

# Falls Among People With Bilateral Vestibulopathy

Citation for published version (APA):

Herssens, N., How, D., van de Berg, R., & McCrum, C. (2022). Falls Among People With Bilateral Vestibulopathy: A Review of Causes, Incidence, Injuries, and Methods. *JAMA Otolaryngology - Head and Neck Surgery*, 148(2), 187-192. <https://doi.org/10.1001/jamaoto.2021.3673>

**Document status and date:**

Published: 01/02/2022

**DOI:**

[10.1001/jamaoto.2021.3673](https://doi.org/10.1001/jamaoto.2021.3673)

**Document Version:**

Publisher's PDF, also known as Version of record

**Document license:**

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# Falls Among People With Bilateral Vestibulopathy A Review of Causes, Incidence, Injuries, and Methods

Nolan Herssens, PhD; Daniella How, MSc; Raymond van de Berg, MD, PhD; Christopher McCrum, PhD

 Supplemental content

**IMPORTANCE** People with bilateral vestibulopathy experience severe balance and mobility issues. Fear and anxiety are associated with reduced activity, which can further affect balance and fall risk. Understanding and intervening on falls in this population is essential. The aims of this narrative review are to provide an overview of the current knowledge and applied methods on fall incidence, causes, and injuries in bilateral vestibulopathy.

**OBSERVATIONS** Eleven articles reporting falls incidence in people with bilateral vestibulopathy were deemed eligible, including 3 prospective and 8 retrospective studies, with a total of 359 participants, of whom 149 (42%) fell during the assessed period. When reported, the most common perceived causes of falls were loss of balance, darkness, and uneven ground. Information on sustained injuries was limited, with bruises and scrapes being the most common, and only 4 fractures were reported. As most studies included falls as a secondary, descriptive outcome measure, fall data obtained using best practice guidelines were lacking. Only 6 studies reported their definition of a fall, of which 2 studies explicitly reported the way participants were asked about their fall status. Only 3 studies performed a prospective daily fall assessment using monthly fall diaries (a recommended practice), whereas the remaining studies retrospectively collected fall-related data through questionnaires or interviews. While most studies reported the number of people who did and did not fall, the number of total falls in individual studies was lacking.

**CONCLUSIONS AND RELEVANCE** The findings from this review suggest that falls in people with bilateral vestibulopathy are common but remain an understudied consequence of the disease. Larger prospective studies that follow best practice guidelines for fall data collection with the aim of obtaining and reporting fall data are required to improve current fall risk assessments and interventions in bilateral vestibulopathy.

*JAMA Otolaryngol Head Neck Surg.* doi:10.1001/jamaoto.2021.3673  
Published online January 6, 2022.

**Author Affiliations:** Author affiliations are listed at the end of this article.

**Corresponding Author:** Christopher McCrum, PhD, Department of Nutrition and Movement Sciences, Maastricht University, PO Box 616, Maastricht, 6200 MD, the Netherlands ([chris.mccrum@maastrichtuniversity.nl](mailto:chris.mccrum@maastrichtuniversity.nl)).

Falls are one of the leading causes of injuries and are associated with a risk of morbidity and mortality.<sup>1,2</sup> Vestibular disorders are associated with an increased mortality of all causes<sup>3</sup> and deficits in gait and balance control.<sup>4-10</sup> In particular, people with bilateral vestibulopathy (BVP) are at an increased risk of falls, with 1 survey showing a 31-fold increased risk over 5 years compared with the US national average.<sup>11</sup>

Bilateral vestibulopathy is characterized by a partial or complete loss of vestibular function because of dysfunction of both vestibular end organs, the eighth cranial nerve, or a combination of both.<sup>12,13</sup> Bilateral vestibulopathy is fairly uncommon, with a prevalence of 28 of 100 000 US adults in 2008<sup>14</sup>; however, this is likely an underestimation because of diagnosis difficulties.<sup>12,15,16</sup> Bilateral vestibulopathy is a highly disabling disorder. People with BVP often report frequently falling alongside many other associated symptoms, such as imbalance, dizziness, oscillopsia, and vertigo, all of which contribute to a decreased quality of life.<sup>17-22</sup> Alongside the direct consequences of a fall (eg, injuries and loss of independence), indirect complications, such as limiting activities of daily life, becoming more sedentary, moving more rigidly to reduce symp-

toms, and increased concern about falling, may further negatively affect physical and psychological well-being and quality of life.<sup>13,16,23,24</sup> Despite the importance of understanding and intervening on falls in this population, there is a distinct lack of data in the literature that might give actionable insight into the incidence and causes of falls in BVP, as well as the most common fall-related injuries.

