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Acceptability of a perturbation-based balance training program for falls prevention in older adults: a qualitative study

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Key words: Balance, perturbation, falls prevention, older adults, accidental falls

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ABSTRACT

Introduction

Perturbation-based balance training (PBT) is reported to effectively reduce daily-life falls in older adults, and may even be superior compared to various exercise programs. Due to the nature of the intervention, requiring unpredictable balance perturbations, the question arises whether acceptability is an issue in PBT. The aim of this study is to evaluate the acceptability of PBT in older adults with a recent history of falls.

Methods

Semi-structured interviews were conducted in older adults who completed a three-session PBT protocol as part of another study. Typical case and purposive sampling strategies were applied. Interviews were based on the theoretical framework of acceptability (TFA) alongside context-specific factors and analysed using a template analysis approach.

Results

Sixteen participants were interviewed. 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 were identified as facilitating factors. Potential issues included initial apprehension or anxiety during training and perceived impact being predominantly psychological instead of physical. Complimentary to the TFA one additional theme emerged, which described challenges regarding the training setting such as preference for group training in some participants and travel to the training location.

Conclusions

The results suggest that PBT is perceived acceptable by older adults with a history of falls, and indicate important factors that should be considered in future implementation of PBT.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first study to use the theoretical framework of acceptability (TFA) to explore older adults' perceived acceptability of PBT.
- Using the TFA enabled a systematic approach to define and assess intervention acceptability.
- Triangulation was applied in data collection as well as data analysis to increase trustworthiness of the research findings.
- The PBT intervention was applied in a research setting, meaning that some specific factors, such as willingness to pay for participation in the intervention, were not evaluated.
- The results only reflect the perceived retrospective acceptability of the PBT, and may not entirely reflect how participant's views changed over time.

INTRODUCTION

Falls in community-dwelling older adults can be effectively reduced through exercise interventions including balance training,[1]. However, the search for the optimal balance training program for falls prevention is still ongoing. With conventional balance training, a relatively high number of training sessions are needed, discontinuation rates are high and retention of training effects is hard to accomplish,[2, 3]. Moreover, conventional balance training seems not sufficiently task-specific to prevent falls due to slips or trips during walking, which cause up to 60% of falls in community-dwelling older adults,[4, 5]. It is not likely that conventional balance training, mostly targeting volitional movements, will improve the change-in-support reactions (e.g. taking a quick step) needed to prevent a slip or a trip, due to the additional speed and stability requirements of these balance reactions,[6]. Therefore, an increasing interest has arisen in more task-specific balance training interventions, such as perturbation-based balance training (PBT).

PBT aims to improve rapid balance reactions after unexpected external perturbations. During PBT, participants are repeatedly exposed to destabilizing perturbations while performing activities of daily living in a safe and controlled environment. A systematic review by Mansfield et al. indicated that PBT may be more effective in reducing daily-life falls in older adults, compared to various interventions ranging from no exercise to individualized physical therapy (risk ratio 0.71, 95% CI=0.52,0.96; P=.02),[7]. With PBT, balance adaptation may occur faster, potentially achieving equal or better results with fewer training sessions compared to conventional balance training,[8].

However promising, even effective interventions are likely to fail if they are not acceptable to the target population. The more acceptable the intervention, the more likely that adherence will be high,[9]. In turn, higher adherence (>80%) may result in larger effects,[10]. Due to the nature of the intervention, the question arises whether acceptability is an issue in PBT. In 2019, Okubo et al found in a pilot study of 10 healthy older adults that self-reported anxiety levels before a training session increased significantly with increasing unpredictability of PBT,[11]. Unpredictable perturbations are required in PBT to maximize learning of reactive balance control, yet these perturbations may cause anxiety and consequentially decrease acceptability.

So far limited evidence exists about the acceptability of PBT. Previous studies reported high training adherence rates, and no significant differences in drop-out rates between PBT and control groups receiving exercise or flexibility training,[12-14]. However, while quantitative data such as adherence rates may be indirect indicators of acceptability, the full-fledged concept of acceptability is a subjective evaluation made by individuals who experience an intervention,[9]. In 2017, Sekhon et al., proposed the Theoretical Framework of Acceptability (TFA) in which acceptability is viewed as a multifaceted construct, consisting of seven components;[9].

To our knowledge, no studies thus far have focused on qualitative aspects of acceptability of PBT in older adults. The aim of this study is to explore acceptability of PBT as perceived by older adults with a recent history of falls. Their views on the components constituting acceptability will be explored. The findings will enable optimisation of future implementation of PBT in clinical practice.

METHODS

Study design

A qualitative study consisting of semi-structured interviews was conducted. All participants provided written informed consent. This study was approved by the Medical Ethics Committee of MUMC+ (Maastricht University Medical Center) and Maastricht University (METC NL67131.068.18). The study is reported in line with the COREQ statement,[15].

Context, study participants and sampling

Older adults who participated in PBT as part of a RCT were included,[16]. Community-dwelling older adults (age ≥65 years) who visited the hospital's outpatient clinic due to a fall incident were informed about the study, and approached by telephone a 3-7 days later. Participants were included in the RCT if they were able to walk for 15 minutes without a walking aid. Exclusion criteria included any risk factors to them participating in PBT (e.g. diagnosed osteoporosis, severe cardiopulmonary disease), or inability to communicate in Dutch. Participants were eligible for the qualitative interviews after they had completed the PBT. They were selected through a combination of typical case and purposive sampling, to select those participants who were representative of the study population and were expected to provide the most detailed input.

The PBT protocol consisted of three 30-minute sessions, during which participants were exposed to sudden balance perturbations while they stood and walked on a dual-belt treadmill embedded in a moveable platform (Computer Assisted Rehabilitation Environment (CAREN), Motek Medical BV). During the training, virtual environments were projected on a 180^{o} screen in front of the platform. Each session consisted of three standardized conditions, while progression of difficulty levels in each condition was individualized.

1. Gait adaptability: participants walked on the treadmill while a virtual environment of a forest road, with various slopes and turns, was projected onto the screen. The platform moved correspondingly.

2. Static reactive balance: participants stood on the platform while the platform and treadmill made sudden, variable and unpredictable movements to perturb balance.

3. Dynamic reactive balance: this training condition was similar to the one above, only the perturbations were applied while the participant was walking on the treadmill.

A detailed description of the PBT protocol is published elsewhere,[16]. For an impression of the PBT setting, see Figure 1.

Insert Figure 1

Figure 1: Picture of a participant during PBT. Picture published with participant's permission.

Theoretical framework

The interviews were based on the TFA as proposed by Sekhon et al.,[9]. In this framework, acceptability is defined as a multi-faceted, seven component construct, including: affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness and self-efficacy. *Table 1* provides an overview of our operationalisation of each construct and an example of a related

question from our interview guide. Questions regarding context-specific barriers and facilitators (e.g. training location, supervision during training) to participate in PBT were added to gain insight in their influence on PBT acceptability.

Table 1: Theoretical framework of acceptability themes and interpretation.

THEME	INTERPRETATION
AFFECTIVE ATTITUDE	How an individual feels about the PBT *How do you feel about the training? What made you feel this way?*
SELF-EFFICACY	The participant's confidence in their ability to perform the PBT *How did you do in the training?*
PERCEIVED EFFECTIVENESS	The extent to which the participant perceives the PBT to potentially and actually (observed) be effective *To what extent did you experience effects from the training?*
ETHICALITY	The extent to which the intervention had good fit with an individual's value system and expectations of a falls prevention intervention *To what extent did the training fit with your views on falls prevention?*
INTERVENTION COHERENCE	The extent to which the participant understands the aim of PBT and how it works *In your own words, what was the aim of the training?*
BURDEN	The perceived amount of effort that was required to participate in the PBT *To what extent did you find the training strenuous? To what extent did you find the training challenging?*
OPPORTUNITY COSTS	The extent to which benefits, profits or values were given up to participate in the PBT *To what extent did you forego other opportunities to participate in the training?*

PBT; perturbation-based balance training

Interview procedure

The interviews took place at the hospital, within one to three weeks after training completion, between February 2020 and May 2021. Interviews and analysis were completed before results on the effectiveness of the PBT protocol were analysed. The first 13 interviews (of in total 16) were led by a researcher (MG) who was involved in the PBT program, because she was familiar with the specifics of the training and could ask targeted follow-up questions. A second researcher was always present at the interviews as an observer, to help keep track of the interview guide, and take field notes. A verbal summary was given at the end of each interview and a written summary was sent to each participant for a member check. Interviews were conducted iteratively; the interview guide was adjusted after the first 3 interviews to include emerging themes. This process was repeated after 10 and 13 interviews were completed. All interviews were recorded using a digital voicerecorder and transcribed verbatim. Any names and other possible identification information were removed from the transcripts. As the interviews and transcripts were in Dutch, all quotes presented were translated with care to conserve the original meaning.

Analysis

Interview transcripts were analysed using a template analysis approach,[17, 18]. The a priori template was formed based on the TFA and interview guide. Two researchers (MG and JS) independently coded

the first three interviews, using NVivo 12,[19]. After coding, they discussed the codes until consensus and formed an initial template. This process was repeated for the next three interviews. Consensus was then reached that this third template version covered the transcripts that were analysed so far. MG subsequently coded the remaining interviews using the third template version. MG and JS discussed if any changes needed to be made to the template based on the later interviews. After the 9th interview was coded, no more changes to the template were indicated. This was confirmed by coding the remaining 4 interviews, and coding saturation was reached,[20].

Reflexivity and triangulation

As MG was involved in the PBT for these participants, it was possible that there was researcher bias or that participants were more inclined to give desirable answers. For the purpose of interviewer triangulation, three additional interviews (interviews 14-16) were conducted by an independent researcher (AW) to confirm or reject previous responses. Coding of these three interviews revealed no new codes, which can be interpreted as secondary confirmation of the coding template and saturation. Participants did not give different answers to different interviewers. JS and AW were not involved in the RCT on PBT and represented an outsider perspective in the design and review of the interview guide, coding and analysis, therewith contributing to further researcher triangulation. Through comparison and discussion of the transcripts, the authors then reached consensus on the most important themes from the interviews.

Patient and public involvement

Patients were first involved in pilot testing of the PBT protocol in this research, and the training protocol was fine-tuned based on their feedback. The aim of this study is to explore participant's perceptions and views on the acceptability of the training, which may be used to guide design or implementation of future PBT interventions.

RESULTS

Participant description

Sixteen participants (14 females and 2 males, mean age 73.6 ± 6.0 years) were approached, all of which accepted. For comparison, the RCT included 66 females and 17 males, and participants' mean age was 72.9 ± 5.3 years. Table 2 provides an overview of participants and characteristics. Nine interviews were conducted at the hospital, seven were telephone interviews due to restrictions related to the COVID-19 pandemic. Interviews lasted 15-35 minutes. One participant (P031) missed one training session due to COVID-19 restrictions.

Table 2: Overview of participant and interview characteristics.

