Appendix

Vestibular rehabilitation protocol

The balance system functions, causes of dizziness, and rationale and contraindications for performing the exercises were explained during the training. The patients were actively involved in adapting the exercise program to suit their symptoms, capabilities, and lifestyle. Following previous protocols [1,2], the home exercise program included a patient-tailored combination of adaptation (without and with the target moving in pitch and yaw planes for 1min each three times per day), substitution, habituation, and balance exercises, and all chronic unilateral vestibular hypofunction patients in both vestibular rehabilitation-only and head-mounted device groups were seen at the ITER Center for Rehabilitation - a regional institutional interdisciplinary disorder clinic - twice a week for 4 weeks for 30–45 minutes and monitored for adherence and compliance by two physiotherapists (IA and DM). Between supervised sessions, patients followed a twice-daily home exercise program for a total of 30–40 minutes/day.

Apparatus and head-mounted device-based vestibular rehabilitation session description

The Track Speed Racing 3D game was run on the 5.2’ display of a Windows Phone (Lumia 930, Windows 10 Mobile, Microsoft Corporation, Redmond, Washington, USA) after its accommodation into the head-mounted device ‘Revelation’ 3D VR Headset (for manufacturing details and patient-tailored procedures see Micarelli et al [3]). Each patient was instructed to perform the game protocol uninterruptedly for 20min/day, while sitting on a chair or sofa, and he was sufficiently motivated to reach the total amount of time to spend in both the vestibular and the head-mounted device-based rehabilitation protocol. The Track Speed Racing 3D game consisted of a point-of-view race in which the car is steered from the cockpit by tilting the head to the left and to the right to avoid swerving off the road and to achieve all the goals before finishing the lap. During this real car experience with a true-to-life automotive journey, the visual background and the scenario change perspective according to the patients’ left or right tilted head movements, possibly emulating eye–head exercises that induce visual-vestibular conflicts. Compliance (including discomfort perception by means of the Simulator Sickness Questionnaire), supervision of correct adjustment, and performances of the patients were evaluated every week in the clinic by two experienced trainers (MA and AM) during a visit lasting about one hour.

Supplementary table 1. Socio-demographic and etiological aspects of HMD and VR subjects.

	HMD	VR	Chi- square
	n= 23	n= 24	
Male	n= 14	n=13	0.41
Female	n= 9	n= 11	
AGE	49.72 ± 10.34 years	50.48 ± 9.12 years	
DD	9.91 ± 2.15 months	9.37 ± 1.55 months	
BMI	23.92 ± 2.7 kg/m2	24.13 ± 2.86 kg/m2	
Etiology	Neuronitis= 14	Neuronitis= 13	
	AN= 4	AN= 5	
	Previous petrous= 2	Previous petrous= 3	
	Previous cochlear= 2	Previous cochlear= 1	
	Ramsay Hunt= 1	Ramsay Hunt= 2	

Socio-demographic and etiological aspects of head-mounted device (HMD) and vestibular rehabilitation (VR) groups. DD, disease duration; BMI, body mass index; AN, acoustic neuroma; petrous, petrous surgery; cochlear, cochlear surgery (obtained with permission of the Editor from previously published work by Micarelli et al. [3])

References:

1. Giray M, Kirazli Y, Karapolat H, et al. Short-term effects of vestibular rehabilitation in patients with chronic unilateral vestibular dysfunction: a randomized controlled study. *Arch Phys Med Rehabil* 2009; 90: 1325–1331.

2. Herdman SJ, Hall CD, Maloney B, et al. Variables associated with outcome in patients with bilateral vestibular hypofunction: preliminary study. *J Vestib Res* 2015; 25: 185–194.

3. Micarelli A, Viziano A, Augimeri I, et al. Threedimensional head-mounted gaming task procedure maximizes effects of vestibular rehabilitation in unilateral vestibular hypofunction: a randomized controlled pilot trial. *Int J Rehabil Res* 2017; 40: 325–332.

