Sex Differences in Postural Control During and Following an Attentional Focus Balance Training Intervention in Older Adults with Elevated Fall Risk

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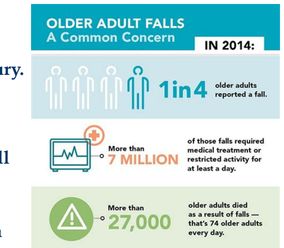
Context

- **For older adults (age 65+), falls are the leading cause of fatal and non-fatal injuries.** (Bergen et al., 2016)
- **Approximately 29.0 million older adult falls occur annually, with 27,000 resulting in death and 7.0 million resulting in injury.** (Bergen et al., 2016)
- **On average, females (30.3%) are more likely to report falling than males (26.5%) ($p < 0.01$) and are more likely to report a fall injury (12.6% compared with 8.3%; $p < 0.01$).** (Bergen et al., 2016)
- **Fall-attributable medical expenses top more than $49.5 billion annually.** (Burns et al., 2016)
  - Females account for 71% of the total annual medical costs of falls, with females aged 85 and older responsible for one-third of total medical costs.



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Context

- **Balance is a critical component of fall risk.**
  - Various balance training interventions have been identified to reduce fall risk in older adults but are moderately effective at best. (Sherrington et al., 2017)
  - Additional benefit may be derived from the inclusion of cognitive factors such as attentional focus.
- **Attentional Focus** (Wulf, 2013)
  - **Internal:** directing the learners attention to their body movements.
  - **External:** directing the learners attention to the effects of their movements on the environment.
  - Learning and performance of motor skills have shown to be enhanced by an external focus of attention.
- **Limited evidence exists regarding sex-related differences in response to balance training in general and more specifically attentional focus instructions.**
- **Understanding these differences is important for optimal individualization of balance training and fall prevention protocols.**

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Objective

- **Purpose:**
  - Examine sex differences during and following a 12-week balance training intervention with attentional focus instructions.
- **Hypothesis:**
  - Regardless of attentional focus group, females would demonstrate superior postural control at baseline with no differences between sexes in the rate of learning or retention during or following the intervention, respectively.

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Participants

Table 1. Participant characteristics

		Females (n = 37)	Males (n = 16)	p
Sex	EF (n)	23	7	
	IF (n)	14	9	
Age (years)		79.89 ± 5.95	82.56 ± 6.51	0.151
Height (cm)		160.20 ± 9.12	175.37 ± 7.46	0.001
Weight (kg)		64.19 ± 12.76	78.09 ± 14.16	< 0.001

Note. Values are reported as mean ± SD, EF = External Focus, IF = Internal Focus.

- Reported falling at least once during the previous 12 months.
- No diagnosis of neurological conditions that impact balance (e.g., MS, Parkinson's Disease, Peripheral Neuropathy, etc.).
- Ability to walk independently for at least 10 minutes.
- 20/70 vision or better.
- MMSE score ≥ 25.
- Medical clearance from their primary care physician.

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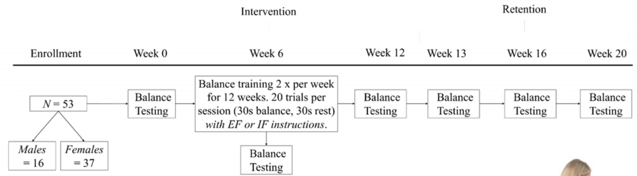
Methods



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Results

- Piecewise linear growth models were estimated using hierarchial linear modeling to assess sex and treatment effects on individual growth trajectories of static (e.g., Pathlength, Center of Pressure (COP) resultant velocity, and sample entropy) and dynamic balance (e.g., mean velocity and acceleration in the anterior-posterior and medial-lateral directions) during the intervention and retention periods.

