Effect of Yoga on Auditory Processing abilities in Older adults

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May-

CERTIFICATE

This is to certify that this dissertation entitled **‘Effect of Yoga on Auditory Processing abilities in Older adults**’ is a bonafide work submitted in part-fulfillment for degree of Master of Science (Audiology) of the student Registration Number: 17AUD010. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru

May-2019

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CERTIFICATE

This is to certify that this dissertation entitled **'Effect of Yoga on Auditory Processing abilities in Older adults'** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **'Effect of Yoga on Auditory Processing abilities in Older adults'** is the result of my own study under the guidance of Ms. Mamatha N. M., Assistant Professor in Audiology, department of Audiology, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DEDICATED TO MY PARENTS.

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Chapter 1

INTRODUCTION

Previous literature has conferred a wide range of studies in the area of age related changes in the auditory system and hearing. Research in this area has distinctly documented the physiological, anatomical and audiological changes showcased by the aging auditory system (Fitzgibbons & Gordon-Salant, 1996; Frisina & Walton, 2001; Willott, 1991). These changes in aging auditory system majorly include deterioration of cochlear hair cells, degeneration of neurons in the central auditory pathways, and reduction in the plasticity of the central auditory system. Along with these changes, co-occurring cognitive decline leads to a bunch of classical features seen in age related hearing loss. The most evidently reported clinical symptoms include overall threshold elevation, poor speech perception in degraded signal conditions (noise & reverberations), perception of rapid fluctuations or modulations in the signal, and impaired localization abilities (Koehnke & Besing. 2001; Willott, 1991).

Hearing loss is evidenced to be the third most common health conditions in older adults (Lethbridge, Schiller & Benrnadel, 2004). The prevalence of significant hearing impairment is estimated to be 40 to 45% in individuals over 65 years and reaches 80% as they approach 70 years of age. Along with peripheral hearing loss, it has been observed that older adults develop significant auditory processing deficit (APD) with aging. Studies by Antonelli (1970), Bergman (1971), Jerger, and Hayes (1977) report the presence of APD in older adults with increasing age. On the contrary, Marshall (1981) found that older adults perform similar to younger adults with the same degree of hearing loss.

Other works by Fabry and Van Tasell (1986), Humes and Roberts (1990), and Humes and Christopherson (1991) attempted to study the effect of hearing loss on speech perception performance in normal young individuals with simulated hearing loss and older individuals. They found that young normal adults performed similar to older adults under simulated hearing gloss conditions. Meanwhile, other researchers like Helfer and Wilber (1990) are of the opinion that older adults often face much greater difficulties in speech perception on a daily basis than younger adults with same degree of hearing loss. Changes in cognition have also been suggested as the factor accounting to the variability in these individuals.

It has been noticed that cognitive abilities like memory and speed of information processing are vital for some of the auditory tests such as dichotic speech tasks, duration and pitch pattern sequence as well as time compression with reverberation tests. It has been suggested that different individuals might experience different degrees of cognitive decline, thereby leading to increased likelihood of variability in the tests (Van Rooije & Plomp, 1992).

Gaeth (1948) is among the earliest studies to describe speech understanding difficulties in older adults that correlated poorly with their degree and configuration of hearing loss (Jerger, Jerger, Oliver & Pirrozolo. 1989). This was referred as 'phonemic regression' after which a bevy of researches has explored central auditory processing deficit and its presence in older individuals (Bergman, 1971; Jerger & Hayes, 1977; Jerger et al, 1989; Bergman, 1980; Johnson, Watson & Jensen, 1987; Yonan & Sommers, 2000).

Central Auditory Processing (CAP) refers to the perceptual processing of auditory information in the central nervous system and the neurobiologic activity that underlies that processing and gives rise to electrophysiologic auditory potentials (American Speech-Language-Hearing Association, 2005). CAP includes the auditory mechanisms that underlie the following abilities or skills: sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal integration, temporal discrimination, temporal ordering, and temporal masking; auditory performance in competing acoustic signals and auditory performance with degraded acoustic signals (American Speech-Language-Hearing Association,1996; Bellis, 2003; Chermak & Musiek, 1997). Central Auditory Processing Disorder (CAPD) refers to difficulties in the perceptual processing of auditory information in the CNS as demonstrated by poor performance in one or more of the above skills.

Yoga is a traditional physical and mental disciplines originated in India. The word is derived from the Sanskrit meaning to control, to yoke or to unite. The goal of yoga is unity of the body, mind and spirit with the focus on body posture, breathing and meditation. It is found to affect nervous energy and the activities in the endocrine, cardiac, pulmonary, muscular, and nervous systems through stimulation. It is found to accelerate physical, emotional, and spiritual recovery of individuals. Yoga has been used as a therapeutic intervention, which began early in the twentieth century, and takes advantage of the various psychophysiological benefits of the component practices (Nada yoga school, 2017; Swami Kriyanand. 2009a).

1.1 Need for the study

Practicing yoga has been found to have an effect on both mental and physical manifestations in human body. Some of the physical benefits of yoga that are reported in literature are: increase in body flexibility, muscle strength and tone, improvement in respiration, energy and vitality, maintenance of balanced metabolism, weight reduction, cardio and circulatory health, improved athletic performance, protection against injury (Yoga Journal, 2007). Raub (2002) reported that there was a significant improvement noted in the cardiovascular system in young individuals performing yoga for various durations. In addition, yoga practice is speculated to have positive effect in individuals with depression (Pilkington, Kirkwood, Rampes & Richardson, 2005; Uebelacker, Epstein, Gaudiano, Tremont, Battle & Miller, 2010).

Hariprasad et al (2013) has found that performing yoga showed a significant improvement in immediate and delayed recall of verbal and visual memory and there was an improvement noted in other domains like working memory, attention, verbal fluency and executive function in older adults. Gothe, Kramer and McAuley (2014) and Gothe, Keswani and McAuley (2016) have shown that yoga has a positive impact on memory, cognitive function and improve executive function in older adults. Alathi and Parulkar (1989) and Madanmohan (1992) have noted that yoga reduces reaction time in older adults by enhancing the brains processing ability. Apart from improving physical and mental aspects, yoga is found to have an effect on auditory system also.

It has been inferred that performing yoga in certain postures is known to circulate more amount of oxygenated blood to the cochlea and there by slowing the aging process. This also has been found to help in better repair and recovery of the system thereby reducing the chances of hearing loss (Arogya yoga school, 2017). Kumar, Shambhu, Prabhu (2017) have studied OAE suppression in 40 participants in the age range of 20-40 years. They reported an increased amount of suppression in both TEOAEs & DPOAEs in individuals who practiced yoga regularly compared to individuals who did not practice yoga. This suggests that yoga can strengthen the efferent auditory system. It has been known that activating efferent auditory system has an advantage in enhancing auditory performance like improvement in threshold detection and intensity discrimination (Micheyl & Collect, 1996), improvement of speech perception in noise (Soli & Linthicum, 1994). Girand et al. (1997) have assessed the function of efferent pathway (medial olivocochlear bundle) in normal individuals and their results concluded that activation of medial olivocochlear bundle (MOCB) improves speech intelligibility in presence of noise. Hence, strengthening of efferent auditory system through the practice of yoga is postulated to improve speech perception abilities.

Along with having an influence on auditory system, yoga is found to have an effect on vestibular system. Oliveira, Faria, Rodrigues, Santaella (2016) have reported that the postural practice of yoga improves the balance system in adults. Ulger and Yaglt (2011) also have indicated the positive effects of practicing yoga on balance and gait parameters in women with musculoskeletal dysfunction. In a study done by Prado, Raso, Scharlach and Kasse (2014) have shown that practicing yoga improves body balance in healthy young individuals.

Tejaswini, Shubhaganga, Prashanth (2017) studied the effect of yoga on cVEMP responses in individuals with age range from 20 – 40 years (n=40). Their results showed a significant increase in the amplitude of P1, N1 and P1–N1 complex and a significant reduction in latency for those who practice yoga compared to those who did not practice yoga. Gauchard, Jeandel and Perrin (2001) have concluded that low-energy exercises have the most positive effect on body balance control by relying more on proprioception thus leading to develop vestibular sensitivity of older adults. The reason for this could be because practice of yoga would have resulted in strengthening the muscles and vestibular system. However there are no evidences on the effect of yoga on auditory processing abilities in older adults.

1.2 AIM:

To determine the effect of yoga on auditory processing abilities in older adults.

1.3 OBJECTIVES:

1. To know the effects of yoga on speech perception abilities in presence of noise in older adults.
2. To know the effects of yoga on temporal processing abilities in older adults.
3. To know the effect of yoga on binaural integration in older adults.
4. To know the effect of yoga on auditory memory in older adults.

