Clinical Neurophysiology xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Epidemiology of vestibular evoked myogenic potentials: Data from the Baltimore Longitudinal Study of Aging

Carol Li, Andrew J. Layman, John P. Carey, Yuri Agrawal *

Department of Otolaryngology-Head and Neck Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD, USA

ARTICLE INFO

Article history:
Accepted 4 January 2015
Available online xxxx

Keywords:
Vestibular evoked myogenic potential
Vestibular
Aging

HIGHLIGHTS

- Black race was associated with better oVEMP function (shorter n10 latency and greater peak-to-peak amplitude) across the age range.
- Ocular VEMP latency and amplitude, along with cervical VEMP corrected amplitude, exhibit age-related declines.
- Cardiovascular risk factors, including hypertension, diabetes mellitus, hyperlipidemia, and smoking history, had no associations with VEMP latency, amplitude or asymmetry ratio.

ABSTRACT

Objective: To evaluate whether age-related changes in vestibular evoked myogenic potentials (VEMPs) differ by demographic and cardiovascular risk groups.
Methods: Participants in the Baltimore Longitudinal Study of Aging underwent cervical and ocular VEMP testing. VEMP latency, amplitude, asymmetry ratios, and prevalence of absent responses were compared across demographic and cardiovascular risk groups.
Results: In 257 participants (mean age 72.9, 57% female), ocular VEMP (oVEMP) n10 latency increased by 0.12 ms/decade while amplitude decreased by 2.9 μV/decade. Black participants had better oVEMP function (shorter latency, increased amplitude, and decreased odds of absent responses) relative to white participants. In 250 participants (mean age 72.6, 54% female), EMG-corrected cervical VEMP (cVEMP) amplitude decreased by 0.14 μV/decade and p13 latency was 0.38 ms longer in males. The odds of absent responses were significantly higher in individuals age ⩾80 for oVEMPs, and age ⩾70 for cVEMPs. Cardiovascular risk factors had no association with VEMP parameters.
Conclusions: We confirmed age-related declines in otolith function, and observed a protective effect of black race on oVEMP latency and amplitude.
Significance: These results illustrate how measures of otolith function change with age in community-dwelling adults. Further investigations are needed to ascertain whether better otolith function in blacks might contribute to a lower risk of mobility disability and falls.

1. Introduction

The human vestibular system, integral to balance control, is composed of three semicircular canals that detect angular acceleration and two otolith organs, the utricle and saccule, which detect linear acceleration. Epidemiologic analyses of data from the National Health and Nutrition Examination Survey (NHANES) found a 35% prevalence of vestibular impairment in over 5000 US adults age ⩾40, and the prevalence was found to increase steeply with age (Agrawal et al., 2009). Additionally, odds of vestibular impairment were 70% higher in individuals with diabetes mellitus. Vestibular impairment in NHANES was defined as the inability to maintain balance on a foam-padded surface with eyes closed for 30 s (Agrawal et al., 2009). Although this study provides strong epidemiologic support for a loss of vestibular function associated with aging, the postural tests used in NHANES are limited in the specificity with which they measure vestibular function, given that

* Corresponding author at: 601 North Caroline Street, Johns Hopkins Outpatient Center, Baltimore, MD 21287, USA. Tel.: +1 410 502 3107; fax: +1 410 955 0035.
E-mail address: yagrawa1@jhmi.edu (Y. Agrawal).

http://dx.doi.org/10.1016/j.clinph.2015.01.008
1388-2457/

performance on these tests also relies on other sensory inputs, central processes, and motor function.

Tests that more specifically measure vestibular function include vestibular evoked myogenic potentials (VEMPs), which are increasingly being used to evaluate otolith function. Cervical VEMPs (cVEMPs) in response to air-conducted sound have been shown to reflect the integrity of the saccule and inferior vestibular nerve, while ocular VEMPs (oVEMPs) in response to midline tap vibration have been shown to reflect the integrity of the utricle and superior vestibular nerve (Rosengren et al., 2011; Kantner and Gurkov, 2012). Several studies have provided normative data for VEMPs elicited by various air-conducted and midline tap stimuli (Welgampola and Colebatch, 2001; Basta et al., 2005; Brantberg et al., 2007; Singh et al., 2013), and have begun to characterize age-related changes in VEMP parameters and tuning properties (Piker et al., 2013; Welgampola and Colebatch, 2001; Zapala and Brey, 2004; Brantberg et al., 2007; Janky and Shepard, 2009; Rosengren et al., 2011; Kantner and Gurkov, 2012; Taylor et al., 2012; Singh et al., 2013). Although age has been shown to have a significant impact on VEMP responses, the effect of other demographic characteristics and cardiovascular risk factors has not been established.

In this study, we evaluated cVEMPs and oVEMPs in a large cohort of community-dwelling individuals across the age range from 26 to 92 years. We performed VEMP testing with air-conducted sound and midline tap stimuli and evaluated changes in VEMP latency, amplitude and asymmetry ratio as a function of age, sex, and race. Given previous findings of an association between vestibular impairment and diabetes mellitus (Agrawal et al., 2009), we also examined the relationship between VEMP parameters and cardiovascular comorbidities such as hypertension, diabetes mellitus, hyperlipidemia, and smoking status. We anticipate that this observational epidemiological study will provide an estimate of the magnitude of otolith dysfunction in community-dwelling older individuals and its distribution in the US population.

