Title: Does perturbation-based balance training prevent falls? A review and meta-analysis of preliminary randomized controlled trials

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ABSTRACT

Background: Older adults and individuals with neurological conditions are at an increased risk for falls. While physical exercise can prevent falls, certain types of exercise may be more effective. Perturbation-based balance training is a novel intervention involving repeated postural perturbations aiming to improve control of rapid balance reactions. **Purpose:** To estimate the effect of perturbation-based balance training on falls in daily life. **Data sources:** Medline (1946-July 2014), EMBASE (1974-July 2014), PEDro (all dates), CENTRAL (1991-July 2014) and Google Scholar (all dates). **Study selection**: Randomized controlled trials written in English were included if they focused on perturbation-based balance training among older adults or individuals with neurological conditions and collected falls data post-training. **Data extraction**: Two investigators extracted data independently. Study authors were contacted to obtain missing information. A PEDro score was obtained for each study. Primary outcomes were proportion of participants who reported one or more falls (i.e., number of fallers) and the total number of falls. The risk ratio (proportion of fallers) and rate ratio (number of falls) were entered into the analysis. **Data synthesis**: Eight studies involving 404 participants were included. Participants who completed perturbation-based balance training were less likely to report a fall (overall risk ratio 0.71, 95% confidence interval [0.52, 0.96]; p=0.02) and reported fewer falls than those in the control groups (overall rate ratio 0.54, 95% confidence interval [0.34, 0.85]; p=0.007). **Limitations:** Study authors do not always identify that they have included perturbation training in their intervention; therefore, it is possible that some appropriate studies were not included. Study designs were heterogeneous preventing sub-analyses. **Conclusions**: Perturbation-based balance training appears to reduce fall risk among older adults and individuals with Parkinson’s disease.

INTRODUCTION

Physiological impairments associated with neurological conditions (such as stroke and Parkinson's disease) and the 'normal' aging process can contribute to impaired balance control and increased falls risk. Falls can have direct negative consequences (i.e., injuries) but can also result in fear and anxiety, reduced independent mobility, and increased risk of admission to long-term care. Previous work has generally found that physical exercise focused on balance training can prevent falls;[1-5] however, there is limited or no evidence for reduced falls following balance training in some cases (e.g., for those with stroke[6,7]). It is possible that more specific exercise, focused on the mechanism of occurrence of falls, might be more effective for falls prevention.

While many factors contribute to increased risk for falls, a specific fall event ultimately occurs when an individual fails to recover from a loss of balance, or postural perturbation.[8] Postural perturbations can occur in daily life for a variety of reasons, including failure to control weight shifting during voluntary movement, or experiencing a slip or trip while walking.[9] Balance recovery reactions, such as swaying around the ankles or hips, taking a step, or grasping a handhold,[10] are executed rapidly to prevent a fall following a postural perturbation. Individuals with impaired balance control and increased fall risk often show difficulty controlling these balance recovery reactions.[11-13] Since all ambulatory individuals are at risk of experiencing a loss of balance during daily life, training to improve control of balance recovery reactions may be an effective means of preventing falls.[14-16] Perturbation-based balance training (PBT) is a novel balance training intervention that incorporates exposure to repeated postural perturbations to evoke rapid balance reactions, enabling participants to improve control of these reactions with practice. The alternative, training voluntary movements (e.g., volitionally-executed stepping or reach-to-grasp movements), will likely not lead to improved reactive balance control due to the additional speed and stability requirements of balance reactions.[15]

Studies have found that PBT can improve speed and control of voluntary movements[17] and rapid balance reactions,[18-20] and can reduce occurrence of 'falls' (into a safety harness) following controlled postural perturbations in the laboratory.[18,20,21] However, the effect of PBT on risk of falls during daily life has not been conclusively demonstrated. Several studies with small sample sizes have reported non-significant reductions in fall rates in the trained group compared to a control group.[22,23] Therefore, the purpose of this study was to estimate the effect of PBT on risk of falls in daily life among individuals at increased risk for falls (i.e., older adults and individuals with neurological conditions) by conducting a comprehensive search for, and meta-analysis of, published and unpublished data from randomized controlled trials of PBT.