The purpose of this narrative review is to provide an overview of current knowledge on the incidence and circumstances of falls in patients with BVP and determine the gaps in knowledge and drawbacks of current methods to obtain this information within this population. This review has the potential to help guide further research on falls incidence and prevention in BVP.

## Methods

For this review, articles were deemed eligible to include if they reported fall incidence data (using any method) among people with bilateral hypofunction or vestibulopathy (age >18 years). Because

**Box. Recommendations to Assess Daily Life Falls as Proposed by the Prevention of Falls Network Europe in 2005<sup>28</sup>**

1. A *fall* should be defined as an unexpected event in which the participants come to rest on the ground, floor, or lower level.
2. Ascertainment must consider the lay perspective of falls. Participants should be asked, "In the past month, have you had any fall, including a slip or trip, in which you lost your balance and landed on the floor or ground or lower level?"
3. Falls should be recorded using prospective daily recording and a notification system with a minimum of monthly reporting. Telephone or face-to-face interviews should be used to rectify missing data and ascertain further details of falls and injuries.
4. Fall data should be summarized as number of falls, number of people who fell/people who did not fall/people who fell frequently, fall rate per person-year, and time to first fall (as a safety measure).
5. The primary analysis of fall data should not be adjusted for physical activity, and reporting should include the absolute risk difference between groups.

the Bárány Society Diagnostic Criteria were only recently published,<sup>25</sup> we did not include or exclude articles on the diagnostic criteria used, but this information was collected from the included studies. Older literature may have used the abbreviation BVD (bilateral vestibular dysfunction) as opposed to the BVP abbreviation recently recommended in the Bárány Society Diagnostic Criteria.<sup>25</sup> Studies were gathered by means of manually screening search results and reference lists from previous projects, including 1 systematic review,<sup>10</sup> doctoral theses,<sup>26,27</sup> and personal bibliographic databases of the authors. In addition, a broad search was completed in PubMed and Web of Science by 2 of us (D.H. and C.M.) (PubMed search string: ((bilateral[Title/Abstract] AND vestibul\*[Title/Abstract])) AND (gait[Title/Abstract] OR balance[Title/Abstract] OR walk\*[Title/Abstract] OR stand\*[Title/Abstract] OR stance[Title/Abstract] OR locomot\*[Title/Abstract] OR fall\*[Title/Abstract])). Finally, 2 of us (D.H. and C.M.) performed snowball searches for all relevant articles. All available data on patient characteristics, BVP etiology, and fall incidence, causes, and injuries (data and methods) were extracted. When there appeared to be missing or erroneous data in the articles (eg, no results for an outcome that was mentioned in the methods), or when only data on combined groups of patients (eg, unilateral vestibulopathy and BVP data combined) were provided, authors of those articles were contacted by email for further clarification. If BVP-specific data could not be obtained, the article was excluded. To evaluate the fall data collection and reporting methods, the recommendations of Lamb et al,<sup>28</sup> shown in the Box, were used for reference as best practice recommendations.

## Observations and Discussion

Eleven articles<sup>9,11,29-37</sup> were reviewed, including a total of 359 patients (176 women [49%]) with ages ranging between 30 and 90 years (Table 1). The most commonly reported etiologies were idiopathic (115 [32%]), followed by unknown 38 [11%] and ototoxic effects 34 [9%], although 4 studies<sup>29,32,36,37</sup> did not report any etiology (113 [31%]). Regarding diagnostic criteria, only 2 of the included studies<sup>35,37</sup> used the Bárány Society Diagnostic Criteria, whereas the