Participant	Sex (F/M)	Age (years)	Falls previous year (n)	Interview type	Interviewer
P022	F	79	1	Face-to-face	MG
P023	F	80	1	Face-to-face	MG
P026	M	65	1	Telephone	MG
P027	F	76	2	Face-to-face	MG
P030	F	83	1	Telephone	MG
P031	M	67	1	Telephone	MG
P032	F	79	1	Telephone	MG
P040	F	73	2	Face-to-face	MG
P042	F	65	2	Face-to-face	MG
P043	F	74	1	Face-to-face	MG

P044	F	79	4	Face-to-face	MG
P045	F	74	1	Face-to-face	MG
P050	F	79	1	Face-to-face	MG
P068	F	70	1	Telephone	AW
P069	F	66	3	Telephone	AW
P082	F	69	1	Telephone	AW

F = female, M = male.

Perceptions of acceptability

The findings are presented below for each of the TFA components, along with illustrative quotes from participants. The theme 'training setting' was added, this theme includes context-specific barriers and facilitators that were described by the participants.

Affective attitude

Overall, participants described that they felt the PBT was an enjoyable experience. Most participants positively related this to the novelty of the experience, reporting feelings of curiosity and excitement. In contrast, some participants related this novelty to a feeling of suspense, and sometimes feeling unsure about their ability to participate in PBT at the start of the first training session. Most often this was described as a good amount of suspense and curiosity about what would happen, and not perceived as a barrier.

P044 *''I didn't know what I could expect. But I said: Guys, I'll just see what happens, I'll leave it up to you. (…) In the beginning, you don't know what is going to happen to you. You feel a little insecure. But I was glad that I did it.''*

One participant described feeling anxious during the first training session, a feeling that fortunately decreased throughout the following sessions.

P030 *''Now you know what you have to do so it's different. But at first it's kind of a startle response I think.''*

All participants reported that feeling safe and able to challenge themselves without fear of falling was closely related to a positive experience. The safety equipment (especially the safety harness), feeling heard by the trainer and receiving information during the training session were identified as important facilitators.

P050 *''And again, (laughing) I was very happy that I didn't need to hang from those ropes* [safety harness]*, but I had complete faith that if anything were to happen I definitely would not fall. So that didn't cause any anxiety for me.''*

Self-efficacy

All participants described that they were able to participate in the training sessions, and that they felt they did well. Some participants reported that their sense of self-efficacy grew throughout the training sessions, starting with feeling unsure about their ability at the first training session, to feeling accomplished after the second or third session. Some of these participants related their initial apprehension to comorbidities.

P031 *''I have COPD and you're aware that there are situations in which you may have to drop out. And in that sense, this could have happened to me in this training as well. Fortunately, it didn't.''*

Finally, one participant provided an example of how she felt after the training sessions.

P022 *''Well, I can say that I feel I did well. It brings you joy if you have something like that* (decreased strength in one leg due to a comorbidity) *and you're still able to catch yourself well.''*

Perceived effectiveness

This construct is understood as the extent to which participants perceived changes in their physical or psychological functioning, and attributed this to the training. Perceived training effects can be divided into physical and psychological effects. For most participants, recognizing physical training effects was not straightforward. Some participants clearly described improvements in their daily activities which they attributed to the training, such as improved walking ability or balance.

P068. *''I've been walking my son's dog a lot lately. (…) I've noticed that because of that* (training) *I'm steadier on my legs. Like this morning when I walked him, I had to walk downhill. And before I did the balance training, I would have thought 'Oh I have to be careful', but now I just know: I have to move like this, I have to put my foot here. And I can do this.''*

Still, most participants expressed that their physical abilities had remained the same, and wondered how they could have noticed possible changes due to training. For most, falling or stumbling was not a daily occurrence to begin with, and as the interviews took place shortly after training completion, they noted that potential changes were not easily identifiable in this short term. This was neither described as a barrier nor a facilitator to participating in the PBT.

P031. *''But if my balance has improved because of it, that's very hard to determine, because I don't fall very often. That I broke my wrist due to a fall was more of an accident.''*

Psychological effects were described as much more apparent and positively related to the acceptability of the intervention. Most participants expressed that the training had helped them gain confidence and improved self-efficacy, during the training sessions and in everyday life. They attributed this to how during the training they experienced that their body was capable of more than they expected.

P068. *''Especially the first time I noticed that I was quite insecure. (…) And that was more related to my confidence, which had been damaged. And I noticed after a few times that I, because of the training actually, gained some confidence. That I got more confident in my body.''*

Ethicality

This construct may not only be related to the extent to which the PBT was perceived to be a good fit with the participant's value system, but also to their expectations of the PBT. Most participants reported that anything they could do to prevent future fall incidents was viewed as valuable.

P069 *''Well, I was really glad about it, because I thought 'anything I can practice or do to help me fall less, will be helpful' ''*

Some participants found it hard to describe if falls prevention in general fit within their value system. Often participants related this to not having heard or thought about falls prevention until they were approached by the study team.

P032 *''I hadn't heard or read anything about it before, I started this without expectations.''*

Some also described having thought about it but not knowing who to approach about the topic, or not considering that they needed it. The lack of prior knowledge or expectations about the PBT was not perceived as a barrier to participating. Conclusively, some participants valued being able to contribute to a scientific study.

Intervention Coherence

All participants were able to recognize and describe the aim of the intervention to a certain degree. For example:

P023 *''In my own words? That you're more able to keep your balance. And it has worked.''*

Another participant provided a more detailed explanation of what she perceived as the aim of the intervention.

P043 *''To be able to recover, when you've lost balance. I think that that was the aim. That you're able to react; your body, your legs, or even with the help of an arm swing. Faster recovery to regain your balance.''*.

A factor that repeatedly emerged related to coherence of the intervention, is 'intervention validity'; understood as the extent to which participants perceived that the intervention had a good fit with its' aims. Most participants who discussed this topic, described the intervention as valid and perceived this as a facilitator to participating in PBT.

P026 *''A few times I nearly fell, but then you're able to correct this and it's a beautiful simulation of what can happen in real life. Especially when the treadmill belts don't run at the same speed, when one decelerates while the other continues. Then you get an effect like you're experiencing a slip.''*

However, a few participants also questioned if it was at all possible to prevent a future fall incident, reasoning that a fall occurs too sudden to make any preventive adjustments.

Burden

Participants agreed that the burden of participating in PBT was acceptable. The training was perceived as challenging, but not too challenging. Some participants positively related this to the way the training sessions were structured, providing a gradual and personalized increase in challenge.

P069 *''No, there was a good and gradual increase in challenge. They started the training quite easy and then it gradually became harder. It was very well structured.''*

Most effort was required to maintain or regain balance, and to stay focused throughout the session. Participants reported that the required physical stamina was not an important contributing factor to the perceived training load. When mentioned, participants described that the unexpected balance perturbations were perceived as more challenging than the first part of the training, where they could anticipate on what would happen next.

P022 *''The hard part was when it was sudden, unexpected. Going left, right, forward. That was, well, not hard; you can get it done, but you have to make sure you don't fall, even if you're in a safety harness.''*

Opportunity costs

Participants agreed that no activities had to be given up to participate in the PBT. Most related this to having enough time after retirement. The possibility to schedule the training sessions in consultation with the trainer instead of having fixed training times was reported as an important facilitator. Most participants accepted travelling to the training location as a fact and did not describe this as either a barrier or a facilitator. A few participants found the central location of the hospital a positive factor, as this was easy to reach using public transportation. Another few participants described that any location outside walking distance provided a challenge and a potential barrier, as they were no longer able to drive a car and had to rely on public transportation or family members to get there. As for the training location being inside a university hospital, this was mostly perceived as an advantage. Participants often described that they thought this was the logical place where they expected to find

the right equipment and expertise for this kind of training. Some also mentioned that they regarded the university hospital as a familiar institute, and therefore easy to find.

Training setting

This additional theme was identified throughout the interviews, and includes specific factors related to the setting of the PBT. The PBT took place in a specific setting with specialized technological equipment (see *Figure 1*) inside a university hospital. Most participants described that they experienced the technological training equipment as positive, as a surprising and interesting novelty. One participant explained that she felt slightly overwhelmed when she first saw the training equipment, but this improved when she got a more detailed explanation of what was going to happen and when she experienced the training for herself.

P031. *''The setting was very surprising. The fact that you're walking on a treadmill in an environment that moves with you. I thought it was a very extraordinary experience.''*

Most participants described the virtual environments that were used during training as surprising and positive. A few participants expressed a preference for the first virtual environment (the forest road), describing that this felt more friendly and stimulating than the second, more industrial environment.

The individual nature of this training was clearly valued by some participants, while others were ambivalent about this. Participants who indicated a preference for training individually, described that they enjoyed being able to really focus on the training itself without distractions from other people or the environment, and to train at their own level. Some also reasoned that this increased the potential of the training to be effective.

P068. *''This, the balance training, is not something you can do in a group. And I just thought it was very pleasant, because you're focusing on yourself. You're focused on what is going to happen, and you can feel everything that happens (…). And I just think that it is much more pleasant this way, and it will be more helpful.''*

While most participants preferred training individually, some described that they were curious to see how other people performed during the training sessions. Additionally, two participants would have appreciated the opportunity to compare and discuss fall-related experiences with peers.

A numeric rating scale (NRS) was used as a tool to individualize training progression. During the training sessions, participants were regularly asked to score how challenged they felt at that moment, ranging from 0 (not challenged at all) to 10 (highest perceivable challenge). Participants described mixed experiences with this system. Some found the scoring easy and even helpful and described that it helped them gain insight in how they felt at that moment. Others described that they had trouble translating their subjective experience to a number that meant little to them. Overall, the NRS scoring was not perceived as an important barrier or facilitator.

DISCUSSION

The aim of this study was to evaluate the acceptability of a PBT program as perceived by older adults, using the TFA. Gaining understanding of the acceptability of PBT in older adults with a recent history of falls is imperative to enable and optimize future implementation of PBT in clinical practice.

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. Besides the TFA, one additional theme emerged from the data, which includes challenges specific to the training setting such as preference for group training in some participants and travel to the training location.

Participants valued being able to feel safe during training. Most reported that this was accomplished by using the safety harness, the physical presence and guidance from the trainer, and individualized training progression. These results reflect those of Miller et al., who evaluated the perceived acceptability of conceptually challenging exercise training to older adults, including dynamic balance tasks with external perturbations,[21]. The novelty of the training and technology were regarded as a positive factor contributing to enjoyment by most participants. However, as in Miller's study, some participants reported feeling initially apprehensive or anxious towards the new training. Okubo et al.,[11], related elevated anxiety levels during PBT to the unpredictability of the perturbations. We previously hypothesized that a more gradual training progression over multiple sessions may help participants build confidence and alleviate anxiety while still being effective,[22]. This hypothesis is partially confirmed by our current findings, which indicated that self-efficacy improved over time. Participants who initially experienced anxiety also reported that this improved over time, and individualized training progression was reported as a facilitator to feeling safe during training. As unexpected perturbations are key for task-specific PBT, the balance between measures to alleviate anxiety while still achieving the desired training stimulus should be considered in future implementation. Our findings suggest that this may be particularly important at the start of training.