Chapter 2

REVIEW OF LITERATURE

It is commonly observed that older adults often experience great difficulty in understanding speech when compared to their younger counterparts. This difficulty is found to worsen in noisy environments, in presence of competing speakers, when listening to a faster rate of speech. Awareness about the existing sound, but failing in comprehension is the most common presenting complaint reported by these individuals (Rodriguez, & Sarno, 1990).

The listening difficulties experienced by older adults have been attributed to several reasons. These various reasons reported in literature includes changes in hearing acuity (Fabry & Tasell,1986; Zurek & Delhorne, 1987; Humes & Roberts, 1990; Cruickshabk et al, 1998; Halling & Humes, 2000), reduction in speech intelligibility (Zurek & Delhorne, 1987; Humes & Roberts, 1990; Fozard, 1990; Pearson et al. 1995; Dubno et al. 2008), and the presence of auditory processing disorders (Jerger & Hayes, 1977; Johnson et al. 1987; Divyeni, Stark & Haupt 2005).

2.1 Effect of advancing age on hearing abilities

Older adults reportedly experience significant increase in pure tone thresholds and a reduction in speech recognition scores with increasing age. Brant and Fozard (1990) assessed pure tone thresholds and speech discrimination scores in 813 males aged between 20 and 85 years. The subjects were monitored for a span of 20 years longitudinally. The results indicated that there was an average longitudinal loss of 35.2 to

53 dB for the 50 years and 69 to 84 dB for the 80 year old individuals. An increase in rate of threshold was found in older adults particularly in the speech frequencies. A reduction in speech scores was also seen but it did not correlate well with the degree of hearing loss. Similar finding were noted by Dubno et al. (2008) who reported that adults show a sharp decline in threshold in speech frequencies with advancing age. The results also indicated significant reduction in speech recognition scores for NU 6 speech material. This report was based on a longitudinal study of 835 subjects.

Humes and Roberts (1990) construed that peripheral hearing loss is found to be an important aspect in determining the variability seen in speech discrimination difficulties that older adults encounter. Another study by Humes and Christopherson (1991) examined the speech perception and central auditory processing skills of four groups of participants using test of basic auditory processing capabilities. The participants comprised of young normal hearing group, young normal hearing group with spectral noise stimulated hearing loss, an older adult group having hearing loss with age ranging from 65 to 75 years and another older adults group having hearing loss with age ranging from 76 to 85 years. Out of 8 tasks, the older adults groups performed poorer than the younger group in 4 tasks of basic auditory capabilities (Frequency discrimination test, embedded test tone task, temporal ordering task for syllables & tones). Even though the young normal hearing group with spectral noise stimulated hearing loss performed slightly better than older adults groups, their performance was not very significant than the two older adults groups. It was also observed that elevation of peripheral hearing sensitivity associated with aging was the most important factor that affected speech perception.

Humes et al (1994) assessed the speech recognition abilities in 50 older adults (63-83 years) for a range of test stimulus that included nonsense syllables and monosyllables sentences along with Test of Basic Auditory Capabilities developed by Watson (1987). The analyses were carried out for auditory, speech perception and cognitive measures. It was observed that the hearing loss contributed to a large part of variability for speech perception performance in older adults. Zurek and Delhorne (1987) assessed the effect of hearing loss on speech perception in 21 older adults with mild – moderate sensorineural hearing loss. They determined the perception of consonants in the presence of speech spectrum noise which was varied to stimulate a myriad of listening situation. The same tests were performed on normal hearing individuals. The findings showed no significant difference in the performance between of both the groups. Hence, it was concluded that most of the speech perception difficulties are primarily due to loss of audibility.

From the above researches, it is indicated that sensorineural hearing loss and general loss of audibility are the primary reasons that are known to cause poor speech perception in older adults. However, it was also noted that, poor speech perception did not always correlated with peripheral hearing loss.

2.2 Effect of advancing age on central auditory processing

An overall processing decline has been noted with advancing age in various physiological systems. Central auditory system also follows the striking pattern of degeneration in older adults. Several investigations over the years have demonstrated the presence of auditory processing problems in older adults, which increases with advancing age. Dubno, Lee, Mathew and Mills (1997) longitudinally assessed 129 individuals ranging from 55 to 84 years of age to know the effect of age and gender on monaural speech recognition scores. Their results revealed a significant decline in word recognition scores; synthetic sentence identification and high and low probability sentence perception in noise were observed for males with increasing age. However, for females this decline was not seen.

A study on older adults by Bergman (1980) reported transmission of degraded signals from the cochlea to the central auditory system that is unable to make fine discriminations (inherent internal redundancy). These two factors are equally important for good speech recognition. Jerger and Hayes (1977) noted that speech perception difficulties encountered by older adults were sometimes much more than their audiometric pattern suggested. It was suggested that speech understanding difficulties experienced by older adults were mainly due to their general decline of cognitive abilities and central auditory perception skills.

Divyeni et al. (2005) assessed 29 older individuals aged from 60 to 83 years and reported the auditory processing problem in this group. The Pure tone thresholds and word recognition in both quiet and noise were tested in these participants again after a gap of 5 years. The findings revealed that word recognition scores in both quiet and noisy situations reduced significantly; however, it did not correlate well with change in pure tone threshold. Hence, it was concluded that auditory processing disorder and cognitive factors could have been the reason for the poor correlation.

2.2.1 Auditory closure / monaural separation in older adults

Older adults have difficulty understanding speech in noisy situation and poor reverberation conditions, in spite of having normal pure tone thresholds. Auditory closure is the ability of an individual to fill gaps in the message using intrinsic and extrinsic redundancy. Speech perception in noise has been considered as a monaural separation or low redundancy closure task (Chermak & Musiek. 1997; Bellis, 2003) and it is assessed using speech-in-noise test (SPIN), low pass filtered speech and time compression with reverberation tests.

Smith and Prather (1971) examined the aging effects on speech perception using synthetic sentence identification with ipsilateral competing noise. Older and young adults were tested across different sensation levels and signal to noise ratio (SNR). The results showed that older adults had greater difficulty when sensation levels were increased and signal to noise rations (SNR's) were less.

Versfeld and Dreschler (2002) compared the speech reception scores in fluctuating noise and time compressed speech in young and older adults with normal hearing. The results revealed that the scores for both the test were significantly poorer in older adults compared to the younger group and a high correlation was seen between the tests.

The effects of aging on speech perception in noise (SPIN) in 55 individuals aged above 60 years were studied by Calais and Russo (2008). All the participants were divided into two groups. The control group consisted of individuals with normal hearing thresholds and the experimental group consisted of individuals having symmetrical sensorineural hearing loss. The results revealed that speech perception scores in presence of noise were similar in both groups. However, the groups with sensorineural hearing loss performed relatively poor.

From the above literature, it can be concluded that SPIN is most often used to assess auditory separation abilities in older adults. From the above findings, it is apparent that older adults perform poorly in noisy environment unlike younger adults.

2.2.2 Binaural integration in older adults

Dichotic tests are primarily used to assess central process known as binaural integration. The most widely used stimulus for dichotic testing are dichotic speech materials (dichotic CV, dichotic sentences or dichotic digits) (Musiek & Pinherio, 1985; Bellis, 2003). Jerger, Alford, Lew, Riveira and Chmiel (1994) evaluated dichotic listening in 40 individuals who were divided into normal hearing young adults and older adults with hearing impairment. There was a marked reduction in dichotic performance in older adults with hearing impairment and in individuals with corpus callosum lesion. The dichotic test was carried out using verbal and non verbal stimulus and electrophysiological and behavioural methods. The results indicated a marked reduction in left ear scores for verbal tasks and an increased deficit in right ear for non verbal tasks in all older adults group. The performance of older adults with hearing impairment yielded the similar scores to that of the subjects with callosal lesion. It was concluded that the inter-hemispheric transfer function was affected in individuals with advancing age.

Goncales and Cury (2011) investigated binaural integration abilities using dichotic test: staggered spondaic test (SSW) in older adults with no complaints of hearing difficulties. The findings showed poor performance in the left ear, especially in the competing conditions. Older adults above 65 years scored significantly poorer than 55 to 60 years old group also there was no gender differences found in the performance.

From the above results it can be concluded that binaural integration in older individuals are significantly affected, even when peripheral hearing is relatively normal.

2.2.3 Temporal resolution in older adults

Temporal resolution ability is found to be affected in older adults even if they have normal hearing sensitivity. Reduced temporal resolution in older adults has been investigated using the random gap detection test (Keith, 2000), Gap-in-noise (GIN) by Musiek, 2004.

