A NORMATIVE STUDY ON AIR AND BONE CONDUCTION OCULAR VESTIBULAR EVOKED MYOGENIC POTENTIALS

Ho Sen Kee

INTRODUCTION

- Dizziness and imbalance are two of the most frequent complains amongst the elderly population.
- Crucial to have vestibular tests accompanied with reliable normative data to determine the integrity of the vestibular organ.
- Otolithic organs can be assessed through vestibular evoked myogenic potentials (VEMPS) e.g. Ocular VEMPS (superior vestibular nerve & utricle)

AIMS & HYPOTHESIS

To determine and compare normative values of

1. N1 and P1 latencies
2. N1 and P1 amplitudes
3. Interaural asymmetry ratio of OVEMP between young adults (21-60 years) and elderly (61-80 years)

Hypothesis: There are significant differences in the 3 parameters between the young adults and elderly.

METHODOLOGY

PATIENT RECRUITMENT

Set out to recruit **40** participants

- 2 groups of 20 participants age between 21 to 60 years old and 61 to 80 years old respectively

- Recruited **47** participants but only **39** made it

- Dropped **8** participants due to conductive hearing loss, previous chemotherapy, fatigue and retinal detachment

- Participants were classmates, friends and members of public recruited via word of mouth

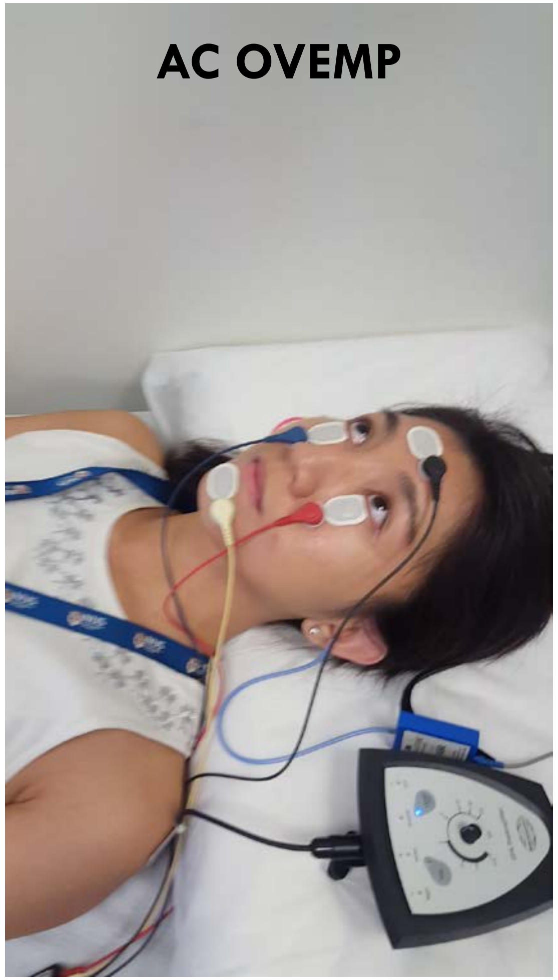
Screening (N=47)

