Postural control in older adults during and following a 12-week balance training intervention with attentional focus instructions

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Higgins, L. Q., Labban, J. D., Stout, R. D., Fairbrother, J. T., Rhea, C. K., & Raisbeck, L. D. (2021). Postural control in older adults during and following a 12-week balance training intervention with attentional focus instructions, *Journal of Motor Learning and Development*, *9*(3), 345-370. https://doi.org/10.1123/jmld.2021-0004

Abstract:

Adults ($N = 54$, 80.78 ± 6.08 years) who reported falling during the previous 12 months participated in a 12-week wobble board training program with internal focus or external focus (EF) instructions. Verbal manipulation checks were performed after training sessions as a self-report of the attentional foci used. The percentage of sessions in which participants reported using an EF (EF_{SR}) was subsequently calculated. Mean velocity and mean power frequency in the anterior–posterior ($MVELO_{AP}$ and MPF_{AP}) and medial–lateral ($MVELO_{ML}$ and MPF_{ML}) direction were assessed during a 35-s wobble board task at Weeks 0, 6, 12, 13, 16, and 20, with the latter three as retention tests. Piecewise linear growth models estimated treatment effects on individual growth trajectories of $MVELO_{AP\ and\ ML}$ and $MPF_{AP\ and\ ML}$ during intervention and retention periods. Regardless of condition, $MVELO_{ML}$ significantly decreased ($\pi = -.0019$, $p = .005$) and MPF_{ML} increased ($\pi = .025$, $p < .02$) during the intervention period. In analyses including interaction terms, participants in the EF group who reported greater EF_{SR} had superior progression of MPF_{AP} during the intervention ($\pi = .0013$, $p = .025$). Verbal manipulation checks suggest a preference for and advantage of EF for facilitating postural control performance and automaticity.

Keywords: external focus | internal focus | falls | wobble board

Article:

Approximately one in three adults aged 65 years and older fall annually, a statistic that translates to falls as the leading cause of fatal and nonfatal injuries in the older adult population (Bergen, Stevens, & Burns, 2016; CDC, 2017). The high prevalence of falls and negative health-related outcomes result in significant burden and financial cost to the health care system as well as loss of independence and quality of life for the older adult (Florence et al., 2018; Haddad, Bergen, & Florence, 2018). Although fall risk is multifactorial, poor postural control has been consistently identified as a strong risk factor (Ambrose, Paul, & Hausdorff, 2013; Shumway-Cook, Baldwin, Polissar, & Gruber, 1997). To navigate constant changes in the environment, postural control relies on contributions from multiple body systems that interact at the central or peripheral level, including vision, vestibular sense, muscular strength, neuromuscular control, and cognitive processes associated with executive function (e.g., attention, working memory, cognitive flexibility, and inhibitory control; Ambrose et al., 2013; Lord & Sturnieks, 2005). With increasing age, a progressive loss of functioning in each of these systems occurs, culminating in reduced postural control (Rubenstein, 2006). Multiple interventions have evidenced improvements in postural control for the older adult; however, they are moderately effective at best and mainly focus on modifying the physical (muscle strength) and sensory system (vision, vestibular sense, and neuromuscular control) inputs contributing to postural control (Gardner, Robertson, & Campbell, 2000; Li et al., 2005; Ogaya, Ikezoe, Soda, & Ichihashi, 2011; Schmid, van Puymbroeck, & Koceja, 2010; Steadman, Donaldson, & Kalra, 2003). Yet, postural control and fall prevention depend considerably on cognitive processes and, more specifically, attention.

To this end, Ellmers, Kal, and Young (2020) observed that in a postural threat condition (e.g., elevated height), older adults reported greater perceived unsteadiness along with greater self-reported conscious processing of balance. However, participants who reported greater anxiety during the postural threat condition reported feeling significantly more stable when prevented from consciously processing their balance during a distracting concurrent cognitive task (e.g., listing the months of the year; Ellmers et al., 2020). Similarly, older adults demonstrated improved postural stability when performing a mental arithmetic task (Richer, Polskaia, & Lajoie, 2017). These findings suggest that conscious movement processing (attention) may alter motor performance or constrain the motor system. However, the aforementioned studies examined static balance. Dual-task studies have observed that when the complexity of a postural task increases (e.g., dynamic conditions), older adults' performance on postural, cognitive, or both tasks is negatively affected when compared with younger adults (Boisgontier et al., 2013). Thus, in more challenging postural control tasks, concurrent cognitive tasks may hinder the postural control system, suggesting that in such scenarios greater attention is needed to maintain upright posture. Yet, movement processing may be modifiable through motor learning approaches, such as attentional focus, and incorporating this cognitive dimension may benefit current postural control and fall prevention intervention with only small modification in delivery methods.

Previous motor learning research has demonstrated that a performer's focus of attention has an important influence on their learning of a motor skill (Wulf, 2013). Specifically, an "external focus (EF)"—directing a performer's attention to the effects their movements have on the environment—has been shown to enhance motor performance and learning, particularly when compared with an "internal focus (IF)"—directing attention to body parts or body movements (Wulf, 2013). For example, previous studies examining attentional focus and postural control in healthy individuals have found that directing participants' attention to the implement on which they are standing (e.g., balance disk, Biodex, Stabilometer) facilitates learning of postural control compared with directing their attention to their feet (McNevin, Weir, & Quinn, 2013; McNevin & Wulf, 2002; Wulf, 2008; Wulf, Mercer, McNevin, & Guadagnoli 2004; Wulf, Weigelt, Poulter, & McNevin, 2003). The *constrained action hypothesis* has been suggested to explain the differential effects of EF versus IF, proposing that EF allows for more natural self-organization of the motor system, whereas IF constrains the motor system by interfering with automatic control processes (Wulf, McNevin, & Shea, 2001). To determine movement automatization, researchers have assessed movement execution-related parameters, including electromyography activity (Lohse, Sherwood, & Healy, 2010; Wulf, Dufek, Lozano, & Pettigrew, 2010; Zachry, Wulf, Mercer, & Bezodis, 2005), dimensionless jerk (Kal, van der Kamp, & Houdijk, 2013), power spectral frequency (Wulf, McNevin, & Shea, 2001), and sample entropy (Lamoth, Lummel, & Beek, 2009; Rhea, Diekfuss, Fairbrother, & Raisbeck, 2019; Roerdink et al., 2006; Roerdink, Hlavackova, & Vuillerme, 2011), that specify the degree to which movements are under automatic control. With regard to movement automatization in a postural control task and attentional focus, Wulf et al. observed that when participants focused on the movement of the platform (keeping it parallel) during a stabilometer balance task as opposed to focusing on the movement of their feet, they exhibited better overall performance as well as higher frequency postural adjustments (Wulf, McNevin, & Shea, 2001). This pattern of postural adjustments suggests integration of the active degrees of freedom as well as the union of reflexive and voluntary control mechanisms (Newell, Broderick, Deutsch, & Slifkin, 2003; Newell & Slifkin, 1996). Consciously interrupting these control mechanisms, such as when a motor task is performed under IF conditions, appears to constrain the active degrees of freedom, resulting in less automatic execution of movement and, thus, degradations in performance (Vereijken, Emmerik, Whiting, & Newell, 1992).

Relative to the context of older adults and fall prevention, adopting an EF during a postural control task has shown to improve performance in individuals with impaired postural control (e.g., older adults and Parkinson's disease patients), providing evidence that modifiable cognitive factors may serve as a pathway to enhance postural control in these populations (Chiviacowsky, Wulf, & Wally, 2010; Landers, Wulf, Wallmann, & Guadagnoli, 2005; Rhea et al., 2019; Wulf, Landers, Lewthwaite, & Toöllner, 2009). However, in these studies, the practice phase was limited and only immediate (same day) or short-term (24 hr) retention effects were reported. Thus, the impact of attentional focus instructions on progression rate during practice (e.g., performance curve) and long-term skill retention was unclear.