**Table 1. Characteristics of the Included Study Populations**

Study	Origin	No. of participants	No. of women	Mean (SD)		Time since onset, mo	No.		Did not fall	Fell	Single fall	Two falls	Multiple falls	Fall episodes	Fall rate (falls per person-year) <sup>a</sup>
				Age, y											
Prospective studies															
McCrum et al, <sup>34</sup> 2019 <sup>b</sup>	Netherlands	10	5	57.3 (8.1)		NA		4	6	2	0	4	4	40	4.16
Schniepp et al, <sup>37</sup> 2021 <sup>b</sup>	Germany	42	21	56.3 (20.4)		NA		28	14	6	3	5	5	28	1.34
Swanenburg et al, <sup>33</sup> 2017	Switzerland	18	6	61.11 (15.19)		NA		10	8	NA	NA	NA	NA	19	1.06
Retrospective studies															
Brown et al, <sup>30</sup> 2001	US	13	7	65 (18)		13.6 (20.3)		7	6	NA	NA	NA	NA	NA	NA
Dobbels et al, <sup>35</sup> 2020	Belgium	119	55	59.4 (12.5)		148.8 (135.6)		71	45	8/69 <sup>c</sup>	8/69 <sup>c</sup>	14/69 <sup>c</sup>	104	1.51 <sup>c</sup>	
Grove et al, <sup>36</sup> 2021	US	5	3	58.65 (9.39)		NA		4	1	NA	NA	NA	NA	NA	NA
Herdman et al, <sup>29</sup> 2000	US	45	27	63.2 (13.7)		NA		22	23	NA	NA	NA <sup>d</sup>	NA	NA	NA
Karapolat et al, <sup>31</sup> 2014	Turkey	19	13	56.95 (11.36)		44.68 (72.66)		12	7	NA	NA	NA	NA	NA	NA
Schlick et al, <sup>32</sup> 2016	Germany	21	7	62.8 (16.4)		90.3 (98.2)		11	10	NA	NA	NA	NA	NA	NA
Schniepp et al, <sup>9</sup> 2017	Germany	55	20	74 (12)		31 (29)		34	21	13	0	8	32	32	1.16
Ward et al, <sup>11</sup> 2013	US	12	11	NA		NA		4	8	NA	NA	NA	NA	NA	NA

Abbreviation: NA, not applicable.

<sup>a</sup> Fall rate calculated as: total number of falls over total years assessed.

<sup>b</sup> Data concerning falls obtained via the corresponding author.

<sup>c</sup> Data from Dobbels et al<sup>35</sup> (2020) represent a subset of the whole population included within the study.

<sup>d</sup> A percentage of people who fell multiple times is reported in the article, but the percentage does not correspond to other patient numbers in the article. Because the source of the error could not be determined, the value has been excluded.

Table 2. Details on Fall Assessments

Study	Assessment characteristics			Fall-related data collected		
	Fall definition	Assessment method	Period	Cause	Location	Injuries
<b>Prospective studies</b>						
McCrum et al, <sup>34</sup> 2019 <sup>a</sup>	"In the past year, have you had any fall, including a slip or trip, in which you lost your balance and landed on the floor or ground or lower level?"	Diary and questionnaire	Fixed period following 12 mo	Yes	Yes	Yes
Schniepp et al, <sup>37</sup> 2021 <sup>a</sup>	"An unexpected event in which the person comes to rest on the ground, floor, or lower level"	Diary, questionnaire, and phone calls	Fixed period following 6 mo	Yes	Yes	Yes <sup>b</sup>
Swanenburg et al, <sup>33</sup> 2017	"An unexpected event in which the participant comes to rest on the ground, floor, or lower level."	Diary and questionnaire	Fixed period following 12 mo	Yes	Yes	Yes
<b>Retrospective studies</b>						
Brown et al, <sup>30</sup> 2001	Not stated	Interview	Fixed period, previous 4 weeks	No	No	No
Dobbels et al, <sup>35</sup> 2020	"Have you fallen in the past year due to slipping or tripping, losing balance; thereby ending on the floor or another lower level?"	Questionnaire	Fixed period, previous 12 mo	Yes	Yes	Yes
Grove et al, <sup>36</sup> 2021	Not stated	Not stated	Fixed period, previous 6 mo	No	No	No
Herdman et al, <sup>29</sup> 2000	"A loss of balance in which the person ended up on the floor."	Interview	Since disease onset	Yes	Yes	Yes
Karapolat et al, <sup>31</sup> 2014	Not stated	Interview	Fixed period, previous 6 mo	No	No	No
Schlick et al, <sup>32</sup> 2016	"An unexpected event in which the participant comes to rest on the ground, floor, or lower level"	Questionnaire	Fixed period, previous 12 mo	No	No	Yes
Schniepp et al, <sup>9</sup> 2017	Not stated	Interview	Fixed period, previous 6 mo	Yes	Yes	No
Ward et al, <sup>11</sup> 2013	Not stated	Questionnaire	Fixed period, previous 12 mo	No	No	Yes

<sup>a</sup> Data concerning falls were obtained via the corresponding author.