METHODS

Design overview

This study involved systematic review and meta-analysis, conducted according to Cochrane guidelines[24] and reported according to the PRISMA statement and checklist.[25]

Data sources and searches

The search strategy and inclusion/exclusion criteria for selected studies were determined *a priori* by the investigators in collaboration with an Information Specialist. Terminology around PBT is inconsistent in the literature. Some investigators refer to 'perturbation training' whereas others use terms such as 'agility training' or 'dynamic balance training'. Additionally, there are no relevant subject headings within literature databases to accurately encompass the content of PBT. Thus, a multi-stage and iterative search strategy was used to identify studies for inclusion in the review:

1. An initial search of Medline (1946-current), EMBASE (1974-current), PEDro (all available dates) and CENTRAL (1991-current) databases was conducted in July 2014. The database searches were

conducted by the Information Specialist. An example of the Medline search strategy is provided in the Appendix; the search terms were modified, as required, for other databases.
2. Relevant review articles and studies that focused on PBT were identified, either based on the abstract or full text of the article.
3. The reference lists of articles identified in step 2 were searched to find additional studies that might have focused on PBT.
4. Steps 2-3 were repeated until no new studies were identified.
5. Titles, abstracts, and full papers of all identified studies were reviewed to determine if they met the inclusion criteria (see below). If a study met all but the last criterion (i.e., no falls were reported in the paper) then the authors were contacted to determine if falls data existed. If such data were available then the study was included in the analysis.
6. A cited reference search was completed using Google Scholar (all available dates) for all studies selected in step 5 to identify any studies that cited relevant articles. This 'snowball' sampling approach has been used in other systematic reviews (e.g.,[26-28]).
7. Steps 2-6 were repeated until no new studies were identified.

Bibliographic management was facilitated using Endnote (Version X5, Thomson Reuters, Philadelphia, USA).

Study selection

All authors were involved in the search and review process. Each abstract was reviewed by at least two authors independently. Disagreements regarding study inclusion were resolved by discussion. The analysis included studies published in English that met the following criteria: 1) focused on PBT (see definition below); 2) included older adults (>60 years old) or individuals with neurological conditions; 3) included a control group that did not do any perturbation training over the course of the study (i.e., crossover designs were excluded); 4) randomly allocated participants to groups; and 5) collected data on falls experienced in daily life. PBT is defined as the intentional application of repeated postural perturbations that cause a loss of balance over the course of a training program, with the goal of improving whole-body reactive balance control. Thus, we excluded studies employing postural perturbations for rehabilitation of a single joint. Perturbations may be applied using equipment (e.g., moving platform), or manually (e.g., nudge from therapist). While postural perturbations may occur during some challenging balance activities (e.g., standing on an unstable surface), such activities can also occur without postural perturbation with adequate feed-forward balance control; therefore, studies that included solely these activities were excluded. Additionally, to be considered 'training', there must be at least two sessions; therefore, we excluded studies examining within-session adaptations.

Data extraction and quality assessment

The following data were extracted from each selected paper: details of the population studied; details of the control and PBT intervention (type of training, frequency and duration of training sessions, duration of the entire training program); sample size; falls monitoring duration; number of participants in each group who reported one or more falls (i.e., number of fallers); and total number of falls reported by participants in each group. Study authors were contacted to obtain any missing information. Additionally, studies were rated for methodological quality according to the PEDro scale.[29,30] The study received a score of 1 for PEDro items relating to key outcome measure if these items applied to collection and reporting of falls data.

Data extraction and PEDro scoring were performed by two authors independently for each selected article. Disagreements between authors regarding data extraction or PEDro scores were resolved by discussion.