With regard to progression rate during practice, a recent randomized controlled trial examined the effects of 3 weeks of balance training with attentional focus instructions on postural control in stroke patients. The researchers observed that both EF and IF groups demonstrated comparable improvements in postural control performance and similar enhancements in automaticity (dual-task cost) following 3 weeks of training (three sessions per week with 15 practice trials per session; Kal et al., 2019). However, they also found that an EF accelerated learning during the first week of practice, thus aligning with previous postural control studies in healthy older adults that reported greater improvements in performance with EF after only a few days of practice (Kal et al., 2019). Yet, in this sample of stroke patients, the effects of instruction were dependent on patients' motor functioning, sensory functioning, and cognition, with EF instruction resulting in greater improvements in postural control in patients with better motor and sensory functioning and IF instructions more effective for those with greater impairments (Kal et al., 2019). Based on these findings, it is possible that the benefits of EF decrease with prolonged practice. In addition, there may be a skill-dependent effect of attentional focus.

In an effort to assess long-term retention, Landers, Hatlevig, Davis, Richards, and Rosenlof (2016) conducted a clinical trial examining the impact of 4 weeks (three sessions per week for 45 min) of a multimodal postural control training with attentional focus cues in patients with Parkinson's disease (Landers et al., 2016). Participants were randomized to one of three experimental groups (EF, IF, or no attentional focus instructions) or a control group that did not receive the training program. Postural control outcomes were assessed immediately prior to and following the training program as well as 2 and 4 weeks after completion. Results suggested that the attentional focus instructions provided during the training program did not significantly affect long-term retention of postural control outcomes in individuals with Parkinson's disease (Landers et al., 2016). However, motor skill learning generally slows with age and neuromotor disease; thus, the frequency and duration of the intervention may not have been sufficient to drive improvements in balance (Coats, Wilson, Snapp-Childs, Fath, & Bringham, 2014; Nieuwboer, Rochester, Müncks, & Swinnen, 2009). Currently, there is no consensus on the optimal training frequency to detect improvements in postural control; the general thought is that longer is better (Sherrington et al., 2017). However, there may be a minimum training frequency required to detect change. As such, Dibble, Addison, and Papa (2009), observed no significant changes to postural control and physical function in Parkinson's patient studies with a duration less than 6 weeks, suggesting longer than 6 weeks is necessary to observe learning effects in Parkinson's patients. Moreover, although Landers et al. (2016) made an effort to modify the challenge of the intervention for individual ability, they suggest that the challenge may not have been sufficient to elicit change (Landers et al., 2016).

Furthermore, it remains unclear how attentional focus may impact the progression rate of postural control during practice (e.g., performance curve) in healthy individuals with impaired balance. As previously mentioned, motor learning declines with age (Coats et al., 2014) and neuromotor disease (Nieuwboer et al., 2009), yet it is probable that the integration of cognitive factors, such as attentional focus, during training interventions would improve the performance curve of postural control (Voelcker-Rehage, 2008). However, the authors are not aware of any previous studies that have specifically examined the effects of attentional focus on performance progression in healthy individuals. Although several studies have assessed change (Wulf, 2013), they most often collect data at only two time points. Such designs are often insufficient for studying growth (additional time points are necessary; Raudenbush & Bryk, 2002). Moreover, traditional methods (e.g., fixed-effects approaches: analysis of variance and multivariate analysis of variance) employed to study growth present limitations. Specifically, repeated measures represent a nested data structure (time points within people), thus observations are not independent. Independence of observations is an assumption of the general linear model (e.g., analysis of variance and multivariate analysis of variance), and the violation of this assumption with nested data presents potential for making incorrect inferences about misleading effect estimates because the only source of variability examined in these fixed-effect approaches (other than explained variability) is individual-level (or time points within individuals) variability. However, in nested data there are two sources of variability: between individual differences and time point differences within individuals. Thus, in fixed-effect approaches, these sources of variability are pooled, and effect estimates can represent within-, between-individual processes, or both. The development of hierarchical linear models has presented a powerful set of tools to overcome the limitations of traditional methodologies to measure growth (Bryk & Raudenbush, 1987; Raudenbush & Bryk, 2002). In these models, individual growth (e.g., learning) can be represented through a two-level hierarchical model (e.g., time points nested within individuals). At Level 1 (time point level), each person's growth is represented by an individual growth trajectory (regression line) dependent on a unique set of parameters (intercept and slope; Raudenbush & Bryk, 2002). The individual growth parameters become outcome variables at Level 2, where they may depend on person-level characteristics (e.g., sex and age; Raudenbush & Bryk, 2002). This structure allows for the disaggregation of within- and between-person effects in models of growth. In addition, hierarchical linear models provide solutions for examining nonlinear growth as well as comparing growth over two time periods (e.g., acquisition and retention). Finally, this type of modeling can handle common challenges in repeated-measures data, including unbalanced treatment groups and missing data (Raudenbush & Bryk, 2002).

Thus, the aim of this study was to examine the effect of a 12-week postural control training intervention (wobble board training) with attentional focus instructions on the performance progression (e.g., during the intervention period) and retention of postural control strategies in healthy, older adults who reported falling during the previous 12 months. Postural control was measured as mean velocity (MVELO) and mean power frequency (MPF) in the anterior–posterior ($MVELO_{AP}$ and MPF_{AP}) and medial–lateral ($MVELO_{ML}$ and MPF_{ML}) axes. Importantly, decreased mean velocity and increased MPF have been associated with increased postural control and greater automaticity, respectively (William et al., 2018; Wulf, McNevin, & Shea, 2001). We hypothesized that EF instructions would facilitate performance progression during the intervention period and longer lasting postural control benefits during the retention period. Second, we hypothesized that age would significantly predict performance progression and retention, with younger individuals showing more rapid facilitation of performance during the intervention and retaining learned skills longer.

Methods

Participants

Older adults were recruited from local retirement communities and fitness facilities through fliers, emails, and on-site presentations. Interested individuals were screened for the following inclusion criteria: adults between the ages of 65–90 years, reported falling at least once during the previous 12 months, the ability to walk independently without the use of assistive devices for at least 10 consecutive minutes, no diagnoses of a neurologic disorder that affects balance or walking ability (e.g., Parkinson's disease, multiple sclerosis, diabetic peripheral neuropathy), 20/70 vision or better with corrective lenses, body mass index ≤ 30 kg/m^2, Mini-Mental State Exam score ≥ 25, and medical clearance from their doctor confirming that the patient had no diagnosis of sensory or neurologic impairment and supporting patient participation in the study. In total, 170 older adults were screened and 65 individuals were eligible for enrollment in the training intervention (Figure 1). All participants gave voluntary informed consent after receiving an explanation of the study's purpose, content, and all potential risks. Eleven individuals dropped out prior to completion of the training intervention: six due to time commitment and five as a result of injury or pain unrelated to the training intervention. The study was approved by the institutional review board of the University of North Carolina at Greensboro (No. 17-0384).

