Supplementary file 1. COVID-19 pandemic impact statement.

This study was conducted from August 2019 to October 2020 and was therefore impacted by the worldwide COVID-19 pandemic.

Generally, for practical management of staff and spatial resources (rooms and laboratories), participants were handled in consecutive blocks, each containing around 25 individuals allocated to the three study groups. The first block of participants (n=18) was finished in November 2019 without any restrictions.

During the time of the second block (n=27) the COVID-19 pandemic was spreading internationally. On 23th of March 2020, the Institute of Sports and Sports Science (study center) was shut down due to a general German governmental act. On that date, the intervention phase of the second block was finished, but only 11 post-assessments were completed. The remaining 16 post-assessments were already scheduled but could not be carried out related to the closure of the Institute and the COVID-19-related lockdown in Germany (participants had to stay in their homes). COVID-19 distancing rules prohibited physical contact during motor assessments, which is however required for guaranteeing the safety of the participants (e.g. providing hold support during balance testing) (until 1th of July 2020; for 14 weeks). Therefore, the majority of outcome parameters could not be collected. Questionnaires such as the Short FES-I could be conducted per telephone, which was done for these 16 participants.

The third block (n=26) was conducted from July 2020 to October 2020 under hygienic guidelines developed in cooperation with the University of Heidelberg, defined in a standard operation procedure (SOP) and specific training of assessors.

In the autumn of 2020, the institute was again shut down due to a governmental act. Unfortunately, we did not receive any extra funding for compensating the COVID-19-related impact on the study and the associated losses for follow-up. This forced us to terminate the study prematurely with a smaller sample size (n=71) than originally intended (n=111).

In addition, we needed to adjust the primary outcomes of the study. It was originally planned to assess the prospective fall rate for 12 months as a second primary outcome (besides the Brief-BEST). Due to COVID-19-related acquisition issues during the follow-up period, this outcome had to be withdrawn.

Supplementary file 2. Randomization procedure.

For the randomization, a custom R-script (R Found. for Stat. Comp.) was used (see below). Participants performed the randomization themselves by starting the routine on a computer with an immediate result of group allocation. This procedure was chosen for transparency reasons and to improve acceptance if the allocated group was not the personally desired one.

```
x <- runif(1)

if (x < 0.33)
   {print ("PBT: Treadmill")
  } else if (x > 0.66)
    {print ("PBT: Stability")
  } else
    {print ("Control group")
}
```

Supplementary file 3. Template for Intervention Description and Replication (TIDieR) checklist.