Data synthesis and analysis
Extracted data were summarized in a table and differences and similarities between studies were noted. Meta-analyses were conducted using Review Manager (version 5.2; The Nordic Cochrane Centre, The Cochrane Collaboration). The two outcomes of interest were proportion of fallers and falls rate. The generic inverse variance method was used, with the natural logarithm and standard error of the risk ratio (proportion of fallers) and rate ratio (falls rate) entered into the analysis. The I^2 statistic was used to assess statistical heterogeneity;[31] as there was significant heterogeneity (I^2>30%) random effects models were used.[32] 95% confidence intervals (CIs) were calculated for the overall effects.

RESULTS

We identified 761 potential articles using the search strategy; Figure 1 outlines the search process. Of the articles identified, 7 met all inclusion criteria.[18,22,23,33-36] However, two of these studies involved several different types of exercise and it was not clear that all participants assigned to the PBT group actually received PBT. Thus, these two studies were excluded from the review.[18,36] Three studies met all but the last criterion (i.e., reported falls experienced in daily life). However, falls data for these studies were available elsewhere; for one of these studies, a subsequent article from the same authors reporting falls data was identified,[37] and for the other two falls data were available from the authors.[19,38] Therefore, 8 studies were included in the final analysis. Additional details for one study[19] was obtained from a published protocol.[39] Table 1 summarizes the 8 selected studies.

Description of studies
There were 404 participants included in the eight selected studies (202 completed PBT and 202 were in the control groups). The selected studies included healthy[19,34,37] and frail[22,38] older adults, and individuals with Parkinson's disease.[23,33,35] Two studies included frail older adults, which represented a heterogeneous sample of individuals with chronic conditions (e.g. stroke, arthritis, cognitive impairment/dementia). Seven studies attempted to target individuals at increased risk for falls; for example, by recruiting those with prior falls history, neurological conditions that increase fall risk, or fear of falling. One study included long-term care residents,[22] whereas the remaining studies included community-dwelling individuals. Falls monitoring periods ranged from 2 weeks to 1 year. The experimental intervention in three studies focused solely on PBT;[19,37,38] in all other studies, PBT was included as part of a broader exercise program. An 'active' control group was included in six studies; for three studies, the control intervention was specifically designed to have minimal effect on balance control,[19,33,35] for two studies the control intervention included balance/mobility exercises,[34,38] and for one the control intervention included individualized exercises that may have benefited balance control.[22] Falls were typically defined as events where the subject came to rest unintentionally on the ground, floor or other lower level.[40] All studies collected falls data via participant self-report; however, the study that involved individuals in long-term care also included nursing reports of falls.[22] Three studies used diaries (or similar) to collect falls data prospectively;[19,33,38] one study collected falls data retrospectively at the end of the monitoring period;[34] and four studies used a 'continuous retrospective' method, with a member of the research team contacting participants daily,[23] fortnightly,[37] or monthly[22,35] to ask if the participant had fallen.