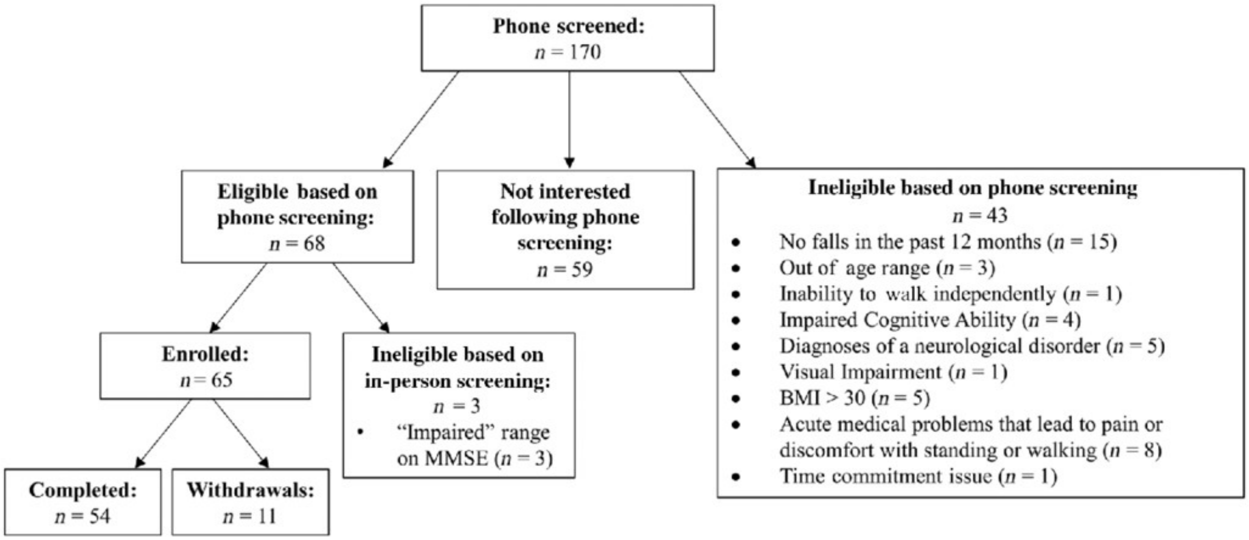

Figure 1. Project recruitment and enrollment. BMI = body mass index; MMSE = Mini-Mental State Exam.

Balance Intervention and Testing Procedures

See Figure 2 for a project timeline. Following the screening process, participants were assigned, using a cohort structure, to one of two intervention groups (EF or IF) and enrolled in the 12-week balance training intervention. Since the intervention was conducted at participating retirement communities and fitness facilities, the cohort structure allowed for offset group assignments at each location; thus, both experimental groups did not take place concurrently at the same location to minimize treatment (intervention) contamination.

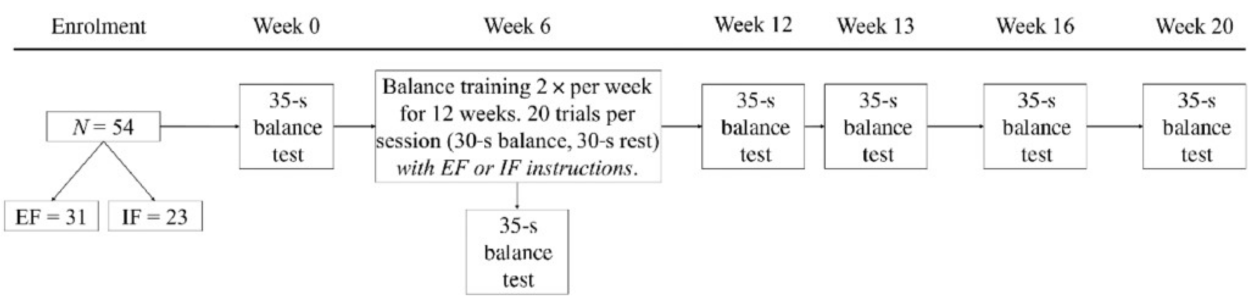

Figure 2. Project timeline. *Note.* The intervention period was 12 weeks in length and included measures from Weeks 0, 6, and 12. The retention period was 8 weeks in length and included measures from Weeks 13, 16, and 20. EF = external focus; IF = internal focus.

The 12-week balance training intervention consisted of twice weekly, 30-min training sessions that took place at participating retirement communities and fitness facilities (24 sessions in total). Sessions occurred in a group setting of five to eight participants and two to four research team members who served as facilitators and spotters for safety. All balance training was completed on a wobble board (CanDo®, White Plains, NY; Figure 3). The circular boards have a diameter of 76.2 cm with a half-sphere secured underneath to provide a multidirectional postural control challenge when participants stand on top. Each session consisted of a 5-min warm-up walk, 20 min of balance training on the wobble boards (30-s balancing: 30s rest), and a 5-min cool down walk. Prior to each balance trial, individuals in the EF group were reminded to "focus on keeping the board parallel to the floor," whereas individuals in the IF group were reminded to "focus on keeping your feet parallel to the floor." Following the completion of each training session, a manipulation check was performed by asking individuals, "What were you thinking about or focusing on during the balance training session?" When participants reported focusing on a body part or body movement, answers were coded as "IF." When they reported focusing on the movement of the board, answers were coded as "EF." In addition, when participants reported focusing internally and externally, answers were coded as "Both." If focus on something other than an IF or EF cue was reported, answers were coded as "Other." Responses were recorded and coded by a single researcher. Examples of reported foci are included in Table 1. All participants started their first training session with the same size (3.5 cm diameter) half-sphere secured underneath the wobble board and progressed to the next size increment at the discretion of a physical therapist who was part of the study team. There were five possible half-sphere sizes that progressively increased in height and diameter.

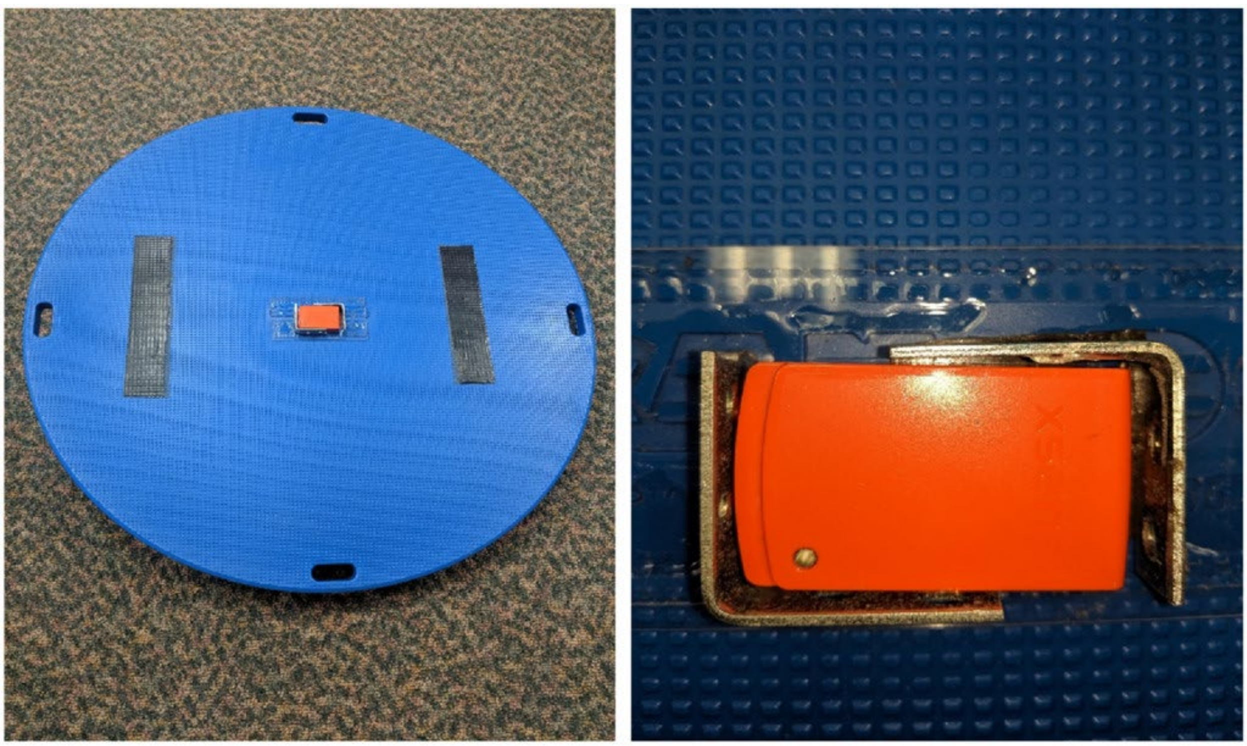

Figure 3. Inertial measurement unit secured to wobble board.