Item No; Name	Description		
1. Brief name	**Perturbation Treadmill Training (PBT_treadmill_)**	**Exercise of dynamic stability in the presence of perturbations (PBT_stability_)**	**Passive control group**
2. Why	Perturbation-based balance training (PBT) is an emerging exercise intervention approach that showed high fall reduction rates in older adults. A variety of different PBT paradigms was presented in the literature. This study is comparing two different paradigms with a supposed high clinical feasibility, namely a PBT on a perturbation treadmill (PBT_treadmill_) and a training of dynamic stability mechanisms (PBT_stability_) and a passive control group. The clinically relevant target group of fall-prone older adults was included.		
	The aim of this training paradigm was to induce a high variety of perturbations in standing and walking in order to mimic real-life fall scenarios with high ecological validity.	The aim of this training paradigm was to train the fundamental mechanisms of dynamic stability control (modulation of base of support and counter-rotation of body segments around the center of mass) for improved balance recovery abilities.	
3. What material	Perturbation treadmill (BalanceTutor™, MediTouch LTD, Netanya, Israel) able to induce anteroposterior (belt acceleration) and mediolateral (platform shift) surface perturbation in 30 different levels of magnitude.	Balance cushions (Sissel® BalanceFit), balance half-balls (Sport-Thieme® Balance Jump), Balance pads (Sport-Thieme® Balance-Pad "Premium"), coordination seesaws (SoftX® Coordination Seesaw Standard), Posturomed® (Haider Bioswing GmbH, Germany) and surrounding exercise mats for safety.	n.a.
4. What procedure	During each session, four 4 min blocks of perturbations were conducted, subdivided into static and dynamic trials. Perturbations further differed in: 4 directions, up to 30 magnitudes, perturbed leg side and gait phase. During the first sessions, perturbations were partly announced in time and direction. Over time, the frequency of perturbations and the gait speed increased. In the last quarter of the training sessions additional motor and/or cognitive tasks were added additionally. The safety of the participant was ensured by a harness system.	During each session, a circle training with 5 stations was conducted in pairs of two. On each station, the 3 main exercises: 1 min standing, 1 min lunges and 1 min jumping were performed alternating between the pairs. These exercises were modified by different challenges (decreased step-width, closed eyes, arms crossed before the chest, stepping on/off devices, external pushes, ball catching, …). Additionally, the lunges were held for several seconds for increased strengthening. The safety of the participants was ensured by the surrounding mats and a securing by the training partners and the therapists.	n.a.
5. Who provided	Training sessions were provided by experienced trainers (sports scientists and physiotherapists) who underwent a two-hour instruction lesson.		n.a.
6. How	The training was provided 3 times a week with a 1:1 ratio of therapist and participant.	The training was provided 3 times a week in groups of up to ten, with a 1:3 ratio of therapist and participants.	n.a.
7. Where	Both Interventions were conducted at the Institute of Sports and Sports Sciences, Heidelberg University, Germany. Participants have been recruited from the same city, allowing short travel times.		n.a.
	PBT_treadmill_ sessions were delivered in the laboratory where the treadmill was installed.	PBT_stability_ sessions were delivered in the gym.	
8. When and how much	Both interventions included 3 training sessions per week for a period of 6 weeks, resulting in a total of 18 sessions. It was aimed for an interval of 48 h between sessions, while 24 h was the minimum. Both interventions were matched in active loading time.		A period of 6 weeks.
	PBT_treadmill_ session lasted for around 30-40 min and included a 5 min warm-up, 4*4 min perturbation blocks and a 3 min cool-down. Usually, 2 perturbation blocks included static exercises and 2 blocks included dynamic trials. An average training session included 75 ± 14 perturbations.	PBT_stability_ sessions usually lasted for around 50 min and included a 5 min warm-up, a circle training with 5*3 min exercises per station that was related to one of the 5 balance devices and a 3 min cool-down.	
9. Tailoring	Training progression was controlled individually by adjusting intensities (separately for each direction in standing and walking) in every session based on a 5-point scale of subjectively perceived difficulty and anxiety. Therefore, the options for increased intensities described in Item 4 were used.	The trainer was ensuring individualized training intensities by controlling the performed challenges during the tasks described in Item 4. The intensity was aimed to bring participants close to the border of stability, indicated by distinct arm movements.	n.a.
10. Modification	For the last wave of participants, we had to deal with the new restrictions due to the COVID-19 pandemic. Therefore, we created a standard operating procedure that we strictly followed. This included, among others safety measures, disinfecting hands for everyone involved, keeping distance between participants as well as therapists as far as it was not necessary and a recommendation to wear a mask also during the training.		n.a.
	These modifications were applied for 30 % percent of participants in PBT_treadmill_.	These modifications were applied for 22 % percent of participants in PBT_stability_. Additionally, for decreased infection risk groups were reduced in size, while the ratio of participants to trainers was maintained.	
11. How well planned	The study coordinator observed at least the first training sessions and provided feedback to the trainers for standardized execution of the training paradigms. Adherence to the programs was assessed by means of attended training sessions.		n.a.
12. How well actual	The mean ± SD of attended training sessions was 91 % ± 9 %. There was one drop-out after the 4th session due to back pain and fear.	The mean ± SD of attended training sessions was 87 % ± 12 %. One participant (4 %) attended less than half of the provided sessions due to complications after an eyesight operation.	n.a.

Supplementary file 4. PBT$_{treadmill}$ protocol template.

	One training session				General challenges	Perturbation frequency	Additional challenges for dynamic trials	
	Block 1	Block 2	Block 3	Block 4			Gait speed	Perturbed gait phase
Week 1	Standing	Walking	Standing	Walking	announced in time and/or direction	3/min	preferred speed	fixed phase (mid-stance)
Week 2	Standing	Walking	Standing	Walking	unannounced		+ 0.3 km/h	
Week 3	Standing	Walking	Standing	Walking		4/min		
Week 4	Standing	Walking	Standing	Walking			+ 0.3 km/h	
Week 5	Standing	Walking	Walking	Walking	+ dual task (motoric or cognitive)	5/min		free phase
Week 6	Standing	Walking	Walking	Walking				

Guidelines:

· Starting parameters: preferred gait speed (as assessed during baseline), moderate perturbation intensities (mediolateral: 14/30, anterior: 11/30, posterior: 10/30), frequency of 3 perturbations/minute

· Each session contains four 4 min blocks, while at least one block is conducted in static and one in dynamic conditions

· The four perturbation directions are induced in a randomized order with an equal distribution

· Intensities are adjusted based on a scale of subjectively perceived difficulty and anxiety, assessed at the end of each session. This assures to constantly challenge the participant, while preventing the development of anxiety

· This template should be tailored individually, if necessary to ensure an appropriate challenge

Supplementary file 5. Participant feedback scale used in PBT$_{treadmill}$.