Perceived psychological effects in the form of increased confidence in balance abilities, and increased self-efficacy in daily life were often reported. Consistent with previous studies on falls prevention interventions, participants described that the PBT helped them gain insight in their ability level and were pleasantly surprised by their ability,[21, 23]. This is important as maintaining balance confidence can help avoid undue activity avoidance and subsequent disability,[24]. Moreover, decreased balance confidence has been identified as a predictor for future falls,[25]. While participants generally felt they did well during training, perceived physical effects in daily life were less apparent. Participants questioned how they would notice physical training effects, as falling was not a daily occurrence for them to begin with. In part, this may have been related to the interviews taking place shortly after training completion, leaving little time for participants to experience training effects. However, we hypothesize that this may also be related to the perceived intervention validity and ethicality.

While the topic of perceived intervention validity emerged in most of the interviews, participants views were mixed. Some described that they perceived the intervention valid as it clearly simulated daily-life balance perturbations. In contrast, other participants did not discuss PBT specifically, rather questioned if it was at all possible to prevent a fall in daily life, describing that falls occurred too sudden to intervene or were 'just accidents that could happen to anybody'. The belief that falls are just bad luck, and disbelief that they are preventable is well-known from the literature,[26-28]. A review by McInnes et al. recommended that these beliefs should be countered prior to intervention,[29]. While all participants in our study had recently fallen and agreed to participate in the current intervention, none of them actively sought to participate in falls prevention before. Participants described that they had previously given little or no thought to falls prevention, or that they did not think they needed it. This is in line with previous studies, indicating that those who have previously fallen are not necessarily more likely to be receptive to falls prevention interventions,[30, 31]. Another study described that older adults may reject the idea that they need falls prevention because they regard themselves as healthy and able to manage,[32]. PBT being a relatively new intervention, it may be assumed that this intervention is even less known to potential participants, thus increasing the challenge to reach the target population. Some participants reported that being informed by or talking to a health practitioner about the PBT, and being approached by the researchers, prompted them to consider falls prevention or to finally participate. This corroborates findings from Yardley et al., reporting that a personal invitation by a health practitioner may be a facilitating factor to participation in falls prevention,[33]. Our findings suggest that these factors may be particularly important to consider for PBT or any relatively unknown intervention, to effectively reach older adults.

Some participants clearly expressed a preference for training individually. Others described that they would have been curious to see how others performed during the training sessions, or to share fall-related experiences with others. Promoting the social value of falls prevention interventions has been previously identified as a facilitator,[29]. Additionally, watching or partnering with a peer completing the same exercises may facilitate participation and improve older adults' confidence for their own attempt,[21, 34, 35]. As PBT is currently not suited for a group intervention, it may be considered to provide a medium between individual and group training, while simultaneously addressing the initial apprehension or anxiety experienced by some participants. Specifically, this could be achieved by providing new participants with a video of a peer completing the exercises before their own participation, or combining training sessions of two participants where they can see each other perform and share experiences. Conclusively, hearing experiences from peers who completed the PBT might also improve perceived intervention validity and ethicality for future participants.

Finally, a practical factor that should be considered is travelling to the training location. As is the case with most set-ups for PBT, the equipment used in this program is not yet available in many locations. Some participants described that while they were able to attend the PBT sessions, travel was a potential barrier. This barrier is well-known in this population, as some older adults are no longer able to drive a car themselves and thus depend on family members or public transportation,[33, 36].

Strengths and Limitations

To our knowledge, this is the first study to use the TFA to examine older adults' perceived acceptability of PBT. Using the TFA enabled a systematic approach to define and assess intervention acceptability,[9]. Triangulation was applied in data collection as well as data analysis to increase trustworthiness of the research findings. A few limitations should be considered when interpreting the results of our study. First, the PBT intervention was applied in a research setting, meaning that some specific factors, such as willingness to pay for participation in the intervention, were not evaluated. Second, the results only reflect the perceived retrospective acceptability of the PBT. Further research is necessary to evaluate prospective and concurrent acceptability, to further elucidate what factors motivate or prevent older adults from participating in PBT,[9].

A final consideration is that due to COVID-19 related restrictions, 7 out of the 16 interviews in this study were telephone interviews. While face-to-face interviews are often regarded as the gold standard, there is little evidence that quality of findings collected through telephone interviews is compromised,[37]. Consistent with Sturges et al., we identified no clear differences between data collected through face-to-face interviews compared to telephone interviews in our study,[38].

CONCLUSIONS

In conclusion, findings from this study indicate that a technology-assisted PBT program is acceptable to older adults with a recent falls history. Enjoyment of the intervention, being able to feel safe, perceived psychological effectiveness and individualized training progression were identified as important factors contributing to the perceived acceptability. Increasing the social aspect of training and sharing experiences of peers may be considered to enhance acceptability to new participants who initially feel apprehensive or anxious about their ability to participate, or who are unsure what to expect. Raising awareness of the importance and possibilities of falls prevention training in general is a challenge in this population.

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Ethics statement

All participants provided written informed consent. This study was approved by the Medical Ethics Committee of MUMC+ (Maastricht University Medical Center) and Maastricht University (METC NL67131.068.18).

Competing interest

The authors declare no competing interests.

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Contributorship statement

Marissa Gerards: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Visualization, Project Administration. Judith Sieben: Methodology, Validation, Formal Analysis, Data Curation, Writing – Review & Editing. Rik Marcellis: Conceptualization, Writing – Review & Editing. Rob de Bie: Conceptualization, Writing – Review & Editing, Supervision. Kenneth Meijer: Conceptualization, Writing – Review & Editing, Supervision. Antoine Lenssen: Conceptualization, Writing – Review & Editing, Supervision, Project Administration. Anouk Weemaes: Investigation.

Data availability

No additional data available.

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Figure 1: Picture of a participant during PBT. Picture published with participant's permission.

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Domain 1: Research team and reflexivity			
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Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	5
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	5
Occupation	3	What was their occupation at the time of the study?	5
Gender	4	Was the researcher male or female?	5
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Relationship with participants			
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Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	5
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Sample size	12	How many participants were in the study?	6
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Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	6
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Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	6,7
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	5
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	n/a
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	5
Field notes	20	Were field notes made during and/or after the inter view or focus group?	5
Duration	21	What was the duration of the inter views or focus group?	6
Data saturation	22	Was data saturation discussed?	5,6
Transcripts returned	23	Were transcripts returned to participants for comment and/or	5

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
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Number of data coders	24	How many data coders coded the data?	5,6
Description of the coding tree	25	Did authors provide a description of the coding tree?	5,6
Derivation of themes	26	Were themes identified in advance or derived from the data?	5,6
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Participant checking	28	Did participants provide feedback on the findings?	5
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	7-10
Data and findings consistent	30	Was there consistency between the data presented and the findings?	7-10
Clarity of major themes	31	Were major themes clearly presented in the findings?	7-10
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	7-10

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Acceptability of a perturbation-based balance training program for falls prevention in older adults: a qualitative study

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Key words: Balance, perturbation, falls prevention, older adults, accidental falls

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ABSTRACT

Introduction

Perturbation-based balance training (PBT) is reported to effectively reduce falls in older adults, and may even be superior compared to various exercise programs. Due to the nature of the intervention, requiring unpredictable balance perturbations, the question arises whether acceptability is an issue in PBT.

Objective To evaluate the acceptability of PBT in older adults with a recent history of falls.

Design, method, participants and setting

Qualitative study in which semi-structured interviews were conducted in 16 older adults (14 females and 2 males, mean age 73.6 ± 6.0 years) who completed a three-session PBT protocol as part of another study in a university medical centre in The Netherlands. Typical case and purposive sampling strategies were applied. Interviews were based on the theoretical framework of acceptability (TFA) alongside context-specific factors and analysed using a template analysis approach.

Results

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 were identified as facilitating factors. Potential issues included initial apprehension or anxiety during training and perceived impact being predominantly psychological instead of physical. Complimentary to the TFA one additional theme emerged, which described challenges regarding the training setting such as preference for group training in some participants and travel to the training location.

Conclusions

The results suggest that PBT is perceived acceptable by older adults with a history of falls. Increasing the social aspect of training and sharing experiences of peers may be considered to enhance acceptability to new participants who initially feel apprehensive or anxious about their ability to participate in future implementation of PBT.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first study to use the theoretical framework of acceptability (TFA) to explore older adults' perceived acceptability of PBT.
- Using the TFA enabled a systematic approach to define and assess intervention acceptability.
- Triangulation was applied in data collection as well as data analysis to increase trustworthiness of the research findings.
- The PBT intervention was applied in a research setting, meaning that some specific factors, such as willingness to pay for participation in the intervention, were not evaluated.
- The results only reflect the perceived retrospective acceptability of the PBT, and may not entirely reflect how participant's views changed over time.

INTRODUCTION

Falls in community-dwelling older adults can be effectively reduced through exercise interventions including balance training,[1]. However, the search for the optimal balance training program for falls prevention is still ongoing. With conventional balance training, a relatively high number of training sessions are needed, discontinuation rates are high and retention of training effects is hard to accomplish,[2, 3]. Moreover, conventional balance training seems not sufficiently task-specific to prevent falls due to slips or trips during walking, which cause up to 60% of falls in community-dwelling older adults,[4, 5]. It is not likely that conventional balance training, mostly targeting volitional movements, will improve the change-in-support reactions (e.g. taking a quick step) needed to prevent a slip or a trip, due to the additional speed and stability requirements of these balance reactions,[6]. Therefore, an increasing interest has arisen in more task-specific balance training interventions, such as perturbation-based balance training (PBT).

PBT aims to improve rapid balance reactions after unexpected external perturbations. During PBT, participants are repeatedly exposed to destabilizing perturbations while performing activities of daily living in a safe and controlled environment. A systematic review by Mansfield et al. indicated that PBT may be more effective in reducing daily-life falls in older adults, compared to various interventions ranging from no exercise to individualized physical therapy (risk ratio 0.71, 95% CI=0.52,0.96; P=.02),[7]. With PBT, balance adaptation may occur faster, potentially achieving equal or better results with fewer training sessions compared to conventional balance training,[8].

However promising, even effective interventions are likely to fail if they are not acceptable to the target population. The more acceptable the intervention, the more likely that adherence will be high,[9]. In turn, higher adherence (>80%) may result in larger effects,[10]. Due to the nature of the intervention, the question arises whether acceptability is an issue in PBT. In 2019, Okubo et al found in a pilot study of 10 healthy older adults that self-reported anxiety levels before a training session increased significantly with increasing unpredictability of PBT,[11]. Unpredictable perturbations are required in PBT to maximize learning of reactive balance control, yet these perturbations may cause anxiety and consequentially decrease acceptability.

So far limited evidence exists about the acceptability of PBT. Previous studies reported high training adherence rates, and no significant differences in drop-out rates between PBT and control groups receiving exercise or flexibility training,[12-14]. However, while quantitative data such as adherence rates may be indirect indicators of acceptability, the full-fledged concept of acceptability is a subjective evaluation made by individuals who experience an intervention,[9]. In 2017, Sekhon et al., proposed the Theoretical Framework of Acceptability (TFA) in which acceptability is viewed as a multifaceted construct, consisting of seven components,[9].