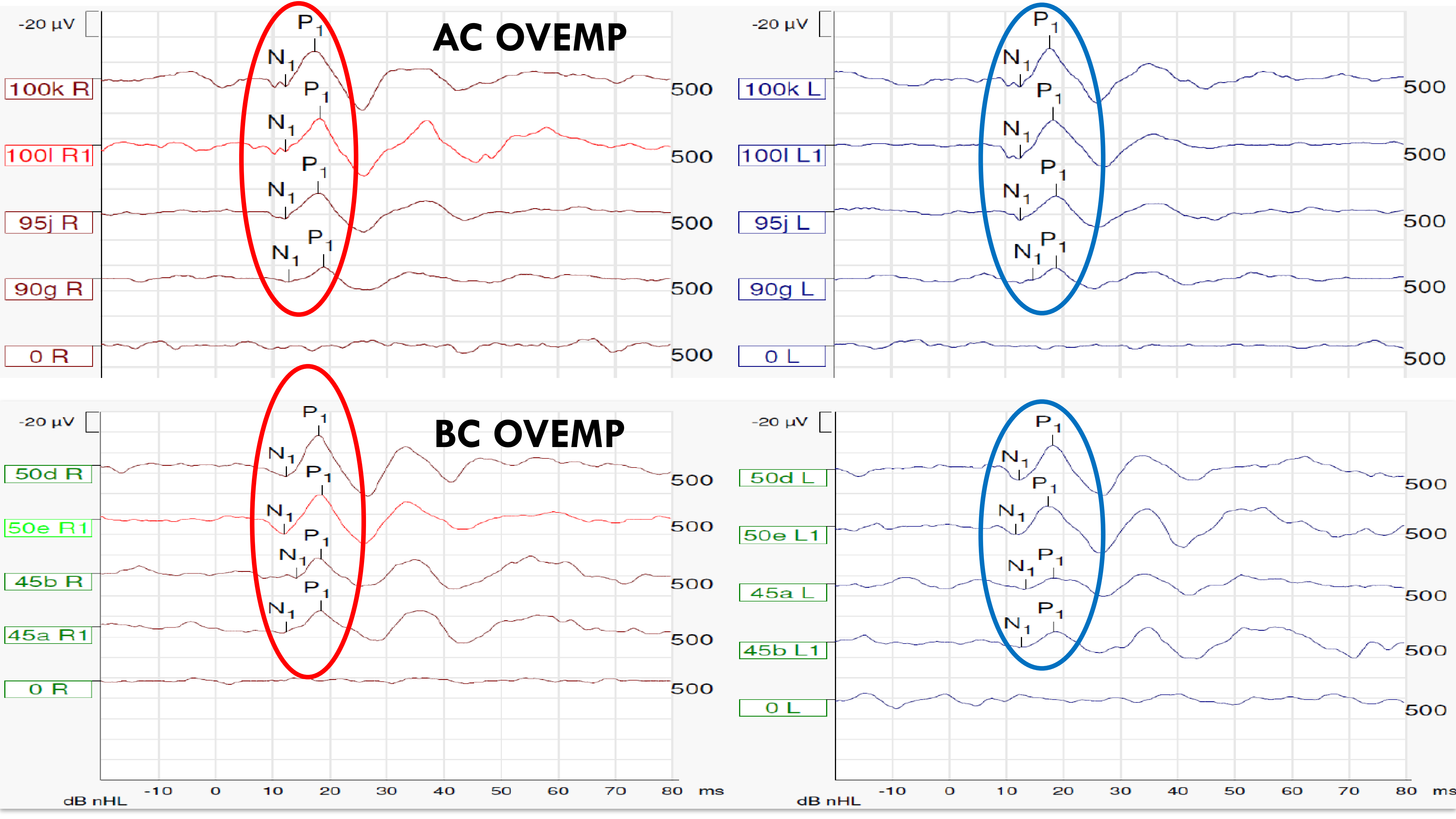
1. Phone Interview
2. Questionnaire on general well being & neurotological illness
3. Otoscopy, Tympanometry (226Hz) and Acoustic Reflex at 500hz & 1kHz to rule out CHL
4. Videonystagmography (rule out peripheral or central vestibular lesions)
5. Video head impulse test (rule out semi circular canal lesions)

OVEMP Testing (N= 39)

1. Clean skin followed by electrode placement
2. Check the impedance (below 5 kΩ)
3. AC testing using tone burst stimuli at 100dBnHL (500Hz and 1kHz) with insert earphones
4. Rest
5. BC testing using tone burst stimuli at 50dBnHL (500Hz and 1kHz) using mini shaker at Fz position