Moore, Peters, and Glasberg (1992) experimented on gap detection thresholds using sinusoidal signals as a function of frequency in older adults. They examined older adults with hearing impairment and individuals with normal hearing. They results indicated that older adults obtained larger gap detection thresholds compared to younger group in spite of having normal hearing thresholds. In addition, there was no significant difference in gap detection thresholds of both the older adults group. This was considered to indicate the role of central auditory processing in accurate processing of temporal information. Similar findings have been reported by Moore et al. (1992) & Schneider et al. (1994). They reported that older adults with normal hearing thresholds performed poorly and in general had very variable results as compared to the younger normal hearing adult group.

Roberts and Lister (2004) examined gap detection in young normal hearing adults and two groups of older individuals with and without hearing loss. The test was performed in two methods, one with across channel gap detection and within channel gap detection processing. The results showed that across channel gap detection task carried out using a dichotic tasks was significantly affected as compared to within channel processing. In addition, both older adults group performed poorly for across channel gap detection task. However, the hearing impaired group showed significantly poor performance in both the tasks, which indicates the influence of hearing loss on certain gap detection tasks.

The studies on temporal processing tasks indicates the effects of aging in the processing of temporal information, despite of having a normal peripheral hearing. This suggests that role of the central mechanisms in the processing of temporal resolution.

2.2.4 Cognitive factors and central auditory processing in older adults

Speech perception skills in older individuals has been noted to be affected by cognitive factors such as memory, speed of processing information and verbal ability even with normal peripheral hearing sensitivity. The effect of advancing aging and associated cognitive decline on speech perception performance were studied by Van Rooije and Plomp (1992). They found that non-auditory cognitive factors such as slow information processing and reduced working memory have accounted for reduced performance, and the major features that reduced the performance in older adult group was noted to be temporal and spectral resolution abilities.

Mythri and Yathiraj (2012) examined the memory and sequencing abilities in 3 groups consisting of younger adults (20 to 30 years) and two older groups (50 to 64 & 65 to 80 years), all individuals have normal peripheral hearing. The results of their findings revealed that the younger group performed significantly better than the older groups.

Thus from the review of literature, it is understood that a general decline in central auditory processing and cognitive abilities were also considered to significantly affect speech perception in older adults (Rodrigo, Di Sarno & Hardiman. 1990; Calais & Russo, 2008; Snell & Frisina, 2000) along with other processing difficulties.

Hence the existing literature indicates that the two factors i.e., central auditory processing and cognitive abilities majorly contributes to reduced speech perception abilities, binaural integration abilities, temporal resolution abilities and auditory memory scores in older individuals. However this natural physiologicalcal changes that takes place as the age advances can be reduced or controlled through various activities such as good diet, exercises which includes walking, jogging or weight training and practicing of yoga(Nam, Kim, Ahn & Yang, 2007; Pilkington, Kirkwood, Rampes & Richardson, 2005; Uebelacker et al 2010)

2.3 Yoga

Yoga is a psycho-somatic-spiritual approach that originated in India and became popular in 20thcentury. It is a science which is over 5000 years old and has helped people to move towards higher state of harmony. Yoga has been utilised for achieving union and harmony between the ultimate union of our individual consciousness with the universal consciousness and the union of our body, mind, and sprit (Yogapedia). In recent years, yoga is making a major contribution to the modern medical technology. Over the last few decades extensive research conducted in this field have bought out the usefulness of yoga in dealing with these ailments as an effective adjunct to medical management and for long term rehabilitation (The Art & Science of Raja Yoga, Swami Kriyananda, 2017;).

Yoga has many types known as Karma yoga which means yoga through actions, Bhakti yoga is yoga through devotion, Gyana yoga or Jnana yoga is the yoga of self study, Raja yoga views human nature as a kingdom composed of many psychological tendencies and physical attributes, which require considerate attention. Pranayama is a technique used in yoga. It is derived from two Sanskrit words, namely, 'Prana', which means vital force or life energy, 'Ayama' means to control. Yoga appears to provide a significant improvement in stress, anxiety and overall health of an individual (Smith, Hancock, Blake-Mortimer & Eckert, 2006).

Practicing yoga regularly is found to have an effect on both mental and physical manifestations in humans. Some of the reported health benefits are improvement seen cardiovascular system functioning (Raub; 2002), changes in brain waves and structure (Radhika, Anisha & Tanvi, 2015), influences on working memory, attention, cognitive function, verbal fluency and executive function of older adults (Hariprasad et al. 2013, Gothe, Pontifex, Hillman & McAuley,2014, Gothe, Keswani & McAuley, 2016), increased reaction time (Alathi & parulkar, 1989, Madanmohan (1992), improves balance and gait parameters (Oliveira, Faria, Rodrigues, Santaella, 2016; Prado, Raso, Scharlach

& Kasse; 2014; Ulger & Yaglt, 2011) helps individuals with depression (Pilkington, Kirkwood, Rampes & Richardson, 2005; Uebelacker et al 2010). Yoga is also found to have an effect on inner ear functioning (Tejaswini, Shubhaganga, Prashanth; 2017; Kumar, Shambhu, Prabhu, 2017)

Sarang and Telles (2007) assessed the immediate effects of yoga relaxation methods on memory and state of anxiety in 57 male adults. Individuals were assessed before and after performing the following activities namely: Cyclic meditation, Postures (Spine rest) on different days. Wechsler memory scales (WMS) were used to assess attention, concentration and associate learning. Spielberger's State-Trait Anxiety Inventory (STAI) was used to assess state of anxiety. They observed a significant improvement in all domains of WMS for both posture and mediation techniques, similarly anxiety scores decreased for both the technique but magnitude of change was high using mediation technique compared to posture method for both the measured domains.

Similarly, Telles, Praghuraj, Ghosh and Nagendra (2006) compared the performance of 26 individuals (group that received yoga & control group who did not practice yoga) aged between 18 to 45 years in a mirror star tracing task as after practice of yoga. They measured the performance of individuals before and after a month of practicing Yoga and the results indicated that individuals who performed yoga had an improvement in reversal ability, eye-hand co-ordination, speed and accuracy which are important for mirror star tracing. Above two studies, indicate the benefits of yoga in adult group.

Hariprasad et al (2013) measure the effect of yoga practice (6 months practice) on sleep and quality of sleep in older adults (>60 yrs). The individuals who were free from any neurological disorder, medical issues like stroke, hearing or visual problems were considered for the study. They included 62 yoga practicing individuals and 58 individuals in control group who did not practice yoga. They measured quality of life (QOL) using World health organization quality of life (WHOQOL) and Pittsburg sleep quality index (PSQI) to assess sleep. It has 7 subscales namely: Subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, medication use and daytime sleepiness. The performance was measured after 6 month of yoga practice and results indicated that yoga is found to have beneficial effects on physical health, psychological health, social relationships and environment domains of life quality. Further, individuals were found to have significant improvement in total quality of sleep. The above mentioned observations indicate the influence of yoga on functioning of central nervous system.

Radhika, Anisha and Tanvi (2015) reviewed 15 articles about yoga and brain related changes. Based on the review it was concluded that, breathing, meditation, and posture-based yoga increased overall brain wave activity. They also reported increase in grey matter, amygdala and increased frontal cortex activation that was evident after yoga practice. Yoga practice may be an effective treatment program for healthy and clinical aging population. Sarang and Telles (2006) assessed the change in P300 cortical potential in 42 adults who practiced two best yoga techniques, namely cyclic meditation (CM), Supine rest posture (SR). They measured the cortical responses from Fz, Cz and Pz electrode sites and compared the pre and post values in terms of amplitude and latency.

Results of the study indicate that the peak latency of P300 was reduced after practice of CM. The SR method also indicated a significant change, even though the change in latency was not as much as that was seen in CM method. The amplitude increased in p300 was seen only seen after CM performance. The observations of this study support the idea that yoga based techniques enhances cognitive processes which intern has an effect on P300 latency and amplitude. From all these findings, it is clear that the yoga has significant benefits in normal individual across different age groups. Yoga is also found to have therapeutic effects on various clinical practices.

Oliveira, Faria, Rodrigues, Santaella (2016) assessed the effect of yoga based rehabilitation on postural balance and subjective impact on postural balance impairment in individuals with multiple sclerosis (MS). They included 12 women, divided into two groups with 6 in each group. One group was provided yoga practice for six months and their outcomes were measured using Berg Balance Scale (BBS), Expanded Disability Status Scale (EDSS), and self-reported postural balance quality and influence of postural balance on activities of daily living. Results of the assessment revealed that there was a significant improvement seen in BBS scores in yoga group, especially in subjects with higher Expanded Disability Status Scale scores. And it was concluded that six months of yoga practice is beneficial for individuals with MS, as it improves postural balance and decreases the influence of postural balance impairment on activities of daily living.

