

The next step

Citation for published version (APA):

Gerards, M. H. G. (2023). *The next step: perturbation-based balance training and falls prevention in older adults*. [Doctoral Thesis, Maastricht University]. Maastricht University. <https://doi.org/10.26481/dis.20230323mg>

Document status and date:

Published: 01/01/2023

DOI:

[10.26481/dis.20230323mg](https://doi.org/10.26481/dis.20230323mg)

Document Version:

Publisher's PDF, also known as Version of record

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.umlib.nl/taverne-license

Take down policy

If you believe that this document breaches copyright please contact us at:

repository@maastrichtuniversity.nl

providing details and we will investigate your claim.

Summary

Falls present a substantial threat to the health and wellbeing of older adults. The ageing of the population presents an increasing need for effective and efficient falls prevention interventions. The incidence and consequences of falls are introduced in **Chapter 1**, alongside a description of falls prevention through balance training in general, and more specifically about perturbation-based balance training (PBT). Lastly, this chapter presents the outline of this thesis.

Balance training is a form of exercise intervention that has been found to be particularly effective in reducing fall risk in older adults. Balance is a multidimensional concept; for example, strategies to achieve, maintain or restore balance can be proactive (when the movement is anticipated), or reactive (when the movement is unexpected or needs to be adjusted). In most balance interventions to date, exercises are mostly focused on training proactive or predictive balance control, and less on reactive balance control. However, many falls in older adults (approximately 59% in community-dwelling older adults) are caused by unexpected perturbations during walking, such as slips or trips, and require a reactive balance recovery strategy. In recent years, there has been an increasing interest in interventions that are more task-specific to the recovery reactions required to prevent a fall.

Perturbation-based balance training (PBT) is such a task-specific intervention, that aims to improve reactive balance control after destabilizing perturbations in a safe and controlled environment. During PBT, participants are exposed to unexpected balance perturbations such as slips or trips, during various activities of daily living such as standing or walking. While recovery from a novel perturbation seems to be less effective in older adults compared to young adults, their capacity to adapt and improve reactive balance with training seems intact. There is a growing body of evidence for the effectiveness of PBT, with studies showing direct balance adaptations during training, as well as retention of these adaptations, and improvements in other measures of balance control. Moreover, studies have found meaningful and significant reductions in daily-life falls in older adults, even after very brief periods of training.

Despite the growing interest in PBT in research, there has been little transfer of PBT to clinical practice. Given the substantial burden of falls on individuals and society, it is essential to evaluate if promising new interventions such as PBT may be feasible and effective for application in clinical practice. Therefore, the aim of this thesis is to further our understanding of the effectiveness and applicability of this relatively new intervention in clinical practice, with the perspective that this knowledge could further the readiness of PBT for implementation in clinical practice.

Chapter 2 describes a systematic review of studies on the effectiveness of PBT to reduce falls in older adults, in which factors that should be considered for application of PBT in clinical practice are synthesized and discussed. A total of eight studies are included in this review, each comparing the effects of PBT versus a control group on falls in the everyday life of older adults. These studies show a significant reduction of falls incidence among healthy older adults and certain patient groups (e.g. people with Parkinson's disease and stroke), and clinically relevant reductions of falls in more frail older adults. Looking at factors that should be considered in the application of PBT in clinical practice, the most practical methods for application in clinical settings might be treadmill-based systems and therapist applied perturbations. Moreover, PBT that incorporates multiple perturbation types and directions might be of most benefit. Based on these findings, PBT appears to be a feasible and effective approach to falls reduction among older adults in clinical settings.

