 to 1.7; P = 0.0011) and inability to step with the blocked limb (rate ratio 1.2, 95% CI 1.0 to 1.3; P = 0.013) were significantly associated with increased fall rates when controlling for age, stroke severity, functional balance and daily walking activity.

Conclusions: Impaired reactive balance control in standing and walking predicted increased risk of falls post-discharge from stroke rehabilitation. Specifically, measures that revealed the capacity of both limbs to respond to instability were related to increased risk of falls. These results suggest that post-stroke rehabilitation strategies for falls prevention should train responses to instability, and focus on remediating decontrol in the more-affected limb.

THE INCIDENCE AND RISK FACTORS OF FALL IN PARKINSON DISEASE: PROSPECTIVE STUDY.

Radzinski M , Bukowczan S , Stożek J , Zajdel K , Mirek E , Chwała W , Wójcik-Pędziwiatr M , Banaszkiewicz K and Szczudlik A Neurol Neurochir Pol. (2013);47(5):431-7.

Background: Although Parkinson disease (PD) patients suffer falls more frequently than other old people, only a few studies have focused on identifying the specific risk factors for falls in PD patients. The aim of this study was to assess the incidence and risk factors of falls in a prospective study in comparison to a control group.

Methods: One hundred patients with PD were recruited to the study along with 55 gender- and age-matched healthy controls. Both groups were examined twice; the second examination took place one year after the first one. Examination of the PD group included: medical history including falls, neurological examination, assessment of the severity of parkinsonism [Unified Parkinson's Disease Rating Scale (UPDRS), Schwab and England scale (S&E), Hoehn and Yahr scale (H&Y), Mini-Mental State Examination (MMSE)], Hamilton scale and quality of life scales (SF-36, EQ-5D) and Freezing of Gait Questionnaire (FOG-Q). In both groups falls were recorded over the 12 months. Frequent fallers are defined as having more than 3 falls a year.

Results: Over the year falls occurred in 54% of PD patients and 18% of controls. In a prospective study 28% of PD patients fell more frequently than in retrospective analysis. Frequent fallers were found in 20% of patients and in 7% of controls. Fallers showed higher scores in UPDRS, H&Y, S&E, MMSE, and Hamilton scale than non-fallers. Independent risk factors for falls were: age, previously reported falls and higher score in the FOG-Q.

Conclusions: Falls in PD patients occurred three times more frequently than in controls. Independent risk factors for falls were: high score in FOG-Q, older age and presence of falls in medical history.

EFFECTS OF PERTURBATION-BASED BALANCE TRAINING IN SUBACUTE PERSONS WITH STROKE: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Background: Reactive balance responses are critical for fall prevention. Perturbation-based balance training (PBBT) has shown a positive effect in reducing the risk of falls among older adults and persons with Parkinson's disease.

Objective: To explore the effect of a short-term PBBT on reactive balance responses, performance-based measures of balance and gait and balance confidence.

Methods: Thirty-four moderate-high functioning, subacute persons with stroke (PwS) (lower extremity Fugl-Meyer score 29.2 ± 4.3; Berg Balance Scale [BBS] score 43.8 ± 9.5, 42.0 ± 18.7 days after stroke onset) hospitalized in a rehabilitation setting were randomly allocated to PBBT (n = 18) and weight shifting and gait training (WS&GT) (n = 16). Both groups received 12 training sessions, 30 minutes each, for a period of 2.5 weeks. PBBT included unexpected balance perturbations during standing and treadmill walking, WS&GT included weight shifting in standing and treadmill walking without perturbations. The main outcome measures, that is, multiple step-threshold and fall-threshold were examined at baseline, immediately postintervention, and about 5 weeks postintervention. The secondary outcome measures, that is, BBS, 6-minute walk test (6MWT), 10-meter walk test (10MWT), and Activity-specific Balance Confidence (ABC) scale were examined at baseline and immediately postintervention.

Results: Compared with the WS&GT group, immediately postintervention participants in the PBBT group showed higher multiple-step thresholds in response to forward and backward surface translations (effect size [ES] = 1.07 and ES = 1.10, respectively) and moderate ES in the ABC scale (ES = 0.74). No significant differences were found in fall-threshold, BBS, 6MWT, and 10MWT between the groups.

