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Ocular Vestibular Evoked Myogenic Potentials: Normative Findings in Children

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Abstract

Background: To add to the limited body of literature on ocular vestibular evoked myogenic potential (oVEMP) responses in children and to assess a different montage for oVEMP recording.

Purpose: To evaluate the characteristics of the oVEMP response in children and compare the results with that of a group of healthy adults.

Research Design: Prospective descriptive study from a tertiary referral center.

Study Sample: Twenty-two children (mean age = 6.3 yr, standard deviation = ±1.5, range = 3.5–8.9 yr) were recruited from families whose parent(s) were employed by the Cincinnati Children's Hospital Medical Center (CCHMC). Pediatric participants were categorized by age into three groups for data analysis. The comparison adult group of ten participants were members of the employee staff at CCHMC.

Data Collection and Analysis: Audiometric assessment was completed in all participants. The latency, amplitude, and threshold of the oVEMP responses were recorded using a modified electrode montage with reference at the chin and compared between the pediatric and adult participants.

Results: All participants completed testing and had bilateral measurable oVEMP responses using a 105-dB nHL, 500-Hz tone burst stimulus. Comparison between right and left ears across all participants for each oVEMP characteristic found no statistically significant difference. oVEMP testing showed no significant differences with respect to latency, amplitude, interaural amplitude asymmetry, and threshold of response as a function of age.

Conclusions: oVEMP responses for ages ≥3 did not differ from responses in adults.

Key Words: ocular evoked myogenic potentials, pediatric, vestibular

Abbreviations: AR = asymmetry ratio; CCHMC = Cincinnati Children's Hospital Medical Center; cVEMP = cervical vestibular evoked myogenic potential; EMG = electromyographic; oVEMP = ocular vestibular evoked myogenic potential; SD = standard deviation; VEMP = vestibular evoked myogenic potential

INTRODUCTION

Disorders of the vestibular system, whether congenital or acquired, can be particularly problematic in children and have a negative impact on a child's development (Rine et al, 2000; Inoue et al, 2013; Rine and Wiener-Vacher, 2013). Despite advances in diagnostic testing and the recognition of the importance of a multidisciplinary approach to care, the identification of a specific deficit or set of deficits is often difficult

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in children with balance disorders. Although vestibular electrodiagnostic testing has become more prevalent in the assessment of children with dizziness, the various testing modalities available may not be well suited for children from the standpoint of practicality and comfort.

Testing equipment may not be easily adapted to accommodate the size of a small child, cooperation may be limited, and the method of stimulation may be uncomfortable. Bithermal caloric testing is not well tolerated by small children and can lead to nausea and vomiting with the additional risk of aspiration. Caloric testing is, therefore, performed more commonly in children >5 yr of age. The rotational chair test is better suited for testing younger children, but the equipment is expensive and not available in every testing center. The development of vestibular evoked myogenic potential (VEMP) testing modalities has provided an additional method for assessing vestibular function in adult patients and may be a valuable complementary method for assessing balance disorders in children.

Both the cervical VEMP (cVEMP) and ocular VEMP (oVEMP) tests have been used to assess vestibular function in children. In cVEMP testing, auditory stimulation is delivered as high-intensity, short-duration signals that can evoke a short-latency relaxation potential in the ipsilateral sternocleidomastoid muscle (Janky and Shepard, 2009). The evoked response represents a signal-averaged attenuation of tonic electromyographic (EMG) activity. Likewise, stimulus-related EMG responses can be recorded from the extra-ocular muscles (Rosengren et al, 2005; Chihara et al, 2007; Todd et al, 2007; Welgampola et al, 2008). Short-latency evoked myogenic potentials can be recorded from surface electrodes placed beneath the eyes in response to acoustic stimulation. These negative polarity potentials (oVEMPs) originate primarily from the contralateral inferior oblique muscle. The cVEMP is a stimulus-evoked attenuation of tonic EMG activity, whereas the oVEMP represents a stimulus-evoked initiation of EMG activity (Todd et al, 2007; Welgampola et al, 2008).

The use of the cVEMP test for assessing vestibular function in children is well characterized (Sheykholeslami et al, 2005; Kelsch et al, 2006; Chang et al, 2007; Picciotti et al, 2007; Valente, 2007). These reports tend to conflict, however, in the course of establishing normative data for this demographic. Although cVEMP responses in children were significantly related to age, head girth, and body weight in some studies (Akin and Murnane, 2001; Lee et al, 2008; Hsu et al, 2009; Wang et al, 2013), other studies have found no correlation with age (Welgampola and Colebatch, 2001; Su et al, 2004; Picciotti et al, 2007).