To our knowledge, no studies thus far have focused on qualitative aspects of acceptability of PBT in older adults. The aim of this study is to explore acceptability of PBT as perceived by older adults with a recent history of falls. Their views on the components constituting acceptability will be explored. The findings will enable optimisation of future implementation of PBT in clinical practice.

METHODS

Study design

A qualitative study consisting of semi-structured interviews was conducted. All participants provided written informed consent. This study was approved by the Medical Ethics Committee of MUMC+ (Maastricht University Medical Center) and Maastricht University (METC NL67131.068.18). The study is reported in line with the COREQ statement,[15].

Context, study participants and sampling

Older adults who participated in PBT as part of a RCT were included,[16]. Community-dwelling older adults (age ≥65 years) who visited the hospital's outpatient clinic due to a fall incident were informed about the study, and approached by telephone a 3-7 days later. Participants were included in the RCT if they were able to walk for 15 minutes without a walking aid. Exclusion criteria included any risk factors to them participating in PBT (e.g. diagnosed osteoporosis, severe cardiopulmonary disease), or inability to communicate in Dutch. Participants were eligible for the qualitative interviews after they had completed the PBT. They were selected by the PBT trainers through a combination of typical case and purposive sampling, to select those participants who were representative of the study population and were expected to provide the most detailed input.

The PBT protocol consisted of three 30-minute sessions, during which participants were exposed to sudden balance perturbations while they stood and walked on a dual-belt treadmill embedded in a moveable platform (Computer Assisted Rehabilitation Environment (CAREN), Motek Medical BV). During the training, virtual environments were projected on a 180^{o} screen in front of the platform. Each session consisted of three standardized conditions, while progression of difficulty levels in each condition was individualized.

1. Gait adaptability: participants walked on the treadmill while a virtual environment of a forest road, with various slopes and turns, was projected onto the screen. The platform moved correspondingly.

2. Static reactive balance: participants stood on the platform while the platform and treadmill made sudden, variable and unpredictable movements to perturb balance.

3. Dynamic reactive balance: this training condition was similar to the one above, only the perturbations were applied while the participant was walking on the treadmill.

A detailed description of the PBT protocol is published elsewhere,[16]. For an impression of the PBT setting, see Figure 1.

Insert Figure 1

Figure 1: Picture of a participant during PBT. Picture published with participant's permission.

Theoretical framework

The interviews were based on the TFA as proposed by Sekhon et al.,[9]. In this framework, acceptability is defined as a multi-faceted, seven component construct, including: affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness and self-efficacy. *Table 1* provides an overview of our operationalisation of each construct and an example of a related

question from our interview guide (supplemental file 1). Questions regarding context-specific barriers and facilitators (e.g. training location, supervision during training) to participate in PBT were added to gain insight in their influence on PBT acceptability.

Table 1: Theoretical framework of acceptability themes and interpretation.

THEME	INTERPRETATION
AFFECTIVE ATTITUDE	How an individual feels about the PBT *How do you feel about the training? What made you feel this way?*
SELF-EFFICACY	The participant's confidence in their ability to perform the PBT *How did you do in the training?*
PERCEIVED EFFECTIVENESS	The extent to which the participant perceives the PBT to potentially and actually (observed) be effective *To what extent did you experience effects from the training?*
ETHICALITY	The extent to which the intervention had good fit with an individual's value system and expectations of a falls prevention intervention *To what extent did the training fit with your views on falls prevention?*
INTERVENTION COHERENCE	The extent to which the participant understands the aim of PBT and how it works *In your own words, what was the aim of the training?*
BURDEN	The perceived amount of effort that was required to participate in the PBT *To what extent did you find the training strenuous? To what extent did you find the training challenging?*
OPPORTUNITY COSTS	The extent to which benefits, profits or values were given up to participate in the PBT *To what extent did you forego other opportunities to participate in the training?*

PBT; perturbation-based balance training

Interview procedure

The interviews took place at the hospital, within one to three weeks after training completion, between February 2020 and May 2021. Interviews and analysis were completed before results on the effectiveness of the PBT protocol were analysed. The first 13 interviews (of in total 16) were led by a researcher (MG) who was involved in the PBT program, because she was familiar with the specifics of the training and could ask targeted follow-up questions. A second researcher was always present at the interviews as an observer, to help keep track of the interview guide, and take field notes. A verbal summary was given at the end of each interview and a written summary was sent to each participant for a member check. Interviews were conducted iteratively; the interview guide was adjusted after the first 3 interviews to include emerging themes. This process was repeated after 10 and 13 interviews were completed. All interviews were recorded using a digital voicerecorder and transcribed verbatim. Any names and other possible identification information were removed from the transcripts. As the interviews and transcripts were in Dutch, all quotes presented were translated with care to conserve the original meaning.

Analysis

Interview transcripts were analysed using a template analysis approach,[17, 18]. The a priori template was formed based on the TFA and interview guide. Two researchers (MG and JS) independently coded

the first three interviews, using NVivo 12,[19]. After coding, they discussed the codes until consensus and formed an initial template. This process was repeated for the next three interviews. Consensus was then reached that this third template version covered the transcripts that were analysed so far. MG subsequently coded the remaining interviews using the third template version. MG and JS discussed if any changes needed to be made to the template based on the later interviews. After the 9th interview was coded, no more changes to the template were indicated. This was confirmed by coding the remaining 4 interviews, and coding saturation was reached,[20].

Reflexivity and triangulation

As MG was involved in the PBT for these participants, as well as sampling and interviewing, it was possible that there was researcher bias or that participants were more inclined to give desirable answers. For the purpose of interviewer triangulation, three additional interviews (interviews 14-16) were conducted by an independent researcher (AW) to confirm or reject previous responses. Coding of these three interviews revealed no new codes, which can be interpreted as secondary confirmation of the coding template and saturation. Participants did not give different answers to different interviewers. JS and AW were not involved in the RCT on PBT and represented an outsider perspective in the design and review of the interview guide, coding and analysis, therewith contributing to further researcher triangulation. Through comparison and discussion of the transcripts, the authors then reached consensus on the most important themes from the interviews.

Patient and public involvement

Patients were first involved in pilot testing of the PBT protocol in this research, and the training protocol was fine-tuned based on their feedback. The aim of this study is to explore participant's perceptions and views on the acceptability of the training, which may be used to guide design or implementation of future PBT interventions.

RESULTS

Participant description

Sixteen participants (14 females and 2 males, mean age 73.6 ± 6.0 years) were approached, all of which accepted. For comparison, the RCT included a total of 82 participants, of which 39 were randomized to the PBT group (median age 73 years (IQR 10 years), 31 females and 8 males). Table 2 provides an overview of participants and characteristics. Nine interviews were conducted at the hospital, seven were telephone interviews due to restrictions related to the COVID-19 pandemic. Interviews lasted 15-35 minutes. One participant (P031) missed one training session due to COVID-19 restrictions. Training adherance was 93,7% for the full PBT group, and 98,3% for participants included in this qualitative study.

Table 2: Overview of participant and interview characteristics.

Participant	Sex (F/M)	Age (years)	Falls previous year (n)	Interview type	Interviewer
P022	F	79	1	Face-to-face	MG
P023	F	80	1	Face-to-face	MG
P026	M	65	1	Telephone	MG
P027	F	76	2	Face-to-face	MG
P030	F	83	1	Telephone	MG
P031	M	67	1	Telephone	MG
P032	F	79	1	Telephone	MG
P040	F	73	2	Face-to-face	MG

P042	F	65	2	Face-to-face	MG
P043	F	74	1	Face-to-face	MG
P044	F	79	4	Face-to-face	MG
P045	F	74	1	Face-to-face	MG
P050	F	79	1	Face-to-face	MG
P068	F	70	1	Telephone	AW
P069	F	66	3	Telephone	AW
P082	F	69	1	Telephone	AW

F = female, M = male.

Perceptions of acceptability

The findings are presented below for each of the TFA components, along with illustrative quotes from participants. The theme 'training setting' was added, this theme includes context-specific barriers and facilitators that were described by the participants.

Affective attitude

Overall, participants described that they felt the PBT was an enjoyable experience. Most participants positively related this to the novelty of the experience, reporting feelings of curiosity and excitement. In contrast, some participants related this novelty to a feeling of suspense, and sometimes feeling unsure about their ability to participate in PBT at the start of the first training session. Most often this was described as a good amount of suspense and curiosity about what would happen, and not perceived as a barrier.

P044 *''I didn't know what I could expect. But I said: Guys, I'll just see what happens, I'll leave it up to you. (…) In the beginning, you don't know what is going to happen to you. You feel a little insecure. But I was glad that I did it.''*

One participant described feeling anxious during the first training session, a feeling that fortunately decreased throughout the following sessions.

P030 *''Now you know what you have to do so it's different. But at first it's kind of a startle response I think.''*

All participants reported that feeling safe and able to challenge themselves without fear of falling was closely related to a positive experience. The safety equipment (especially the safety harness), feeling heard by the trainer and receiving information during the training session were identified as important facilitators.

P050 *''And again, (laughing) I was very happy that I didn't need to hang from those ropes* [safety harness]*, but I had complete faith that if anything were to happen I definitely would not fall. So that didn't cause any anxiety for me.''*

Self-efficacy

All participants described that they were able to participate in the training sessions, and that they felt they did well. Some participants reported that their sense of self-efficacy grew throughout the training sessions, starting with feeling unsure about their ability at the first training session, to feeling accomplished after the second or third session. Some of these participants related their initial apprehension to comorbidities.

P031 *''I have COPD and you're aware that there are situations in which you may have to drop out. And in that sense, this could have happened to me in this training as well. Fortunately, it didn't.''*

Finally, one participant provided an example of how she felt after the training sessions.

P022 *''Well, I can say that I feel I did well. It brings you joy if you have something like that* (decreased strength in one leg due to a comorbidity) *and you're still able to catch yourself well.''*

Perceived effectiveness

This construct is understood as the extent to which participants perceived changes in their physical or psychological functioning, and attributed this to the training. Perceived training effects can be divided into physical and psychological effects. For most participants, recognizing physical training effects was not straightforward. Some participants clearly described improvements in their daily activities which they attributed to the training, such as improved walking ability or balance.

P068. *''I've been walking my son's dog a lot lately. (…) I've noticed that because of that* (training) *I'm steadier on my legs. Like this morning when I walked him, I had to walk downhill. And before I did the balance training, I would have thought 'Oh I have to be careful', but now I just know: I have to move like this, I have to put my foot here. And I can do this.''*

Still, most participants expressed that their physical abilities had remained the same, and wondered how they could have noticed possible changes due to training. For most, falling or stumbling was not a daily occurrence to begin with, and as the interviews took place shortly after training completion, they noted that potential changes were not easily identifiable in this short term. This was neither described as a barrier nor a facilitator to participating in the PBT.