Outcome measures were collected at six time points: prior to (Week 0: Baseline), half-way through the intervention (Week 6: midpoint), immediately following the intervention (Week 12: Post), and at three follow-up time points (Week 13: 1-week retention, Week 16: 4-week retention, and Week 20: 8-week retention; Figure 2). Testing consisted of a single 35-s balance trial on the wobble board with an inertial measurement unit (MTw Awinda; Xsens Technology, El Segunda, CA) secured to the center of the board by two brackets (Figure 3). The inertial measurement unit allowed us to quantify board velocity at a rate of 60 Hz, which was used as an indirect measure of participants' postural sway. Prior to each testing trial, all participants—regardless of their experimental group assignment—were instructed to "do your best." This study design allowed for the testing of a carryover effect from the previous training sessions wherein attentional focused instructions were provided. Foot placement was standardized by instructing participants to place their feet on pieces of black tape that were 48 cm apart and placed on either side of the center of the board. In addition, participants completed the Berg Balance Scale at baseline to insure group similarities in functional balance.

Table 1. Participant-Reported Focus During Training Sessions

	EF (*n* = 27)	**IF (*n* = 23)**	***p***	**Examples of reported foci**
Number of coded responses	648	551		
EF	69.18 ± 22.55	37.72 ± 34.81	<.001	"Keeping the board level with the floor." "A focal point on the wall."
IF	17.65 ± 19.54	39.2 ± 32.47	<.001	"Keeping my feet parallel to the floor." "Engaging my core muscles." "Keeping my hips moving."
Both	5.58 ± 7.9	1.83 ± 6.94	<.001	"Keeping the board straight and controlling my breathing." Standing up straight and a focal point on the floor."
Other	7.61 ± 14.76	20.99 ± 27.54	<.001	"The doctor's appointment I have later." "How others around me were doing." "The weather outside."

Note. Data are reported as mean% ± *SD*% of 24 training sessions. EF = external focus; IF = internal focus; both = reported both EF and IF; other = focus other than exclusively EF of IF.

Data Reduction

The raw anterior–posterior and medial–lateral velocity time series were extracted from the inertial measurement unit and filtered with a fifth-order low-pass Butterworth filter using a 5-Hz cut off. These data were then entered into a custom MATLAB script (MathWorks Inc., Natick, MA) where the 35 s of data was shortened by 2.5 s at either end. The mean velocity for the anterior–posterior ($MVELO_{AP}$) and medial–lateral ($MVELO_{ML}$) directions was then extracted for each 30-s trial. Next, the vector magnitude was transformed to the frequency domain by calculating the power spectral density of the signal. To calculate MPF, the mean frequency of the power spectral density estimate was then calculated for the anterior–posterior (MPF_{AP}) and medial–lateral (MPF_{ML}) directions.

Data Analysis

All data analyses were performed using R (version 4.0.1; R Foundation for Statistical Computing, Vienna, Austria). Independent samples *t* tests were used to compare group anthropometrics and baseline measures (e.g., Mini-Mental State Exam, Berg Balance Scale, $MVELO_{AP}$, $MVELO_{ML}$, MPF_{AP}, and MPF_{ML}). Piecewise linear growth models were estimated using multilevel modeling (Bryk & Raudenbush, 1987; Raudenbush & Bryk, 2002), as executed in the "nlme" package (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2020), to assess treatment effects on individual growth trajectories of the dependent variables $MVELO_{AP}$, $MVELO_{ML}$, MPF_{AP}, and MPF_{ML} during the intervention and retention periods. For each dependent variable, the Level 1 model describes the two-piece linear growth model with one individual growth rate for the intervention period and a second growth rate for the retention period. Specifically, the Level 1 model was in the structure:

$$\mathrm{MVELO_{AP}} = \pi_{0i} + \pi_{0i}a_{0ti} + \pi_{2i}a_{2ti} + \mathrm{e}_{ti},$$

$$\mathrm{MVELO}_{\mathrm{ML}} = \pi_{0i} + \pi_{0i}a_{0ti} + \pi_{2i}a_{2ti} + \mathrm{e}_{ti},$$
$$\mathrm{MPF}_{\mathrm{AP}} = \pi_{0i} + \pi_{0i}a_{0ti} + \pi_{2i}a_{2ti} + \mathrm{e}_{ti},$$
$$\mathrm{MPF}_{\mathrm{ML}} = \pi_{0i} + \pi_{0i}a_{0ti} + \pi_{2i}a_{2ti} + \mathrm{e}_{ti},$$

where a_{1ti} and a_{2ti} were coded to predict status during the intervention and retention periods, respectively (see Table 2). The Level 2 model examined the influence of participant characteristics (age, condition: EF or IF, and the percentage of training sessions participants self-reported an EF [EF_{SR}] during the manipulation check) on the piecewise growth curves, and was in the structure:

$$\pi_{0i} = \beta_{00} + \beta_{01}(\mathrm{EF}_{\mathrm{SR}}) + \beta_{02}(\mathrm{age}) + r_{0i},$$
$$\pi_{1i} = \beta_{10} + \beta_{11}(\mathrm{condition}) + \beta_{12}(\mathrm{EF}_{\mathrm{SR}}) + \beta_{13}(\mathrm{age}) + r_{1i},$$
$$\pi_{2i} = \beta_{20} + \beta_{21}(\mathrm{condition}) + \beta_{22}(\mathrm{EF}_{\mathrm{SR}}) + \beta_{23}(\mathrm{age}) + r_{2i},$$

Table 2. Coding Scheme for Two-Piece Linear Model

Testing time points (weeks)							
	0	**6**	**12**	**13**	**16**	**20**	
α_{1ti}	0	1	2	2	2	2	π_{1i} intervention growth rate
α_{2ti}	0	0	0	0	1	2	π_{2i}retention growth rate
							π_{0i}baseline status

The variable EF_{SR} was selected because studies have repeatedly demonstrated the beneficial effects of EF, and participants in both treatment groups reported substantial use of EF. Age and EF_{SR} were grand mean centered. The effect of condition was tested on the intercept but was found to be nonsignificant; thus, the intercept model was simplified. Condition assignment, originally coded as EF = 1 and IF = 0, was also centered for ease in interpreting intercepts, main effects, and interaction terms. All Level 1 and Level 2 assumptions were not met for homogeneity of variance; therefore, we estimated the proposed models accounting for heteroscedastic Level 1 residuals. In six cases, participants were unable to complete the baseline wobble board assessment without assistance for stability. In such situations, these data were not considered valid and were removed from the analysis.

Results

Analysis of the treatment groups indicated that they did not differ on any demographic, anthropometric, or baseline postural control variables (Table 3).

Table 3. Participant Characteristics

	EF (*n* = 31)	**IF (*n* = 23)**	***p***
Sex			
Male (*n*)	8	9	
Female (*n*)	23	14	
Age (years)	80.73 ± 6.04	80.82 ± 6.11	.895
Height (cm)	164.99 ± 10.45	164.98 ± 11.9	.991
Weight (kg)	67.94 ± 12.9	69.67 ± 16.37	.312
MMSE	28.75 ± 1.62	29.27 ± 1.28	.103

	EF ($n = 31$)	IF ($n = 23$)	p
Berg Balance Scale	50.10 ± 5.50	52.22 ± 3.38	.092
Baseline MPF_{AP}	0.16 ± 0.1	0.16 ± 0.12	.882
Baseline MPF_{ML}	0.15 ± 0.14	0.18 ± 0.15	.123
$MVELO_{AP}$	0.08 ± 0.07	0.12 ± 0.17	.312
$MVELO_{ML}$	0.02 ± 0.01	0.02 ± 0.01	.261

Note. Values are reported as mean ± *SD*. AP = anterior–posterior; ML = medial–lateral; EF, external focus; IF = internal focus; $MVELO_{AP}$ = mean velocity in the anterior–posterior direction; MPF_{AP} = mean power frequency in the anterior–posterior direction; MPF_{ML} = mean power frequency in the medial–lateral direction; $MVELO_{ML}$ = mean velocity in the medial–lateral direction; MMSE = Mini-Mental State Exam.