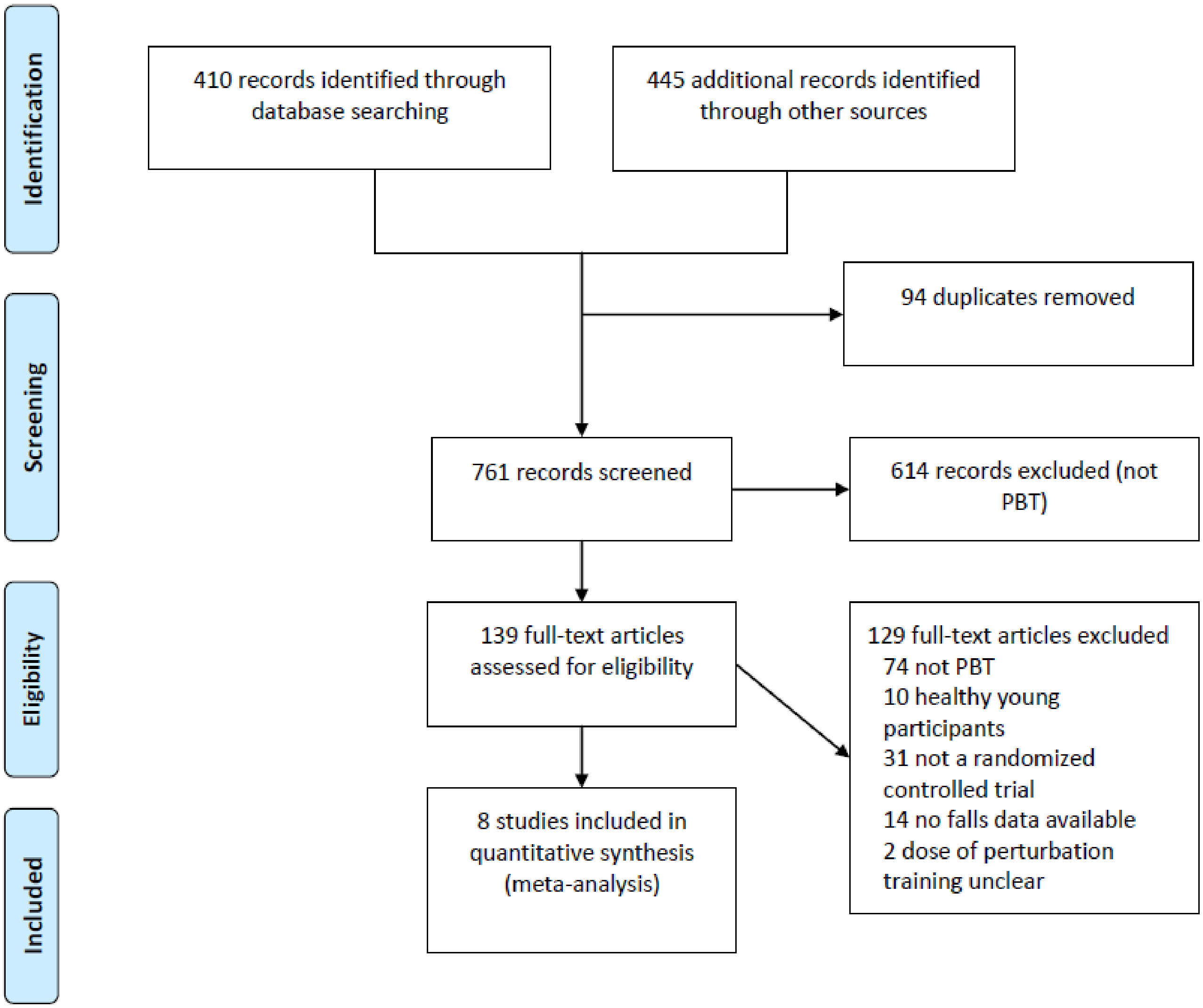

Figure 1. Summary of search strategy. The initial database search yielded 410 abstracts. A further 445 studies were considered for inclusion through 'snowball' sampling (as described in the text). The majority of studies were excluded because they did not focus on perturbation-based balance training (PBT). Eight studies were selected and included in the final analysis.

Table 1: Characteristics of studies included in the analysis.