Chapter 3 explores the extent to which unperturbed walking variability, stability following a novel perturbation and adaptability to repeated perturbations relate to falls history in older adults. As falls most commonly occur during walking due to unexpected balance perturbations, walking-based balance assessment including walking stability and adaptability to such perturbations could be beneficial for fall risk assessment in older adults. This cross-sectional study compares data from community-dwelling older adults with and without a history of falls that completed a series of unperturbed and perturbed walking trials. No significant differences were found in unperturbed walking parameters or their variability. Overall perturbation-recovery step behavior differed slightly (not statistically significant) between groups after the first perturbation, where the group with a history of falls showed slightly delayed and more inconsistent recovery responses. These differences became more pronounced and significant after repetition of perturbations, and the group without a history of falls significantly reduced the number of recovery steps needed across the trials, whereas the group with a history of falls did not. Older adults without a history of falls demonstrated more signs of adaptability to repeated perturbations. Adaptability may give a broader indication of the ability of the locomotor system to respond and improve responses to sudden walking perturbations than unperturbed walking variability or recovery to a single novel perturbation. Adaptability may thus be a more useful marker of falls history in older adults, but may also have implications for the required training dose in older adults with a history of falls, and should be considered in further research.

Chapter 4 describes how the lessons learned from the systematic review in Chapter 2 are applied to the setting of the MUMC+ in the design of a PBT protocol. This study protocol describes how community-dwelling older adults who presented at the MUMC+ outpatient clinic after a fall incident will be included and randomized to receive usual care (physiotherapy referral) with or without the addition of PBT. A PBT

intervention is designed consisting of three 30-minute training sessions including multiple perturbation types and directions applied during standing and treadmill walking on the Computer Assisted Rehabilitation Environment (CAREN) system. The training content and duration is standardized, while training progression is individualized based on each participant's balance abilities. The protocol includes two quantitative outcome measures which are measured at one week and three months post-intervention; balance control measured with the Mini Balance Evaluation Systems Test (Mini-BESTest), and fear of falling measured with the Falls Efficacy Scale International (FES-I). Additionally, daily-life falls will be monitored for six months using falls calendars. To evaluate the acceptability of the PBT protocol for older adults, a qualitative study is embedded in the protocol of this randomized controlled trial (RCT).

Chapter 5 reports on this qualitative study with the aim of evaluating the acceptability of PBT in community-dwelling older adults with a recent history of falls. This study includes a representative subsample of 16 older adults who completed the PBT intervention as part of our RCT. The acceptability of the training protocol is discussed using semi-structured interviews based on the Theoretical Framework of Acceptability (TFA). The results indicate that this PBT protocol is perceived as acceptable by older adults with a recent history of falls, and highlight key areas for potential future modifications. Enjoyment of the novel training and technology, being able to feel safe during training, and perceived impact of increased self-efficacy and balance confidence are identified as facilitating factors. Potential issues include initial apprehension or anxiety during training and perceived impact being predominantly psychological instead of physical. Complementary to the TFA one additional theme emerged which describes challenges regarding the training setting for some participants, such as preference for group training and difficulty travelling to the training location.

The short-term results (1 week post-intervention) of our RCT are presented in **Chapter 6**. In this study, 82 community-dwelling older adults are included, receiving usual care with ($n = 39$) or without the addition of three 30-minute sessions of PBT. Balance control measured with the Mini-BESTest shows a trend towards improvement in both groups, but changes are not significantly different between groups. Falls efficacy measured with the FES-I did not change in either group. Participation in a PBT program including multiple perturbation types and directions did not lead to significant additional effects to usual care on balance control or fear of falling in community-dwelling older adults with a recent history of falls.

Chapter 7 provides a reflection on the main study findings of this thesis in relation to recent literature, discusses methodological considerations and makes suggestions for future research. This thesis resulted in an improved understanding of the effectiveness and applicability of PBT for community-dwelling older adults, knowledge which could

underpin the implementation of PBT in clinical practice. The findings of our RCT and systematic review showed mixed results on the effectiveness of PBT in older adults. Although the PBT literature predating this thesis provided some indications of feasibility and acceptability, our review and qualitative study present the first in-depth explorations of this topic in older adults and provide important insights for future development and implementation of PBT interventions. In synthesis with mixed results in other recent studies, the results in this thesis highlight the need for further research to elucidate the mechanisms underlying effective PBT, how to best measure PBT effects, and how this intervention can be successfully applied for each target population. The findings in this thesis provide important insights in the effectiveness and applicability of PBT in community-dwelling older adults and offer starting points for future research and implementation.