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LETTER TO THE EDITORS

Prevalence of motion sickness in various vestibular disorders: a study on 749 patients

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Dear Sirs,

Motion sickness is a clinically and scientifically relevant topic. According to a Medline Search, 5768 articles use the terms "motion sickness" or "kinetosis" (date 13-05-2018). Its underlying mechanism is best explained by an intersensory mismatch involving conflicting vestibular, visual, and somatosensory stimuli [1, 2]. The typical signs and symptoms of initial dizziness, physical distress, fatigue, yawning, facial pallor, oversensitivity to smells, sweating, headache and, once fully developed, nausea and vomiting with apathy and fear of annihilation [3] were already described in ancient Greek and Roman literature [4]. The prevalence of motion sickness is higher in certain vestibular disorders like vestibular migraine due to hypersensitivity to sensory input and is lower in others like bilateral vestibulopathy because the vestibular input is diminished, resulting in less visuo-/somatosensory, vestibular mismatch [5–8].

The objective of this epidemiological study was to evaluate the prevalence of motion sickness in various vestibular disorders. At a specialized tertiary center for vertigo and dizziness, patients underwent a systematic and complete neurological, neuroophthalmological, neurootological and neuroorthoptic examination and the following laboratory examinations: video head-impulse test, caloric testing, cervical and ocular vestibular evoked myogenic potentials, and auditory evoked brainstem potentials. The diagnostic criteria were based on the current criteria of the Bárány Society for vestibular migraine [9], benign paroxysmal positional vertigo [10], Menière's disease [11], vestibular paroxysmia [12], bilateral vestibulopathy [13], and persistent postural-perceptural dizziness (PPPD)/functional dizziness [14]. Consecutive patients with various vestibular disorders were asked about their susceptibility to motion sickness on a standardized questionnaire ["Do you suffer from motion sickness (for instance, nausea while travelling by car, bus, train, ship, or riding on a carousel or looping?")].

In a study published previously, a control group of 3517 healthy individuals had a prevalence of 13.4% [15]. Those patients < 30 years of age had the highest prevalence (50.2%), and those 80+, the lowest (12%). Women showed a relatively higher prevalence than men (37.5 vs. 27.9%).

In this sample of 785 consecutive patients (mean age 62.9, 46.0% females) presenting with vertigo or dizziness, 31.1% reported motion sickness; because of missing data only 749 were included in the current study for further analysis. Significant differences were observed among the following disease entities (listed in the order of decreasing prevalence of motion sickness; for details see Table 1 with the statistical analyses): 56.9% in vestibular migraine, 48.0% in benign paroxysmal positional vertigo, 37.5% in orthostatic dizziness, 35.1% in Menière's disease, 32.7% in functional dizziness, 32.0% in unilateral vestibulopathy, 30.8% in vestibular paroxysmia, 25.5% in central dizziness, and 12.4% in patients with bilateral vestibulopathy. In the latter, however, a lower prevalence had been expected because of the functional vestibular loss. Evidently the loss was incomplete, for sufficient vestibular function remained to elicit more motion sickness than anticipated. In another study, patients with bilateral vestibulopathy had reduced motion

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Table 1 Prevalence of motion sickness (yes vs. no) in various age groups, males and females, and various vestibular diseases as well as a healthy control group of 3517 individuals

	Total	Motion sickness				SMR[a]	95% Confidence limits of SMR		*p* value
		No		Yes			Lower	Upper	
	N	*N*	%	*N*	%				
Age group									
< 30	23	11	47.8	12	52.2				
30–39	42	26	61.9	16	38.1				
40–49	110	61	55.5	49	44.5				
50–59	129	64	49.6	65	50.4				
60–69	123	85	69.1	38	30.9				
70–79	230	179	77.8	51	22.2				
80+	92	81	88.0	11	12.0				
Sex									
Male	405	292	72.1	113	27.9				
Female	344	215	62.5	129	37.5				
Diagnosis									
Vestibular migraine	51	22	43.1	29	56.9	3.7218	2.3672	5.0764	< 0.0001
BPPV	100	52	52.0	48	48.0	3.3556	2.4063	4.3049	< 0.0001
Menière's disease (MD)	114	74	64.9	40	35.1	2.8541	1.9696	3.7386	< 0.0001
Functional dizziness	107	72	67.3	35	32.7	2.5298	1.6917	3.3679	0.0003
Unilateral vestibulopathy	97	66	68.0	31	32.0	2.6264	1.7019	3.5509	0.0006
Vertigo of central origin	51	38	74.5	13	25.5	2.2272	0.6838	3.7705	0.1191
BVP	155	135	87.1	20	12.9	1.0548	0.5925	1.5171	0.8163
Vestibular migraine and MD	8	5	62.5	3	(37.5)				
Orthostatic dizziness	8	5	62.5	3	(37.5)				
Other	32	20	62.5	12	37.5				
Vestibular paroxysmia	26	18	69.2	8	(30.8)				
Total	749	507	67.7	242	32.3				
Control group	3517	3044	86.6	473	13.4				

Due to low sample sizes in the age/sex strata SMR was only calculated for diagnoses in which $n > 50$ and based on six age groups (< 40, 40–49, 50–59, 60–69, 70–79, 80+). We used the indirect standardization method. Pooled estimates across strata were not calculated because of the heterogeneity of estimates

BPPV benign paroxysmal positional vertigo, *BVP* bilateral vestibulopathy

[a]*SMR* standardized morbidity rate, i.e., the ratio of the observed number of events in the study population to the computed expected number of events based on event rates in a reference population ($n = 3517$, see [15]). An SMR > 1 indicates that the rate of events in the study population is higher than expected; the underlying null-hypothesis is SMR = 1. "Other" means rare diseases such as superior canal dehiscence syndrome or symptoms that could not be precisely diagnosed

sickness susceptibility, but were also slightly sensitive to experimental vestibular stimulations [16].