Table 4. $MVELO_{AP}$ Model Results

(a)				**CI_{95}**	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.131	0.020	<.001	0.092	0.171
Condition	−.052	0.028	.070	−0.109	0.005
EF_{SR}	.000	0.000	.005	−0.000	0.001
Age	−.004	0.002	.068	−0.001	0.000
$Time_{Int}$	.007	0.009	.445	−0.011	0.025
$Time_{Ret}$	−.000	0.004	.974	−0.009	0.009
Age × $Time_{Int}$	−.000	0.001	.878	−0.002	0.002
Age × $Time_{Ret}$	−.000	0.000	.681	−0.001	0.001
Cond × $Time_{Int}$	−.005	0.013	.694	−0.030	0.020
Cond × $Time_{Ret}$	−.002	0.001	.751	−0.010	0.014
(b)				**CI_{95}**	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.122	0.021	<.001	0.081	0.163
Condition	−.035	0.030	.243	−0.095	0.025
EF_{SR}	.000	0.000	.496	−0.001	0.001
Age	−.004	0.002	.079	−0.008	0.000
$Time_{Int}$	.011	0.010	.260	−0.008	0.030
$Time_{Ret}$	.001	0.005	.843	−0.009	0.011
Age × $Time_{Int}$	−.000	0.001	.832	−0.002	0.002
Age × $Time_{Ret}$	−.000	0.000	.607	−0.001	0.001
Cond × $Time_{Int}$	−.013	0.014	.368	−0.040	0.015
Cond × $Time_{Ret}$	−.000	0.007	.993	−0.014	0.014
EF_{SR} × $Time_{Int}$	−.000	0.000	.215	−0.000	0.001
EF_{SR} × $Time_{Ret}$	−.000	0.000	.625	−0.000	0.000

Note. $Time_{Int}$ = intervention time period; $Time_{Ret}$ = retention time period; EF_{SR} = percentage of training sessions in which participants reported using an external focus of attention; Cond = condition (external focus or internal focus); UL = upper limit; LL = lower limit; MVELOAP = mean velocity in the anterior–posterior direction.

Mean Velocity in the Anterior–Posterior Direction

Full model results are presented in Table 4a. The fixed effect of EF_{SR} was significantly and positively associated with $MVELO_{AP}$ ($\beta = 0.0003$, $p = .005$); however, all other simple effects ($p > .06$) and tests of the time by condition and time by age interactions ($p > .68$) failed to reach significance. Therefore, the model was refit without interactions. Results from the reduced model indicated that participants in the EF condition were significantly lower on $MVELO_{AP}$ at baseline

($\beta = -0.0582$, $p = .005$) but that EF_{SR} ($\beta = 0.0009$, $p = .005$) was positively associated with $MVELO_{AP}$. Age was also significantly negatively associated with $MVELO_{AP}$ ($\beta = -0.0047$, $p = .001$). The effects of time during the training intervention and time during the retention period failed to reach significance. Table 5 and Figure 4 depict the estimated marginal means by group for this model.

Table 5. Estimated Mean and *SE* of the Outcome Variables

	$MVELO_{AP}$		$MVELO_{ML}$		MPF_{AP}		MPF_{ML}	
	EF	**IF**	**EF**	**IF**	**EF**	**IF**	**EF**	**IF**
Week 0	0.080 ± 0.023	0.133 ± 0.025	0.019 ± 0.002	0.020 ± 0.002	0.175 ± 0.030	0.153 ± 0.032	0.080 ± 0.037	0.160 ± 0.039
Week 6	0.075 ± 0.022	0.117 ± 0.024	0.019 ± 0.002	0.017 ± 0.002	0.132 ± 0.029	0.140 ± 0.031	0.086 ± 0.035	0.142 ± 0.038
Week 12	0.088 ± 0.013	0.145 ± 0.014	0.018 ± 0.001	0.016 ± 0.001	0.141 ± 0.018	0.176 ± 0.019	0.127 ± 0.020	0.224 ± 0.022
Week 13	0.081 ± 0.018	0.128 ± 0.020	0.019 ± 0.001	0.017 ± 0.001	0.146 ± 0.024	0.145 ± 0.026	0.097 ± 0.030	0.164 ± 0.033
Week 16	0.077 ± 0.018	0.136 ± 0.019	0.019 ± 0.001	0.017 ± 0.001	0.151 ± 0.024	0.158 ± 0.026	0.079 ± 0.023	0.193 ± 0.033
Week 20	0.087 ± 0.019	0.124 ± 0.021	0.019 ± 0.001	0.019 ± 0.001	0.149 ± 0.030	0.163 ± 0.032	0.101 ± 0.029	0.152 ± 0.032

Note. Values are reported as mean ± *SE*. EF = external focus group; IF = internal focus group; $MVELO_{AP}$ = mean velocity in the anterior–posterior direction; $MVELO_{ML}$ = mean velocity in the medial–lateral direction; MPF_{AP} = mean power frequency in the anterior–posterior direction; MPF_{ML} = mean power frequency in the medial–lateral direction; Weeks 0, 6, and 12 = intervention period; Weeks 13, 16, and 20 = retention period.

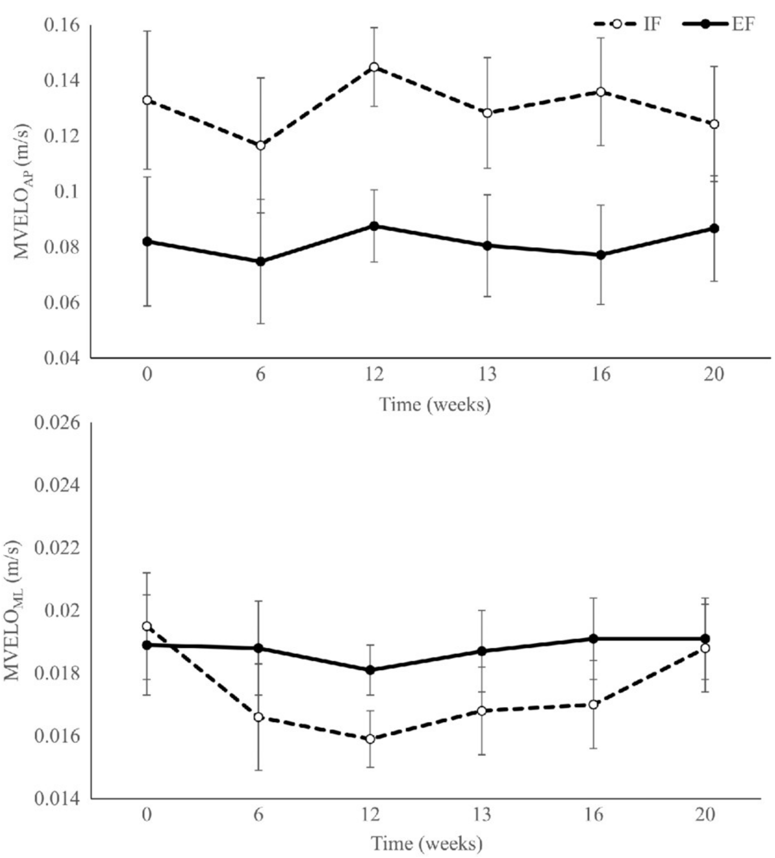

Figure 4. Estimated means for $MVELO_{AP}$ and $MVELO_{ML}$. Weeks 0, 6, and 12 correspond to time during the training intervention, whereas Weeks 13, 16, and 20 correspond to the retention time period. *Note*. $MVELO_{AP}$ = mean velocity in the anterior–posterior direction; $MVELO_{ML}$ = mean velocity in the medial–lateral direction; EF= external focus; IF = internal focus.