The effect yoga on respiratory system was examined on 57 Adults with mild / moderate bronchial asthma by Vempati, Bijlani and Deepak (2009). They randomly assigned two groups: Group I: Intervention group (n=29), this group received yoga care and conventional treatment. Group II: Wait-listed control group (n=28), this group received only conventional care. They measured the results at 0 week, 2, 4, and 8 weeks of yoga practice. The results indicated that yoga group exhibited a steady and progressive improvement in pulmonary function, there was a significant change in first forced expiratory volume (FEV_1) at 8 wk, and peak expiratory flow rate (PEFR) at 2, 4 and 8 wk as compared to the baseline values. Both the group had a significant improvement in Asthma Quality of Life (AQOL) scores over the 8-wk study period. However, in yoga practicing individuals, improvement was observed was more and it was earlier. Ramos-Jimenez et al, (2009) examined the effect of intensive hatha yoga intervention on middle aged (n=4) and old aged adults (n=9) with cardiovascular risks. The intervention (intensive yoga program) was given for 11-week, that consisted of 5 sessions/week for 90 min (55 sessions). After the end of 11 week training, it was observed that, in both the groups, the heart rate increased by 26 beats/min higher and BMI ~3kg $/m^2$ lower in middle-aged women compared to older group. In addition, maximum expired air volume and maximum oxygen consumption volume were increased in both the groups. Also, yoga had an increased effect on biochemical parameters like glucose, high density lipo protein cholesterol (HDL-C), total cholesterol (TC). It was concluded that yoga is found to reduce the risk of cardiac problems.

Along with yoga being having an effect on central nervous system, cardiovascular system, respiratory system, it has also been found to have an effect on body balance and inner ear structures. A good body balance is required for proper functioning of vestibular, visual, and somatosensory system, which can be attained through practice of yoga or exercises. Prado, Raso, Scharlach and Kasse (2014) evaluated the effect of yoga on body balance and postural control in 34 men aged between 25 -55 years old and they were randomized into two groups. They measured the limit of stability and velocity of oscillation (VOS) in three conditions (Standing on firm ground, eyes open, Standing on firm ground, eyes closed, Standing on a foam pad, eyes closed) of the balance rehabilitation unit (BRU) using field procedures, namely: "four position," "plane," "flamingo," and "hopscotch" tests. One group was given yoga practice for 5 months and the control group was not provided any training. The results of the study revealed that BRU parameters and field procedures revealed key effects due to hatha yoga training. Partial eta squared on BRU parameters ranged from 0.78 -0.9, which indicated the strong effect of yoga training.

Ulger and Yakult (2011) measured the effect of yoga on balance and gait properties in woman with musculoskeletal problem. They included 27 women, aged between 30-45 years with musculoskeletal problems and measured static balance and gait parameters. The post study results showed that there was a statistically significant improvement noted in gait parameters after the training. Balance values of the individuals were addressed anterior-posterior and right-left positions with eyes open and closed. It was observed that anterior-posterior values and right-left values were almost equal after the treatment. In addition, the eye open and close values were also noted to be minimal after yoga practice. These results signify that practicing yoga can improve vestibular function.

The effect of yoga on vestibular function was assessed in 40 individuals (20 yoga participants & 20 non yoga participants) aged from 20 to 40 years through cVEMP responses (Tejaswini, Shubhaganga, Prashanth, 2017). The results showed a significant increase in the amplitude of P1, N1 and P1–N1 complex and a significant reduction in latency in individuals who practiced yoga regularly compared to those who did not practice yoga. They also reported significantly lower asymmetry ratio in individuals performing yoga. From these studies, it can be conclude that practicing yoga improves postural stability, strengthens the muscles and vestibular system leading to enhanced cVEMP responses.

Vestibular system and cochlea are the two important structures of inner ear. Since yoga is found to influence vestibular function, it is assumed that it could also influence cochlear Function. Kumar, Shambhu and Prabhu (2017) studied effect of yoga on the suppression of otoacoustic emission (OAE) in 40 participants in the age range of 20-40 years. They reported an increased amount of suppression in both transient evoked otoacoustic emissions (TEOAEs) & distortion product otoacoustic emissions (DPOAEs) in individuals who performed yoga regularly compared to individuals who did not perform yoga. This suggests that yoga can strengthen the efferent auditory system. It has been known that activating efferent auditory system has an advantage on enhancing auditory performance like improvement in threshold detection and intensity discrimination (Micheyl & Collect, 1996), improvement of speech perception in noise (Soli & Linthicum, 1994). Girand et al. (1997) studied the function of efferent pathway (medial olivocochlear bundle) in normal individuals and it was concluded that activation of MOCB improves the speech in noise intelligibility. Hence strengthening of efferent auditory system through practice of yoga can improve speech perception abilities. However, there are no studies reported in literature regarding yoga and its influence on auditory processing abilities. Hence, the present study is considered to study the effect of yoga on auditory processing abilities in older adults

Chapter 3

METHOD:

The method of the study was designed with the aim to assess the effect of Yoga on auditory processing abilities in older adults. The various auditory processing abilities were assessed using speech-in-noise test in Kannada (SPIN-K) (Vaidyanath & Yathiraj, 2012), Gap detection test (GDT) (Shivaprakash & Manjula, 2003), Dichotic CV test (Yathiraj, 1999) and Auditory memory and sequencing test (Yathiraj & Vijayalakshmi,2006). Standard group comparison design was used for comparing the auditory processing abilities. In order to fulfil the aim, the following method was planned. The data was obtained in compliance with the Ethical guidelines for Bio-Behavioural Research Involving Human Subjets (2009) of the All India Institute of Speech and Hearing, Mysuru.

3.1 Participants

Two groups of participants were recruited for the study. A total of 30 participants were enrolled for the study. Group I (experimental group) included individuals who have practiced yoga regularly for a minimum of at least 2 years and Group II (control group) included individuals who have not practiced yoga. Individuals who performed Yoga followed certain methods during yoga practice i.e., the yoga participants start their practice by chanting spiritual mantras, followed by body relaxation exercises, surya namaskara, practicing yoga postures then end with pranayama (breathing exercise) sessions. The completion of Yoga practice takes about 1.5 hours. The age of the individual included in the study ranged from 50 to 65 years. All the participants were native of Kannada and had no complaints of any speech and language problems. The participants having Pure-tone AC thresholds less than 15 dB HL in the frequencies 250 Hz, to 2 kHz, indicating normal hearing sensitivity and thresholds at 4kHz to 8kHz within 30dB HL (Carhart & Jerger, 1959) were selected for the study. Individuals with history of middle ear infection, speech understanding problem, smoking or drinking habits, diabetes, hypertension, neurological issues were not included in the study. Also individuals recruited in group I (individuals practicing yoga) needed to full the criteria of practicing yoga for a minimum of 6 to 9 hours a week for at least 2 years. The presence of any cognitive decline or impairment was ruled out based on the results of the Mini Mental Status Examination (MMSE) given by Folstein, Folstein and McHugh (1975). All individual recruited were right handed.

3.2 Test material

The following test material was used to assess hearing sensitivity as well as auditory processing abilities in individuals considered for the study.

- To assess speech identification scores speech identification test in Kannada developed by Yathiraj and Vijayalakshmi (2005) was utilised
- To assess auditory closure (speech perception abilities in presence of noise) Speech identification in noise in Kannada (SPIN-K) developed by Vaidyanath and Yathiraj (2012) was used .

- To assess auditory integration dichotic CV test developed by (Yathiraj, 1999) was used.
- To assess temporal resolution abilities Gap Detection test (Shivaprakash and Manjula, 2003) was used.
- To assess memory and sequencing skills, Auditory memory and sequencing test developed by Yathiraj and Vijayalakshmi (2006) was used.

3.3 Instrumentation

The following instruments were used in the present research:

- An otoscope was used to observe the status of the external auditory canal and visualise the tympanic membrane and a calibrated screening Immittance meter to confirm normal middle ear functioning (GSI-Tympstar).
- A calibrated double channel diagnostic audiometer, Inventis piano with supra aural ear phones (TDH-39); BC vibrator (B-71) was used to select the participants for the study and administer the diagnostic auditory processing tests.
- A personal computer with windows IOS 8.1 and an intel core i3 7th Gen processor was used to play the CD versions of the diagnostic auditory processing tests.

3.4 Test Environment

The diagnostic audiological tests were carried out in a sound-treated double room situation. The centrally air conditioned room had optimum temperature and lighting. The noise levels in sound-treated room was within permissible limits as per American National Standards Institute (S3.1-1999). The cognitive test (MMSE) was carried out in a quiet and distraction free environment.