<table>
<tr><th>Author, year</th><th>Population</th><th>Control/comparison intervention</th><th>Experimental intervention</th><th>Monitoring duration</th></tr>
<tr><td>Shimada 2004</td><td>Frail long-term care residents at high risk for falls (66-98 years old)</td><td>Individualized usual exercise (e.g. physiotherapy for pain, stretching, resistance training
(n=11)</td><td>Usual exercise plus perturbed walking on a treadmill, 600 minutes over 6-months (1-3 times per week)
(n=15)</td><td>6 months</td></tr>
<tr><td>Protas 2005</td><td>Men with Parkinson's disease (mean age: 72 years)</td><td>Nothing
(n=9)</td><td>Gait and step training with treadmill-based perturbations to stance, ~25-35 perturbations per session, 3 times per week for 8 weeks
(n=9)</td><td>2 weeks</td></tr>
<tr><td rowspan="2">Maki 2008</td><td rowspan="2">Older adults attending a falls prevention program (69-89 years old)</td><td>Voluntary stepping and reach-to-grasp training
(n=4)</td><td>Moving platform perturbations to stance to train stepping and grasping reactions, 335-774 perturbations total
(n=4)</td><td rowspan="2">1 year</td></tr>
<tr><td colspan="2">30 minute sessions, three times/week for 6 weeks</td></tr>
<tr><td rowspan="2">Mansfield 2010</td><td rowspan="2">Healthy older adults (64-80 years old)</td><td>Stretching and relaxation exercises
(n=15)</td><td>Moving platform perturbations to stance to train stepping and grasping reactions, 48-64 perturbations per session
(n=16)</td><td rowspan="2">1 year</td></tr>
<tr><td colspan="2">30 minute sessions, three times/week for 6 weeks</td></tr>
<tr><td rowspan="2">Smania 2010</td><td rowspan="2">Individuals with idiopathic Parkinson's disease and postural instability (50-79 years old)</td><td>Joint mobilization, muscle stretching and motor coordination exercises not designed to improve balance control
(n=27)</td><td>Balance training program that included external perturbations (push/pull from a physiotherapist; 10 minutes per session).
(n=28)</td><td rowspan="2">1 month</td></tr>
<tr><td colspan="2">50 minute sessions, three times/week for 7 weeks</td></tr>
<tr><td>Lurie 2013</td><td>Older adults at risk of falling (65-96 years old)</td><td>Individualized 'standard' physiotherapy, including strength, flexibility, balance, and mobility exercises, 3-17 sessions of mean duration 43 mins,
(n=33)</td><td>Standard physiotherapy plus treadmill-induced perturbations, 1-19 sessions of mean duration 44 mins
(n=26)</td><td>3 months</td></tr>
<tr><td>Rosenblatt 2013</td><td>Healthy community-dwelling older women (mean age: 65 years old)</td><td>Nothing (n=80)</td><td>Backward-directed treadmill perturbations, four 1-hour sessions over two weeks, average of 20 perturbations per session* (n=82)</td><td>1 year</td></tr>
<tr><td rowspan="2">Shen 2014</td><td rowspan="2">Individuals with idiopathic Parkinson's disease (mean age: 64 years old)</td><td>Lower-extremity strength training (n=23)</td><td>Voluntary stepping and walking with external perturbation delivered by a treadmill or manually (n=22)</td><td rowspan="2">1 year</td></tr>
<tr><td colspan="2">60 minute sessions, three times/week for 8 weeks (delivered in two 4-week blocks with 4 weeks of home exercise in between)</td></tr>
</table>

*Data provided by the study authors.

Intervention characteristics

Intervention characteristics are described according to the FITT principle (i.e., frequency, intensity, time, and type of perturbation training) as well as the overall intervention duration. For the purpose of PBT, the ‘time’ principle is equivalent to the amount of training per session (i.e., number of perturbations). One study did not report the prescribed intervention duration, or number or frequency of sessions.[34] Five studies reported training session frequency of three times/week,[19,23,33,35,38] one trained twice per week,[37] and one study reported that the frequency ranged from 1-3 sessions per week.[22] When specified (6 studies), participants were prescribed 4-24 training sessions over 2-8 weeks.[19,23,33,35,37,38] Number of perturbations prescribed per session ranged from 20-64, for a total of 80-1,536 perturbations over the course of the training programs.[19,23,37,38] Two studies specified the amount of perturbation training in terms of the amount of time (10 minutes per session[33] or 600 minutes total[22]) rather than the number of perturbations. Intensity of training, in terms of the magnitude of the perturbation (e.g., velocity or acceleration) was only specified in two studies.[22,38] Most studies applied perturbations either using equipment readily available in physiotherapy practice (i.e., treadmills[22,23,34,35,37]) or manual external perturbations (i.e., a push or pull from the physiotherapist[33,35]). Two studies used a custom moving platform to deliver the postural perturbations.[19,38]

Risk of bias in included studies

PEDro scores ranged from 2 to 8 out of a maximum of 10 (Table 2). As is common in physiotherapy research, blinding of participants to the treatment was not possible and no study met this criterion. Only one study[33] blinded therapists to the treatment; a different therapist administered each intervention and they were not informed which was the control and which was the experimental intervention. In addition to these criteria, the least frequently-met PEDro criteria were: falls data available for at least 85% of participants initially allocated (5 studies); point measures and measures of variability reported for falls data (4 studies); and blinding of assessors who collected falls data (or failure to report that assessors were blinded; 4 studies).