Full model results of the secondary analysis are presented in Table 4b. Neither the three-way interactions of condition, EF_{SR}, and time at either segment nor the interaction of condition and EF_{SR} reached significance ($p > .15$). Therefore, the secondary model was refit without these terms to aid in interpretation of the low-order model terms. All simple effects ($p > .08$) and tests of the time by condition, time by age, and time by EF_{SR} interactions ($p > .22$) failed to reach significance.

Table 6. $MVELO_{ML}$ Model Results

(a)				CI_{95}	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.018	0.001	<.001	0.016	0.021
Condition	−.001	0.002	.728	−0.004	0.003
EF_{SR}	−.000	0.000	.076	−0.000	0.000
Age	.000	0.003	.507	−0.000	0.000
$Time_{Int}$	−.002	0.001	.005	−0.003	−0.000
$Time_{Ret}$	.001	0.000	.037	0.000	0.002
Age × $Time_{Int}$	.000	0.000	.673	−0.000	0.000
Age × $Time_{Ret}$	.000	0.000	.324	−0.000	0.000
Cond × $Time_{Int}$	.002	0.001	.057	−0.000	0.004
Cond × $Time_{Ret}$	−.000	0.001	.472	−0.001	0.000

(b)				CI_{95}	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.019	0.001	<.001	0.017	0.022
Condition	−.002	0.001	.239	−0.006	0.002
EF_{SR}	.000	0.000	.429	−0.000	0.000
Age	.000	0.000	.573	−0.000	0.000
$Time_{Int}$	−.002	0.001	.001	−0.004	−0.001
$Time_{Ret}$	.001	0.000	.071	−0.000	0.002
Age × $Time_{Int}$	.000	0.000	.596	−0.000	0.000
Age × $Time_{Ret}$	.000	0.000	.286	−0.000	0.000
Cond × $Time_{Int}$	.003	0.001	.011	0.000	0.005
Cond × $Time_{Ret}$	−.000	0.001	.649	−0.001	0.001
EF_{SR} × $Time_{Int}$	−.000	0.000	.055	−0.000	0.000
EF_{SR} × $Time_{Ret}$	−.000	0.000	.735	−0.000	0.000

Note. $Time_{Int}$ = intervention time period; $Time_{Ret}$ = retention time period; EF_{SR} = percentage of training sessions in which participants reported using an external focus of attention; Cond = condition (external focus or internal focus); MVELOML = mean velocity in the medial–lateral direction.

Mean Velocity in the Medial–Lateral Direction

Full model results are presented in Table 6a. Time during the intervention was significantly negatively associated with $MVELO_{ML}$ ($\pi = -.0019$, $p = .005$), whereas time during retention was significantly positively associated with $MVELO_{ML}$ ($\pi = .0008$, $p = .037$). Only the condition by time during the intervention interaction approached significance ($\beta = .0018$, $p = .057$). All other simple effects ($p > .08$) and time by condition and time by age interactions ($p > .32$) failed to reach significance. Therefore, the model was refit without interactions. Results from the reduced model indicated that for both conditions, time during the interventions was negatively associated with $MVELO_{ML}$ ($\beta = -.0001$, $p = .043$) but that time during retention was positively associated with $MVELO_{ML}$ ($\beta = .0006$, $p = .027$). Table 5 and Figure 4 depict the estimated marginal means by group for this model.

Full model results of the secondary analysis are presented in Table 6b. Neither the three-way interactions of condition, EF_{SR}, and time at either segment nor the interaction of condition and EF_{SR} reached significance ($p > .62$). Therefore, the secondary model was refit without these terms to aid in interpretation of the low-order model terms. Similar to the primary model results, $MVELO_{ML}$ tended to decrease during the intervention time period regardless of condition ($\pi = -.0024$, $p = .0001$). However, a significant condition by time interaction was observed for the first segment ($\pi = .0027$, $p = .001$) with the EF condition demonstrating greater increases in $MVELO_{ML}$ compared with IF. The EF_{SR} by time interaction also approached significance ($\pi = -.00003$, $p = .055$) for the first segment.

Mean Velocity in the Anterior–Posterior Direction

Full model results are presented in Table 7a. Only the fixed effect for age approached significance ($\beta = -0.0053$, $p < .067$). All other simple effects ($p >.12$) and tests of the time by condition and time by age interactions ($p > .20$) failed to reach significance. Therefore, the model was refit without the interactions. Results from the reduced model, again, indicated that only age was significantly associated with MPF_{AP} ($\beta = -0.0052$, $p = .008$). Table 5 and Figure 5 depict the estimated marginal means by group for this model.

Table 7. MPF_{AP} Model Results

(a)				**CI_{95}**	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.160	0.017	<.001	0.126	0.194
Condition	.014	0.037	.701	−0.059	0.088
EF_{SR}	.001	0.000	.126	0.000	0.001
Age	−.005	0.003	.067	−0.011	0.000
$Time_{Int}$	−.007	0.008	.418	−0.023	0.010
$Time_{Ret}$	.005	0.005	.353	−0.005	0.015
Age × $Time_{Int}$	.000	0.001	.992	−0.003	0.003
Age × $Time_{Ret}$	.000	0.001	.973	−0.002	0.002
Cond × $Time_{Int}$	−.021	0.017	.210	−0.053	0.012
Cond × $Time_{Ret}$	−.004	0.010	.721	−0.024	0.016
(b)				**CI_{95}**	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.180	0.019	<.001	0.142	0.218
Condition	.064	0.038	.102	−0.013	0.141
EF_{SR}	−.001	0.001	.060	−0.003	0.000
Age	−.004	0.003	.156	−0.010	0.002
$Time_{Int}$	−.018	0.009	.057	−0.036	0.000
$Time_{Ret}$	.007	0.006	.216	−0.004	0.019
Age × $Time_{Int}$	−.001	0.001	.631	−0.003	0.002
Age × $Time_{Ret}$	.000	0.001	.968	−0.002	0.002
Cond × $Time_{Int}$	−.045	0.018	.014	−0.081	−0.009
Cond × $Time_{Ret}$	−.007	0.012	.562	−0.030	0.016

(b)				CI$_{95}$	
Variable	Coefficient	*SE*	*p*	LL	UL
$EF_{SR} \times Time_{Int}$	.001	0.000	.003	0.000	0.002
$EF_{SR} \times Time_{Ret}$	.000	0.000	.758	0.000	0.000
Cond × EF_{SR}	−.002	0.001	.052	−0.005	0.000
Cond × $EF_{SR} \times Time_{Int}$	.001	0.001	.025	0.000	0.002
Cond × $EF_{SR} \times Time_{Ret}$	.000	0.000	.370	−0.001	0.000

Note. $Time_{Int}$ = intervention time period; $Time_{Ret}$ = retention time period; EF_{SR} = percentage of training sessions in which participants reported using an external focus of attention; Cond = condition (external focus or internal focus).