OBTAINING AC & BC OVEMP

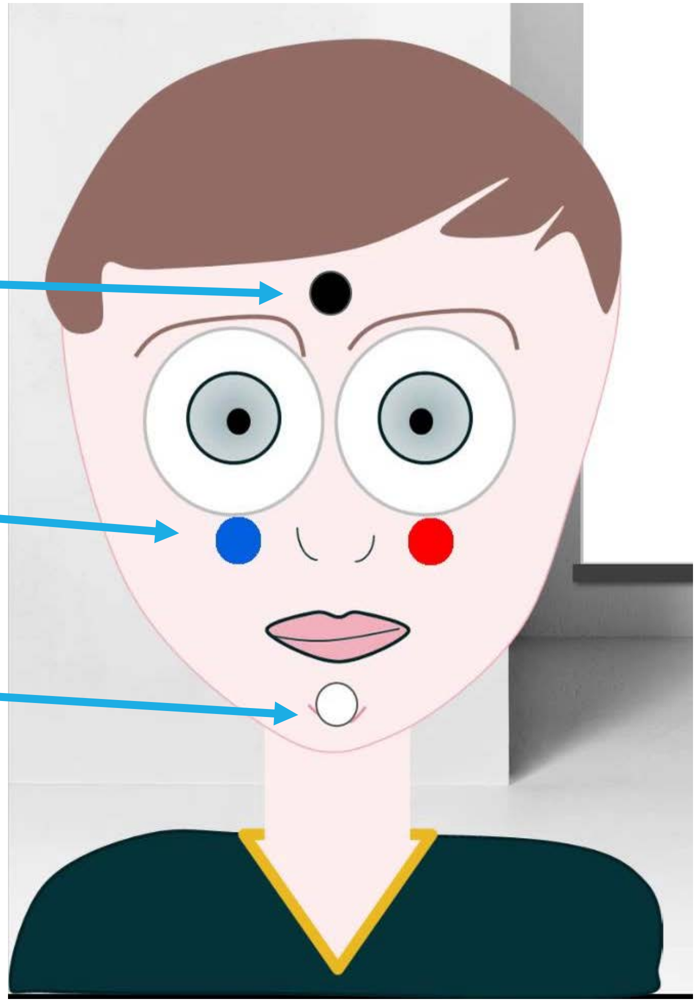




AC OVEMP
BC OVEMP
-20 µV
100k R
100l R1
95j R
90g R
0 R
100k L
100l L1
95j L
90g L
0 L
50d R
50e R1
45b R
45a R1
50d L
50e L1
45a L
45b L1
N1
P1
500
dB nHL
-10
0
10
20
30
40
50
60
70
80
ms

ELECTRODE MONTAGE

1. The **ground electrode** was placed on the forehead.
2. **Inverting electrodes** placed directly below the eyes.
3. **Non-inverting electrode** that was placed on the chin.



Maintain 30 degrees' upwards gaze, staring at a fixed point approximately 100cm from the eyes while lying down.

INCLUSION CRITERIA

Participants aged 21 to 80 years old fulfilling the criteria below were included in the study

1. Intact eardrum with no occlusion via otoscopic examination
2. Normal middle ear function via tympanometry (Type A or As)
3. Normal acoustic reflexes at 500Hz and 1kHz tone
4. Normal results for videonystagmography and video head impulse test
5. Unremarkable self-reported otological and vestibular history bilaterally as determined by questionnaire
6. Well on the day of testing

EXCLUSION CRITERIA

Participants with present or past medical history as specified below were excluded

1. Conductive hearing loss (abnormal tympanogram - Type Ad, B or C)
2. History of ototoxic medications use
3. Inability to maintain upward gaze
4. History of retinal detachment
5. Reported severe tinnitus
6. Pregnant women

