The Role of Rotational Stimulation in Vestibular Compensation

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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Recently, clinical vestibular tests have been developed for assessing otolith function. Little is known about treatment for otolith dysfunction, and this case report offers a perspective on using otolith stimulation to treat vestibular loss.

A 62-year-old man underwent a left vestibular neurectomy for Ménière’s disease and presented to the Mountain Home Veterans Affairs (VA) Medical Center Vestibular/Balance Clinic 5 years later with complaints of imbalance and a “floating sensation.” Pure-tone audiometry revealed a mild right sensorineural hearing loss and a moderately severe left sensorineural hearing loss. Videonystagmography revealed normal ocular motor function, mild right beating spontaneous nystagmus, and 100% left unilateral weakness and 68% right directional preponderance on the bithermal binaural caloric test. The rotary chair test revealed normal vestibulo-ocular reflex (VOR) gain, borderline-normal low-frequency phase lead, and a left asymmetry. These findings are consistent with an uncompensated peripheral vestibular (horizontal semicircular canal and/or superior vestibular nerve) hypofunction on the left side.

Vestibular-evoked myogenic potentials (VEMPs) and subjective visual vertical (SVV) testing were performed as a measure of otolith function. Cervical VEMPs to air-conducted 500-Hz tone bursts (120 peak sound pressure level [SPL]) were absent on the left and present on the right using recording methods described previously. Bone conduction ocular VEMPs were recorded using a 500-Hz tone burst (155 dB peak Force Level) delivered to the midline forehead by a handheld vibrator (Brüel & Kjær Mini-Shaker, model 4810; Brüel & Kjær, Naerum, Denmark) fitted with a custom acrylic rod. Responses were present from the left eye and absent from the right eye at both gaze elevations (30° and maximum). The SVV angle was measured during constant on- and off-axis rotation at 300 deg/s (bilateral and unilateral centrifugation) using methods described previously. The static SVV was −3°, and SVV was −2° during centrifugation offset left and −8° during centrifugation offset right. The box plots show normative data for the 4 SVV test conditions. The box edges represent the 25th and 75th percentiles, the error bars represent the 10th and 90th percentiles, and outliers are represented by the solid circles. The median is represented by the thin solid line within each box, and the mean is represented by the dashed line within each box.

Figure 1. Open circles represent subjective visual vertical (SVV) angles for the patient at the baseline visit. The static SVV was −3°, and SVV was −2° during centrifugation offset left and −8° during centrifugation offset right. The box plots show normative data for the 4 SVV test conditions. The box edges represent the 25th and 75th percentiles, the error bars represent the 10th and 90th percentiles, and outliers are represented by the solid circles. The median is represented by the thin solid line within each box, and the mean is represented by the dashed line within each box.

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Three months later, the patient reported that his symptoms had returned and requested off-axis rotation. The patient was secured in an upright, sitting position with 1 ear positioned 7 to 8 cm off-axis and the other ear positioned on-axis. The chair was accelerated clockwise to 300 deg/s in 60 seconds (acceleration = 5 deg/s^2), rotated at a constant velocity (300 deg/s) for 60 seconds, and decelerated to 0 deg/s in 60 seconds (deceleration = 5 deg/s^2). Following a 5-minute rest period, the procedure was repeated with the opposite ear positioned off-axis.

Computerized dynamic posturography was used to quantify postural stability pre- and postrotation. Prior to rotation, the patient had an abnormal sensory organization test (SOT) composite score (total = 51; normal ≥67.6; Figure 2). He demonstrated increased postural sway or fell in all conditions (4-6) where the surface was sway-referenced and increased sway with vision absent on a firm surface (condition 2). Immediately after off-axis rotation, the SOT composite score was normal (Figure 2) and symptoms resolved.

Discussion

Vestibular rehabilitation typically includes gaze stability exercises, gait and balance activities, and general conditioning. Gaze stability exercises involve frequent, brief periods of head rotation while maintaining visual focus on a target. The goal of these exercises is to improve gaze stability by facilitating vestibular compensation of the semicircular canal-mediated VOR. Little is known about interventions to facilitate compensation of the otolith organs. Off-axis rotation stimulates the utricle, and thus the improvement in symptoms and balance following centrifugation suggests the possibility of otolith compensation. There is evidence in patients with acute vestibular loss that static and off-axis SVV shifts over time, suggesting recovery. In healthy individuals, shifts in static SVV and habituation of motion sickness have been demonstrated following repeated off-vertical axis rotation sessions, suggesting that the otoliths may be adaptable. To the best of our knowledge, no study has examined the use of rotational stimulation for adaptation of otolith loss. This report is in compliance with the institutional review board regulations at our institution.

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Author Contributions

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References