Table 2: PEDro scores. Note PEDro items: 1=eligibility criteria were specified; 2=participants were randomly allocated to groups; 3=allocation was concealed; 4=groups were similar at baseline; 5=participants were blinded to group allocation; 6=therapists were blinded to participant group allocation; 7=individuals who collected falls data were blinded to participant group allocation; 8=falls data were available for at least 85% of participants initially allocated to groups; 9=participants received the treatment as allocated or intention-to-treat analysis was used; 10=statistical analysis of falls data were reported; 11=point estimates and variability of falls data were reported. 0=No; 1=Yes

Author, year	**PEDro item**										
	1*	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Shimada 2004	Yes	1	0	1	0	0	1	0	1	1	1	6
Protas 2005	Yes	1	0	1	0	0	0	0	1	1	0	4
Maki 2008	Yes	1	0	0	0	0	0	0	1	0	0	2
Mansfield 2010	Yes	1	1	1	0	0	0	1	1	0	0	5
Smania 2010	Yes	1	1	1	0	1	1	1	0	1	1	8
Rosenblatt 2013	Yes	0	0	1	0	0	1	1	1	1	0	5
Lurie 2013	Yes	1	1	0	0	0	0	1	1	1	1	6
Shen 2014	Yes	1	1	1	0	0	1	1	1	1	1	8
Total		**7**	**5**	**6**	**0**	**1**	**4**	**4**	**7**	**6**	**4**	

*Not included in the final score.

Effects of intervention

Data were available for proportion of fallers for all studies (Table 3). Six of the eight studies reported that fewer participants in the PBT group experienced falls following training than the control group. Individuals who completed PBT were less likely to fall than those in the control groups; the overall risk ratio for all eight studies combined was 0.71, 95% CI [0.52, 0.96] (p=0.02; Figure 2). Six of eight studies reported lower fall rates in the PBT group compared to the control group. Overall, participants who completed PBT reported fewer falls in daily life than those in the control groups. The rate ratio for all eight studies combined was 0.54, 95% CI [0.34, 0.85] (p=0.007; Figure 3).

Table 3: Summary of results. The number of individuals who reported one or more falls during the follow-up period (i.e., number of "fallers") and number of falls reported are presented for each study. The natural logarithm for the risk ratio (proportion of fallers) and rate ratio (number of falls) were entered into the meta-analysis (Figures 2 & 3).

Author, year	Control group			Experimental group		
	Number of fallers	Number of falls	Sample size	Number of fallers	Number of falls	Sample size
Shimada 2004	6	11	11	5	8	15
Protas 2005	6	23*	9	5	10*	9
Maki 2008	3*	4*	4	2*	4*	4
Mansfield 2010	4*	4*	15	5*	6*	16
Smania 2010	19*	111	27	8*	36	28
Rosenblatt 2013	45*	91	80	46*	87	82
Lurie 2013	11	32*	33	5	10*	26
Shen 2014	13	18**	23	6	6**	22
Total	**107**	**294**	**202**	**82**	**167**	**202**

*Data provided by the study authors

**Fall rates reported from the start of the intervention period. Falls that occurred during the intervention period were not included in this count. Additionally, 2 individuals from the control and 1 from the experimental groups were excluded from reporting of fall rates; thus, the same size is 21 per group for number of falls.