P031. *''But if my balance has improved because of it, that's very hard to determine, because I don't fall very often. That I broke my wrist due to a fall was more of an accident.''*

Psychological effects were described as much more apparent and positively related to the acceptability of the intervention. Most participants expressed that the training had helped them gain confidence and improved self-efficacy, during the training sessions and in everyday life. They attributed this to how during the training they experienced that their body was capable of more than they expected.

P068. *''Especially the first time I noticed that I was quite insecure. (…) And that was more related to my confidence, which had been damaged. And I noticed after a few times that I, because of the training actually, gained some confidence. That I got more confident in my body.''*

Ethicality

This construct may not only be related to the extent to which the PBT was perceived to be a good fit with the participant's value system, but also to their expectations of the PBT. Most participants reported that anything they could do to prevent future fall incidents was viewed as valuable.

P069 *''Well, I was really glad about it, because I thought 'anything I can practice or do to help me fall less, will be helpful' ''*

Some participants found it hard to describe if falls prevention in general fit within their value system. Often participants related this to not having heard or thought about falls prevention until they were approached by the study team.

P032 *''I hadn't heard or read anything about it before, I started this without expectations.''*

Some also described having thought about it but not knowing who to approach about the topic, or not considering that they needed it. The lack of prior knowledge or expectations about the PBT was not perceived as a barrier to participating. Conclusively, some participants valued being able to contribute to a scientific study.

Intervention Coherence

All participants were able to recognize and describe the aim of the intervention to a certain degree. For example:

P023 *''In my own words? That you're more able to keep your balance. And it has worked.''*

Another participant provided a more detailed explanation of what she perceived as the aim of the intervention.

P043 *''To be able to recover, when you've lost balance. I think that that was the aim. That you're able to react; your body, your legs, or even with the help of an arm swing. Faster recovery to regain your balance.''*.

A factor that repeatedly emerged related to coherence of the intervention, is 'intervention validity'; understood as the extent to which participants perceived that the intervention had a good fit with its' aims. Most participants who discussed this topic, described the intervention as valid and perceived this as a facilitator to participating in PBT.

P026 *''A few times I nearly fell, but then you're able to correct this and it's a beautiful simulation of what can happen in real life. Especially when the treadmill belts don't run at the same speed, when one decelerates while the other continues. Then you get an effect like you're experiencing a slip.''*

However, a few participants also questioned if it was at all possible to prevent a future fall incident, reasoning that a fall occurs too sudden to make any preventive adjustments.

Burden

Participants agreed that the burden of participating in PBT was acceptable. The training was perceived as challenging, but not too challenging. Some participants positively related this to the way the training sessions were structured, providing a gradual and personalized increase in challenge.

P069 *''No, there was a good and gradual increase in challenge. They started the training quite easy and then it gradually became harder. It was very well structured.''*

Most effort was required to maintain or regain balance, and to stay focused throughout the session. Participants reported that the required physical stamina was not an important contributing factor to the perceived training load. When mentioned, participants described that the unexpected balance perturbations were perceived as more challenging than the first part of the training, where they could anticipate on what would happen next.

P022 *''The hard part was when it was sudden, unexpected. Going left, right, forward. That was, well, not hard; you can get it done, but you have to make sure you don't fall, even if you're in a safety harness.''*

Opportunity costs

Participants agreed that no activities had to be given up to participate in the PBT. Most related this to having enough time after retirement. The possibility to schedule the training sessions in consultation with the trainer instead of having fixed training times was reported as an important facilitator. Most participants accepted travelling to the training location as a fact and did not describe this as either a barrier or a facilitator. A few participants found the central location of the hospital a positive factor, as this was easy to reach using public transportation. Another few participants described that any location outside walking distance provided a challenge and a potential barrier, as they were no longer able to drive a car and had to rely on public transportation or family members to get there. As for the training location being inside a university hospital, this was mostly perceived as an advantage. Participants often described that they thought this was the logical place where they expected to find

the right equipment and expertise for this kind of training. Some also mentioned that they regarded the university hospital as a familiar institute, and therefore easy to find.

Training setting

This additional theme was identified throughout the interviews, and includes specific factors related to the setting of the PBT. The PBT took place in a specific setting with specialized technological equipment (see *Figure 1*) inside a university hospital. Most participants described that they experienced the technological training equipment as positive, as a surprising and interesting novelty. One participant explained that she felt slightly overwhelmed when she first saw the training equipment, but this improved when she got a more detailed explanation of what was going to happen and when she experienced the training for herself.

P031. *''The setting was very surprising. The fact that you're walking on a treadmill in an environment that moves with you. I thought it was a very extraordinary experience.''*

Most participants described the virtual environments that were used during training as surprising and positive. A few participants expressed a preference for the first virtual environment (the forest road), describing that this felt more friendly and stimulating than the second, more industrial environment.

The individual nature of this training was clearly valued by some participants, while others were ambivalent about this. Participants who indicated a preference for training individually, described that they enjoyed being able to really focus on the training itself without distractions from other people or the environment, and to train at their own level. Some also reasoned that this increased the potential of the training to be effective.

P068. *''This, the balance training, is not something you can do in a group. And I just thought it was very pleasant, because you're focusing on yourself. You're focused on what is going to happen, and you can feel everything that happens (…). And I just think that it is much more pleasant this way, and it will be more helpful.''*

While most participants preferred training individually, some described that they were curious to see how other people performed during the training sessions. Additionally, two participants would have appreciated the opportunity to compare and discuss fall-related experiences with peers.

A numeric rating scale (NRS) was used as a tool to individualize training progression. During the training sessions, participants were regularly asked to score how challenged they felt at that moment, ranging from 0 (not challenged at all) to 10 (highest perceivable challenge). Participants described mixed experiences with this system. Some found the scoring easy and even helpful and described that it helped them gain insight in how they felt at that moment. Others described that they had trouble translating their subjective experience to a number that meant little to them. Overall, the NRS scoring was not perceived as an important barrier or facilitator.

DISCUSSION

The aim of this study was to evaluate the acceptability of a PBT program as perceived by older adults, using the TFA. Gaining understanding of the acceptability of PBT in older adults with a recent history of falls is imperative to enable and optimize future implementation of PBT in clinical practice.

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. Besides the TFA, one additional theme emerged from the data, which includes challenges specific to the training setting such as preference for group training in some participants and travel to the training location.

Participants valued being able to feel safe during training. Most reported that this was accomplished by using the safety harness, the physical presence and guidance from the trainer, and individualized training progression. These results reflect those of Miller et al., who evaluated the perceived acceptability of conceptually challenging exercise training to older adults, including dynamic balance tasks with external perturbations,[21]. The novelty of the training and technology were regarded as a positive factor contributing to enjoyment by most participants. However, as in Miller's study, some participants reported feeling initially apprehensive or anxious towards the new training. Okubo et al.,[11], related elevated anxiety levels during PBT to the unpredictability of the perturbations. We previously hypothesized that a more gradual training progression over multiple sessions may help participants build confidence and alleviate anxiety while still being effective,[22]. This hypothesis is partially confirmed by our current findings, which indicated that self-efficacy improved over time. Participants who initially experienced anxiety also reported that this improved over time, and individualized training progression was reported as a facilitator to feeling safe during training. As unexpected perturbations are key for task-specific PBT, the trade-off between measures to alleviate anxiety while still achieving the desired training stimulus should be considered in future implementation. Our findings suggest that this may be particularly important at the start of training.

Perceived psychological effects in the form of increased confidence in balance abilities, and increased self-efficacy in daily life were often reported. Consistent with previous studies on falls prevention interventions, participants described that the PBT helped them gain insight in their ability level and were pleasantly surprised by their ability,[21, 23]. This is important as maintaining balance confidence can help avoid undue activity avoidance and subsequent disability,[24]. Moreover, decreased balance confidence has been identified as a predictor for future falls,[25]. While participants generally felt they did well during training, perceived physical effects in daily life were less apparent. Participants questioned how they would notice physical training effects, as falling was not a daily occurrence for them to begin with. In part, this may have been related to the interviews taking place shortly after training completion, leaving little time for participants to experience training effects. However, we hypothesize that this may also be related to the perceived intervention validity and ethicality.

While the topic of perceived intervention validity emerged in most of the interviews, participants views were mixed. Some described that they perceived the intervention valid as it clearly simulated daily-life balance perturbations. In contrast, other participants did not discuss PBT specifically, rather questioned if it was at all possible to prevent a fall in daily life, describing that falls occurred too sudden to intervene or were 'just accidents that could happen to anybody'. The belief that falls are just bad luck, and disbelief that they are preventable is well-known from the literature,[26-29]. A review by McInnes et al. recommended that these beliefs should be countered prior to intervention,[30]. While all participants in our study had recently fallen and agreed to participate in the current intervention, none of them actively sought to participate in falls prevention before. Participants described that they had previously given little or no thought to falls prevention, or that they did not think they needed it. This is in line with previous studies, indicating that those who have previously fallen are not necessarily more likely to be receptive to falls prevention interventions,[31, 32]. Another study described that older adults may reject the idea that they need falls prevention because they regard themselves as healthy and able to manage,[33]. PBT being a relatively new intervention, it may be assumed that this intervention is even less known to potential participants, thus increasing the challenge to reach the target population. Some participants reported that being informed by or talking to a health practitioner about the PBT, and being approached by the researchers, prompted them to consider falls prevention or to finally participate. This corroborates findings from Yardley et al., reporting that a personal invitation by a health practitioner may be a facilitating factor to participation in falls prevention,[34]. Our findings suggest that these factors may be particularly important to consider for PBT or any relatively unknown intervention, to effectively reach older adults.

Some participants clearly expressed a preference for training individually. Others described that they would have been curious to see how others performed during the training sessions, or to share fall-related experiences with others. Promoting the social value of falls prevention interventions has been previously identified as a facilitator,[30]. Additionally, watching or partnering with a peer completing the same exercises may facilitate participation and improve older adults' confidence for their own attempt,[21, 35, 36]. As PBT is currently not suited for a group intervention, it may be considered to provide a medium between individual and group training, while simultaneously addressing the initial apprehension or anxiety experienced by some participants. Specifically, this could be achieved by providing new participants with a video of a peer completing the exercises before their own participation, or combining training sessions of two participants where they can see each other perform and share experiences. Conclusively, hearing experiences from peers who completed the PBT might also improve perceived intervention validity and ethicality for future participants.

Finally, a practical factor that should be considered is travelling to the training location. As is the case with most set-ups for PBT, the equipment used in this program is not yet available in many locations. Some participants described that while they were able to attend the PBT sessions, travel was a potential barrier. This barrier is well-known in this population, as some older adults are no longer able to drive a car themselves and thus depend on family members or public transportation,[34, 37].