RESULTS

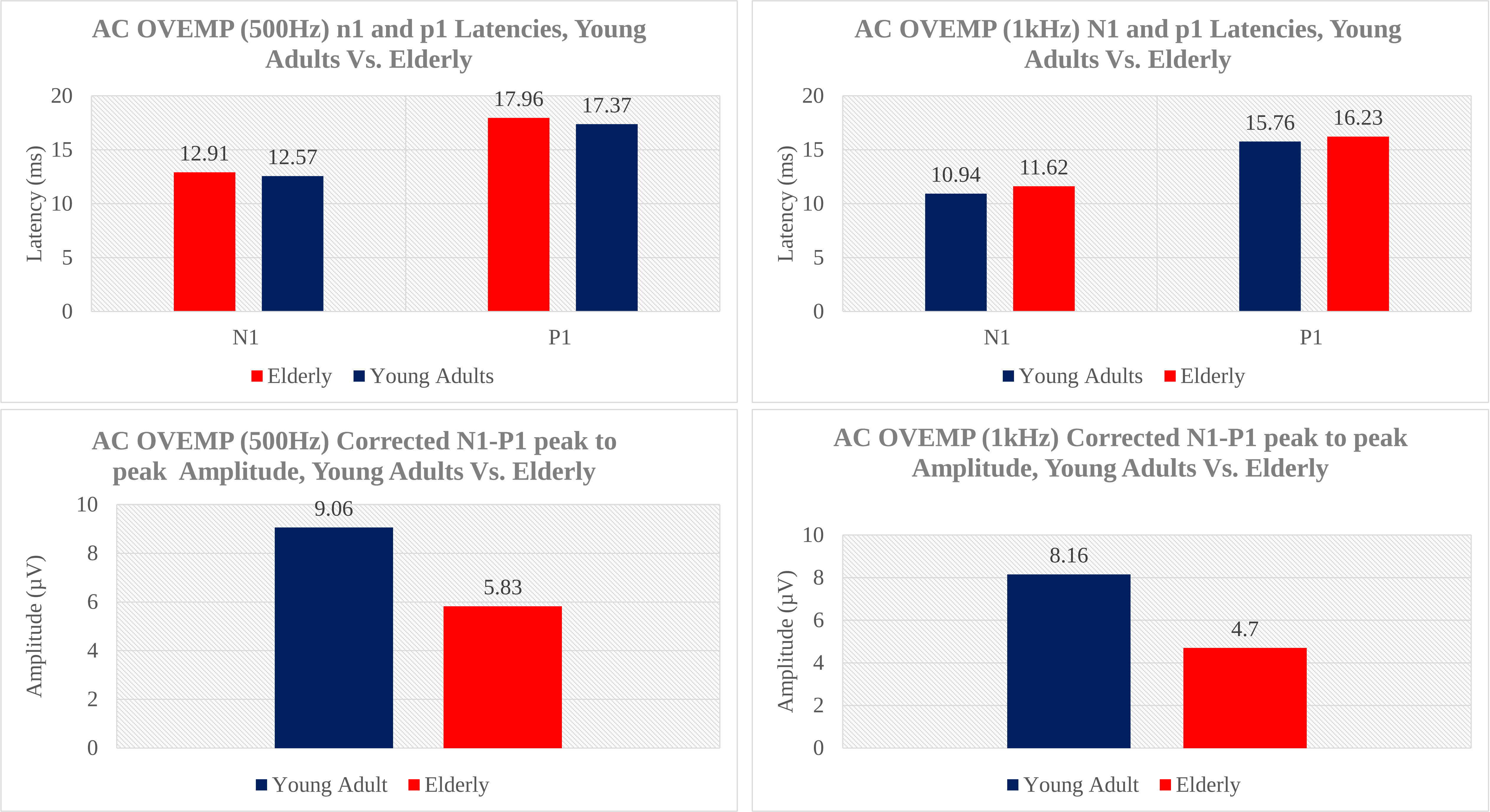
DEMOGRAPHIC

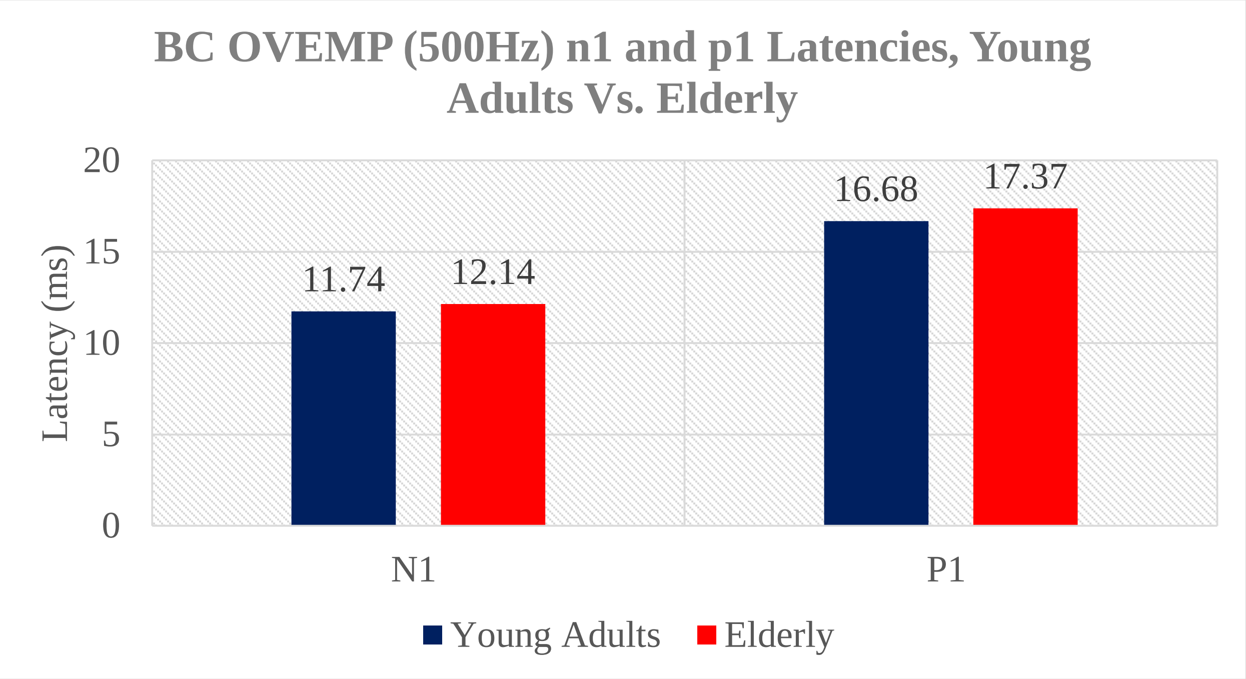
39 subjects were divided into two age groups. In both groups, there were more females than males.