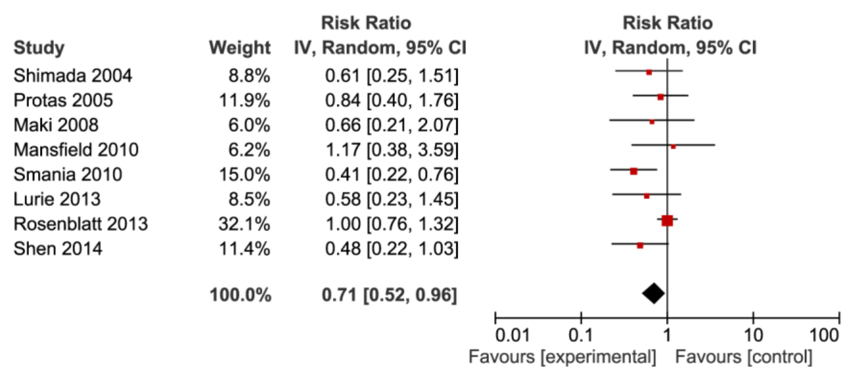

Figure 2: Results of meta-analysis for proportion of fallers. The risk ratio was calculated from the proportion of fallers (see Table 2). Studies were heterogeneous (I^2=31%). The natural logarithm of the risk ratio and standard error of the risk ratio was calculated based on the proportion of fallers in each group for each study and included in the meta-analysis. The overall risk ratio was 0.71, 95% confidence interval [0.52, 0.96], p=0.02.

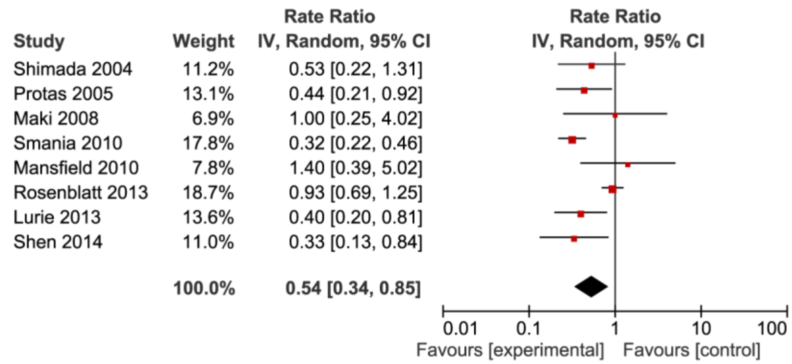

Figure 3: Results of meta-analysis for rate of falls. The rate ratio was calculated from fall rates (i.e. number of falls per person reported during the follow-up period; Table 2). Studies were heterogeneous (I^2=73%). The natural logarithm of the rate ratio and standard error of the rate ratio were calculated based on the number of falls in each group for each study and included in the meta-analysis. The overall rate ratio was 0.54, 95% confidence interval [0.34, 0.85], p=0.007.

DISCUSSION

The results of this meta-analysis provide evidence that PBT appears to both reduce the likelihood of being a 'faller' and reduce the frequency of falling among individuals at increased risk for falls (i.e., older adults and individuals with Parkinson's disease). Importantly, the overall effect for fall rate (rate ratio: 0.54) was lower than reported in previous meta-analyses of general balance training for falls prevention in older adults (rate ratios: 0.65-0.86).[1-5] However, the relative effectiveness of PBT compared to more 'typical' balance training (i.e., training that relies on maintaining stability rather than responding to instability, as is the case for PBT) will need to be evaluated in future studies.

Previous work has demonstrated that PBT improves control of reactions to postural perturbations in the laboratory among healthy older adults.[19,20] Improved control of balance reactions may translate to improved ability to respond to an unexpected 'real world' loss of balance, thereby preventing falls. There is evidence that the effects of PBT are specific to the nature of the perturbations experienced in training. One study included in the current meta-analysis only applied 'forward fall' postural perturbations in training (i.e., simulated trips).[37] While this study did not report a statistically significant reduction in total falls with training, there was a significant decrease in the number of falls resulting from trips. These results imply that training to respond to simulated trips may specifically improve the ability to respond to trips occurring in daily life, but that these training effects do not translate to other types of postural perturbations experienced in daily life. Thus, we recommend that PBT programs include a variety of perturbation modalities, directions, amplitudes, and concurrent cognitive and motor tasks in order to train balance reactions in varied situations. Ultimately, this may result in a greater reduction in fall rates compared to PBT programs that employ a single perturbation modality.