<sup>b</sup> Falls requiring outpatient and inpatient medical care were recorded.

other studies most frequently used combinations of caloric testing with varying cutoffs,<sup>9,11,29,31,32,34,36</sup> video head impulse testing,<sup>9,29,32,33</sup> and rotary chair testing.<sup>29,30,36</sup> Full details of the criteria used can be found in the eTable in the Supplement.

Of the 359 patients, 149 people who fell (42%) were identified (Table 1). Details on how fall assessments were performed in the included studies can be found in Table 2. Six studies<sup>29,32-35,37</sup> reported a definition of a fall that was the same or similar to that proposed by Lamb et al<sup>28</sup> (recommendation 1, Box). For the second recommendation, only 2 studies<sup>34,35</sup> explicitly reported the way participants were asked about fall status; both aligned with the recommendation. All studies defined a specific period ranging from the previous 4 weeks<sup>30</sup> to the previous 6 months<sup>9,31,36</sup> 12 months<sup>11,32-35</sup> up until the onset of the disease.<sup>29</sup> Only 3 studies<sup>33,34,37</sup> performed a prospective fall assessment using monthly fall diaries, with 1 study<sup>33</sup> using telephone interviews to enquire about missing questionnaires and another<sup>37</sup> using monthly telephone calls to validate all diary information (recommendation 3). These had small samples of participants with BVP (70 in total).<sup>33,34,37</sup> Prospective fall monitoring is considered the best method for obtaining reliable information associated with falls because of, among other issues, difficulty in recalling falls and their consequences, especially if not severe.<sup>28,38</sup> The remaining studies retrospectively collected fall-related data through questionnaires or interviews. Concerning recommendation 4, 5 studies<sup>9,33-35,37</sup> reported the total number of fall episodes, ranging from 19<sup>33</sup> to 104 falls.<sup>35</sup> Also, the number of people who fell once, twice, and multiple times was lacking in most of the included studies,<sup>11,29-33,36</sup> and

none of the included studies reported the fall rate per person year or time to first fall. Where possible, the fall rate per person years was calculated (total number of falls / total years assessed [participant number multiplied by assessment duration in years]; Table 1), which ranged between 4.16<sup>34</sup> and 1.06.<sup>33</sup> Lastly, none of the studies adjusted for physical activity, which aligned with recommendation 5. The lack of application of best practices in obtaining fall data may have been because of the lack of studies that used falls as their primary outcome or tested the association of an intervention with falls, with most studies including falls as a secondary, descriptive outcome measure.

Four studies investigated the causes and locations of the falls, as well as any injuries that followed a fall.<sup>29,33-35</sup> One study<sup>9</sup> investigated causes and locations. Three studies<sup>11,32,37</sup> only reported the injuries sustained from the fall. The remaining studies<sup>30,31,36</sup> did not report whether they collected additional details of the fall episodes. Specific details on fall episodes can be found in Table 3. Studies that investigated the location of falls<sup>9,33-35</sup> reported a total of 87 fall episodes in an indoor setting, such as at home or in a public building, vs 73 falls in an outdoor setting, such as the garden or a public space. Two studies reported a high proportion of falls on stairs,<sup>33,35</sup> whereas 1 study did not find falls on stairs to be particularly common.<sup>34</sup> Causes were mostly attributed to a loss of balance,<sup>34,35</sup> darkness,<sup>9,33</sup> or uneven ground.<sup>9,33</sup> These common causes represent a different profile than that seen in healthy adults, for whom trips and slips have been frequently reported to be the most common causes.<sup>27,39-45</sup>