Strengths and Limitations

To our knowledge, this is the first study to use the TFA to examine older adults' perceived acceptability of PBT. Using the TFA enabled a systematic approach to define and assess intervention acceptability,[9]. While triangulation was applied in data collection as well as data analysis to increase trustworthiness of the research findings, it should be noted that one researcher (MG) was involved in the PBT sessions, as well as most of the interviews. In future studies, it may be considered to include a dedicated interviewer separate to the intervention team. A few limitations should be considered when interpreting the results of our study. First, the PBT intervention was applied in a research setting, meaning that some specific factors, such as willingness to pay for participation in the intervention, were not evaluated. Second, the results only reflect the perceived retrospective acceptability of the PBT. Further research is necessary to evaluate prospective and concurrent acceptability, to further elucidate what factors motivate or prevent older adults from participating in PBT,[9].

A final consideration is that due to COVID-19 related restrictions, 7 out of the 16 interviews in this study were telephone interviews. While face-to-face interviews are often regarded as the gold standard, there is little evidence that quality of findings collected through telephone interviews is compromised,[38]. Consistent with Sturges et al., we identified no clear differences between data collected through face-to-face interviews compared to telephone interviews in our study,[39].

CONCLUSIONS

In conclusion, findings from this study indicate that a technology-assisted PBT program is acceptable to older adults with a recent falls history. Enjoyment of the intervention, being able to feel safe, perceived psychological effectiveness and individualized training progression were identified as important factors contributing to the perceived acceptability. Increasing the social aspect of training and sharing experiences of peers may be considered to enhance acceptability to new participants who initially feel apprehensive or anxious about their ability to participate, or who are unsure what to expect. Raising awareness of the importance and possibilities of falls prevention training in general is a challenge in this population.

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Ethics statement

All participants provided written informed consent. This study was approved by the Medical Ethics Committee of MUMC+ (Maastricht University Medical Center) and Maastricht University (METC NL67131.068.18).

Competing interest

The authors declare no competing interests.

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Contributorship statement

Marissa Gerards: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Visualization, Project Administration. Judith Sieben: Methodology, Validation, Formal Analysis, Data Curation, Writing – Review & Editing. Rik Marcellis: Conceptualization, Writing – Review & Editing. Rob de Bie: Conceptualization, Writing – Review & Editing, Supervision. Kenneth Meijer: Conceptualization, Writing – Review & Editing, Supervision. Antoine Lenssen: Conceptualization, Writing – Review & Editing, Supervision, Project Administration.

Data availability

No additional data available.

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Figure 1: Picture of a participant during PBT. Picture published with participant's permission.

73x56mm (300 x 300 DPI)

Interview guide Acceptability of Perturbation-based balance training (PBT)

This interview guide gives an overview of the opening questions for each topic. The interviewers used a range of follow-up questions to obtain more information which were adapted and used as appropriate in each interview.

Theoretical framework

Opening question: Can you tell me how you experienced the training?

Affective attitude

How do you feel about the training?

Burden

To what extent did you find the training difficult?

To what extent did you find it challenging?

Self-efficacy

How do you feel you did during the training?

Perceived effectiveness

To what extent did you notice effects from the training (during training and in daily-life)?

Ethicality

To what extent did the training fit with your values? To what extent did it fit with your views on falls prevention?

Intervention coherence

Can you explain to me what the goal of the training was?

Opportunity costs

To what extent did you have to give up other activities or values to participate in the training?

Context-specific factors

What are your thoughts about…

… the location of the training?

… training individually, as opposed to in a group?

… the technological equipment used in the training?

… the scoring system that was used during training?

… the way the training was supervised?

Acceptability of a perturbation-based balance training program for falls prevention in older adults: a qualitative study

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Key words: Balance, perturbation, falls prevention, older adults, accidental falls

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ABSTRACT

Introduction

Perturbation-based balance training (PBT) is reported to effectively reduce ~~daily-life~~ falls in older adults, and may even be superior compared to various exercise programs. Due to the nature of the intervention, requiring unpredictable balance perturbations, the question arises whether acceptability is an issue in PBT.

Objective T~~he aim of this study is t~~o evaluate the acceptability of PBT in older adults with a recent history of falls.

Design, m~~M~~ethod, participants and settings~~

Qualitative study in which s~~S~~emi-structured interviews were conducted in 16 older adults (14 females and 2 males, mean age 73.6 ± 6.0 years) who completed a three-session PBT protocol as part of another study in a university medical centre in The Netherlands. Typical case and purposive sampling strategies were applied. Interviews were based on the theoretical framework of acceptability (TFA) alongside context-specific factors and analysed using a template analysis approach.

Results

~~Sixteen participants were interviewed.~~ 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 were identified as facilitating factors. Potential issues included initial apprehension or anxiety during training and perceived impact being predominantly psychological instead of physical. Complimentary to the TFA one additional theme emerged, which described challenges regarding the training setting such as preference for group training in some participants and travel to the training location.

Conclusions

The results suggest that PBT is perceived acceptable by older adults with a history of falls.~~,~~ Increasing the social aspect of training and sharing experiences of peers may be considered to enhance acceptability to new participants who initially feel apprehensive or anxious about their ability to participate ~~and indicate important factors that should be considered~~ in future implementation of PBT.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first study to use the theoretical framework of acceptability (TFA) to explore older adults' perceived acceptability of PBT.
- Using the TFA enabled a systematic approach to define and assess intervention acceptability.
- Triangulation was applied in data collection as well as data analysis to increase trustworthiness of the research findings.
- The PBT intervention was applied in a research setting, meaning that some specific factors, such as willingness to pay for participation in the intervention, were not evaluated.
- The results only reflect the perceived retrospective acceptability of the PBT, and may not entirely reflect how participant's views changed over time.

INTRODUCTION

Falls in community-dwelling older adults can be effectively reduced through exercise interventions including balance training,[1]. However, the search for the optimal balance training program for falls prevention is still ongoing. With conventional balance training, a relatively high number of training sessions are needed, discontinuation rates are high and retention of training effects is hard to accomplish,[2, 3]. Moreover, conventional balance training seems not sufficiently task-specific to prevent falls due to slips or trips during walking, which cause up to 60% of falls in community-dwelling older adults,[4, 5]. It is not likely that conventional balance training, mostly targeting volitional movements, will improve the change-in-support reactions (e.g. taking a quick step) needed to prevent a slip or a trip, due to the additional speed and stability requirements of these balance reactions,[6]. Therefore, an increasing interest has arisen in more task-specific balance training interventions, such as perturbation-based balance training (PBT).

PBT aims to improve rapid balance reactions after unexpected external perturbations. During PBT, participants are repeatedly exposed to destabilizing perturbations while performing activities of daily living in a safe and controlled environment. A systematic review by Mansfield et al. indicated that PBT may be more effective in reducing daily-life falls in older adults, compared to various interventions ranging from no exercise to individualized physical therapy (risk ratio 0.71, 95% CI=0.52,0.96; P=.02),[7]. With PBT, balance adaptation may occur faster, potentially achieving equal or better results with fewer training sessions compared to conventional balance training,[8].

However promising, even effective interventions are likely to fail if they are not acceptable to the target population. The more acceptable the intervention, the more likely that adherence will be high,[9]. In turn, higher adherence (>80%) may result in larger effects,[10]. Due to the nature of the intervention, the question arises whether acceptability is an issue in PBT. In 2019, Okubo et al found in a pilot study of 10 healthy older adults that self-reported anxiety levels before a training session increased significantly with increasing unpredictability of PBT,[11]. Unpredictable perturbations are required in PBT to maximize learning of reactive balance control, yet these perturbations may cause anxiety and consequentially decrease acceptability.

So far limited evidence exists about the acceptability of PBT. Previous studies reported high training adherence rates, and no significant differences in drop-out rates between PBT and control groups receiving exercise or flexibility training,[12-14]. However, while quantitative data such as adherence rates may be indirect indicators of acceptability, the full-fledged concept of acceptability is a subjective evaluation made by individuals who experience an intervention,[9]. In 2017, Sekhon et al., proposed the Theoretical Framework of Acceptability (TFA) in which acceptability is viewed as a multifaceted construct, consisting of seven components,[9].

To our knowledge, no studies thus far have focused on qualitative aspects of acceptability of PBT in older adults. The aim of this study is to explore acceptability of PBT as perceived by older adults with a recent history of falls. Their views on the components constituting acceptability will be explored. The findings will enable optimisation of future implementation of PBT in clinical practice.

METHODS

Study design

A qualitative study consisting of semi-structured interviews was conducted. All participants provided written informed consent. This study was approved by the Medical Ethics Committee of MUMC+ (Maastricht University Medical Center) and Maastricht University (METC NL67131.068.18). The study is reported in line with the COREQ statement,[15].

Context, study participants and sampling

Older adults who participated in PBT as part of a RCT were included,[16]. Community-dwelling older adults (age ≥65 years) who visited the hospital's outpatient clinic due to a fall incident were informed about the study, and approached by telephone a 3-7 days later. Participants were included in the RCT if they were able to walk for 15 minutes without a walking aid. Exclusion criteria included any risk factors to them participating in PBT (e.g. diagnosed osteoporosis, severe cardiopulmonary disease), or inability to communicate in Dutch. Participants were eligible for the qualitative interviews after they had completed the PBT. They were selected by the PBT trainers through a combination of typical case and purposive sampling, to select those participants who were representative of the study population and were expected to provide the most detailed input.

The PBT protocol consisted of three 30-minute sessions, during which participants were exposed to sudden balance perturbations while they stood and walked on a dual-belt treadmill embedded in a moveable platform (Computer Assisted Rehabilitation Environment (CAREN), Motek Medical BV). During the training, virtual environments were projected on a 180° screen in front of the platform. Each session consisted of three standardized conditions, while progression of difficulty levels in each condition was individualized.

1. Gait adaptability: participants walked on the treadmill while a virtual environment of a forest road, with various slopes and turns, was projected onto the screen. The platform moved correspondingly.

2. Static reactive balance: participants stood on the platform while the platform and treadmill made sudden, variable and unpredictable movements to perturb balance.

3. Dynamic reactive balance: this training condition was similar to the one above, only the perturbations were applied while the participant was walking on the treadmill.

A detailed description of the PBT protocol is published elsewhere,[16]. For an impression of the PBT setting, see Figure 1.

Insert Figure 1

Figure 1: Picture of a participant during PBT. Picture published with participant's permission.

Theoretical framework

The interviews were based on the TFA as proposed by Sekhon et al.,[9]. In this framework, acceptability is defined as a multi-faceted, seven component construct, including: affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness and self-efficacy. *Table 1* provides an overview of our operationalisation of each construct and an example of a related

question from our interview guide (supplemental file 1). Questions regarding context-specific barriers and facilitators (e.g. training location, supervision during training) to participate in PBT were added to gain insight in their influence on PBT acceptability.

Table 1: Theoretical framework of acceptability themes and interpretation.