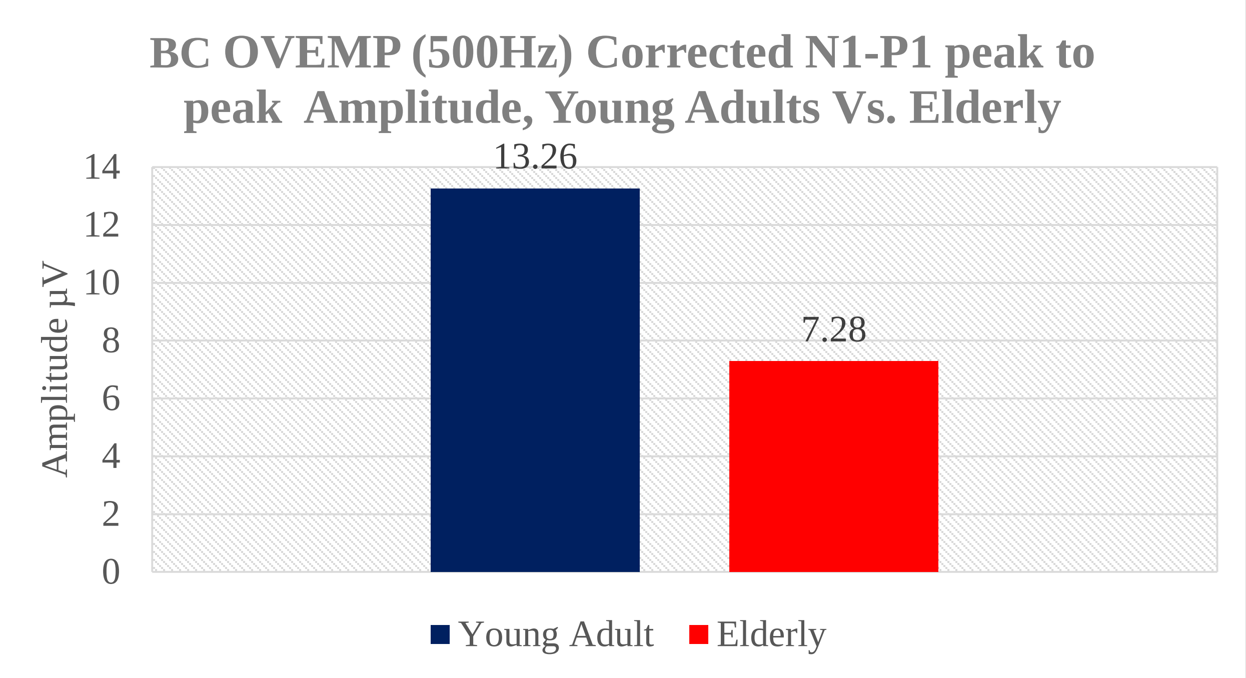
Table 2: OVEMP study participants demographic

Groups	Age range (years)	No. of Participants	Mean Age (years)
Young Adults	21 – 60	29	38 (SD=13.27)
Elderly	61 – 80	10	65.2 (SD=4.26)

Fewer elderly subjects were included due to the higher incidence of confounding factors such as previous chemotherapy, conductive hearing loss, eye conditions and fatigue.


