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REFERENCES

1. Yong M, Zaia E, Westerberg B, et al. Diagnosis of superior semicircular canal dehiscence in the presence of concomitant otosclerosis. *Otol Neurotol* 2017;38:1071–5.
2. Pritchett CV, Spector ME, Kileny PR, et al. Surgical treatment of hearing loss when otosclerosis coexists with superior semicircular canal dehiscence syndrome. *Otol Neurotol* 2014;35:1163–7.
3. Van Rompaey V, Potvin J, van den Hauwe L, et al. Third mobile window associated with suspected otosclerotic foci in two patients with an air-bone gap. *J Laryngol Otol* 2011;125:89–92.
4. Pekkola J, Pitkaranta A, Jappel A, et al. Localized pericochlear hypoattenuating foci at temporal-bone thin-section CT in pediatric patients: Nonpathologic differential diagnostic entity? *Radiology* 2004;230:88–92.
5. Chadwell JB, Halsted MJ, Choo DI, et al. The cochlear cleft. *AJNR Am J Neuroradiol* 2004;25:21–4.
6. Wegner I, van Waes AM, Bittermann AJ, et al. A systematic review of the diagnostic value of CT imaging in diagnosing otosclerosis. *Otol Neurotol* 2016;37:9–15.
7. Van Haesendonck G, Van de Heyning P, Van Rompaey V. Retrospective cohort study on hearing outcome after transmastoid plugging in superior semicircular canal dehiscence syndrome: Our experience. *Clin Otolaryngol* 2016;41:601–6.
8. Ossen ME, Stokroos R, Kingma H, et al. Heterogeneity in reported outcome measures after surgery in superior canal dehiscence syndrome—A systematic literature review. *Front Neurol* 2017; 8:347.
9. Ward BK, Carey JP, Minor LB. Superior canal dehiscence syndrome: Lessons from the first 20 years. *Front Neurol* 2017;8:177.

RESPONSE TO WEAVER TS, SHAYMAN CS, HULLER TE. THE EFFECT OF HEARING AIDS AND COCHLEAR IMPLANTS ON BALANCE DURING GAIT. *OTOL NEUROTOL* 2017;38:1327–1332

To the Editor: In the article ''The effect of hearing aids and cochlear implants on balance during gait'' reported in 2017 by Weaver et al. (1) the authors did not find an overall effect of the use of hearing aids or cochlear implants on spatio-temporal parameters of gait nor on gait variability expressed as coefficients of variation. Nevertheless, the authors themselves stress the considerable variation among participants and highlight that some individuals might indeed benefit from sound as an additional source of sensory input to supplement balance. However, their study did not give insight regarding which individuals might present with this benefit.

Recently, we performed a study (2) with a research hypothesis very similar to that from Weaver et al. (1); adults wearing a cochlear implant (CI) and presenting with bilateral caloric areflexia walked overground at self-selected speed in three different conditions: with CI turned and no additional sound source, with CI turned on and an additional sound source, and with CI turned off. Gait parameters significantly improved in the condition with sound compared with walking with the CI turned on but with no additional sound source. By increasing the motion of the pelvis, the knee, and the ankle, stride length significantly increased (mean difference 7.8 ± 1.2 cm) while stride time decreased (mean difference 0.059 ± 0.016 s).

At first sight, these results seem contradictory to the findings from Weaver et al. (1). However, some individuals in their study also improved their gait pattern in the condition where auditory feedback was available. Surprisingly, four out of five of the individuals that did improve their gait pattern belong to the cochlear implant group and thus represent the individuals in our sample. An explanatory hypothesis related to cochlear implantation is the increased possibility for vestibular compensation through spread of current from the CI to the vestibular system. Parkes et al. (3) showed that electrical stimulation from a CI could elicit vestibular evoked myogenic potentials responses.