Conclusions: Inclusion of perturbation training during rehabilitation of PwS improved reactive balance and balance confidence.

EXERCISES OF DYNAMIC STABILITY UNDER UNSTABLE CONDITIONS INCREASE MUSCLE STRENGTH AND BALANCE ABILITY IN THE ELDERLY

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Abstract

The purpose of this study was to assess the effectiveness of a specific exercise intervention of mechanisms to control dynamic postural stability under unstable conditions in old adults. Forty-seven old adults (65-80 years) were assigned to 2 experimental groups (muscle strength group, n = 15; perturbation-based group, n = 16) and a control group (n = 16). The strength group performed resistance exercises for leg and trunk muscles, while the perturbation-based group exercised mechanisms of dynamic stability under unstable conditions. The training duration was 14 weeks, with training sessions twice a week for 1.5 hours. Muscle strength, balance ability, and balance recovery performance were investigated before and after the interventions using maximal isometric plantar flexion and knee extension contractions, the approach of the center of pressure to the anterior limits of stability and simulated forward falls. Both interventions increased balance recovery performance in simulated forward falls (81%, d = 1.50 and 80%, d = 1.08 in the muscle strength and perturbation-based group, respectively), while the control group did not show any changes. Plantar flexor strength increased 20% (d = 0.72) in the muscle strength and 23% (d = 1.03) in the perturbation-based group, while muscle strength of the knee extensors increased only in the muscle strength group (8%, d = 0.76). On the other hand, only the perturbation-based group showed a significant improvement of standing balance ability (38%, d = 1.61). We conclude that a perturbation-based training program focusing on exercising mechanisms of dynamic stability in unstable conditions has the potential to enhance muscle strength as well as sensory information processing within the motor system during sudden and static balance tasks and, as a consequence, reduce the risk of falls in old adults.

PERTURBATION TRAINING FOR FALL-RISK REDUCTION IN HEALTHY OLDER ADULTS: INTERFERENCE AND GENERALIZATION TO OPPOSING NOVEL PERTURBATIONS POST INTERVENTION

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Abstract

This study examined the effects of perturbation training on the contextual interference and generalization of encountering a novel opposing perturbation. One hundred and sixty-nine community-dwelling healthy older adults (69.6 ± 6.4 years) were randomly assigned to one of the three groups: slip-perturbation training (St, n = 67) group received 24 slips, trip-perturbation training (Tt, n = 67) group received 24 trips, and control (Ctrl: n = 31) group received only non-perturbed walking trials (ClinicalTrials.gov [NCT03199729](#); https://clinicaltrials.gov/ct2/show/NCT03199729). After training, all groups had 30 min of rest and three post-training non-perturbed walking trials, followed by a reslip and a novel trip trial for St, a retrip and a novel slip trial for Tt, and randomized novel slip and trip trials for Ctrl. The margin of stability (MOS), step length, and toe clearance of post-training walking trials were compared among three groups to examine interferences in proactive adjustment. Falls, MOS at the instant of recovery foot touchdown, and hip height of post-training perturbation trials were investigated to detect interferences and generalization in reactive responses. Results indicated that prior adaptation to slip perturbation training, resulting in walking with a greater MOS (more anterior) and a shorter step length (p < 0.01) than that of the Ctrl group, would be associated with a greater likelihood to forward balance loss if encountered with a trip. The trip adaptation training mainly induced a higher toe clearance during walking (p < 0.01) than the Ctrl group, which could lead to reduced effectiveness of the reactive response when encountered with a novel slip. However, there was no difference in the reactive MOS, limb support, and falls between the control group and the slip and trip training groups on their respective opposing novel perturbation post-training (MOS, limb support, and falls for novel slip: Tt = Ctrl; for the novel trip: St = Ctrl, both p > 0.05). Current findings suggested that, although perturbation training results in proactive adjustments that could worsen the reactive response (interference) when exposed to an unexpected opposing perturbation, older adults demonstrated the ability to immediately generalize the training-induced adaptive reactive control to maintain MOS, to preserve limb support control, and to reduce fall risk.