	1	2	3	4	5
Difficulty	Easy	Fairly easy	Challenging	Very challenging	Too hard
Anxiety	Not at all	Just a little	Moderately	Strongly	Extremely

This scale was prompted after each training session. Training was adjusted aiming for a mid-range in perceived difficulty (i.e. 3/5="challenging"), while anxiety should not become too heavy (i.e. max. 3/5="moderate"). The scale is a slightly modified version of Okubo et al. (2019).

Supplementary file 6. Leg strength test on force plate (mod. Nintendo Wii Balance Board) in custom build bracket.

Supplementary file 7. Overview of included trials per outcome.

Outcome	Total	PBT$_{treadmill}$	PBT$_{stability}$	Control	Explanations	
					Dropouts	**Additional missing data in single outcomes**
Brief-BEST	50/71	17/23	17/27	16/21	These outcomes were lost for 20 dropouts: 6 in PBT$_{treadmill}$ 10 in PBT$_{stability}$ 4 in CG	One participant of Control refused to perform the reactive item of this test during post-assessment.
STT	49/71	17/23	17/27	15/21		Two participants of Control refused to perform this reactive test during post-assessment.
COP$_{path}$	51/71	17/23	17/27	17/21		
LoS	51/71	17/23	17/27	17/21		
Chair-stand	51/71	17/23	17/27	17/21		
TUG$_{fast}$	51/71	17/23	17/27	17/21		
Leg strength	51/71	17/23	17/27	17/21		
Gait speed	51/71	17/23	17/27	17/21		
Short FES-I	69/71	22/23	27/27	20/21	This data was not lost for the dropouts	One dropout in PBT$_{treadmill}$ did not finish the intervention. One dropout in CG was not willing to respond.
Adherence	49/50	22/23	27/27	n.a.		Adherence was determined for all participants that finished an intervention.
Adverse events	50/50	23/23	27/27	n.a.		

The number of participants per outcome for per-protocol analysis. PBT$_{treadmill}$: perturbation treadmill training, PBT$_{stability}$: exercise of dynamic stability training in the presence of perturbations

Supplementary file 8. Sub-analysis of Brief-BEST items.

	PBT$_{treadmill}$ (n=17)				PBT$_{instable}$ (n=17)				Control (n=17)			
	Pre	Post	*p*	*r*	Pre	Post	*p*	*r*	Pre	Post	*p*	*r*
Hip abduction	2.1 ± 0.8	2.1 ± 1.0	.766	.07	2.1 ± 0.8	2.2 ± 0.9	.594	.13	2.5 ± 0.5	2.6 ± 0.6	.233	.29
Single leg stand (left+right)	3.6 ± 1.9	3.5 ± 1.9	> .999	.00	3.5 ± 1.8	4.0 ± 1.8	.066	**.45**	4.5 ± 1.7	4.4 ± 1.9	.429	.19
Stand on foam	2.2 ± 0.8	2.2 ± 0.8	.777	.07	2.4 ± 0.7	2.5 ± 0.8	.484	.17	2.7 ± 0.5	2.6 ± 0.6	.766	.07
Comp. stepping (left+right)	3.7 ± 1.4	3.9 ± 1.5	.149	**.35**	3.8 ± 1.3	4.3 ± 0.8	.112	**.39**	3.9 ± 1.1	4.2 ± 1.0	.401	.20
Functional reach	2.2 ± 0.4	2.3 ± 0.5	.773	.07	2.3 ± 0.6	2.5 ± 0.5	.182	**.32**	2.2 ± 0.4	2.2 ± 0.4	.773	.07
TUG	2.9 ± 0.2	2.9 ± 0.2	> .999	.00	3.0 ± 0.0	3.0 ± 0.0	> .999	.00	3.0 ± 0.0	3.0 ± 0.0	> .999	.00

Pre and post-values of the outcomes as mean ± SD. Comparison by Wilcoxon test. Effect sizes are given as Cohen's r. Effect sizes of at least medium magnitude (≥ .30) are highlighted in bold.