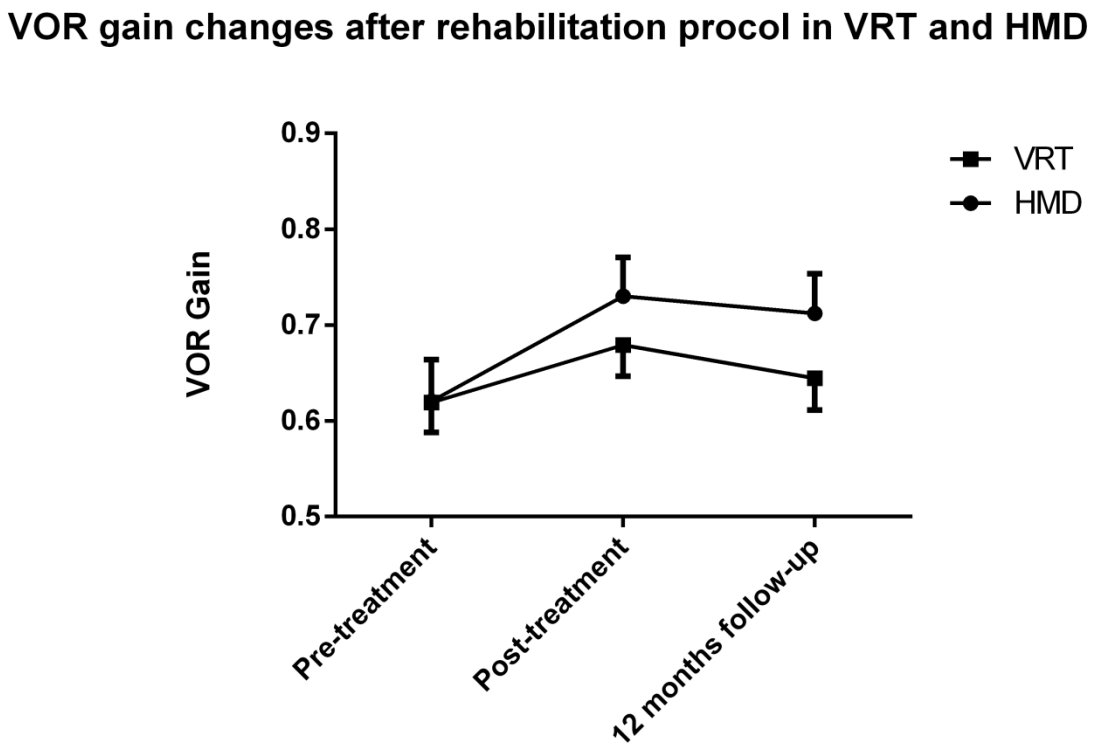

Figure 1. Pre-, post-treatment and 12-month follow-up vestibulo-ocular reflex (VOR) gain changes recorded in patients who underwent vestibular rehabilitation (VRT) alone or the mixed protocol including head mounted device (HMD).