Furthermore, all participants in our study had confirmed vestibular loss by bilateral areflexia on caloric testing. Weaver et al. (1) used 30 seconds standing Romberg test on solid surface with eyes closed to assess normality of vestibular function. However, several studies indicate this test is not sensitive enough to detect loss of balance or vestibular function in the age range (age 19–95) under investigation (4,5). It is, therefore, possible that some of his participants did show some degree of vestibulopathy. It cannot be ruled out that these were the top performers that showed most benefit from the auditory feedback.

Finally, attention should be paid to the sound source under consideration. Weaver used broadband white noise (0–4 kHz) combined with the sound of natural rain whereas in our study music was played at a comfortable sound level. Music inherently possesses a rhythm component that might serve as a cue to adjust both rhytm (stride time) and pace (stride length) of gait. These beneficial effects of cues are lacking when using broadband white noise.

In conclusion, while one study on its own cannot give insight regarding which individuals can benefit from sound as an additional source of balance related feedback, a combined look at the studies from Weaver et al.

(1) and ourselves (2) suggests that it might be patients with a cochlear implant and possible suspicion of vestibulopathy that can benefit from sound. Future research perspectives should focus on the confirmation of these patient characteristics. Attention should also be paid to the features of sound, comprising but not limited to loudness, rhythm, or localization.

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REFERENCES

1. Weaver TS, Shayman CS, Huller TE. The effect of hearing aids and cochlear implants on balance during gait. *Otol Neurotol* 2017;38: 1327–32.
2. Hallemans A, Mertens G, Van de Heyning P, Van Rompaey V. Playing music may improve the gait pattern in patients with bilateral caloric areflexia wearing a cochlear implant: results from a pilot study. *Front Neurol* 2017;8:404.
3. Parkes WJ, Gnanasegaram JJ, Cushing SL, McKnight CL, Papsin BC, Gordon KA. Vestibular evoked myogenic potential testing as an objective measure of vestibular stimulation with cochlear implants. *Laryngoscope* 2017;127:E75–81.
4. Vereeck L, Bastiaensen A, Verboven N, Truijen S, Wuyts F, Van de Heyning P. Sensitivity and specificity of clinical balance tests for identifying subjects with vertigo and/or instability. Presented at the 6th World Congress for Neurorehabilitation, Vienna, Austria, March 21–25; 2010.
5. Cohen S, Mulavara AP, Peters BT, Sangi-Haghpeykar H, Bloomberg JJ. Standing balance tests for screening people with vestibular impairments. *Laryngoscope* 2014;124:545–50.

REPLY TO LETTER REGARDING ''THE EFFECT OF HEARING AIDS AND COCHLEAR IMPLANTS ON BALANCE DURING GAIT''

In Reply: We are delighted to read the paper by Hallemans et al. (1) which reported, consistent with our own findings (2,3), that auditory input can improve gait in cochlear implant users. This expands on papers showing that wearing cochlear implants can improve balance in static situations (4–6), and that people with normal hearing may also benefit from auditory input while standing or walking (7,8).

These observations contribute to our rapidly growing understanding that the canonical triad of vestibular, visual, and proprioceptive balance cues is incomplete and must include audition as a fourth significant contributor. The novel principle of ''balance augmentation through sound'' has several clinical and scientific implications. First, balance may be improved through careful design of soundscapes or wearing hearing devices. Second, specific ''auditory-assisted balance therapy'' techniques can be developed to emphasize the use of sound cues in people with imbalance. Third, the increased risk of falls noted among people with hearing loss can be attributed, at least in part, to hearing loss itself and not necessarily to the vestibular loss that may accompany it (9,10). Fourth, a new opportunity presents itself to understand critical processes of high-speed multisensory integration of complex spatial signals at the cellular and systems level. Finally, a century of vestibular research may have missed an important confounder by not controlling for environmental sounds. In one prescient but underappreciated early report, these included the ''peculiarly disturbing snapping of radiators'' and ''[a]ccidental disturbances, such as the movement of classes, or individuals in the halls'' (11).

Hallemans et al. (1) considered several possible mechanisms for improvement in gait with external sound: a rhythmic component of musical cues, direct electrical stimulation of the vestibular system, or the use of external sound sources as spatial landmarks. Of these, we find the