Table 3. Specific Details on Fall Episodes

Study	Location of falls	Cause of falls	Injuries associated with falls
<b>Prospective studies</b>			
McCrum et al, <sup>34</sup> 2019 <sup>a</sup>	A total of 18 fall episodes were inside the house (ie, flat surface: [10], on a staircase [6], getting out of bed [1], shower/bath [1]); 7 occurred outside at home (step/stairs [1], on a path [3], in the garden [3]); and 9 outdoor away from home (footpath [4], getting out of a vehicle [3], public building [1], on the beach [1])	Most falls were attributed to losing balance (n = 20), followed by tripping (n = 3) or feeling dizzy (n = 3)	A total of 13 falls that were associated with injuries were reported that included 10 instances of bruises, 5 of cuts or grazes, and 1 hip fracture.
Schniepp et al, <sup>37</sup> 2021 <sup>a</sup>	The authors stated that this information was to be included in a future publication.	The authors stated that this information was to be included in a future publication.	Four falls led to outpatient medical care and 3 falls led to inpatient medical care.
Swanenburg et al, <sup>33</sup> 2017	A total of 19 falls were recorded, of which 10 occurred outside and 9 inside a building. Nearly half of the fall episodes (n = 8) were associated with stair negotiation in which 6 fall episodes occurred at the last steps when descending the stairs	Sixteen falls were associated with lightning conditions: 3 in the morning, 8 at noon, and 5 in the afternoon. Five falls were associated with head turns during standing (n = 2) or running (n = 3).	Inquired, but no information reported.
<b>Retrospective studies</b>			
Brown et al, <sup>30</sup> 2001	NA	NA	NA
Dobbels et al, <sup>35</sup> 2020	A total of 46 fall episodes were inside the house (ie, stairs [11], flat surface [11], shower/bath [8], chair [8], toilet [3]); 40 in the garden; and 18 away from home (someone else's house [5], public building [6], car [2], gutter [5]).	Most falls were due to loss of balance (n = 23), followed by tripping (n = 8), slipping (n = 7), or dizziness (n = 7).	A total of 33 fall-related injuries were reported: bruises (n = 17), scrapes (n = 8), backache (n = 5), rib fracture (n = 2), and hip fracture (n = 1).
Grove et al, <sup>36</sup> 2021	NA	NA	NA
Herdman et al, <sup>29</sup> 2000	Inquired, but no information reported. <sup>b</sup>	Inquired, but no information reported. <sup>b</sup>	None of the injuries associated with falls needed medical attention.
Karapolat et al, <sup>31</sup> 2014	NA	NA	NA
Schlick et al, <sup>32</sup> 2016	NA	NA	A total of 2 fall episodes required medical attention.
Schniepp et al, <sup>9</sup> 2017	Only 2 fall events took place during ambulation at home.	A total of 28 of 32 reported falls (88%) were associated with darkness or uneven ground.	NA
Ward et al, <sup>11</sup> 2013	NA	NA	Three subjects reported a fall related injury, one subject missed 3 mo of work due to bodily injury.

Abbreviation: NA, not applicable.

<sup>a</sup> Data concerning falls were obtained via the corresponding author.<sup>b</sup> Herdman et al<sup>28</sup> state that "data concerning the circumstances in which the

falls occur were incomplete as many patients were not clear as to why they had fallen."

Most of the injuries sustained by the patients were limited to bruises, cuts, or scrapes,<sup>34,35</sup> while injuries that needed medical attention, such as fractures, or rendered the patient unable to work were limited.<sup>29,34,35</sup> One study did not report the specific injuries but did report that 4 falls led to outpatient medical care and 3 falls led to inpatient medical care.<sup>37</sup> The limited number of severe injuries associated with falls may appear positive, but people with vestibular disorders are known to reduce social and physical activity participation,<sup>46,47</sup> thereby reducing their exposure to risky situations. In the future, it will be important to evaluate physical activity in association with falls and fall-related injuries.

To obtain a more extensive and reliable picture of falls incidence, cause and injuries in BVP, larger, prospective studies that follow the recommendations of Lamb et al<sup>28</sup> are needed. Based on these limited data, the only general recommendation that can be made currently is that adequate lighting in the homes of people with BVP should be confirmed. Other home modifications to reduce fall risk, like those for the general older adult population, may also be worth considering,<sup>48,49</sup> but to our knowledge have not yet been evaluated in the BVP population. Regarding other potential interventions to reduce falls in BVP, no intervention study was identified with falls as a primary outcome. Exercise, physical therapy, and vestibular rehabilitation interventions have generally not been very successful in BVP.<sup>50-52</sup> Emerging

technical therapeutic interventions using vibrotactile feedback and noisy galvanic vestibular stimulation may be promising.<sup>53-55</sup> Recent advances in the vestibular implant in humans are promising, with partial or complete restoration of various vestibular reflexes and functions having already been demonstrated.<sup>56-61</sup> However, the evaluation of the effectiveness of such interventions, in particular in association with falls and improving patients' mobility in daily life, requires more investigation. In addition to the causes mentioned previously that imply a pathological vestibular-ocular reflex and/or visual dependence as a contributing factor to falls in BVP, several potential physiological mechanisms may also be considered in future research, including attention deficits,<sup>62</sup> increased walking variability,<sup>9,34</sup> and altered stability control during steady state<sup>63</sup> and perturbed walking,<sup>7</sup> that may contribute to increased risk of stability loss and decreased ability to recover stability once lost.