AC OVEMP (500Hz) n1 and p1 Latencies, Young Adults Vs. Elderly
Latency (ms)
20
15
10
5
0
12.91
12.57
17.96
17.37
N1
P1
Elderly
Young Adults
AC OVEMP (1kHz) N1 and p1 Latencies, Young Adults Vs. Elderly
Latency (ms)
20
15
10
5
0
10.94
11.62
15.76
16.23
N1
P1
Young Adults
Elderly
AC OVEMP (500Hz) Corrected N1-P1 peak to peak Amplitude, Young Adults Vs. Elderly
Amplitude (µV)
10
8
6
4
2
0
9.06
5.83
Young Adult
Elderly
AC OVEMP (1kHz) Corrected N1-P1 peak to peak Amplitude, Young Adults Vs. Elderly
Amplitude (µV)
10
8
6
4
2
0
8.16
4.7
Young Adult
Elderly


BC OVEMP (500Hz) n1 and p1 Latencies, Young Adults Vs. Elderly
Latency (ms)
20
15
10
5
0
11.74
12.14
16.68
17.37
N1
P1
Young Adults
Elderly


BC OVEMP (500Hz) Corrected N1-P1 peak to peak Amplitude, Young Adults Vs. Elderly
Amplitude µV
14
12
10
8
6
4
2
0
13.26
7.28
Young Adult
Elderly

ASYMMETRY RATIO

Methods	Young adults		Elderly		p-value
AC OVEMP 500Hz	N=13	0.27 (SD=0.19)	N=2	0.54 (SD = 0.51)	0.38
AC OVEMP 1kHz	N=20	0.2 (SD=0.14)	N=5	0.30 (SD=0.15)	0.14
BC OVEMP 500Hz	N=15	0.18 (SD=0.13)	N=7	0.16 (SD=0.22)	0.24
BC OVEMP 1kHz	-	-		-	-

* p-value < 0.05 was used to denote statistical significance

YOUNG ADULTS VS ELDERLY

MANN-WHITNEY TEST WAS PERFORMED TO COMPARE OVEMP RESPONSES BETWEEN TWO GROUPS.

Stimuli Parameters	Response Indices	Outcome
AC OVEMP (500Hz)	**N1 & P1 latencies** **N1 – P1 amplitude** **Asymmetry ratio**	No significant difference was found between the young adult and elderly group in both ears.
AC OVEMP (1kHz)		No significant difference was found between the young adult and elderly group in both ears.
BC OVEMP (500Hz)		No significant difference was found between the young adult and elderly group in both ears.
BC OVEMP (1kHz)		Only the young adult group (N=4) had responses at 1kHz.

*** No significant differences were detected and this was likely due to a small sample size**

OVEMP RESPONSE RATE

Method	Young adults		Elderly	
	Left Ear	Right Ear	Left ear	Right Ear
Air Conduction 500Hz	62%	52%	30%	40%
Air Conduction 1kHz	**79%**	**79%**	50%	60%
Bone Conduction 500Hz	59%	69%	**60%**	**70%**
Bone Conduction 1kHz	7%	7%	0%	0%

DISCUSSION

LATENCY OF N1 AND P1 AC OVEMP (500HZ) YOUNG ADULTS

- Current study are 12.57ms and 17.37ms. Kumar et al. (2015) reported absolute N1 and P1 latency to be 12.0ms and 16.10ms.
- After taking SD into account, similar latency range between studies.
- Kantner et al. (2014) reported the mean N1 and P1 latency to be 10.66ms and 15.35ms.
- Slight difference in the findings among the studies could be due to **mean age (26.2 years)** and **ethnicity** of the participants involved.

DIFFERENCE IN ETHNICITIES

In Kantner's study, participants were Caucasians while in the current study and Kumar's were Asians.