Table 2

Coding scheme for two-piece linear model

	Testing Time Points (Weeks) 0	6	12	13	16	20	
a_{1ti}	0	6	12	12	12	12	π_{1i} growth rate during intervention
a_{2ti}	0	0	0	1	4	8	π_{2i} growth rate during retention π_{0i} baseline status

- Age was group mean centered.
- Sex: 0 = Male, 1 = Female
- Condition: 0 = IF, 1 = EF

Level-1 model:

$$MVELO - AP = \pi_{0i} + \pi_{1i}a_{1ti} + \pi_{2i}a_{2ti} + e_{ti}$$
$$MVELO - ML = \pi_{0i} + \pi_{1i}a_{1ti} + \pi_{2i}a_{2ti} + e_{ti}$$

Level-2 model:

$$\pi_{0i} = \beta_{00} + \beta_{01}(Condition) + \beta_{02}(Age) + \beta_{03}(Sex) + \beta_{04}(Condition * Sex) + r_{0i}$$
$$\pi_{1i} = \beta_{01} + \beta_{11}(Condition) + \beta_{12}(Age) + \beta_{13}(Sex) + \beta_{14}(Condition * Sex) + r_{1i}$$
$$\pi_{2i} = \beta_{02} + \beta_{21}(Condition) + \beta_{22}(Age) + \beta_{23}(Sex) + \beta_{24}(Condition * Sex) + r_{2i}$$

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Static Balance Results

- **Three-way interactions terms were non-significant in all models; therefore, models were simplified.**

Table 3. Pathlength model results

Variable	Coeff	SE	p	95% CI Lower	95% CI Upper
Intercept	43.25	5.60	<0.001	32.220	54.270
Condition	3.99	6.26	0.528	-8.630	16.600
Female	**-17.07**	**6.35**	**0.004**	**-27.510**	**-2.320**
Age	0.81	0.45	0.079	-0.100	1.720
$Time_{Int}$	1.31	2.02	0.517	-2.670	5.300
$Time_{ret}$	-1.32	1.15	0.253	-3.590	0.950
$Age*Time_{Int}$	-0.08	0.16	0.626	-0.410	0.240
$Age*Time_{ret}$	-0.05	0.10	0.574	-0.240	0.130
$Female*Time_{Int}$	-1.87	2.28	0.895	-6.370	2.630
$Female*Time_{ret}$	0.57	1.32	0.801	-2.040	3.170
$Cond*Time_{Int}$	0.27	2.05	0.413	-3.770	4.310
$Cond*Time_{ret}$	0.30	1.20	0.670	-2.040	2.640

Note. $Time_{int}$: Intervention time period, $Time_{ret}$: Retention time period.

Table 4. COP resultant velocity model results

Variable	Coeff	SE	p	95% CI Lower	95% CI Upper
Intercept	0.00330	0.00059	<0.001	0.00214	0.00446
Condition	0.00060	0.00065	0.322	-0.00670	0.00193
Female	**-0.00119**	**0.00066**	**0.026**	**-0.00252**	**-0.00014**
Age	**0.00013**	**0.00005**	**0.008**	**0.00004**	**0.00023**
$Time_{Int}$	0.00011	0.00029	0.714	-0.00047	0.00068
$Time_{ret}$	-0.00028	0.00019	0.148	-0.00066	0.00010
$Age*Time_{Int}$	-0.00004	0.00002	0.107	-0.00009	0.00001
$Age*Time_{ret}$	0.00001	0.00002	0.536	-0.00002	0.00004
$Female*Time_{Int}$	-0.00014	0.00033	0.679	-0.00078	0.00051
$Female*Time_{ret}$	0.00021	0.00022	0.343	-0.00023	0.00065
$Cond*Time_{Int}$	-0.00003	0.00030	0.927	-0.00061	0.00056
$Cond*Time_{ret}$	-0.00005	0.00022	0.808	-0.00044	0.00034

Note. $Time_{int}$: Intervention time period, $Time_{ret}$: Retention time period.

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Dynamic Balance Results

Table 5. Mean velocity in the medial-lateral direction model results

				95% CI	
Variable	Coeff	SE	*p*	Lower	Upper
Intercept	0.02129	0.00181	<0.001	0.01772	0.02485
Condition	-0.00002	0.00189	0.992	-0.00383	0.00379
Female	**-0.00443**	**0.00200**	**0.032**	**-0.00845**	**-0.00040**
Age	0.00001	0.00015	0.962	-0.00030	0.00031
Time$_{Int}$	**-0.00378**	**0.00093**	**<0.001**	**-0.00562**	**-0.00194**
Time$_{ret}$	**0.00106**	**0.00048**	**0.027**	**0.00012**	**0.00199**
Age*Time$_{Int}$	0.00009	0.00080	0.277	-0.00007	0.00014
Age*Time$_{ret}$	0.00004	0.00004	0.321	-0.00004	0.00011
Female*Time$_{Int}$	**0.00289**	**0.00103**	**0.006**	**0.00086**	**0.00493**
Female*Time$_{ret}$	-0.00040	0.00054	0.463	-0.00145	0.00066
Cond*Time$_{Int}$	0.00130	0.00093	0.162	-0.00053	0.00312
Cond*Time$_{ret}$	-0.00017	0.00048	0.731	-0.00111	0.00078

Note. Time$_{int}$: Intervention time period, Time$_{ret}$: Retention time period.

