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Reference:
Herssens Nolan, Verbecque Evi, Van Criekinge Tamaya, Saeys Wim, Van Rompaey Vincent, Hallemans Ann.- P 010 : the effect of bilateral vestibular function loss on locomotion, a pilot study
Gait and posture - ISSN 0966-6362 - 65:S1(2018), p. 247-248
Full text (Publisher's DOI): https://doi.org/10.1016/J.GAITPOST.2018.06.154
To cite this reference: https://hdl.handle.net/10067/1522750151162165141

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The effect of bilateral vestibular loss on locomotion, a pilot study.

Introduction: During locomotion, vestibular feedback is essential in maintaining dynamic stability through adjusting the timing and magnitude of foot placements[1]. Additionally, vestibular feedback regulates the head movements and provides a stable gaze during walking[2]. In case of a complete or partial vestibular function loss, as found in bilateral vestibulopathy (BV) patients, an increased postural imbalance during standing and walking is noted which is associated with an increased risk of falling[3]. Additionally, gaze stability is reduced[4]. To investigate the effect of vestibular loss on locomotion in BV-patients, the gait performance of these patients was compared with that of healthy adults and correlated to performance on a functional balance test.

Research question: How does bilateral vestibular loss affect gait performance?

Methods: An instrumented gait analysis was performed in a convenience sample of nine *BV-patients* and nine *age- and sex-matched healthy adults*, randomly selected from an existing database. All subjects walked barefoot overground at self-selected walking speed. Additionally, BV-patients performed the Tinetti-test and completed the Dizziness Handicap Index (DHI). Mean walking speed, stride and step time (s), -length (m), step width (m) and stance (%) were selected as outcome variables, as well as their variability expressed as standard deviations (SD). Differences between left and right spatio-temporal parameters (STP) were investigated with the Wilcoxon Signed Rank test, and as no significant differences were found (p=[0.086;0.953]), the data were pooled for further analysis. Between group differences were analyzed using the Mann-Whitney U test. Correlations between Tinetti (sub)scores and STP were calculated with the Spearman's rho.

Results: Subject characteristics are presented in Table 1. Significant differences in step width (m), stride time SD (s), step time SD (s) and stance SD (%) were noted (Table 2). A worse performance of the Tinetti-test was correlated with a greater gait variability (r=[-0.503;-0.851]) and a shorter stride and step length (r=0.557;r=0.537) (Table 3).

Discussion: Up until now, information about the effects of bilateral vestibular function loss on gait performance is lacking. Our results, although preliminary, were similar to those of Pradhan et al. where BV-patients had a slower walking speed, wider base of support, shorter stride length and an increased stride time variability as compared to healthy controls. These gait alterations could indicate a more cautious way of walking, due to loss of vestibular feedback resulting in postural imbalance[3], and act as a way to increase the dynamic walking stability[6]. Further investigation of gait characteristics in a large cohort of BV-patients is advised in order to fully understand the alterations in gait performance due to bilateral vestibular function loss.

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Table 1. Patient characteristics

		Bilateral Vestibulopathy	Healthy
Subjects (n)		9	9
M/F (n)		5/4	5/4
Age (years)[a]	Mean (SD)	60.67 (12.85)	61.15 (11.68)
	Range	28.00 – 73.00	27.00 – 72.00
Length (m)[b]		1.68 (0.13)	1.66 (0.08)
Weight (kg)[c]		73.34 (16.05)	72.97 (12.05)
Etiology BV		Idiopathic (n=2) Gentamicin toxicity (n=2) Auto-immune inner ear disorder (n=2) Meningitis (n=2) Bilateral vestibular neuritis (n=1)	
DHI scores	Mean (SD)	39.11 (27.57)	
	Range	0.00 – 84.00	
Tinetti test	Balance	13.67 (2.83)	
	Gait	10.33 (2.24)	
	Total	24.00 (4.97)	

BV: Bilateral Vestibulopathy; DHI: Dizziness Handicap Inventory; M: male; F: Female; m: meters; [a]: no significant difference in age between groups (p = .815); [b]: no significant difference in length between groups (p = .724); [c]: no significant difference in weight between groups (p = .965)

Table 2. Comparison of gait characteristics between healthy subjects and bilateral vestibulopathy patients.