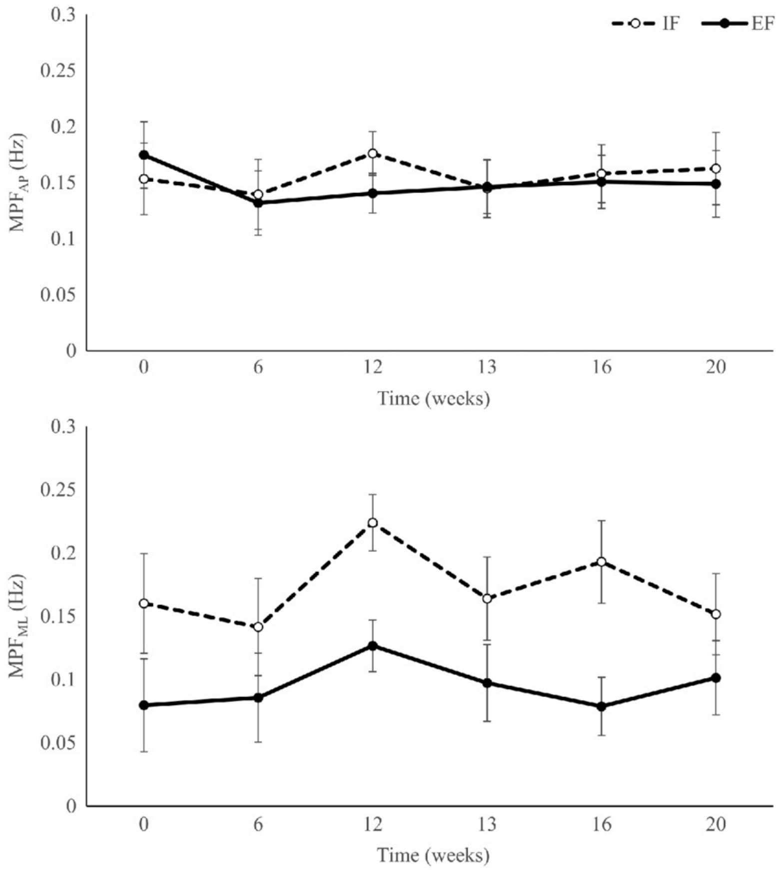

Figure 5. Estimated means for MPF_{AP} and MPF_{ML}. *Note*. Weeks 0, 6, and 12 correspond to time during the training intervention, whereas Weeks 13, 16, and 20 correspond to the retention time period. *Note*. MPF_{AP} = mean power frequency in the anterior–posterior direction; MPF_{ML} = mean power frequency in the medial–lateral direction; EF = external focus; IF = internal focus.

Full model results of the secondary analysis are presented in Table 7b. Results indicated a significant three-way interaction of condition, EF_{SR}, and time for the first segment (intervention period; $\pi = .0013$, $p = .025$) such that participants assigned to the EF group who also reported higher levels of EF_{SR} tended to improve the quickest during the intervention. No main effect or interaction terms involving change during follow-up reached significance ($p > .210$), suggesting that performance did not tend to decrease from posttest to follow-up.

Mean Power Frequency in the Medial–Lateral Direction

Full model results are presented in Table 8a. Fixed effects for EF_{SR} ($\beta = 0.0016$, $p < .002$) and time during training ($\pi = .025$, $p < .02$) were significant and positively associated with MPF_{ML}, and a negative association of age approached significance ($\beta = -0.0059$, $p = .095$). However, all other simple effects *($p > .13$)* and tests of the time by condition and time by age interactions *($p > .22$)* failed to reach significance. Therefore, the model was refit without the interactions. Results from the reduced model indicated that participants in the EF condition were significantly lower on MPF_{ML} at baseline ($\beta = -0.0908$, $p = .006$) but that EF_{SR} ($\beta = 0.0016$, $p = .002$) was positively associated with MPF_{ML}. Age was also significantly negatively associated with MPF_{ML} ($\beta = -0.0088$, $p < .001$). As in the full model, time during training ($\pi = .0249$, $p = .018$) was still positively associated with MPF_{ML} gains. Table 5 and Figure 5 depict the estimated marginal means by group for this model.

Table 8. MPF_{ML} Model Results

(a)				**CI_{95}**	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.119	0.021	<.001	0.078	0.161
Condition	−.069	0.045	.131	−0.158	0.021
EF_{SR}	.002	0.000	.002	0.001	0.003
Age	−.006	0.003	.095	−0.013	0.001
$Time_{Int}$	.025	0.011	.018	0.004	0.046
$Time_{Ret}$	−.003	0.005	.575	−0.013	0.007
Age × $Time_{Int}$	−.001	0.002	.662	−0.004	0.003
Age × $Time_{Ret}$	−.001	0.001	.222	−0.003	0.001
Cond × $Time_{Int}$	−.017	0.021	.419	−0.059	0.024
Cond × $Time_{Ret}$	.005	0.010	.612	−0.015	0.025
(b)				**CI_{95}**	
Variable	**Coefficient**	***SE***	***p***	**LL**	**UL**
Intercept	.121	0.021	<.001	0.080	0.162
Condition	−.032	0.047	.498	−0.126	0.062
EF_{SR}	.000	0.001	.635	−0.001	0.002
Age	−.006	0.003	.112	−0.012	0.001
$Time_{Int}$	.024	0.010	.022	0.004	0.045
$Time_{Ret}$	−.003	0.005	.565	−0.013	0.007
Age × $Time_{Int}$	−.001	0.002	.594	−0.004	0.002
Age × $Time_{Ret}$	−.001	0.001	.191	−0.003	0.001
Cond × $Time_{Int}$	−.035	0.023	.140	−0.081	0.011
Cond × $Time_{Ret}$	.001	0.012	.903	−0.022	0.024
EF_{SR} × $Time_{Int}$	.001	0.000	.089	0.000	0.001
EF_{SR} × $Time_{Ret}$	.000	0.000	.551	0.000	0.000

Note. $Time_{Int}$ = intervention time period; $Time_{Ret}$ = retention time period; EF_{SR} = percentage of training sessions in which participants reported using an external focus of attention; Cond = condition (external focus or internal focus); MPFML = mean power frequency in the medial–lateral direction.

Full model results of the secondary analysis are presented in Table 8b. Neither the three-way interactions of condition, EF_{SR}, and time at either segment nor the interaction of condition and EF_{SR} reached significance ($p > .35$). Therefore, the secondary model was refit without these terms to aid in interpretation of the low-order model terms. Similar to the primary model results, participants, again, tended to improve on MPF_{ML} regardless of condition ($\pi = .0241$, $p = .022$). In addition, the EF_{SR} by time interaction also approached significance ($\pi = .0006$, $p = .089$) for the first segment.

Discussion

The aim of this study was to investigate the effects of attentional focus instructions on the performance progression and retention of a challenging postural control task in older adult fallers. As the fall rate in the older adult population continues to rise, it is essential to identify variables, such as attentional focus, that are modifiable and can improve fall prevention intervention delivery and outcomes. In the present study, older adults (age: 80.78 ± 6.08 years) who reported falling during the previous 12 months participated in a 12-week wobble board training intervention with either EF or IF instructions. Based on the previous literature, it was hypothesized that EF would facilitate performance progression during the intervention period and longer lasting postural control benefits following the training intervention. It was also hypothesized that age would significantly predict performance progression and retention, with younger individuals improving more quickly and retaining learned skills longer. In addition, following each training session (24 training sessions in total), participants were asked to respond to a retrospective verbal report to serve as a manipulation check for treatment effectiveness.

Based on the attentional focus manipulations, our results suggest that an EF during a standardized postural control training program did not facilitate performance progression or lasting benefits of postural control in healthy, older adult fallers. Specifically, regardless of group assignment, $MVELO_{ML}$ significantly decreased during the training intervention, accompanied by a significant increase MPF_{ML}. Previous research examining postural control during a seated wobble board task observed increased mean velocity in the anterior–posterior and medial–lateral axis with decreased stability (e.g., increased dome size underneath the wobble board) and with removal of sensory information (e.g., eyes-closed condition), suggesting decreased postural control (William et al., 2018). In addition, increased MPF has been associated with greater automaticity (Wulf, McNevin, & Shea, 2001). Thus, our findings would suggest increased postural control and automaticity during the training intervention. However, time during retention was significantly positively associated with $MVELO_{ML}$, with no significant differences in MPF_{ML} observed during this time period. This may also suggest that although postural control performance decreased during retention, automaticity was retained during the 8-week follow-up period.