The oVEMP test has recently gained attention as a potentially more reliable method for eliciting VEMP responses in children >3 yr of age as than the cVEMP test. In one study, the mean latency of responses and amplitude of response of oVEMPs in children did not differ significantly from those of adults (Hsu et al, 2009). Furthermore, attaining an accurate and repeatable p1-n1 amplitude may be challenging with cVEMP testing in young children because the tonic level of neck contraction cannot be monitored (Valente, 2007). The oVEMP is thought to test the vestibular ocular reflex pathway originating from the utricle and ascending the superior division of the VIII nerve. Air conduction sound and bone-conducted vibration stimuli have been used to elicit an oVEMP response in children >3 yr of age and in adults (Hsu et al, 2009; Lin et al, 2010; Piker et al, 2011; Chou et al, 2012; Wang et al, 2013). Although the amplitude and threshold of response may change with advancing age in adults (>50 yr of age) (Lin et al, 2010) the amplitude, latency, and threshold of response appear to be consistent in children >3 yr of age (Wang et al, 2013). Characterization of oVEMP responses has also been studied in children <3 yr of age with a modified technique to establish activation of the inferior oblique muscle (Wang et al, 2013).

The oVEMP has been slowly emerging in literature as a useful tool to identify specific deficits of the utricle and superior division of the VIII nerve pathway. In adults, most of the literature suggests that the oVEMP may help identify peripheral vestibular disorders and very specifically, superior semicircular canal dehiscence (Rosengren et al, 2008; Murofushi et al, 2011). Recent studies even suggest that impaired utricular function in patients with benign paroxysmal positional vertigo can be detected through oVEMP testing (Singh and Barman, 2015). oVEMP testing in the pediatric population has been used in patients with autism spectrum disorder and sound sensitivity due to superior semicircular canal dehiscence (Thabet, 2014). In addition to pinpointing peripheral vestibular disorders, a combined cVEMP/oVEMP test battery has been described to identify young children with benign paroxysmal vertigo of childhood (Lin et al, 2010).

Although normative data for oVEMP responses in young children have been previously established (Hsu et al, 2009; Lin et al, 2010; Wang et al, 2013), it is difficult to compare the results among various testing centers while accounting for differences in equipment, procedure, and stimulus conditions. The use of standardized test procedures are desirable to use published normative data. Before the oVEMP test can be used as a widespread diagnostic tool for pediatric patients, additional normative data are needed. Although previous studies have demonstrated reliable responses using both bone conduction and air conduction stimuli, the data collected have been limited to the latency and amplitude of response in most cases (Hsu et al, 2009; Lin et al, 2010; Chou et al, 2012). Furthermore, each study has used different stimulus conditions, electrode location, and recording characteristics, making it difficult to compare results among various institutions. The present study objectives were to establish normative data with respect to latency, amplitude, and threshold of responses in children aged 3–8 yr using a recently described oVEMP electrode montage (Piker et al, 2011), determine any maturational trends of the test findings, and compare the results with adult normative data.

MATERIALS AND METHODS

Design

The characteristics of the oVEMP response, including n1 and p1 latencies, n1-p1 interval, n1-p1 amplitude, and threshold, were measured in three age groups of children and compared with the results obtained in a group of healthy adults. An alternative recording montage was used in this study. Typically, an active electrode is placed 5 mm below each eye with a reference electrode centered 2 cm below each active electrode. A ground electrode is also used. Piker et al (2011) and Zuniga et al (2014) each suggested that oVEMP amplitudes recorded with the standard montage may show reference electrode contamination by the close proximity of second electrode resulting in an approximate 25–30% amplitude reduction. By moving the reference electrode (i.e., to the chin), the reference electrode was less likely to capture activity from the inferior oblique muscle. In children, because of the small face size and large muscle potentials, we choose to change the position of the reference to the chin to minimize electrode contamination and increase oVEMP amplitude.