Table 6. Mean acceleration in the medial-lateral direction model results

				95% CI	
Variable	Coeff	SE	*p*	Lower	Upper
Intercept	1.316	0.106	<0.001	1.108	1.525
Condition	-0.020	0.111	0.861	-0.244	0.205
Female	**-0.297**	**0.117**	**0.015**	**-0.533**	**-0.061**
Age	-0.002	0.009	0.097	-0.020	0.016
Time$_{Int}$	**-0.247**	**0.054**	**<0.001**	**-0.354**	**-0.140**
Time$_{ret}$	**0.071**	**0.028**	**0.014**	**0.015**	**0.127**
Age*Time$_{Int}$	0.006	0.005	0.166	-0.003	0.015
Age*Time$_{ret}$	0.002	0.002	0.430	-0.003	0.006
Female*Time$_{Int}$	**0.192**	**0.060**	**0.002**	**0.074**	**0.310**
Female*Time$_{ret}$	-0.031	0.032	0.333	-0.095	0.032
Cond*Time$_{Int}$	0.084	0.054	0.119	-0.022	0.190
Cond*Time$_{ret}$	-0.011	0.029	0.698	-0.068	0.045

Note. Time$_{int}$: Intervention time period, Time$_{ret}$: Retention time period.

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Dynamic Balance Results

Table 7. Mean acceleration in the anterior-posterior direction model results

				95% CI	
Variable	Coeff	SE	*p*	Lower	Upper
Intercept	0.940	0.092	<0.001	0.758	1.121
Condition	-0.099	0.097	0.311	-0.295	0.096
Female	-0.078	0.102	0.450	-0.283	0.128
Age	0.001	0.007	0.925	-0.015	0.016
Time$_{Int}$	-0.003	0.049	0.958	-0.100	0.095
Time$_{ret}$	-0.011	0.031	0.721	-0.072	0.050
Age*Time$_{Int}$	-0.005	0.004	0.254	-0.013	0.003
Age*Time$_{ret}$	0.001	0.003	0.716	-0.004	0.006
Female*Time$_{Int}$	-0.042	0.055	0.445	-0.149	0.066
Female*Time$_{ret}$	**0.083**	**0.035**	**0.019**	**0.014**	**0.152**
Cond*Time$_{Int}$	0.036	0.049	0.459	-0.060	0.133
Cond*Time$_{ret}$	**-0.061**	**0.031**	**0.053**	**-0.123**	**0.001**

Note. Time$_{int}$: Intervention time period, Time$_{ret}$: Retention time period.

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Conclusions

- **Compared to males, females demonstrated superior static postural control at baseline as evidenced by shorter pathlengths and more frequent COP movement.**
- **While female demonstrated superior dynamic postural control at baseline as evidenced by more frequent movement of the wobble board in the medial-lateral direction, males demonstrated superior improvement in performance during the intervention.**
  - Females may tend to adopt a more cautious postural control strategy. (Era and Rantanen, 1997)
  - Muscle quality (strength/muscle mass) is lower in older adult females compared to males. Thus, less frequent postural corrections may be the result of decreased stiffness controlled by hip abductors/adductors. (Straight et al., 2015)
- **Attentional focus instructions did not significantly influence learning or retention of postural control.**
  - Manipulation checks were not performed following outcome measure assessments.
  - EF and IF instructions may have different effects based on sensory and motor functioning. (Kal et al., 2019)

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Impact

- **Our findings suggest sex differences in response to a dynamic postural control training intervention for older adults, with females responding less favorably compared to males.**
- **Tailoring fall prevention intervention based on sex may be important for reducing female falls and fall related injuries.**
- **A more concrete explanation of the underlying physiology of sex differences in response to balance training is needed and would be possible through further research incorporating direct comparison of balance learning with other factors (e.g., muscle properties, sensory function, cognitive function, as well as prospective fall rates).**

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Questions?

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