From this prospective epidemiological study, we conclude that motion sickness is a relevant comorbidity of most vestibular disorders. This is particularly true for patients who have recurrent attacks of vertigo, which is the case in benign paroxysmal positional vertigo (almost 50%), Menière's disease, and vestibular migraine, and in particular for all younger individuals with these diseases. Therefore, doctors should specifically ask whether their patients have experienced this frequently accompanying condition when discussing treatment options (for an overview see [5]). The susceptibility to fear of heights is similarly heightened in vestibular syndromes due to an increased comorbidity of anxiety disorders, such as in vestibular migraine, vestibular paroxysmia, Menière's disease, and functional dizziness [17].

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Compliance with ethical standards

Conflicts of interest T. Brandt, D. Huppert and E. Grill declare that there are no COI. M. Strupp is Joint Chief Editor of the Journal of Neurology, Editor in Chief of Frontiers of Neuro-otology and Section Editor of F1000. He has received speaker's honoraria from Abbott,

Actelion, Auris Medical, Biogen, Eisai, GSK, Henning Pharma, Interacoustics, MSD, Otometrics, Pierre-Fabre, TEVA, UCB. He acts as a consultant for Abbott, Actelion, AurisMedical, Heel, IntraBio and Sensorion.

Ethical approval The questionnaire used in our study was part of a clinical routine assessment made after obtaining the prior written informed consent of the outpatients who presented at the dizziness unit. The evaluation of the data was completely anonymized. Ethical approval was not required for this study according to the ethical standards laid down in the 1964 Declaration of Helsinki.

Statistical analysis Eva Grill, PhD, Institute for Medical Information Processing, Biometrics and Epidemiology and German Center for Vertigo and Balance Disorders, Ludwig Maximilians University, Munich, Campus Grosshadern, Marchioninistrasse 15, 81377 Munich, Germany, conducted the statistical analysis.

References

1. Reason JT (1978) Motion sickness and adaptation: a neural mismatch model. J R Soc Med 71:819–829
2. Brandt T, Daroff RB (1980) The multisensory physiological and pathological vertigo syndromes. Ann Neurol 7:195–203
3. Zhang LL, Wang JQ, Qi RR, Pan LL, Li M, Cai YL (2016) Motion sickness: current knowledge and recent advantage. CNS Neurosci Ther 22:15–24
4. Huppert D, Oldelehr H, Krammling B, Benson J, Brandt T (2016) What the ancient Greeks and Romans knew (and did not know) about seasickness. Neurology 86:560–565
5. Golding JF (2016) Motion sickness. Handb Clin Neurol 137:371–390
6. Golding JF, Patel M (2017) Meniere's, migraine, and motion sickness. Acta Otolaryngol 137:495–502
7. Paillard AC, Quarck G, Paolino F, Denise P, Paolino M, Golding JF, Ghulyan-Bedikian V (2013) Motion sickness susceptibility in healthy subjects and vestibular patients: effects of gender, age and trait-anxiety. J Vestib Res 23:203–209
8. Takahashi M, Ogata M, Miura M (1997) The significance of motion sickness in the vestibular system. J Vestib Res 7:179–187
9. Lempert T, Olesen J, Furman J, Waterston J, Seemungal B, Carey J, Bisdorff A, Versino M, Evers S, Newman-Toker D (2012) Vestibular migraine: diagnostic criteria. J Vestib Res 22:167–172
10. von Brevern M, Bertholon P, Brandt T, Fife T, Imai T, Nuti D, Newman-Toker D (2015) Benign paroxysmal positional vertigo: diagnostic criteria. J Vestib Res 25:105–117
11. Lopez-Escamez JA, Carey J, Chung WH, Goebel JA, Magnusson M, Mandala M, Newman-Toker DE, Strupp M, Suzuki M, Trabalzini F, Bisdorff A (2015) Diagnostic criteria for Meniere's disease. J Vestib Res 25:1–7
12. Strupp M, Lopez-Escamez JA, Kim JS, Straumann D, Jen JC, Carey J, Bisdorff A, Brandt T (2016) Vestibular paroxysmia: diagnostic criteria. J Vestib Res 26:409–415
13. Strupp M, Kim JS, Murofushi T, Straumann D, Jen JC, Rosengren SM et al (2017) Bilateral vestibulopathy: diagnostic criteria consensus document of the classification committee of the Bárány Society. J Vestib Res 27:177–189
14. Staab J, Eckhardt-Henn A, Horii A, Jacob R, Strupp M, Brandt T, Bronstein A (2017) Diagnostic criteria for persistent postural-perceptual dizziness (PPPD): consensus document of the committee for the classification of vestibular disorders of the Bárány Society. J Vest Res 27:191–2018
15. Huppert D, Grill E, Brandt T (2013) Down on heights? One in three has visual height intolerance. J Neurol 260:597–604
16. Murdin L, Chamberlain F, Cheema S, Arshad Q, gresty MA, Golding JF, Bronstein A (2015) Motion sickness in migraine and vestibular disorders. J Neurol Neurosurg Psychiatry 86:585–587
17. Brandt T, Grill E, Strupp M, Huppert D (2018) Susceptibility to fear of heights in bilateral vestibulopathy and other disorders of vertigo and balance. Front Neurol. https://doi.org/10.3389/fneur.2018.00406