Two articles were identified, but not included in our results, that presented relevant information on fall incidence but combined data from patients with unilateral vestibulopathy with data from patients with BVP.<sup>64,65</sup> As the prognosis of the 2 categories of vestibulopathy differ, the information cannot necessarily be combined and used to draw conclusions specific to BVP, as was the goal of this review. These studies reported that 74% and 55% of included participants had experienced at least 1 fall during the last 12 months. We



recommend that future research provide as much disease-specific data as possible and avoid presenting data for combined groups. An associated matter is that only 2 of the included studies<sup>35,37</sup> used the Bárány Society Diagnostic Criteria. This may be attributed to the fact that many of the included studies collected data before the publication of these criteria. As it is not known how slight differences in diagnostic criteria might affect balance and fall risk, this leads to a less precise picture of falls in BVP. Similarly, 2 studies<sup>29,30</sup> were published before publication of the recommendations of Lamb et al.<sup>28</sup>

## Conclusions

Falls are more common and have different causes in people with BVP compared with the healthy population, but remain a relatively understudied consequence of the disease. To better guide improvements in fall risk assessment and interventions in BVP, larger prospective studies that follow best practice recommendations<sup>28</sup> for obtaining and reporting falls data are required.

### ARTICLE INFORMATION

**Accepted for Publication:** November 2, 2021.

**Published Online:** January 6, 2022.  
doi:10.1001/jamaoto.2021.3673

**Author Affiliations:** Space Medicine Team (HRE-OM), European Astronaut Centre, European Space Agency, Cologne, Germany (Herssens); Department of Rehabilitation Sciences and Physiotherapy/MOVANT, Faculty of Medicine and Health Sciences, University of Antwerp, Wilrijk, Belgium (Herssens); Institute of Sport and Exercise Sciences, Münster University, Münster, Germany (How); Division of Balance Disorders, Department of Otorhinolaryngology and Head and Neck Surgery, Faculty of Health Medicine and Life Sciences, School for Mental Health and Neuroscience, Maastricht University Medical Centre+, Maastricht, the Netherlands (van de Berg); Faculty of Physics, Tomsk State University, Tomsk, Russia (van de Berg); Department of Nutrition and Movement Sciences, NUTRIM School of Nutrition and Translational Research in Metabolism, Maastricht University Medical Centre+, Maastricht, the Netherlands (McCrum).

**Author Contributions:** Drs Herssens and McCrum had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

**Concept and design:** Herssens, McCrum.

**Acquisition, analysis, or interpretation of data:** All authors.

**Drafting of the manuscript:** Herssens, McCrum.

**Critical revision of the manuscript for important intellectual content:** How, Van de Berg, McCrum.

**Statistical analysis:** Herssens.

**Obtained funding:** Herssens.

**Administrative, technical, or material support:** McCrum.

**Supervision:** Van de Berg, McCrum.

**Conflict of Interest Disclosures:** Dr Herssens reported grants from the Young European Research Universities Research Mobility Awards. Dr McCrum reports research support from the NUTRIM Graduate Programme Grant. Dr Van de Berg reported nonfinancial support from Medel and grants from the Dutch government, Dutch Hearing Foundation, and University Maastricht and Hasselt outside the submitted work. No other disclosures were reported.

**Funding/Support:** This work was supported by the Young European Research Universities Research Mobility Award (Dr Herssens) and the NUTRIM Graduate Programme Grant (Maastricht University; Dr McCrum).

**Role of the Funder/Sponsor:** The funding organizations had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or

approval of the manuscript; and decision to submit the manuscript for publication.

**Additional Contributions:** We thank Vincent Van Rompaey, MD, PhD, Ann Hallemans, PhD (University of Antwerp), Kenneth Meijer, PhD, Florence Lucieer, MD (Maastricht University, The Netherlands), Angélica Pérez Fornos, PhD, and Nils Guinand, MD, PhD (University of Geneva, Switzerland), for their feedback on an earlier version of the manuscript. We thank Max Wühr, PhD, and Roman Schniepp, MD (Ludwig Maximilian University of Munich, Germany), for providing us with the bilateral vestibulopathy-specific data for their article.<sup>37</sup> None of the people acknowledged here received compensation for the stated contributions.

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