THEME	INTERPRETATION
AFFECTIVE ATTITUDE	How an individual feels about the PBT *How do you feel about the training? What made you feel this way?*
SELF-EFFICACY	The participant's confidence in their ability to perform the PBT *How did you do in the training?*
PERCEIVED EFFECTIVENESS	The extent to which the participant perceives the PBT to potentially and actually (observed) be effective *To what extent did you experience effects from the training?*
ETHICALITY	The extent to which the intervention had good fit with an individual's value system and expectations of a falls prevention intervention *To what extent did the training fit with your views on falls prevention?*
INTERVENTION COHERENCE	The extent to which the participant understands the aim of PBT and how it works *In your own words, what was the aim of the training?*
BURDEN	The perceived amount of effort that was required to participate in the PBT *To what extent did you find the training strenuous? To what extent did you find the training challenging?*
OPPORTUNITY COSTS	The extent to which benefits, profits or values were given up to participate in the PBT *To what extent did you forego other opportunities to participate in the training?*

PBT; perturbation-based balance training

Interview procedure

The interviews took place at the hospital, within one to three weeks after training completion, between February 2020 and May 2021. Interviews and analysis were completed before results on the effectiveness of the PBT protocol were analysed. The first 13 interviews (of in total 16) were led by a researcher (MG) who was involved in the PBT program, because she was familiar with the specifics of the training and could ask targeted follow-up questions. A second researcher was always present at the interviews as an observer, to help keep track of the interview guide, and take field notes. A verbal summary was given at the end of each interview and a written summary was sent to each participant for a member check. Interviews were conducted iteratively; the interview guide was adjusted after the first 3 interviews to include emerging themes. This process was repeated after 10 and 13 interviews were completed. All interviews were recorded using a digital voicerecorder and transcribed verbatim. Any names and other possible identification information were removed from the transcripts. As the interviews and transcripts were in Dutch, all quotes presented were translated with care to conserve the original meaning.

Analysis

Interview transcripts were analysed using a template analysis approach,[17, 18]. The a priori template was formed based on the TFA and interview guide. Two researchers (MG and JS) independently coded

the first three interviews, using NVivo 12,[19]. After coding, they discussed the codes until consensus and formed an initial template. This process was repeated for the next three interviews. Consensus was then reached that this third template version covered the transcripts that were analysed so far. MG subsequently coded the remaining interviews using the third template version. MG and JS discussed if any changes needed to be made to the template based on the later interviews. After the 9th interview was coded, no more changes to the template were indicated. This was confirmed by coding the remaining 4 interviews, and coding saturation was reached,[20].

Reflexivity and triangulation

As MG was involved in the PBT for these participants, as well as sampling and interviewing, it was possible that there was researcher bias or that participants were more inclined to give desirable answers. For the purpose of interviewer triangulation, three additional interviews (interviews 14-16) were conducted by an independent researcher (AW) to confirm or reject previous responses. Coding of these three interviews revealed no new codes, which can be interpreted as secondary confirmation of the coding template and saturation. Participants did not give different answers to different interviewers. JS and AW were not involved in the RCT on PBT and represented an outsider perspective in the design and review of the interview guide, coding and analysis, therewith contributing to further researcher triangulation. Through comparison and discussion of the transcripts, the authors then reached consensus on the most important themes from the interviews.

Patient and public involvement

Patients were first involved in pilot testing of the PBT protocol in this research, and the training protocol was fine-tuned based on their feedback. The aim of this study is to explore participant's perceptions and views on the acceptability of the training, which may be used to guide design or implementation of future PBT interventions.

RESULTS

Participant description

Sixteen participants (14 females and 2 males, mean age 73.6 ± 6.0 years) were approached, all of which accepted. For comparison, the RCT included- a total of 82 participants, of which 39 were randomized to the PBT group (median age 73 years (IQR 10 years), 31 females and 8 males)~~66 females and 17 males, and participants' mean age was 72.9 ± 5.3 years~~. Table 2 provides an overview of participants and characteristics. Nine interviews were conducted at the hospital, seven were telephone interviews due to restrictions related to the COVID-19 pandemic. Interviews lasted 15-35 minutes. One participant (P031) missed one training session due to COVID-19 restrictions. Training adherance was 93,7% for the full PBT group, and 98,3% for participants included in this qualitative study.

Table 2: Overview of participant and interview characteristics.

Participant	Sex (F/M)	Age (years)	Falls previous year (n)	Interview type	Interviewer
P022	F	79	1	Face-to-face	MG
P023	F	80	1	Face-to-face	MG
P026	M	65	1	Telephone	MG
P027	F	76	2	Face-to-face	MG
P030	F	83	1	Telephone	MG
P031	M	67	1	Telephone	MG
P032	F	79	1	Telephone	MG
P040	F	73	2	Face-to-face	MG

P042	F	65	2	Face-to-face	MG
P043	F	74	1	Face-to-face	MG
P044	F	79	4	Face-to-face	MG
P045	F	74	1	Face-to-face	MG
P050	F	79	1	Face-to-face	MG
P068	F	70	1	Telephone	AW
P069	F	66	3	Telephone	AW
P082	F	69	1	Telephone	AW

F = female, M = male.

Perceptions of acceptability

The findings are presented below for each of the TFA components, along with illustrative quotes from participants. The theme 'training setting' was added, this theme includes context-specific barriers and facilitators that were described by the participants.

Affective attitude

Overall, participants described that they felt the PBT was an enjoyable experience. Most participants positively related this to the novelty of the experience, reporting feelings of curiosity and excitement. In contrast, some participants related this novelty to a feeling of suspense, and sometimes feeling unsure about their ability to participate in PBT at the start of the first training session. Most often this was described as a good amount of suspense and curiosity about what would happen, and not perceived as a barrier.

P044 *''I didn't know what I could expect. But I said: Guys, I'll just see what happens, I'll leave it up to you. (…) In the beginning, you don't know what is going to happen to you. You feel a little insecure. But I was glad that I did it.''*

One participant described feeling anxious during the first training session, a feeling that fortunately decreased throughout the following sessions.

P030 *''Now you know what you have to do so it's different. But at first it's kind of a startle response I think.''*

All participants reported that feeling safe and able to challenge themselves without fear of falling was closely related to a positive experience. The safety equipment (especially the safety harness), feeling heard by the trainer and receiving information during the training session were identified as important facilitators.

P050 *''And again, (laughing) I was very happy that I didn't need to hang from those ropes* [safety harness]*, but I had complete faith that if anything were to happen I definitely would not fall. So that didn't cause any anxiety for me.''*

Self-efficacy

All participants described that they were able to participate in the training sessions, and that they felt they did well. Some participants reported that their sense of self-efficacy grew throughout the training sessions, starting with feeling unsure about their ability at the first training session, to feeling accomplished after the second or third session. Some of these participants related their initial apprehension to comorbidities.

P031 *''I have COPD and you're aware that there are situations in which you may have to drop out. And in that sense, this could have happened to me in this training as well. Fortunately, it didn't.''*

Finally, one participant provided an example of how she felt after the training sessions.

P022 *''Well, I can say that I feel I did well. It brings you joy if you have something like that* (decreased strength in one leg due to a comorbidity) *and you're still able to catch yourself well.''*

Perceived effectiveness

This construct is understood as the extent to which participants perceived changes in their physical or psychological functioning, and attributed this to the training. Perceived training effects can be divided into physical and psychological effects. For most participants, recognizing physical training effects was not straightforward. Some participants clearly described improvements in their daily activities which they attributed to the training, such as improved walking ability or balance.

P068. *''I've been walking my son's dog a lot lately. (…) I've noticed that because of that* (training) *I'm steadier on my legs. Like this morning when I walked him, I had to walk downhill. And before I did the balance training, I would have thought 'Oh I have to be careful', but now I just know: I have to move like this, I have to put my foot here. And I can do this.''*

Still, most participants expressed that their physical abilities had remained the same, and wondered how they could have noticed possible changes due to training. For most, falling or stumbling was not a daily occurrence to begin with, and as the interviews took place shortly after training completion, they noted that potential changes were not easily identifiable in this short term. This was neither described as a barrier nor a facilitator to participating in the PBT.

P031. *''But if my balance has improved because of it, that's very hard to determine, because I don't fall very often. That I broke my wrist due to a fall was more of an accident.''*

Psychological effects were described as much more apparent and positively related to the acceptability of the intervention. Most participants expressed that the training had helped them gain confidence and improved self-efficacy, during the training sessions and in everyday life. They attributed this to how during the training they experienced that their body was capable of more than they expected.

P068. *''Especially the first time I noticed that I was quite insecure. (…) And that was more related to my confidence, which had been damaged. And I noticed after a few times that I, because of the training actually, gained some confidence. That I got more confident in my body.''*

Ethicality

This construct may not only be related to the extent to which the PBT was perceived to be a good fit with the participant's value system, but also to their expectations of the PBT. Most participants reported that anything they could do to prevent future fall incidents was viewed as valuable.

P069 *''Well, I was really glad about it, because I thought 'anything I can practice or do to help me fall less, will be helpful' ''*

Some participants found it hard to describe if falls prevention in general fit within their value system. Often participants related this to not having heard or thought about falls prevention until they were approached by the study team.

P032 *''I hadn't heard or read anything about it before, I started this without expectations.''*

Some also described having thought about it but not knowing who to approach about the topic, or not considering that they needed it. The lack of prior knowledge or expectations about the PBT was not perceived as a barrier to participating. Conclusively, some participants valued being able to contribute to a scientific study.

Intervention Coherence

All participants were able to recognize and describe the aim of the intervention to a certain degree. For example:

P023 *''In my own words? That you're more able to keep your balance. And it has worked.''*

Another participant provided a more detailed explanation of what she perceived as the aim of the intervention.

P043 *''To be able to recover, when you've lost balance. I think that that was the aim. That you're able to react; your body, your legs, or even with the help of an arm swing. Faster recovery to regain your balance.''*.

A factor that repeatedly emerged related to coherence of the intervention, is 'intervention validity'; understood as the extent to which participants perceived that the intervention had a good fit with its' aims. Most participants who discussed this topic, described the intervention as valid and perceived this as a facilitator to participating in PBT.

P026 *''A few times I nearly fell, but then you're able to correct this and it's a beautiful simulation of what can happen in real life. Especially when the treadmill belts don't run at the same speed, when one decelerates while the other continues. Then you get an effect like you're experiencing a slip.''*

However, a few participants also questioned if it was at all possible to prevent a future fall incident, reasoning that a fall occurs too sudden to make any preventive adjustments.

Burden

Participants agreed that the burden of participating in PBT was acceptable. The training was perceived as challenging, but not too challenging. Some participants positively related this to the way the training sessions were structured, providing a gradual and personalized increase in challenge.

P069 *''No, there was a good and gradual increase in challenge. They started the training quite easy and then it gradually became harder. It was very well structured.''*

Most effort was required to maintain or regain balance, and to stay focused throughout the session. Participants reported that the required physical stamina was not an important contributing factor to the perceived training load. When mentioned, participants described that the unexpected balance perturbations were perceived as more challenging than the first part of the training, where they could anticipate on what would happen next.