3.5 0Procedure

The air conduction (250 Hz to 8 KHz) and bone conduction (250 Hz to 4KHz) pure-tone thresholds of all the subjects were measured using modified Hughson-Westlake method (Carhart & Jerger, 1959). Speech reception thresholds were determined using spondee word list (Rajshekar, 1978); Tympanomerty and acoustic reflex threshold were measured using conventional protocol.

The Mini mental status examination (MMSE) translated by Shobha et al. (2011) to Kannada was administered to assess cognitive abilities in the older adults. Individuals who cleared the criteria (score of $\geq$24) which was recommended by Folstein, Folstein and McHugh (1975) was included for the further study.

The individuals selected for the study were instructed to listen to the recorded instructions and respond appropriately while carrying out the diagnostic auditory processing tests. Four different diagnostic auditory processing tests were carried out to assess monaural auditory separation / closure, binaural auditory integration, temporal resolution, and auditory memory and sequencing. The various tests that were included for evaluating these auditory processes were Speech-in-noise test in Kannada (SPIN-K) developed by Vaidyanath and Yathiraj (2012), Dichotic CV test (Yathiraj, 1999), Gap Detection Test (GDT) (Shivaprakash and Manjula, 2003), and the Revised Auditory Memory and Sequencing test in Kannada, developed by Yathiraj and Vijayalakshmi (2006).

For all the monaural tests (SPIN, GDT & DPT), half the participants from each group were initially tested in the righter ear and the other half in the left ear, to avoid any possible ear order effect. Additionally, order in which the tests presented was randomised across the individuals to avoid test order effect.

3.6 Administration of diagnostic tests to assess auditory processing abilities

The CD versions of all the four diagnostic auditory processing tests were played on a computer, the output of which were routed through supra aural headphones via a diagnostic audiometer. To calibrate the VU meter deflection, the 1 kHz calibration tone recorded in the CDs of each test was used before presenting the stimuli.

SPIN-K (Vaidyanath & Yathiraj, 2012) stimuli were presented at 0 dB SNR monaurally, routed via a calibrated audiometer through headphones at 40 dB SL (Ref SRT). The participants were instructed to repeat the words and ignore the noise (8 speaker speech babble) and the responses were noted and scored. A score of 1 were given for correct response and a score of 0 were given for an incorrect response. The scores were later converted into percentage.

Dichotic CV test (Yathiraj, 1999) stimuli consisting of six stop consonants (/pa/, /ta/, /ka/ /ba/, /da/ & /ga/) were administered at 40 dB SL (ref. SRT) using the list containing 0 msec lag. The individual was informed that they are going to hear two syllables simultaneously, one in each ear and they have to repeat both the syllables heard. A single correct score were given if the subject repeated the syllable presented to any one ear correctly. A double correct score (score of 1) were given for the correct repetition of both the syllables presented in the two ears. The double correct responses were noted and compared with age appropriate norms given by Yathiraj et al. (2012).

Gap detection threshold (Shivaprakash and Manjula, 2003): The GDT consists totally 60 sets of stimuli. Each stimulus set contains 3 noise bursts of 300 msec duration which is separated by a silence of 750 msec. The gap is introduced at the center in one of the three bursts in all the stimuli. The duration of gap starts from 20 msec and later gap were be reduced from 20 msec to 11 msec in 2 msec steps, and after 11 msec, it was reduce to 1 msec steps. Initially 4 practice sets (gap of 20, 16, 12 & 10 msec) were presented for training. One of the 3 noise-bursts in the set will have a gap of varying duration. The GDT test was administered at 40 dB SL (ref. PTA). The participants were instructed to indicate as to which of the 3 noise bursts in the set the gap has. Each time the gap is detected correctly, the size of the gap was reduced to find the smallest gap the participant can detect using the bracketing technique. The minimum gap that was detected is considered as gap detection threshold. The GDT were obtained for each ear separately.

Kannada auditory memory and sequencing test (Yathiraj & Vijayalakshmi, 2006) were presented binaurally at comfortable level (40 dB SL Ref. SRT). The stimuli consists of three to eight words sequences (e.g., la:ri, s:ebu, ta:ku). Subjects were instructed to listen to the group of words and repeat them in correct order. A score of 1 were given if the word is recalled correctly and a score of 1 were given if the words are repeated in a correct sequence. The maximum possible score is 118.

3.7 Statistical Analyses

The data obtained was subjected to statistical analyses using SPSS Version 21 software. Descriptive statistics was used to obtain the mean and standard deviation scores of SPIN-K, Dichotic CV, GDT and Auditory memory and sequencing tests. As all the assumptions of parametric test were satisfied, an independent sample t-test was used to see the significant difference between the groups.

Chapter 4

Results

The aim of the study was to assess the auditory processing abilities of older individuals who practice Yoga. In order to fulfil the aim, four different auditory processing abilities: Speech perception abilities in presence of noise, Binaural integration, Temporal processing and Auditory memory and Sequencing skills were assessed. These auditory processes were assessed using Speech-in-noise in Kannada (SPIN-K), Dichotic CV (DCV), Gap detection threshold (GDT), Auditory memory and Sequencing tests. The auditory processing abilities were compared between yoga participants (experimental group) and non yoga participants (control group). To analyze the data, Statistical Package for the Social Science Version 21 was used. The following Statistical tools were used to analyze the obtained data:

- Shapiro Wilks test of normality was used to check for the normality of the obtained data.
- As Shapiro Wilks test of normality indicated that data were normally distributed ($p > 0.05$), further parametric tests (Independent sample t-test) were done for the between group comparison.
- Descriptive statistics was done to calculate the mean, standard deviation and range for SPIN-K, DCV (Right, left & double correct scores), GDT and auditory memory and sequencing scores.
- Independent sample t-test was done to check for the significant difference between the groups.

4.1 The results of the study are provided under the following headings:

- Comparison of auditory processing abilities in experimental and control groups.
- Comparison of auditory processing abilities between groups (Experimental & Control).

4.1.1 Comparison of auditory processing abilities in Experimental and Control groups

In order to compare the auditory processing abilities in both the groups (Experimental & Control), Mean, Standard Deviation (SD) was obtained for SPIN-K (combined), DCV (right, left & double correct), GDT (combined) and auditory memory and sequencing scores. The results are summarized in Table 1 and Figure 1.

Table 1: Mean (M) and Standard Deviation (SD) of SPIN-K, DCV (right, left & double correct), GDT and auditory memory and sequencing scores of control and experimental groups

Test to assess processing abilities	Control group (N=15)		Experimental group (N=15)	
	Mean (M)	**Standard Deviation (SD)**	**Mean (M)**	**Standard Deviation (SD)**
Speech In Noise-Kannada	54.00	1.32	66.60	0.80
Dichotic CV-Right	18.93	1.90	22.46	1.50
Dichotic CV-Left	16.73	1.66	20.60	1.50
Dichotic CV-Double correct	11.00	1.06	12.80	1.97
Gap detection threshold	15.66	2.66	6.66	1.54

Auditory Memory	102.33	2.69	105.40	3.01
Auditory Sequencing	79.73	2.12	80.86	2.38

Note: SPIN-K scores are given in percentage, Dichotic CV (right, left & double correct) maximum raw scores is 30, GDT raw scores are in msec, Auditory memory and sequencing maximum scores is 118.

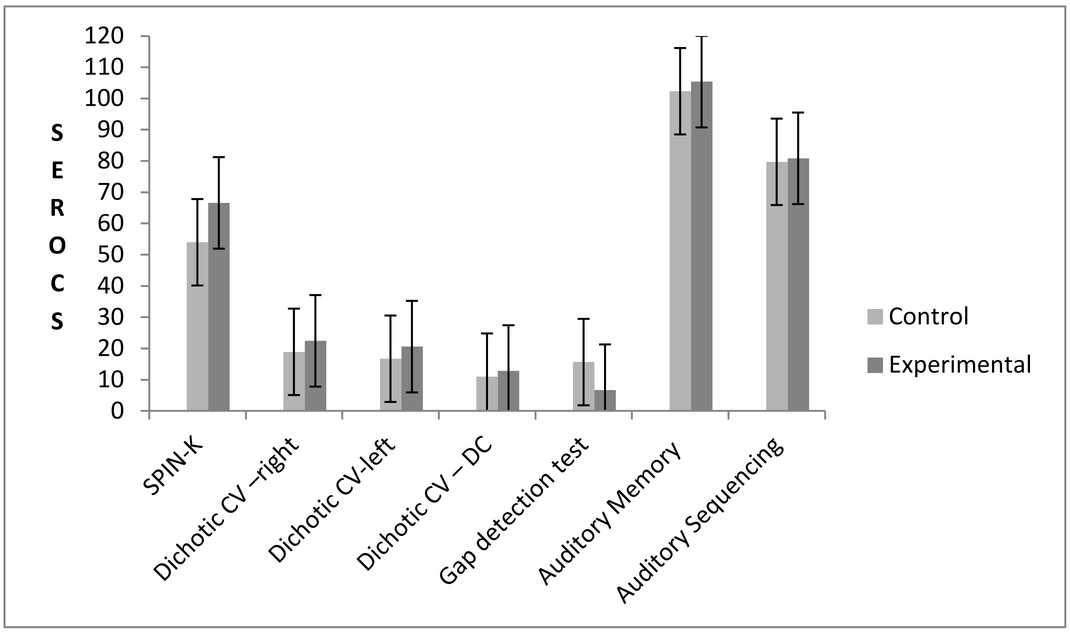

Figure 1: Mean (M) and Standard Deviation (SD) of SPIN-K, DCV (right, left & both), GDT and auditory memory and sequencing of control (Non yoga practitioners) and experimental (Yoga practitioners) groups.