We included studies in the current analysis if they involved two or more sessions of perturbation training. However, it is possible that a single session of 24 perturbations is sufficient to bring about lasting improvements in reactive balance control[20] and prevent falls in daily life.[41] Three of the studies in the current review aimed to achieve a dose of approximately 700-1,150 perturbations over several weeks of training.[19,23,38] However, one study only included approximately 80 perturbations over four sessions.[37] Thus the optimal dose of perturbation training for causing lasting changes in reactive balance control must be determined. Additionally, the potential benefit of 'booster' training sessions after an initial period of training should be explored.[41]

Most of the included studies compared PBT to an 'active' control group. The characteristics of the control activities varied widely from low-intensity stretching exercises with minimal physiological benefit[19] to activities resembling current 'best practice' for improving balance and mobility, and preventing falls (e.g., strengthening exercises, activities to challenge static and dynamic balance, and gait training).[34] Existing evidence suggests that exercise, specifically exercise that challenges balance control, can prevent falls. Evidence for novel interventions can only be provided by comparing the effect of the novel intervention against current best practice.[42] Thus, future studies of novel interventions for falls prevention should include a control group that engages in activities that have previously been shown to prevent falls.

Limitations

Study quality was generally low to fair with half of the studies scoring 5 or less on the PEDro scale. Thus, despite the significant effect of perturbation training on falls with the current meta-analysis, the evidence for perturbation training is currently limited by the quality of the studies included. All studies included were potentially biased by failure to blind research participants to the intervention. True blinding of research participants is not possible for exercise interventions of this nature;[43] however, when study designs incorporate an active control intervention, participants in the control group may believe that the intervention is beneficial. One study attempted to blind the therapists administering the intervention by having different therapists administer the different interventions.[33] However, this approach may actually have the effect of further biasing the results; as there were two differences between the groups (therapist and intervention type) it is not clear if the differences between the two groups were due to differences in the intervention or differences in the way the interventions were administered by the therapists. Study authors did not always report the interventions with enough detail to be replicated. In particular, the intensity (magnitude) and number of perturbations were not well described. Furthermore, it was not always clear if the intervention was carried out as prescribed. Thus, there is a need for improved reporting of balance training intervention characteristics.[44]

Terminology regarding PBT is not consistent in current literature. Thus, a simple literature search would not have identified all appropriate studies. However, we are reasonably confident that the multi-stage search strategy employed, including ‘snowball’ sampling, enabled us to identify all relevant studies. Additionally, all meta-analyses are potentially limited by publication biases towards studies reporting positive results. We attempted to address this limitation by seeking and including unpublished falls data from randomized controlled trials of PBT. Furthermore, only two studies included in the current meta-analysis reported positive results in terms of occurrence of falls[33,35] (i.e., a statistically significant reduction in falls with PBT compared to the control group). Finally, we identified only eight studies for inclusion in the meta-analysis. The study designs differed in several ways that could have contributed to differing results between studies, including population studied, characteristics of training (e.g., frequency, duration, method of perturbation, inclusion of non-perturbation balance training), characteristics of the control intervention, method of collection of falls data, and duration of falls follow-up period. Thus, we were unable to conduct exploratory sub-analyses to determine if the effects of PBT differ based on these differing study or population characteristics.

Conclusions

PBT appears to reduce fall rates among older adults and individuals with Parkinson’s disease. Additional work is required to determine if PBT is superior to more traditional, well-established exercise programs for preventing falls. Future work should also consider the effect of PBT on balance confidence, daily physical activity, and participation.

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APPENDIX

Sample search strategy (Medline).

1. (perturbat* adj2 (train* or rehab* or exercis*)).tw.
2. ((platform* or "dynamic balanc*" or "slip" or "dynamic stabili*") adj2 (train* or rehab* or exercis*)).tw.
3. 1 or 2
4. limit 3 to humans
5. remove duplicates from 4