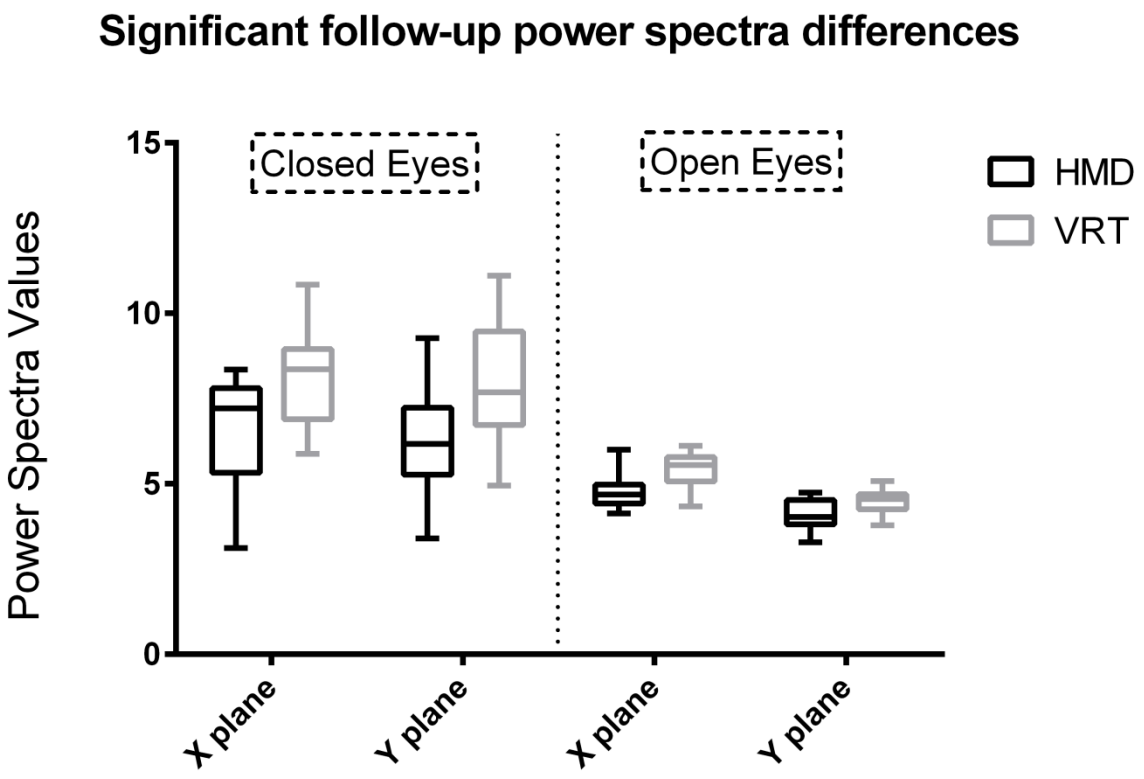

Figure 2. Box and whiskers plot (mean ± standard deviations) depicting significant differences in power spectra values (mm) recorded in patients who underwent only vestibular rehabilitation (VRT) or the mixed protocol including head-mounted device (HMD) in closed and open eyes conditions in both X and Y planes.

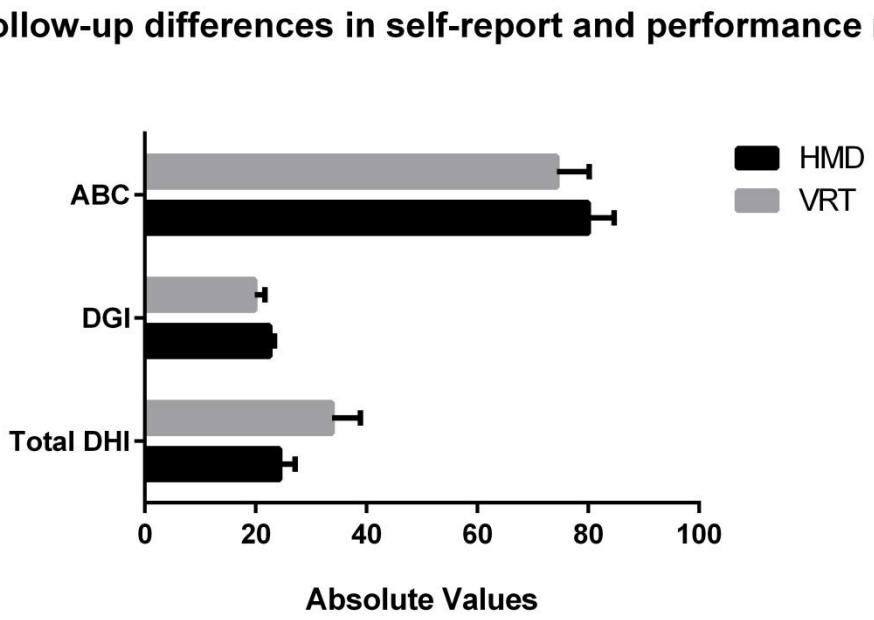

Figure 3. Interleaved bars showing mean and standard deviations of significant outcomes in Activities-specific Balance Confidence (ABC), total Dizziness Handicap Inventory (DHI) and Dynamic Gait Index (DGI) found at the 12-month follow-up visit between patients who underwent vestibular rehabilitation (VRT) alone or the mixed protocol including head-mounted device (HMD).