Participants

Written consent for participation was obtained from a parent of each child and from each adult participant. The study was approved by the Institutional Review Board at Cincinnati Children's Hospital Medical Center (CCHMC). Twenty-two pediatric-aged participants (ages 3 yr to 8 yr 11 mo) were recruited from families whose parent(s) were employed by the CCHMC. The comparison adult group of participants consisted of members of the employee staff at CCHMC who agreed to participate. Each participant and/or parent received information about the objectives of the study and specific testing requirements. Pediatric participants were then categorized by age into three groups for data analysis as Group I (ages 3 yr to 4 yr 11 mo), Group II (ages 5 yr to 6 yr 11 mo), and Group III (ages 7 yr to 8 yr 11 mo). In addition, because of the small number of children tested, all children combined were compared with the adult participants.

All pediatric (n = 22) and adult (n = 10) participants completed oVEMP testing with data available for analysis. Within the pediatric cohort, Group I had six participants and Groups II and III had eight participants each. There were 13 (59%) female and nine (41%) male participants with a mean age of 6.3 yr (standard deviation [SD] = ±1.5, range = 3.5–8.9 yr). The adult cohort included one (10%) male and nine (90%) female participants with a mean age of 31.4 yr (SD = ±4.9, range = 24–40 yr).

Inclusion and Exclusion Criteria

Each participant received an audiometric assessment that consisted of air- and bone conduction threshold testing at 500, 1000, 2000, and 4000 Hz and tympanometry. With the help of a parent, a 15-item hearing and balance questionnaire was completed to identify any history that might suggest a hearing or balance deficit in the child. Exclusion criteria for all participants included abnormal hearing at any test frequency in either ear (defined as threshold >20-dB HL), evidence of an air-bone gap of ≥5-dB HL at any test frequency, abnormal tympanometry results (e.g., flat tympanogram or negative pressure <−200 daPa) in either ear, known otologic disease, neurologic disease, history of developmental delay, craniofacial developmental abnormalities, or complaints of dizziness or imbalance (e.g., vertigo, unsteadiness, frequent falls, and delayed walking).

Procedure

EMG surface potentials were recorded using a modified electrode montage. Silver chloride electrodes were placed in a two-channel recording configuration. The active electrodes were placed approximately 1 cm below each lower eyelid, the reference electrodes were placed on the chin, and the ground electrode was placed on the midline forehead (Figure 1A). Individual electrode impedances were ≤3 kΩ and interelectrode impedances were ≤3 kΩ. To elicit consistent responses, the participants were seated and instructed to view an iPhone cartoon presentation held 0.5 m from the head at a vertical visual angle of 45° above horizontal with the head in a midline neutral position and with the goal of having the participant elevate their eyes maximally (Figures 1A and B). The 45° upward gaze provided the best means for recording a response from the inferior oblique muscle on the side contralateral to the stimulus presentation. Acoustic stimuli, consisting of a 500-Hz tone burst (Blackman-gated with a rise/fall time = 1 msec, plateau = 2 msec, and rate = 5.1/sec), was delivered through an insert earphone at an initial presentation level of 105-dB nHL (129-dB peSPL) (Universal Smart Box; Intelligent Hearing Systems, Miami, FL) (equipment is calibrated and maintained annually via manufacturer specifications using an IEC 711 coupler). oVEMP thresholds were obtained in descending

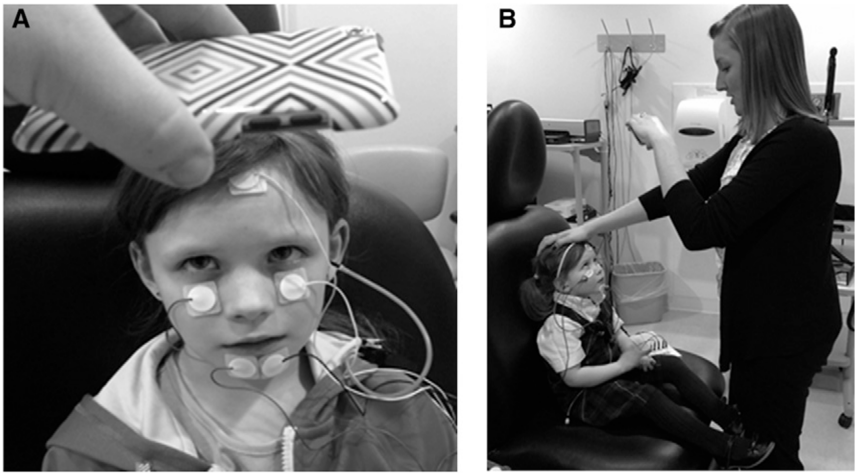

Figure 1. (A) Electrode montage used for oVEMP recording. The visual target is held at a 45° angle to obtain an upward eye gaze. (B) Position of the visual target to obtain the 45° upward gaze.