2. Methods

2.1. Subjects

The Baltimore Longitudinal Study of Aging (BLSA) is an ongoing prospective cohort study initiated by the National Institute on Aging (NIA) in 1958. Subjects consist of community-dwelling participants who travel to the NIA for 2.5 days of comprehensive testing. Ocular and cervical VEMP testing were added to the test protocol in February 2013. Individuals were excluded from oVEMP testing if they could not participate in the protocol because of blindness. Individuals were excluded from cVEMP testing if they had a history of conductive hearing loss and/or could not move their neck without restriction or pain. From February to December 2013, 314 participants completed one study visit, of whom 257 completed ocular VEMP testing and 250 completed cervical VEMP testing. Of the participants who did not undergo oVEMP testing, 31 individuals were not tested due to time constraints and/or tester unavailability, 5 individuals were ineligible according to exclusion criteria, and 21 individuals were unable to complete testing due to technical difficulties. Of the participants who did not undergo cVEMP testing, 31 individuals were not tested due to time constraints and/or tester unavailability, 11 individuals were ineligible according to exclusion criteria, and 22 individuals were unable to complete testing due to technical difficulties. Technical difficulties included mechanical and recording problems associated with the EMG system and not the subject. Tested vs. untested participants did not differ significantly by age, gender or race. Demographics (including gender and race), cardiovascular risk factor data, and smoking history were collected from extensive subject interviews. Participants were asked to designate a race from the following options: White, Black or African Americans, Asian, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, "Two or More Races", "Don't Know", and "Refused". History of hypertension was assessed with the question, "Has a doctor or other health professional ever said you had high blood pressure or hypertension?" History of diabetes mellitus was assessed with the question, "Has a doctor or other health professional ever said you had diabetes, glucose intolerance, or high blood sugar?" History of hyperlipidemia was assessed with the question, "Has a doctor or other health professional ever said you had high cholesterol, triglycerides, dyslipidemia, or hypercholesterolemia?" History of smoking was assessed by asking participants "Have you smoked at least 100 cigarettes over your entire life," "Have you smoked at least 50 cigars over your entire life," and "Have you smoked at least 3 packages of pipe tobacco over your entire life?" All participants provided written informed consent, and the BLSA study protocol was approved by the Institutional Review Board associated with the BLSA at Harbor Hospital in Baltimore, MD.

2.2. Vestibular evoked myogenic potential recording conditions

A commercial electromyographic (EMG) system (Carefusion Synergy, software version 14.1, Dublin, OH, USA) was used. EMG signals were recorded with disposable, self-adhesive, pregelled, Ag/AgCl electrodes with 40-inch safety leadwires from GN Otometrics (Schaumburg, IL, USA). EMG signals were amplified 2500× and band-pass filtered, 20–2000 Hz for cVEMPs, 3–500 Hz for oVEMPs (Nguyen et al., 2010).

2.3. Ocular vestibular evoked myogenic potential testing

Subjects laid with upper bodies elevated at 30° from horizontal. The skin overlying both cheeks and the manubrium sterni was cleansed with alcohol preps before electrode placement. A noninverting electrode was placed on the cheek approximately 3 mm below the eye, directly beneath the pupil, an inverting electrode was placed 2 cm below the noninverting electrode and a ground electrode was placed on the manubrium sterni. Before stimulation, participants were instructed to perform 20-degree vertical saccades to ensure that symmetrical signals were recorded from both eyes. In the experimental set-up, the participant's eye level is marked on the wall next to the participant's chair and targets on the ceiling were measured and marked to elicit the 20-degree vertical saccades with the participant's eyes at the specified level. If signals showed greater than 25% asymmetry, the electrodes were removed and new ones applied. Participants were instructed to maintain a 20° upgaze during oVEMP stimulation and recording.

Midline vibration stimuli consisted of head taps delivered manually with an Aesculap model ACO12C reflex hammer fitted with an inertial microswitch trigger. Head taps were delivered at Fz, in the midline at the hairline, 30% of the distance between the inion and nasion. Fifty sweeps for head taps were averaged for each test.

2.4. Cervical vestibular evoked myogenic potential testing

Participants laid with upper bodies elevated at 30° from horizontal. The skin overlying both sternocleidomastoid (SCM) muscles and the manubrium sterni was cleansed with alcohol preps before electrode placement. A noninverting electrode was placed at the midpoint of the SCM muscle, an inverting electrode was placed on the sternoclavicular junction, and a ground electrode was placed on the manubrium sterni. Participants were

Please cite this article in press as: Li C et al. Epidemiology of vestibular evoked myogenic potentials: Data from the Baltimore Longitudinal Study of Aging. Clin Neurophysiol (2015), http://dx.doi.org/10.1016/j.clinph.2015.01.008