Moreover, based on our findings of no group differences in postural control during or following the training intervention, it is possible that the observed benefits of an EF during an on-going balance task (Kim, Jimenez-Diaz, & Chen, 2017) may not carry over to long-term balance learning. To this end, Kal et al. (2019) observed that although an EF accelerated learning of postural control during the first week of balance training in stroke patients, comparable improvements in postural control performance and similar enhancements in automaticity (dual-task cost) were observed in EF and IF groups following 3 weeks of training. Although not assessed in the current investigation, similar changes may have occurred during our 12-week training intervention. Furthermore, in the current study, the focus strategies were utilized during the 12-week training intervention, but no instructions were given when outcome measures were assessed. Therefore, participants were free to choose whatever strategy (attentional focus or an alternative strategy) at these time points. This design was similar to Landers et al. (2016) and was used to determine whether there would be carryover from the treatment. However, it is important to note that we do not know from previous research whether or not participants covertly adopt an EF during retention testing. If they do, then what we are reporting could be a performance effect as opposed to a learning effect. Thus, it is difficult to actually know whether EF has a learning effect because we cannot directly manipulate it during retention testing. Although our findings, as well as those of Landers and colleagues, would suggest that carryover from training did not occur, manipulation check data collected in our study following each training session provide an alternative suggestion.

In the current study, we observed that the EF group reported greater adherence to the treatment manipulation, with the IF group demonstrating a larger distribution of focus use with almost equal proportions EF and IF reported. To account for this, we included a term in the piecewise linear growth models representing the percentage of training sessions in which participants self-reported use of an EF (EF_{SR}). This term was selected because studies have repeatedly demonstrated the beneficial effects of EF, and participants in both treatment groups reported substantial use of EF. Interestingly, the EF_{SR} does provide some support for the EF effect on performance progression. Although no group differences were observed in $MVELO_{AP}$, participants in the EF group who reported higher levels of EF_{SR} demonstrated increases in MPF_{AP} more quickly during the intervention period. In addition, regardless of group assignment, participants who reported higher levels of EF_{SR} demonstrated marginally significant decreases in $MVELO_{ML}$ ($p = .55$) and greater increases in MPF_{ML}, particularly during the intervention period. These findings suggest that regardless of the treatment group, greater use of EF is beneficial for learning a challenging postural control task. This supports previous attentional focus literature, which has demonstrated superior balance control when individuals adopt an EF (Chiviacowsky et al., 2010; Jackson & Holmes, 2011; Landers et al., 2005; McNevin & Wulf, 2002; Wulf, Shea, and Park, 2001; Wulf et al., 2009). Moreover, this also proposes that with sufficient practice, considerably more individuals may choose to use EF rather than an IF strategy. A potential explanation for EF preference with extended practice periods can be derived from the classical learning model (Anderson, 1982; Fitts & Posner, 1967). According to these theories, the beginning stages of motor learning are characterized by considerable cognitive activity in which movements are controlled in a relatively conscious manner, and thus, participants may initially find adopting an IF to be more comfortable. In addition, in early stages of learning, participants will likely experiment with several strategies to find out which one gets them closest to the movement goal (Wulf, 2007). Independent of whether participants are assigned to an EF, an EF tends to result in superior motor performance and learning (Wulf et al., 2001); thus, observing the benefits, participants likely choose to use an EF. Moreover, following extensive practice, a performer reaches the autonomous phase, characterized by automatic skill execution requiring little attention. At this stage, it may be more perceptible that an IF disrupts the natural self-organization of the motor system, and participants may find the use of EF more beneficial. Consequently, it is also probable that as learning progressed, participants chose to use an EF.

Based on previous research, we also hypothesized that the EF group would demonstrate longer lasting benefits (retention) to postural control. However, no differences were observed between conditions in the retention rate of any outcome variables. This may be a result of the wide variance of foci use reported during training sessions (Table 1), resulting in cross contamination of the treatment groups. Yet, no significant interactions were observed between EF_{SR} and time during retention, suggesting that the percentage of training sessions and EF focus used did not significantly affect retention of postural control. In addition, in alignment with typical retention measures, instructions were not provided during assessment of outcome measures, and manipulations checks were not performed following assessment of outcome measures. As a result, it is unclear whether participants used an EF or IF at retention, and thus, results may not reflect the focus strategy used during training but rather the strategy used during assessment of the outcome measures. Furthermore, observations from Wulf et al. (2001) suggest that with sufficient practice, participants prefer an EF. Thus, it can be postulated that regardless of treatment group or the dominant focus used during training, a greater proportion of participants may have used an EF at retention, resulting in the observed effects.

In the reduced models, age was significantly negatively associated with $MVELO_{AP}$, MPF_{AP}, and MPF_{ML} such that as age increased, baseline $MVELO_{AP}$, MPF_{AP}, and MPF_{ML} decreased. The negative association of $MVELO_{AP}$ is contrary to what was expected; however, based on qualitative observation, participants initially struggled to move the board in the anterior–posterior direction, with many resting the rear portion of the board on the floor and only moving in the medial–lateral direction. This resulted in little to no movement of the board in the anterior–posterior direction at baseline. The observation of the associations between age and MPF was expected due to the fact that the automaticity of postural control declines with age (Boisgontier et al., 2013; Huxhold, Li, Schmiedek, & Lindenberger, 2006; Melzer, Benjuya, & Kaplanski, 2001). Contrary to our hypothesis, age did not significantly predict the rate of performance progression or retention of postural control. Our hypothesis was based on the findings that although learning capabilities tend to remain intact in older adults, relative age differences become more robust when effortful resources are required for motor performance (Voelcker-Rehage, 2008), such as those required when performing the wobble board task used in the present study. It is likely that the use of attentional focus strategies reduced the resources needed to attain the movement goal in the wobble board task and, thus, accounted for the relative age differences in learning capabilities. Although caution must be taken with the interpretation because a control condition was not included in the present study, this suggests that regardless of age, attentional focus instructions may facilitate performance and retention of postural control. This suggestion is congruent with previous research that found that EF instructions increased postural control entropy similarly for older and younger adults (Rhea et al., 2019). Collectively, this observation is particularly important for supporting the inclusion of attentional focus strategies in current fall prevention interventions.

The current study was not without limitations. First, although participants were mostly blind to their treatment group and the study hypotheses, the research assistants who conducted the treatment and outcome measures were not. This could have been accounted for by having a blinded research assistant conduct the treatment and outcomes. Second, although a cohort design was employed to reduce cross contamination by communication with other treatment groups, the recruitment from retirement communities made it such that participants lived in close communities. Therefore, previous participants assigned to an opposing treatment group could have communicated with participants during their enrollment period. Third, manipulation checks were not performed following outcome measures; thus, it is unclear what participants focused on during the measures reported in the present study. It was inferred that the focus strategy during training influenced their focus during outcome assessments. Fourth, though the designation of high fall risk based on a single fall during the previous 12-month is supported (Russell et al., 2009), data on multiple or recurrent falls during this time period would provide further description of fall risk. However, the current investigation did not collect information regarding the number of falls a participant experienced during the previous 12 months. Thus, although unlikely given that our participants were otherwise healthy, variance in fall number and risk may exist between groups. Finally, a single researcher coded responses to the manipulation check, which may reduce reliability of these data.

The present study adds to the research on attentional focus and postural control in healthy, older adults with fall risk. Despite observing no differences between treatment groups on the learning rate and retention of postural control, responses to the retrospective verbal manipulation check suggest a preference for and advantage of an EF on the learning rate and automaticity of postural control. In addition, attentional focus instructions may reduce the age-related differences in the cognitive resources needed for performance of a complex gross motor task, thereby improving the learning rate of postural control in older adults. These findings support the inclusion of attentional focus instructions in fall prevention interventions. Importantly, the addition of attentional focus strategies to current interventions is cost effective, requiring only slight reworking of current delivery methods with minimal supplementary training needed. Finally, future research on attentional focus and postural control training should investigate the interaction between stage of learning and attentional foci preference to consider individualizing training modalities to individual capabilities. This would guide practitioners in optimal practices for challenging patient postural control through effectively guiding implementation of attentional strategies.

Acknowledgments

This research was funded by a grant (1R15AG053866-01A1) from the National Institute on Aging. The authors confirm that there are no known conflicts of interest regarding the work described in this article.

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