10-dB steps and ascending 5-dB steps. Tracings were repeated at the no response level and again at threshold if the patient was cooperative and the peaks (n1-p1) were unclear. Example waveforms are shown in Figure 2 for threshold measurement. The EMG signal was amplified (gain = 100,000 μV), band-pass filtered (1–1000 Hz), and signal averaged over a 25-msec interval.

Each oVEMP recording represented an average of at least 100 samples per run. Recordings for each ear were replicated at least twice to confirm reproducibility. The artifact rejection circuitry was disabled before data collection. One-channel recordings were obtained for contralateral oVEMP waveforms. The initial negative–positive biphasic waveform comprised peaks n1 and p1 (Figure 2). The latencies of peaks n1 and p1, n1-p1 interval, and n1-p1 amplitude were measured. In addition, the participants' minimum response level (threshold) was recorded for each ear; the response was repeated at the threshold level. The amplitude asymmetry ratio (AR) between the two ears was calculated using the formula: amplitude AR = 100(AR − AL/AR + AL), where AR is the n1-p1 amplitude of the right ear and AL is the n1-p1 amplitude of the left ear.

Statistical Analysis

Latencies, amplitudes, amplitude AR values, and response thresholds were expressed as mean ± SD and median with ranges as appropriate. Differences across the three pediatric specific age groups were tested using analysis of variance or the Kruskal–Wallis nonparametric test as appropriate. Because of the small group sizes, differences in the measurements between the combined pediatric and adult groups were tested using both Student's *t*-test and nonlinear regression because the age ranges were widely spaced and normality tests did not pass for several of the variables (Shapiro–Wilk). Significance was set for $p < 0.05$.

RESULTS

All pediatric (44 ears) and adult (20 ears) participants had measurable bilateral responses at 105-dB

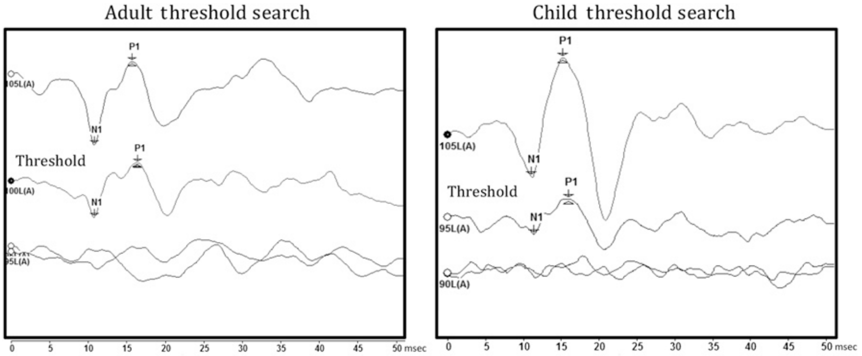

Figure 2. Typical left ear oVEMP waveforms traced down to threshold for an adult, age 26 yr and a child, age 8 yr. The oVEMP amplitude for the adult and child was 17.8 and 28.6 μV, respectively, at 105-dB nHL (129-dB SPL). The adult's threshold was 100-dB nHL and the child's was 95-dB nHL.

nHL. Comparison of right and left ears for each oVEMP response characteristic demonstrated neither a clinically meaningful nor statistically significant difference between ears for the entire group of study participants. Therefore, the measurements derived from both right and left ears were used to calculate mean values for n1 and p1 latencies, n1-p1 interval, n1-p1 amplitude, and threshold. No significant differences were found among pediatric age Groups I through III or between the combined pediatric and adult cohorts with respect to n1 and p1 latency, n1-p1 interval, n1-p1 amplitude, interaural amplitude AR, or threshold of response (Tables 1 and 2). Although there appeared to be a trend toward higher mean n1-p1 amplitude in the 7–8 yr age group, there was no significant difference in n1-p1 amplitude among the pediatric age groups.