From Table 1 and Figure 1, it can be seen that mean SPIN-K scores obtained were higher for experimental group compared to the control group. All the three Dichotic CV scores (right, left & double correct) were also observed to be higher in the experimental group than control group. Both the groups followed a trend of having highest scores for right ear followed by left ear and least double correct scores.

In the experimental group, the mean GDT score obtained were smaller compared to control group, which means individuals who practiced Yoga were able to detect smaller gaps in the stimuli. The mean auditory memory scores were also higher in the experimental group, which indicates that individuals who practice yoga were able to store the information better in mind and recall the same later compared to control group who had not practiced yoga. This indicates that individuals who practiced yoga had better listening, attending and recalling skills. However, in sequencing task both the groups performed almost similar but experimental group showed slightly better performance but it was noted to be very marginal.

4.1.2 Comparison of auditory processing abilities between groups (Experimental & Control).

As the data was normality distributed, parametric test was carried out for further analysis. Independent sample t-test was administered to compare the scores of SPIN-K, DCV (right, left & double correct), GDT and auditory memory and sequencing test of individuals in both the groups. This was done to examine the significant effect of yoga on auditory processing abilities between the groups. The results of Independent sample t-test obtained for SPIN-K, DCV, GDT and auditory memory and sequencing test are given in Table 2.

Table 2: Results of independent sample t-test (t value & significance level) comparing two groups for SPIN-K, DCV (right, left & double correct), GDT and auditory memory and sequencing test.

Test to assess processing abilities	**T value**	***p* value**
Speech In Noise-Kannada	8.13	0.00**

Dichotic CV-Right	-5.63	0.00**
Dichotic CV-Left	-6.67	0.00**
Dichotic CV-Double correct	-3.10	0.00**
Gap detection threshold	11.323	0.00**
Auditory Memory	-2.937	0.00**
Auditory Sequencing	-1.375	0.18

*Note: p=Level of significance, **p < 0.01 indicates significant difference.*

From the results shown in Table 2, it can be observed that there was a significant difference noted between the groups for various auditory processing abilities: there was a significant difference noted between the groups for SPIN-K scores (combined) [t(28)=8.13.; p,<0.01)]; DCV right ear scores [t(28)=-5.63; p,<0.01]; DCV left ear scores [t(28)=-6.67; p,<0.01]; DCV both ear scores [t(28)=-3.10; p,<0.01]; GDT (combined) [t(28)=11.32; p,<0.01]; and auditory memory scores [t(28)=-2.93; p,<0.01]. However, there was no significant difference noted between the groups for auditory sequencing scores [t(28)=-1.37; p>0.05].

From the above results, it can be observed that the SPIN-K scores were higher in the older adult group who practiced yoga regularly, i.e., their auditory closure abilities were good which indicates better speech understanding ability in presence of noise. The binaural integration abilities were good in individuals who practiced yoga regularly and hence they were able to fuse the different stimuli presented to each ear separately. In addition, the GDT were better i.e., individuals who practice yoga regularly were able to detect the smallest gap. Hence, their temporal resolution abilities were noted to be good which will aid in better speech discrimination abilities. The Auditory memory skills were also noted to be significantly higher in experimental group compared to control group.

Chapter 5

Discussion

The results of the present study reveals that the auditory processing abilities of older individuals who practice yoga regularly were significantly better when compared to their age matched counterparts who do not practice yoga. It is widely reported in the literature that as age progress there is a general decline in the performance of auditory abilities along with other general physiological aspects. However, there is a general decline in auditory capacities with increase in age, which is considered to be within the allowable normal limits.

There are number of researches carried out to find the effects of yoga on various physiological function and has revealed that Yoga has an effect on overall physiological aspects'. However, its effect on auditory processing abilities is not studied. Hence, the present study aimed to study the effect of yoga on auditory processing abilities in older adults who practice Yoga. Various auditory processing abilities such as auditory closure, binaural integration, temporal resolution, auditory memory & sequencing abilities were assessed using SPIN-K, Dichotic CV, GDT, auditory memory and sequencing test respectively. As the data was normally distributed, parametric test was used to find if there was any significant difference found in auditory processing abilities between the experimental and control groups.

The results of the present study on measures of various auditory processing abilities (auditory closure, binaural integration, temporal resolution and auditory memory & sequencing) reveals that individuals who practice yoga regularly have better auditory processing abilities. This was evident for all the auditory processing skills that were considered. That is individuals who practiced Yoga regularly obtained higher SPIN- K scores compared to individuals who did not practice Yoga. The temporal resolution abilities were noted to be better in individuals who perform yoga as this was evidenced through smaller gap detection threshold obtained in individuals who practice yoga regularly. In addition, auditory memory skills were found to be better in experimental group. However, both the groups did not differ significantly on auditory sequencing task, even though the mean auditory sequencing scores were found to be slightly better in the experimental group.

The current study supports the positive effects of yoga on human physiological function. It has been reported in the literature that individuals performing Yoga has improved functioning of cardiovascular system (Raub, 2002), Yoga is found to have positive effect on working memory, attention, cognitive function, verbal fluency and executive function in older adults (Hariprasad et al. 2013). Yoga is found to reduce reaction time for sensory stimulus (auditory & visual) due to the increased neural firing and synchrony (Alathi & Parulkar, 1989; Madanmohan, 1992).

Attention, working memory, cognitive function is found to influence an individual's auditory processing abilities (auditory closure, binaural integration, temporal resolution abilities & auditory memory). It has been known from the literature that yoga has a positive effect on memory, attention, cognitive and executive function (Hariprasad et al. 2013; Gothe, Pontifex, Hillman & McAuley, 2014; Gothe, Keswani & McAuley, 2016). Attention, memory and cognitive functions are also important for better auditory processing abilities. As the yoga is found to have positive effects on an individual's attention, memory and cognition, it would have also influenced in improving auditory processing skills of the individuals considered in the present study.

Hence, in the current study it has been evidenced that individuals who practice yoga regularly have shown an improved performance on most of the auditory processing skills compared to individuals who had not practiced yoga. Yoga is also found to have positive effect on an individual’s mental health and has benefited individuals with depression (Pilkington, Kirkwood, Rampes and Richardson, 2005 & Uebelacker et al. 2010).

Along with having positive effects on general body and mind functioning, yoga is also found to have a positive effect on inner ear physiology in adults. Yoga is found to have shown a significant improvement in amplitude and latency of cVEMP (Tejaswini, Shubhaganga, Prashanth, 2017). It has also been reported that amount of suppression (TEOAE & DPOAE’s) increases in individuals who practice Yoga compared non Yoga practisers (Kumar, Shambhu, Prabhu, 2017). The results of this study supports of current research findings i.e., practicing of yoga regularly is found to increase the speech perception abilities and auditory memory skills. This could be due to the fact that practice of yoga is found to strengthen the efferent auditory system and activation of efferent pathway is found to improve speech perception abilities in presence of noise (Girand et al. 1997).

There are no studies reported in literature about the effect of Yoga on individual’s auditory processing skills. From the literature, it has been evidenced that along with having an effect on general physiological function like respiration, cardiovascular system

Yoga is also found to improve performance in cognitive function, attention, reaction time, memory, attention, cognitive function and inner ear physiology. This indicates the overall improvement in functioning abilities of central nervous system and the physiology of inner ear. Hence, these improvements would have resulted in improving the auditory processing abilities and has been evidenced from the current study.

Chapter 6

SUMMARY AND CONCLUTION.

Yoga is a traditional physical and mental disciplines originated in India. The word is derived from the Sanskrit meaning to control, to yoke or to unite. The goal of yoga is unity of the body, mind and spirit with the focus on body posture, breathing and meditation. Practicing yoga has been found to have an effect both mental and physical manifestations in humans. Positive effects of yoga on muscular, respiratory, nervous, cardio and circulatory systems, regulation of metabolism, weight reduction, improvement in athletic performance, protection from injury are some of the well reported and documented benefits of yoga in literature.