Characteristics	Group	Q1	Median/Q2	Q3	IQR	p-value[a] (Healthy vs BV)
MEAN						
Walking speed (m/s)	Healthy	1.0553	1.1076	1.2412	0.18	0.090
	BV	.8347	1.0242	1.1763	0.34	
Stride time (s)	Healthy	.9879	1.0575	1.1267	0.16	0.121
	BV	1.0292	1.1158	1.2808	0.25	
Stride length (m)	Healthy	1.1925	1.2629	1.3432	0.10	0.062
	BV	.9824	1.0920	1.3048	0.32	
Step time (s)	Healthy	.4879	.5275	.5696	0.09	0.100
	BV	.5145	.5617	.6417	0.13	
Stance (%)	Healthy	60.0324	60.6226	61.7889	2.24	0.155
	BV	60.0693	61.7491	63.1023	3.03	
Step length (m)	Healthy	.6002	.6299	.6894	0.05	0.050
	BV	.4893	.5492	.6389	0.15	
Step width (m)	Healthy	.1470	***.1687***	.1995	0.05	**0.031**
	BV	.1701	***.1945***	.2204	0.05	
VARIABILITY – Standard Deviation						
Walking speed (m/s)	Healthy	.0331	.0407	.0608	0.04	0.506
	BV	.0191	.0387	.0715	0.05	
Stride time (s)	Healthy	.0047	***.0094***	.0129	0.01	**0.001**
	BV	.0165	***.0283***	.0336	0.02	
Stride length (m)	Healthy	.0144	.0182	.0299	0.02	0.352
	BV	.0154	.0245	.0476	0.03	
Step time (s)	Healthy	.0038	***.0071***	.0072	0.00	**<0.001**
	BV	.0153	***.0189***	.0273	0.01	
Stance (%)	Healthy	.2326	***.4230***	1.3791	1.15	**0.006**
	BV	.8145	***1.1658***	2.0151	1.20	
Step length (m)	Healthy	.0070	.0117	.0147	0.01	0.058
	BV	.0116	.0148	.0288	0.02	
Step width (m)	Healthy	.0126	.0209	.0346	0.02	0.581
	BV	.0157	.0223	.0304	0.01	

BV: Bilateral vestibulopathy; Q1: 1st Quartile; Q2: 2nd Quartile/Median; Q3: 3rd Quartile; IQR: Interquartile range; m: meters; s: seconds; [a]: p-value of the difference between medians as calculated by the Mann-Whitney U test

Table 3. Correlations between the Tinetti-test (sub)scores and the spatio-temporal parameters in patients with bilateral vestibulopathy.

	Tinetti Balance		Tinetti Gait		Tinetti Total	
	r	p-value	r	p-value	r	p-value
MEAN						
Walking speed (m/s)	.315	.202	.176	.484	.189	.452
Stride time (s)	.104	.680	***.507***	***.032***	.407	.094
Stride length (m)	***.557***	***.016***	***.548***	***.018***	***.557***	***.016***
Step time (s)	.120	.636	***.479***	***.044***	.398	.102
Stance (%)	-.048	.850	-.091	.718	.000	1.000
Step length (m)	***.529***	***.024***	***.537***	***.021***	***.537***	***.021***
Step width (m)	-.015	.952	-.205	.416	-.148	.558
VARIABILITY – Standard Deviation						
Walking speed (m/s)	-.089	.725	.078	.757	.022	.932
Stride time (s)	***-.535***	***.022***	-.363	.138	***-.503***	***.034***
Stride length (m)	***-.781***	***.000***	***-.729***	***.001***	***-.851***	***.000***
Step time (s)	-.450	.061	-.111	.661	-.307	.216
Stance (%)	***-.633***	***.005***	-.352	.151	***-.513***	***.029***
Step length (m)	***-.690***	***.002***	***-.698***	***.001***	***-.755***	***.000***
Step width (m)	-.224	.330	-.102	.686	-.133	.600

The Spearman's rho was used to calculate correlation coefficients between the Tinetti-test (sub)scores and the spatio-temporal parameters of the bilateral vestibulopathy patients; m: meters; s: seconds; r: correlation coefficient.