Because of the small size of the three pediatric groups and possible insufficient power, we also tested for differences between the combined pediatric and adult groups. There were no significant differences between the combined pediatric and the adult groups (Table 2). In addition, although n1-p1 amplitude variability was higher in children, there was no significant difference in mean n1-p1 amplitudes between the pediatric and adult groups (Table 2, Figure 3). In addition, none of the variables were significant for an age effect using nonlinear regression across the entire combined pediatric and adult sample ($p > 0.05$).

DISCUSSION

Objectives of this study were to establish normative data with respect to latency, amplitude, and threshold of responses in children aged 3–8 yr using a recently described oVEMP electrode montage (Piker et al, 2011), determine any maturational trends of the test findings, and compare the results with adult normative data. The electrode montage selected for conducting the oVEMP test in this study has been previously described (Piker et al, 2011). Piker et al studied the effect of electrode placement on oVEMP n1-p1 amplitude in ten adult participants. The authors reported an average increase in amplitude of 30% when using a more electrically indifferent chin reference in comparison with a 3 cm infraorbital reference (1-cm infraorbital active electrode used in both configurations). The range of amplitude increase was 18–43%, suggesting that the magnitude of reference contamination varied across participants. The mean n1-p1 amplitude significantly increased from 6.85 to 9.64 μV with the use of a chin reference in their participants.

In our group of pediatric participants, the mean amplitude was 13.9 μV (SD = ±9.89), whereas the mean amplitude in the adult group was 13.9 μV (SD = ±6.66). Although amplitude variability was higher in the pediatric group, there was no significant difference in amplitude mean between the pediatric and adult groups in our study. The stimulus level used by Piker et al was 95-dB nHL, whereas the stimulus level used in our participants was 105-dB nHL. The difference in stimulus level may account for the higher mean amplitude values for our two groups of participants.

There were no significant differences among the three pediatric subgroups or between the entire pediatric group and the adult group with respect to n1 and p1 latencies, n1-p1 amplitude, or threshold of response. The findings in our pediatric group assessment are consistent with other studies that have performed oVEMP testing in children using an air conduction acoustic stimulus (Hsu et al, 2009; Lin et al, 2010; Wang et al, 2013). Wang et al found no significant relationship between age and oVEMP parameters including n1/p1 latencies or n1-p1 amplitudes when comparing subgroups of children aged 1–3 yr and 4–13 yr. Although Wang et al showed a significant difference in p1 latency and n1-p1 interval between the two subgroups, they attributed this difference to the influence of measurements obtained in participants with eyes closed. This finding is consistent with a recent study that reported significant prolongation of mean latencies and n1-p1 interval with eyes closed compared with responses with eyes gazing upward (Huang et al, 2012).

Table 1. oVEMP Responses for the Three Pediatric Age Groups (Mean Values for Each Group Computed from the Mean of Right and Left Ears for Each Participant)

	Age 3–4, N = 6	Age 5–6, N = 8	Age 7–8, N = 8	*p* Value
n1 latency (msec) (both ears)	10.7 (0.4)	11.1 (1.4)	10.98 (1.0)	0.67
p1 latency (msec)	15.4 (0.9)	14.7 (1.7)	15.0 (0.96)	0.48
n1-p1 interval (msec)	4.7 (0.6) 4.7 (3.8–5.6)	3.7 (2.2) 4.65 (1.6–5.8)	4.02 (0.6) 3.95 (3.0–5.7)	0.06*
Interaural n1 latency difference†	0.32 (0.4) 0.2 (0.1–1.1)	0.92 (1.96) 0.10 (0–30.7)	0.86 (1.3) 0.5 (0–3.8)	0.54*
AR	10.3 (4.3) 8.7 (6.4–15.8)	19.7 (10.5) 22.3 (5.2–30.7)	24.8 (13.3) 28.2 (4.3–42.1)	0.15*
Amplitude μV (at 105-dB nHL)	11.9 (6.8) 9.1 (5.7–21.5)	15.2 (8.6) 13.1 (6.7–32.3)	18.0 (14.1) 12.7 (2.9–45.1)	0.50*
Threshold dB (nHL)	91.7 (6.9)	92.8 (6.6)	92.8 (6.6)	0.98

Note: *p* values reported from analysis of variance unless otherwise noted.

**p* value reported from Kruskal–Wallis test.

†Absolute difference (regardless of left or right ear).