- Due to differences in cranial shapes and sizes among individuals from different ethnic groups (Ball et al., 2010; Curthoys et al., 2012).

N1 latencies African Americans were significantly shorter from that of the Whites (Li et al., 2015).

- Might be due to melanin pigmentation. Individuals with dark skin have more melanin in the neuroepithelia of the vestibular organ (Wolff, 1931). Melanin may protect against the loss of labyrinthine function from ageing (Li et al., 2015). This effect was however not seen in this study.

RESPONSE RATE OF N1 AND P1 AC OVEMP (500HZ)

- Response rate was **57%** among the young adults. In contrast, Walther et al. (2011) and Kantner et al. (2014) reported a response rate of **100%**.
- Piker et al. (2015) reported response rate of **59%** elderly patients. These patients complained of dizziness but had normal vestibular function.
- **35%** of young adults were found to have previous complains of dizziness or lightheadedness with no known vestibular dysfunction detected during screening.
- More young adults responded than the elderly **(57% vs. 35%).** May be due to the degeneration of vestibular afferent nerve and loss of hair cells in the otolith organs with increasing age.

LATENCY OF N1 AND P1 AC OVEMP (1KHZ) YOUNG ADULTS

- Shorter N1 latencies as compared to at 500Hz and this could be due to variability in frequency tuning. Frequency tuning reflects the resonance properties of the otolithic organ.
- Welgampola and Colebatch (2001) discovered that a handful of their participants presented with tuning peaks at 1kHz.
- Tuning curves of ocular movement elicited by sound presented with tuning peaks at 1kHz (Zhang et al. 2004).
- Might explain why AC OVEMP at 1kHz might have a shorter latency as compared to AC OVEMP at 500Hz for the same intensity.

LATENCY OF N1 AND P1 BC OVEMP (500HZ) YOUNG ADULTS

- N1 and P1 were 11.74ms and 16.68ms latency. Sung et al. (2010) reported shorter N1 and P1 latency values at 8.65ms and 13.4ms.
  - Some participants complained of discomfort at Fz and a slight adjustment was made to relieve the discomfort. It was shifted slightly to a position in between Fpz and Fz and this might have accounted for the delay.

N1 – P1 AMPLITUDE OF AC OVEMP (500HZ) ELDERLY POPULATION

- N1-P1 amplitude in this study is 5.83 µV. Smaller N1-P1 amplitudes were reported in other studies (Kumar et al., 2015; Rosengren et al., 2011).

- Likely due to the gaze effect. Participants who gazed upwards at 35 degrees had larger amplitudes (Kantner & Gürkov, 2014).

N1 – P1 AMPLITUDE OF BC OVEMP (500HZ) YOUNG ADULTS

BC OVEMP (500Hz) amplitude is significantly larger than AC OVEMP (500Hz).

- Vibration generated via BC is more efficient in activating otolithic receptor. Increase in firing of more vestibular nerve fiber.
- AC stimulation can stimulate each ear separately but BC vibration gave larger response hence was more reliable (Cheng et al., 2009).

LIMITATIONS & SUGGESTIONS

Limitations	Suggestions
1. Small sample size	• A larger and equal sample size between the two groups will provide a better representation of the population and might be able to exemplify the age effect.
2. Screening and testing lasted for 3hrs in a single session	• Elderly subjects complained of extraocular muscle fatigue. • Testing held over 2 sessions but might decrease subject’s enthusiasm and willingness to participate. • Can provide longer rest time between screening and threshold seeking.
3. Keeping eyes opened during testing dries out the eyes	• Put a humidifier in the testing room • Eyes less dry -> less taxing on the eyes -> hence producing better responses.
4. Only 2 subjects had responses at BC (1kHz) at maximum intensity	• Underreported in the literature (I. Curthoys et al., 2009; Manzari et al., 2012; Rosengren et al., 2011). • Future studies to conduct testing at a lower frequency as BC at frequency as high as 1kHz did not yield any response.
5. Learning curve observed	• New clinician to get more practice and familiarization before commencing the study in order to obtain good response.