P022 *''The hard part was when it was sudden, unexpected. Going left, right, forward. That was, well, not hard; you can get it done, but you have to make sure you don't fall, even if you're in a safety harness.''*

Opportunity costs

Participants agreed that no activities had to be given up to participate in the PBT. Most related this to having enough time after retirement. The possibility to schedule the training sessions in consultation with the trainer instead of having fixed training times was reported as an important facilitator. Most participants accepted travelling to the training location as a fact and did not describe this as either a barrier or a facilitator. A few participants found the central location of the hospital a positive factor, as this was easy to reach using public transportation. Another few participants described that any location outside walking distance provided a challenge and a potential barrier, as they were no longer able to drive a car and had to rely on public transportation or family members to get there. As for the training location being inside a university hospital, this was mostly perceived as an advantage. Participants often described that they thought this was the logical place where they expected to find

the right equipment and expertise for this kind of training. Some also mentioned that they regarded the university hospital as a familiar institute, and therefore easy to find.

Training setting

This additional theme was identified throughout the interviews, and includes specific factors related to the setting of the PBT. The PBT took place in a specific setting with specialized technological equipment (see *Figure 1*) inside a university hospital. Most participants described that they experienced the technological training equipment as positive, as a surprising and interesting novelty. One participant explained that she felt slightly overwhelmed when she first saw the training equipment, but this improved when she got a more detailed explanation of what was going to happen and when she experienced the training for herself.

P031. *''The setting was very surprising. The fact that you're walking on a treadmill in an environment that moves with you. I thought it was a very extraordinary experience.''*

Most participants described the virtual environments that were used during training as surprising and positive. A few participants expressed a preference for the first virtual environment (the forest road), describing that this felt more friendly and stimulating than the second, more industrial environment.

The individual nature of this training was clearly valued by some participants, while others were ambivalent about this. Participants who indicated a preference for training individually, described that they enjoyed being able to really focus on the training itself without distractions from other people or the environment, and to train at their own level. Some also reasoned that this increased the potential of the training to be effective.

P068. *''This, the balance training, is not something you can do in a group. And I just thought it was very pleasant, because you're focusing on yourself. You're focused on what is going to happen, and you can feel everything that happens (…). And I just think that it is much more pleasant this way, and it will be more helpful.''*

While most participants preferred training individually, some described that they were curious to see how other people performed during the training sessions. Additionally, two participants would have appreciated the opportunity to compare and discuss fall-related experiences with peers.

A numeric rating scale (NRS) was used as a tool to individualize training progression. During the training sessions, participants were regularly asked to score how challenged they felt at that moment, ranging from 0 (not challenged at all) to 10 (highest perceivable challenge). Participants described mixed experiences with this system. Some found the scoring easy and even helpful and described that it helped them gain insight in how they felt at that moment. Others described that they had trouble translating their subjective experience to a number that meant little to them. Overall, the NRS scoring was not perceived as an important barrier or facilitator.

DISCUSSION

The aim of this study was to evaluate the acceptability of a PBT program as perceived by older adults, using the TFA. Gaining understanding of the acceptability of PBT in older adults with a recent history of falls is imperative to enable and optimize future implementation of PBT in clinical practice.

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. Besides the TFA, one additional theme emerged from the data, which includes challenges specific to the training setting such as preference for group training in some participants and travel to the training location.

Participants valued being able to feel safe during training. Most reported that this was accomplished by using the safety harness, the physical presence and guidance from the trainer, and individualized training progression. These results reflect those of Miller et al., who evaluated the perceived acceptability of conceptually challenging exercise training to older adults, including dynamic balance tasks with external perturbations,[21]. The novelty of the training and technology were regarded as a positive factor contributing to enjoyment by most participants. However, as in Miller's study, some participants reported feeling initially apprehensive or anxious towards the new training. Okubo et al.,[11], related elevated anxiety levels during PBT to the unpredictability of the perturbations. We previously hypothesized that a more gradual training progression over multiple sessions may help participants build confidence and alleviate anxiety while still being effective,[22]. This hypothesis is partially confirmed by our current findings, which indicated that self-efficacy improved over time. Participants who initially experienced anxiety also reported that this improved over time, and individualized training progression was reported as a facilitator to feeling safe during training. As unexpected perturbations are key for task-specific PBT, the trade-off~~balance~~ between measures to alleviate anxiety while still achieving the desired training stimulus should be considered in future implementation. Our findings suggest that this may be particularly important at the start of training.

Perceived psychological effects in the form of increased confidence in balance abilities, and increased self-efficacy in daily life were often reported. Consistent with previous studies on falls prevention interventions, participants described that the PBT helped them gain insight in their ability level and were pleasantly surprised by their ability,[21, 23]. This is important as maintaining balance confidence can help avoid undue activity avoidance and subsequent disability,[24]. Moreover, decreased balance confidence has been identified as a predictor for future falls,[25]. While participants generally felt they did well during training, perceived physical effects in daily life were less apparent. Participants questioned how they would notice physical training effects, as falling was not a daily occurrence for them to begin with. In part, this may have been related to the interviews taking place shortly after training completion, leaving little time for participants to experience training effects. However, we hypothesize that this may also be related to the perceived intervention validity and ethicality.

While the topic of perceived intervention validity emerged in most of the interviews, participants views were mixed. Some described that they perceived the intervention valid as it clearly simulated daily-life balance perturbations. In contrast, other participants did not discuss PBT specifically, rather questioned if it was at all possible to prevent a fall in daily life, describing that falls occurred too sudden to intervene or were 'just accidents that could happen to anybody'. The belief that falls are just bad luck, and disbelief that they are preventable is well-known from the literature,[26-298]. A review by McInnes et al. recommended that these beliefs should be countered prior to intervention,[3029]. While all participants in our study had recently fallen and agreed to participate in the current intervention, none of them actively sought to participate in falls prevention before. Participants described that they had previously given little or no thought to falls prevention, or that they did not think they needed it. This is in line with previous studies, indicating that those who have previously fallen are not necessarily more likely to be receptive to falls prevention interventions,[310, 321]. Another study described that older adults may reject the idea that they need falls prevention because they regard themselves as healthy and able to manage,[332]. PBT being a relatively new intervention, it may be assumed that this intervention is even less known to potential participants, thus increasing the challenge to reach the target population. Some participants reported that being informed by or talking to a health practitioner about the PBT, and being approached by the researchers, prompted them to consider falls prevention or to finally participate. This corroborates findings from Yardley et al., reporting that a personal invitation by a health practitioner may be a facilitating factor to participation in falls prevention,[343]. Our findings suggest that these factors may be particularly important to consider for PBT or any relatively unknown intervention, to effectively reach older adults.

Some participants clearly expressed a preference for training individually. Others described that they would have been curious to see how others performed during the training sessions, or to share fall-related experiences with others. Promoting the social value of falls prevention interventions has been previously identified as a facilitator,[3029]. Additionally, watching or partnering with a peer completing the same exercises may facilitate participation and improve older adults' confidence for their own attempt,[21, 354, 365]. As PBT is currently not suited for a group intervention, it may be considered to provide a medium between individual and group training, while simultaneously addressing the initial apprehension or anxiety experienced by some participants. Specifically, this could be achieved by providing new participants with a video of a peer completing the exercises before their own participation, or combining training sessions of two participants where they can see each other perform and share experiences. Conclusively, hearing experiences from peers who completed the PBT might also improve perceived intervention validity and ethicality for future participants.

Finally, a practical factor that should be considered is travelling to the training location. As is the case with most set-ups for PBT, the equipment used in this program is not yet available in many locations. Some participants described that while they were able to attend the PBT sessions, travel was a potential barrier. This barrier is well-known in this population, as some older adults are no longer able to drive a car themselves and thus depend on family members or public transportation,[343, 376].

Strengths and Limitations

To our knowledge, this is the first study to use the TFA to examine older adults' perceived acceptability of PBT. Using the TFA enabled a systematic approach to define and assess intervention acceptability,[9]. While tTriangulation was applied in data collection as well as data analysis to increase trustworthiness of the research findings, it should be noted that one researcher (MG) was involved in the PBT sessions, as well as most of the interviews. In future studies, it may be considered to include a dedicated interviewer separate to the intervention team. A few limitations should be considered when interpreting the results of our study. First, the PBT intervention was applied in a research setting, meaning that some specific factors, such as willingness to pay for participation in the intervention, were not evaluated. Second, the results only reflect the perceived retrospective acceptability of the PBT. Further research is necessary to evaluate prospective and concurrent acceptability, to further elucidate what factors motivate or prevent older adults from participating in PBT,[9].

A final consideration is that due to COVID-19 related restrictions, 7 out of the 16 interviews in this study were telephone interviews. While face-to-face interviews are often regarded as the gold standard, there is little evidence that quality of findings collected through telephone interviews is compromised,[387]. Consistent with Sturges et al., we identified no clear differences between data collected through face-to-face interviews compared to telephone interviews in our study,[398].

CONCLUSIONS

In conclusion, findings from this study indicate that a technology-assisted PBT program is acceptable to older adults with a recent falls history. Enjoyment of the intervention, being able to feel safe, perceived psychological effectiveness and individualized training progression were identified as important factors contributing to the perceived acceptability. Increasing the social aspect of training and sharing experiences of peers may be considered to enhance acceptability to new participants who initially feel apprehensive or anxious about their ability to participate, or who are unsure what to expect. Raising awareness of the importance and possibilities of falls prevention training in general is a challenge in this population.

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Ethics statement

All participants provided written informed consent. This study was approved by the Medical Ethics Committee of MUMC+ (Maastricht University Medical Center) and Maastricht University (METC NL67131.068.18).

Competing interest

The authors declare no competing interests.

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Contributorship statement

Marissa Gerards: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Visualization, Project Administration. Judith Sieben: Methodology, Validation, Formal Analysis, Data Curation, Writing – Review & Editing. Rik Marcellis: Conceptualization, Writing – Review & Editing. Rob de Bie: Conceptualization, Writing – Review & Editing, Supervision. Kenneth Meijer: Conceptualization, Writing – Review & Editing, Supervision. Antoine Lenssen: Conceptualization, Writing – Review & Editing, Supervision, Project Administration.

Data availability

No additional data available.

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COREQ (COnsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	5
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	5
Occupation	3	What was their occupation at the time of the study?	5
Gender	4	Was the researcher male or female?	5
Experience and training	5	What experience or training did the researcher have?	5
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	5
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	5
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	5,6
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	5,6
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	4
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	4
Sample size	12	How many participants were in the study?	6
Non-participation	13	How many people refused to participate or dropped out? Reasons?	6
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	6
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	5
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	6,7
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	5
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	n/a
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	5
Field notes	20	Were field notes made during and/or after the inter view or focus group?	5
Duration	21	What was the duration of the inter views or focus group?	6
Data saturation	22	Was data saturation discussed?	5,6
Transcripts returned	23	Were transcripts returned to participants for comment and/or	5

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
Data analysis			
Number of data coders	24	How many data coders coded the data?	5,6
Description of the coding tree	25	Did authors provide a description of the coding tree?	5,6
Derivation of themes	26	Were themes identified in advance or derived from the data?	5,6
Software	27	What software, if applicable, was used to manage the data?	5
Participant checking	28	Did participants provide feedback on the findings?	5
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	7-10
Data and findings consistent	30	Was there consistency between the data presented and the findings?	7-10
Clarity of major themes	31	Were major themes clearly presented in the findings?	7-10
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	7-10

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.