Apart from improving physical and mental aspects, yoga is found to have an effect on inner ear functioning. The positive effects of yoga on suppression of OAEs and VEMP have been reported in the literature (Kumar, Shambhu, Prabhu, 2017; Tejaswini, Shubhaganga, Prashanth, 2017). Also, Hariprasad et al. (2013) has found that performing yoga showed a significant improvement in immediate and delayed recall of verbal and visual memory along with other domains such as working memory, attention, verbal fluency and executive function in older adults. From this reports, it can be concluded that yoga has significant effect on functioning of the cochlea, development and functioning of nervous system which in turn improves attention, working memory and executive function. Thus it is assumed that, these factors could result in improved auditory processing performance in older adults. Hence the current study has been planned to measure the impact of yoga on different auditory processing abilities.

A total of 30 number of participants, age ranged between 50 to 65 were enrolled for the study and divided to two groups; Group I consisted of experimental group that included individuals who have practiced yoga regularly for a minimum of at least 2 years and Group II consisted of control group that included individuals who have no exposure to yoga. Age related decline in cognition and auditory thresholds was ruled out using the Kannada version MMSE, given by Folstein (1978). The presence of middle ear pathology, degenerative neural condition, speech understanding problem, smoking and drinking habits was also ruled out.

All the participants were assessed on four different auditory processing abilities using four different tests. Auditory separation, binaural integration, temporal resolution and auditory memory and sequencing abilities were tested using Speech in noise test in Kannada (SPIN-K) developed by Vaidyanath and Yathiraj (2012), Yathiraj (1999), Shivaprakash and Manjula (2003) and Auditory memory and sequencing test developed by Yathiraj and Vijayalakshmi (2006) respectively. These tests were employed to determine the auditory processing abilities of the two groups. These tests were administered using CD version of the stimuli that were presented through a computer the output of which was routed to a calibrated diagnostic audiometer. The test stimuli were heard by the participants through headphone.

6.1 The results highlighted the following:

- Individuals who practice yoga regularly had a high mean scores in all auditory processing aspects like speech perception in noise, binaural integration, temporal resolution, memory and sequencing.
- The mean SPIN-K scores obtained were higher for experimental group compared to the control group, indicating better speech perception in noise by the experimental group.
- All three Dichotic CV scores (right, left & combined) were also observed to be higher in experimental group than control group. Both the groups followed a trend of having highest scores for right ear followed by left ear and least double correct scores.

- In experimental group, the mean GDT score is smaller compared to control group, which means individuals who practiced Yoga were able to detect smaller gaps in the stimuli
- The mean auditory memory scores were also higher in the experimental group, which indicates that individuals who practice yoga were able to store the information better in mind and recall the same later compared to control group who had not practiced yoga. This indicates that individuals who practiced yoga had better listening, attending and recalling skills. However, in sequencing task both the groups performed almost similar but experimental group showed higher performance but it was marginal.

6.2 Implications

The findings of the study can be used to:

- Understand the effect of yoga on auditory processing abilities.
- Appreciate the positive effects of yoga in older adultgroup.
- Infer an insight about therapeutic approach while dealing with individuals having auditory processing difficulties.

As a treatment option in age related degenerated cases such as presbyacusis, dementia.

REFERENCE

American Speech-Language-Hearing Association. (2005). (Central) auditory processing disorders. [Technical Report]. doi:10.1044/policy.TR2005-00043

American National Standards Institute. (S3.1-1999). American National Standards for Maximum Permissible Ambient Noise Levels for audiometric test room. (ANSI S3.1 - 1999). *New York: American National Standards Institute*.

Bellis, T. J. (2003). Assessment and Management of centrsl suditory processing disorder in the educational setting: From sceience to practice,(2nd ed.), Delmar learning.

Borod, J.C., & Goodglass, H. (1980). *Aging and the perception of speech.* Baltimone: University Park Press.

Brant, L.J., & Fozard, J.L. (1990). Age change in pure tone hearing thresholds in a longitudinal study of normal human aging. *Journal of Acoustical Scociety of America, 88,813-820.*

Cruickshanks, K. J., Wiley, T.L., Tweed, T.S, Klein, B.E., Mares-Perlam, J.A., & Nondahl, D.M (1998). Prevalence of hearing loss in older adults in beaver dam, wiscons in: The epidemiology od hearing loss study. *American journal of Epidemiology, 148(9) 879-886.*

Calais, L.L., & Ruso, I.C.(2008). Performance of elderly in a speech in noise test, *Pro Fon, 20(3),147-53.*

Chermak, G.D., & Musiek, F.E (1997). *Central auditory processing: New perspectives singular publishing Group.*

Carhart, R., & Jerger, J. (1959). Preferred method of clinical determination of puretone threshold. . *Journal of Speech & Hearing Disoders*, *24*, 330-345. doi:10.1044/jshd.2404.330.

Desai, R., Tailor, A., & Bhatt, T. (2015). Effects of yoga on brain waves and structural activation: A review. *Complementary therapies in clinical practice*, *21*(2), 112-118.

de Oliveira, G., Fernandes, M. D. C. C. G., de Faria Oliveira, J. D., Rodrigues, M. R., & Santaella, D. F. (2016). Yoga training has positive effects on postural balance and its influence on activities of daily living in people with multiple sclerosis: a pilot study. *EXPLORE*, *12*(5), 325-332.

Dubno, J.R., Lee, F.S., Matthews, L., Ahlstrom, J.B., Horwitz, A.R., & Mills, J.H. (2008). Logitiudinal changes in speech recognition in older persons. *Journal of Acoustical Scociety of America, 123(1), 462-475.*

Dubno, J.R., Lee, F.S., Matthews, L. & Mills, J. (1997). Age-related and gender-related changes in monaural speech recognition. *Journal Of Speech Language And Hearing Research, 40.444-452.*

Divenyi, P.L., Stark, P.B., & Haupt, K.M. (2005). Decline of speech understanding and auditory thresholds in the elderly. *Journal of Acoustical Scociety of America, 118, 1089-1100.*

Dubno, J.R., Lee, F.S., Matthews, L., Ahlstrom, J.B., Horwitz, A.R., & Mills, J.H. (2008). Logitiudinal changes in speech recognition in older persons. *Journal of Acoustical Scociety of America, 123(1), 462-475.*

Dubno, J.R., Lee, F.S., Matthews, L. & Mills, J. (1997). Age-related and gender-related changes in monaural speech recognition. *Journal Of Speech Language And Hearing Research, 40.444-452.*

Divenyi, P.L., Stark, P.B., & Haupt, K.M. (2005). Decline of speech understanding and auditory thresholds in the elderly. *Journal of Acoustical Scociety of America, 118, 1089-1100.*

Ethical guidelines for Bio-Behavioural Research Involving Human Subjets. (2009). Mysore, India: All India Institute of Speech and Hearing.

Fabry, D.A., & Van Tasell, D.J (1986). Masked and filtered simulation of hearinh loss: effects on consonants recognition. *Journal of speech language and hearing research, 29, 170-178.*

Gauchard, G. C., Jeandel, C., & Perrin, P. P. (2001). Physical and sporting activities improve vestibular afferent usage and balance in elderly human subjects. *Gerontology*, *47*(5), 263-270.

Goncales, A.s., & Cury, M.C.(2011). Assessment of two central auditory tests in elderly patients without hearing complaints. *Brazilian Journal of otorhinolaryngology,77(1), 24-32.*

Hariprasad, V. R., Koparde, V., Sivakumar, P. T., Varambally, S., Thirthalli, J., Varghese, M., ... & Gangadhar, B. N. (2013). Randomized clinical trial of yoga-based intervention in residents from elderly homes: Effects on cognitive function. *Indian journal of psychiatry*, *55*(Suppl 3), S357.

Halling, D.C., & Humes, L.E. (2000). Factors affecting the recognition of reverberant speech by elderly listerns. *Journal of speech language and hearing research 43, 414 - 431.*

Humes, L.E., & Roberts, L. (1990). Speecg-recognition difficulties of the hearing-impaired elderly: The contributions of audibility. *Journal Of Speech Language And Hearing Research,33, 726-735.*

Humes, L.E., & Christopherson, L. (1991). Speech identification difficulties of hearing impaired elderly persons: The contributions of auditory- processing deficits. *Journal Of Speech Language And Hearing Research,34, 686-693.*

Humes, L.E., Watson, B.U., Christensen, L.A., Cokely, C.G., Halling, D.C., & Lee, L. (1994). Factors associated with individual difference in clinical measures of speech recognition among the elderly. *Journal Of Speech Language And Hearing Research, 37, 465-474.*

Johnson, D.M., Watson, C.S., Jensen, J.K. (1987). Individuals difference in auditory capabilities. *Journal of Acoustical Scociety of America, 81,427-438.*

Jerger J., & Hayes, D. (1977). Diagnostic speech audiometry. Archives of otolaryngology, 13(4), 272-77.