Table 2. oVEMP Characteristics in the Pediatric and Adult Groups (Mean Values for Each Group Computed from the Mean of Right and Left Ears for Each Participant)

	Child, N = 22 (44 Ears)	Adult, N = 10 (20 Ears)	*p* Value
Mean (SD) age (years)	6.3 (1.5)	31.4 (4.9)	
n1 latency (msec) (both ears)	10.9 (1.1)	10.98 (0.41)	0.81
p1 latency (msec)	15.0 (1.3)	15.2 (0.97)	0.51
n1-p1 interval (msec)	4.1 (1.4)	4.3 (0.8)	0.56
Interaural n1 latency difference[*]	0.72 (1.3)	0.23 (0.28)	0.13[†]
AR	18.9 (11.7)	16.3 (10.2)	0.55[†]
Amplitude μV (at 105-dB nHL)	15.3 (13.4)	13.9 (6.7)	0.70
Threshold dB	92.4 (7.2)	92.5 (6.0)	0.95

Note: p value reported from *t* test unless otherwise noted.

[*] Absolute difference (regardless of left or right ear).

[†] The nonparametric test (Wilcoxon rank sum test) provides a *p* value of 0.46.

Using similar stimulation parameters as outlined in our study, Lin et al reported a mean n1 latency of 11.1 msec (SD = ±0.9 msec) and mean p1 latency of 16.1 msec (SD = ±1.2 msec) in 15 children aged 4–14 yr. These results compared favorably with the latency measurements in our pediatric group. Specifically, the mean n1-p1 amplitude in their study was 7.0 μV (SD = ±2.9 μV), which was lower than the mean n1-p1 amplitude of 13.9 μV (SD = ±9.89 μV) recorded in our pediatric cohort. This difference may be attributed to the fact that Lin et al used an electrode montage that included a 3-cm infraorbital reference.

Hsu et al (2009) conducted both cVEMP and oVEMP testing in children ages 3–13 yr and compared the results with that of a group of adults having received the same testing. Although they reported that the p13 and n23 latencies of the cVEMP in children were significantly related to age, head girth, and body height and weight, they found no significant difference between the pediatric and adult groups with respect to oVEMP latencies and amplitudes. Therefore, our findings and those of other studies would suggest, then, that oVEMPS are well developed by age 3. Furthermore, oVEMP parameters seem to be consistent for patients aged 3 yr through at least 50 yr.

Although the age range in our adult cohort was limited to 40 yr, other studies have demonstrated consistent oVEMP responses through age 49 yr (Piker et al, 2011) and through age 60 yr (Tseng et al, 2010). Piker et al (2011) found that the mean n1-p1 amplitude significantly decreased in participants ≥50 yr compared with those aged ≤18 yr and 18–49 yr. The fact that oVEMP responses remain consistent across a wide range of ages leads to two assumptions. First, oVEMPs mature at a rather young age, and second, oVEMP responses remain consistent as a result of a compensatory increase in conduction velocity with increasing age and brainstem circumference. In contrast, cVEMP responses may be affected by maturational factors. Although some studies have not demonstrated a significant difference in p1 and n1 latencies and/or p1-n1 amplitudes between young children and adults (Welgampola and Colebatch,

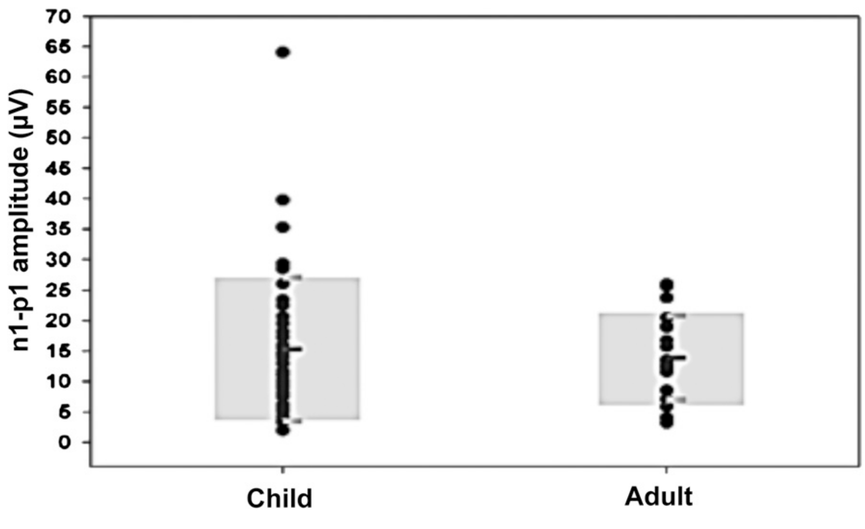

Figure 3. Scatter plot of amplitude values for pediatric and adult participants.