AC AND BC OVEMP (500HZ & 1KHZ) NORMATIVE DATA

Method	Group	Response Indices			
		n1 Latency (ms)	p1 Latency (ms)	n1-p1 Amplitude	Asymmetry Ratio
AC OVEMP (500Hz)	Young Adults	12.57 (SD=0.59)	17.37 (SD=0.81)	9.06 (SD=0.90)	0.27 (SD=0.19)
	Elderly	12.91 (SD=0.02)	17.96 (SD=0.06)	5.83 (SD=0.73)	0.54 (SD = 0.51)
AC OVEMP (1kHz)	Young Adults	10.94 (SD=0.26)	15.76 (SD=0.25)	8.16 (SD=0.76)	0.20 (SD=0.14)
	Elderly	11.62 (SD=0.72)	16.23 (SD=0.24)	4.70 (SD=0.75)	0.30 (SD=0.15)
BC OVEMP (500Hz)	Young Adults	11.74 (SD=0.15)	16.68 (SD=0.28)	13.31 (SD=0.17)	0.18 (SD=0.13)
	Elderly	12.14 (SD=0.20)	17.37 (SD=0.28)	7.28 (SD=1.12)	0.16 (SD=0.22
BC OVEMP (1kHz)	Young Adults	12.17 (SD=0.47)	16.92 (SD=0.35)	2.72 (SD=0.18)	-
	Elderly	-	-	-	-

AC AND BC THRESHOLD (500HZ & 1KHZ)

	Young Adults		Elderly	
	Left Ear	Right Ear	Left Ear	Right Ear
AC OVEMP 500Hz Threshold	90dBnHL	90dBnHL	100dBnHL	95dBnHL
AC OVEMP 1kHz Threshold	90dBnHL	85dBnHL	100dBnHL	95dBnHL
BC OVEMP 500Hz Threshold	40dBnHL	40dBnHL	45dBnHL	45dBnHL
BC OVEMP 1kHz Threshold	50dBnHL	50dBnHL	--	-

Thank you all for making it happen ☺!

REFERENCES

Abstracts of the Barany Society XXIII International Congress. Paris, France, July 7-9, 2004. (2004). *J Vestib Res, 14*(2-3), 95-303.

Bergström, B. (1973). Morphology of the vestibular nerve: II. The number of myelinated vestibular nerve fibers in man at various ages. *Acta Otolaryngol, 76*(1-6), 173-179.

Curthoys, I. S., Iwasaki, S., Chihara, Y., Ushio, M., McGarvie, L. A., & Burgess, A. M. (2011). The ocular vestibular-evoked myogenic potential to air-conducted sound; probable superior vestibular nerve origin. *Clin Neurophysiol, 122*(3), 611-616. doi:10.1016/j.clinph.2010.07.018

Hsu, Y.-S., Wang, S.-J., & Young, Y.-H. (2009). Ocular vestibular-evoked myogenic potentials in children using air conducted sound stimulation. *Clinical Neurophysiology, 120*(7), 1381-1385. doi:10.1016/j.clinph.2009.04.009

Lin, C.-M., Wang, S.-J., & Young, Y.-H. (2010). Ocular vestibular evoked myogenic potentials via bone-conducted vibrations applied to various midsagittal cranial sites. *Otology & Neurotology, 31*(1), 157-161.

REFERENCES

National Population and Talent Division, P. M. s. O. (2013).*A sustainable population for a dynamic Singapore, Population*

Piker, E. G., Jacobson, G. P.,McCaslin, D. L., & Hood, L. J. (2011). Normal characteristics of the ocular vestibular evoked myogenic potential. *J Am Acad Audiol, 22*(4), 222-230. doi:10.3766/jaaa.22.4.5

Rosengren, S. M., Govender, S., & Colebatch, J. G. (2011). Ocular and cervical vestibular evoked myogenic potentials produced by air- and bone-conducted stimuli: Comparative properties and effects of age. *Clinical Neurophysiology, 122*(11), 2282-2289. doi:http://dx.doi.org/10.1016/j.clinph.2011.04.001

Sung, P.-H., Cheng, P.-W., & Young, Y.-H. (2011). Effect of gender on ocular vestibular-evoked myogenic potentials via various stimulation modes. *Clinical Neurophysiology, 122*(1), 183-187.

Kantner, C., & Gürkov, R. (2014). The effects of commonly used upward gaze angles on ocular vestibular evoked myogenic potentials. *Otology & Neurotology, 35*(2), 289-293.