Keith, R.W.(2000). *Random gap detection test [CD]*.St Louis: MO:AUDiTEC.

Katz, J. (1962). The use of Staggered Spondaic Words for assessing the integrity of the central auditory nervous system. *Journal of Auditory Research, 2*, 327-337.

Kumar, S. D., Shambhu, T., & Prabhu, P. (2017). Effect of practicing yoga on functioning of efferent auditory system. *Indian Journal of Otology*, *23*(4), 230.

Madan, M., Thombre, D. P., Bharathi, B., Nambinarayan, T. K., Thakur, S., Krishnamurthy, N., & Chandrabose, A. (1992). Effects of yoga training on reaction time, respiratory endurance and muscle strength. *Indian J Physiol Pharmacol*, *36*(4), 229-233.

Malathi, A., & Parulkar, V. G. (1989). Effect of yogasanas on the visual and auditory reaction time. *Indian J Physiol Pharmacol*, *33*(2), 110-112.

Mythri, H.M. (2012). Age related changes in auditory memory and sequencing. *Unpublished masters dissertation in part-fulfilment for the master's degree in speech and hearing, university of Mysore, Mysore* .

Musick, F., & Pinheiro, M.L. (1985). Dichotic speech test in the detection of central auditory dysfunction. *Assessment of central auditory dysfunction: Foundations and Clinical correlates*(pp.201-219). Baltimore: Williams and Wilkins.

Mody, M., Studdert-Kennedy, M., & Brady, S. (1997). Speech perception deficits in poor readers: Auditory processing or phonological coding? *Journal of Experimental Child Psychology, 64*(2), 199-231. doi:10.1111/j.1467-9817.2006.00286

Musiek, F. E. (1983). Assessment of central auditory dysfunction: The dichotic digit test revisited. *Ear and Hearing, 4*(2), 79-83.

Musiek, F. E., Baran, J. A., & Pinheiro, M. (1990). Duration pattern recognition in normal subjects and in patients with cerebral and cochlear lesions. *Audiology, 29*(6), 304-313.

Nam, M. R., Kim, Y. H., Ahn, O. H., & Yang, B. S. (2007). The Effects of a Low Intensity Excercise Program on Psychosocial Factors of Excercise and Physical Factors in Elderly Women. *Journal of Korean Academy of Community Health Nursing*, *18*(3), 373-381.

Pilkington, K., Kirkwood, G., Rampes, H., & Richardson, J. (2005). Yoga for depression: the research evidence. *Journal of affective disorders*, *89*(1-3), 13-24.

Person,J.D., Morrell, C.H., Gordon-salant, S., Brant, L.j., Metter, E.J., Klein, L.L., & Fozard, J.L (1995). Gender difference in a longitudinal study of age associated hearing loss. *Journal of Acoustical Scociety of America, 97(2), 1196- 1205.*

Prado, E. T., Raso, V., Scharlach, R. C., & Kasse, C. A. (2014). Hatha yoga on body balance. *International journal of yoga*, *7*(2), 133.

Raub, J. A. (2002). Psychophysiologic effects of Hatha Yoga on musculoskeletal and cardiopulmonary function: a literature review. *The Journal of Alternative & Complementary Medicine*, *8*(6), 797-812.

Roland, K. P., Jakobi, J. M., & Jones, G. R. (2011). Does yoga engender fitness in older adults? A critical review. *Journal of aging and physical activity*, *19*(1), 62-79.

Roberts, R., &Lister, J. (2004). Effects of age and hearing loss on gap detection and the precedence effect: Broadband stimuli. *Journal of speech, Language and Hearing Research, 47,965-978.*

Rodriguez, G.P,Disarno, N.J & Hardiman,C.J (1990). *Central auditory processing in nirmal hearing elderlt adults. Audilogy*, 29, 85-92.

Snell, K.B., & Frisina, D.R. (2000). Relationships among age- related difference in gap detection and word recognition, *Journal of Acoustical Scociety of America*, 107, 1615-1626.

Smith, Y. S., & Bhatara, A. (2012). Laterality of basic auditory perception. *Laterality:Asymmeteris of body, Brain and Cognition,* 17(2), 129-149.

Sarang, S. P., & Telles, S. (2007). Immediate effect of two yoga-based relaxation techniques on performance in a letter-cancellation task. *Perceptual and Motor Skills*, *105*(2), 379-385.

Sarda, S., Bhat, S., & Vanaja, C. S. (2014). Variation in the gaze, caloric test and vestibular-evoked myogenic potential with advancing age. *Indian Journal of Otology*, *20*(1), 4.

Shambhu, T., Kumar, S. D., & Prabhu, P. (2017). Effect of practicing yoga on cervical vestibular evoked myogenic potential. *European Archives of Oto-Rhino Laryngology*, *274*(10), 3811-3815.

Moore,B., Peters, R., & Glasberg, B. (1992). Detection of temporal gaps in sinusoids by elderly subjects with and without hearing loss. *Journal of Acoustical Scociety of America*, 92, 1923-1932.

Sandeep Mohan, 2013. Central auditory processing abilities in older individuals. *Unpublished masters dissertation in part-fulfilment for the master's degree in speech and hearing, university of Mysore, Mysore.*

Singh, N. K., Kashyap, R. S., Supreetha, L., & Sahana, V. (2014). Characterization of age-related changes in sacculocolic response parameters assessed by cervical vestibular evoked myogenic potentials. *European Archives of Oto-Rhino-Laryngology, 271*(7), 1869-1877.

Sarang, P., & Telles, S. (2006). Effects of two yoga based relaxation techniques on heart rate variability (HRV). *International Journal of Stress Management*, *13*(4), 460.

TELLES, S., Praghuraj, P., GHOSH, A., & Nagendra, H. (2006). SHORT COMMUNICATION EFFECT OF A ONE-MONTH YOGA TRAINING PROGRAM ON PERFORMANCE IN A MIRROR-TRACING TASK. *Indian J Physiol Pharmacol*, *50*(2), 187-190.

The Art and Science of Raja Yoga, Swami Kriyananda, 2017.

Ülger, Ö., & Yağlı, N. V. (2011). Effects of yoga on balance and gait properties in women with musculoskeletal problems: a pilot study. *Complementary therapies in clinical practice, 17*(1), 13-15.

Uebelacker, L. A., Epstein-Lubow, G., Gaudiano, B. A., Tremont, G., Battle, C. L., & Miller, I. W. (2010). Hatha yoga for depression: critical review of the evidence for efficacy, plausible mechanisms of action, and directions for future research. *Journal of Psychiatric Practice®, 16*(1), 22-33.

Van Rooij, J.C &Plomp,R.(1992). Auditive and cognitive factors in speech perception by elderly listeners. *Journal of acoustical society of American, 91(2), 1028-33.*

Versfeld, N.J., & Dreschler, W. A. (2002). The relationship bwteen the intelligibility of time- compressed speech and speech noise in young and elderly listeners. *Journal of Acoustical Scociety of America.* 111, 401-408.

Vempati, R., Bijlani, R. L., & Deepak, K. K. (2009). The efficacy of a comprehensive lifestyle modification programme based on yoga in the management of bronchial asthma: a randomized controlled trial. *BMC pulmonary medicine, 9*(1), 37.

Vaidyanath, R., & Yathiraj, A. (2012). Speech-in-Noise test in Kannda: Material Developed at the All India Institute of Speech and Hearing, Mysuru.

Yathiraj, A. (1999). The Dichotic CV test. Developed at the department of Audiology. All India Institute of Speech and Hearing. Mysore.

Yathiraj, A., & Vijayalakshmi, C. (2005). Phonemicall balanced word identification test in Kannada. *Developed in the Department of Audiology, AIISH, Mysore*.

Yathiraj, A., & Vijayalakshmi, C. (2006). *Kannada auditory memory and sequencing test.* (AIISH research fund project), All India Institute of Speech and Hearing, Mysore. Retrieved from http:/192.168.100.20:8080/digitallibrary/HomeAdvanveResult.do.

Yoga journal ; 2007.

Zeng, F. G., Lehmann, K. M., Soli, S. D., & Linthicum, F. H. (1994). Effects of vestibular neurectomy on intensity discrimination and speech perception in noise. *The Journal of the Acoustical Society of America, 95*(5), 2993-2994.

Zurek, P.M., & Delhorne, L.A (1987). Consonant reception in noise by listeners with mild and moderate sensorineural hearing impairment. *Journal of Acoustical Scociety of America, 82, 1548-1559.*