2001) others have shown a correlation between age and specific cVEMP response characteristics (Sheykholeslami et al, 2005; Kelsch et al, 2006; Valente, 2007; Hsu et al, 2009; Lin et al, 2010).

There tends to be substantial intersubject and interaural variability when measuring amplitude with cVEMP. This is particularly true in children as several factors may influence amplitude values, such as effort, attention, and fatigue (Valente, 2007). The p1-n1 amplitude is directly related to the tonic level of contraction and this may vary among patients and between sides tested. Although our youngest group of children required additional motivation and redirection during oVEMP testing, activation of the inferior oblique muscle using a novel smartphone visual target was achieved consistently, and amplitude values were reliable. oVEMP parameters could be measured in as short as 15 sec and the testing conditions were not uncomfortable for our pediatric participants.

We identified no age-related factors that affected testing time in the pediatric groups. Regardless of age, the time required to complete a single trial ranged from 15 to 30 sec (100 sweeps). The youngest children required more redirection and motivation from the research team to maintain proper gaze position. Response amplitudes were acquired rather quickly, allowing the testing staff to use a shortened trial time (100 sweeps). This was advantageous given the level of stimulus intensity. Practitioners should be cognizant of the risk of a high-level stimulus in pediatric ears due to their smaller ear canal volumes and an effective increase in sound pressure presentation levels by 3 dB (Thomas et al, 2017). Because reducing the stimulus intensity level may not produce the desired response, reducing the duration of signal exposure would compensate for the level of signal presentation. There were no complaints of discomfort, muffled hearing, or eye fatigue due to the amount of time required to maintain eccentric upward gaze during a single trial. Between trials, the participants were given the hand-held smartphone video to watch on their own or rest their eyes to prevent fatigue.

The large amplitude of response in some of the pediatric participants may be a manifestation of the chosen recording montage in addition to physiologic and/or anatomic factors. Even though the chin reference electrode may represent a more electrically indifferent reference location, there still exists the possibility of reference contamination. The magnitude of reference contamination may vary based on the distance between the active and reference electrodes. Therefore, we would expect a greater likelihood of reference contamination in the pediatric group of participants (i.e., shorter distance between active and reference electrodes) than the adult participants resulting in a greater potential for high-amplitude responses in adults than children. Small variation in the position of the active electrode in a standard montage has been shown to result in significant changes in the response amplitude in adult participants (Sandhu et al, 2013). The smaller facial anatomy in a child may predispose to an increased likelihood of variability in response amplitude as the consistency of active electrode placement becomes more difficult for a standard size electrode pad. Other factors that may influence variability in response amplitude include the force of contraction and the distance between the surface electrode and the inferior oblique muscle and the change in the intervening soft tissue with contraction of the inferior oblique and elevation of the globe. Furthermore, in as much as stimulus intensity may be effectively increased by 3 dB in children because of smaller ear canal volumes, there may be considerable variability in ear canal volumes among the pediatric standard size to account for the variability in response amplitude.

In summary, oVEMP testing in pediatric participants showed no significant difference for n1 or p1 latencies, n1-p1 amplitude, interaural amplitude AR, and threshold of response when comparing results among three pediatric age groups. When these results were analyzed and compared with that of a group of ten adults, there was no significant difference between the pediatric and adult groups with respect to any of the oVEMP parameters measured. oVEMP responses do not appear to be correlated with age and, therefore, are not affected by maturational trends. Although these findings may be considered preliminary because of the relatively few participants included, the simplicity, speed, and reproducibility of our testing protocol set a foundation of confidence for the use of oVEMP testing in the assessment of balance disorders in children.

Unlike the variability in responses observed with cVEMP testing in children (Valente, 2007) our methodology for eliciting an oVEMP response showed that activation of the inferior oblique muscle was achieved consistently. oVEMPs were present bilaterally in all pediatric participants (n = 22). The use of a child-friendly hand-held computer screen visual target (smartphone) proved beneficial for maintaining the appropriate gaze angle for even the youngest participants. Although positive encouragement was sometimes necessary, testing could be completed for a single trial within about 15–25 sec in most cases.

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