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Normative Voice Data On Selected Parameters For Young Adults Using VISI PITCH IV

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Abstract: The purpose of the present study is to obtain and compare the normative values of Relative Average Perturbation (RAP), Noise to Harmonic Ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI) in young adults. For this purpose, 200 individuals were taken and divided into two groups, group 1 young males (18-40 years) and group 2 young females (18-40 years). Each of the groups consisted of 100 participants. MDVP software module under VISI PITCH IV was used. Results indicated that the VTI is the only parameter which has not shown significant difference with respect to gender. It can be concluded that there is vast difference between the western norms given in the MDVP manual and the Indian norms established in the present study for the four MDVP parameters which are RAP, NHR, SPI and VTI.

Index Terms: MDVP, Norms, NHR, RAP, SPI, VTI, VISI PITCH IV.

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1. INTRODUCTION

Voice is one of the most unique characteristic of any individual. It defines the personality of the individual. According to ‘’Sataloff [1]’’ the loss of voice quality and strength is often seen as a result of physical deterioration, but may in fact be a biological precursor for various pathologies. ‘’Aronson [2]’’ reported that voice disorder exists when quality, pitch, loudness, and flexibility of a person’s voice differs from the voices of others of similar age, gender and cultural group.

‘’Boone et al. [3]’’ stated that due to advances in technology and an increase in affordability of equipment, objective acoustic measurements of voice have been increasingly used in clinical and research pursuits in an effort to analyse the voice and account for vocal changing mechanism conditions. ‘’ Stemple, Glaze and Klaben [4]’’ reported that for acoustic measurements to be valid, they must be able to discriminate the normal from perceptual judgements of the voice, and be sufficiently stable to assess change across time. VISI PITCH is one of the instruments used for the dysphonic voice, correlate positively with the clinician’s auditory- acoustic assessment and management of voice disorders. Visi-Pitch IV (Model 3950B; KayPENTAX Corp., Montvale, New Jersey) is a widely used clinical instrument for measuring habitual pitch and loudness, frequency and intensity variability, and MPFR (Maximum Phonational Frequency Range) and dynamic range, among other things. Visi Pitch has many models and also it is readily available and easy to use. Multi-Dimensional Voice Program (MDVP) is a software module under Visi-Pitch. ‘’Kent et al. [5]’’ reported that Multi-Dimensional Voice Profile (MDVP) is a well-established software program used for quantitative acoustic signal assessment of voice quality. According to Visi Pitch IV KayPENTAX manual, MDVP can analyse 33 quantitative voice parameters. Out of these 33 parameters, Relative Average Perturbation (RAP) and noise parameters like Noise to Harmonic Ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI) have important clinical utility in assessing dysphonic voice which has not been studied extensively [6].

Relative Average Perturbation (RAP) is a measure that evaluates the variability of the pitch period at smoothing factor 3 periods. Noise to Harmonic Ratio (NHR) is a ratio of inharmonic energy in 70-4200Hz range to harmonic spectral energy in 70-4200Hz range. NHR is useful for quantifying the amount of noise in the signal [6]. ‘’Gejo [7]’’ stated that Soft Phonation Index (SPI) is an indicator of vocal fold adduction. ‘’Koreman and Pützer [8]’’ compared the Electroglottography (EGG) and acoustic voice findings between normal speakers and speakers with unilateral vocal fold paralysis and cordectomy by using vowels /a:/, /i:/ and /u:/ as stimulus and reported that SPI is a better indicator of breathiness in voice than EGG. Voice Turbulence Index (VTI) measures the relative energy level of the high frequency noise in the voice signal. It correlates with the turbulence components caused by incomplete or loose adduction of the vocal folds [6]. Past studies on healthy adults are done on small numbers of participants which ranged from sample size of 4-6 to 20 per age and gender group which may have rendered findings prone to sampling biases [9],[10],[11].

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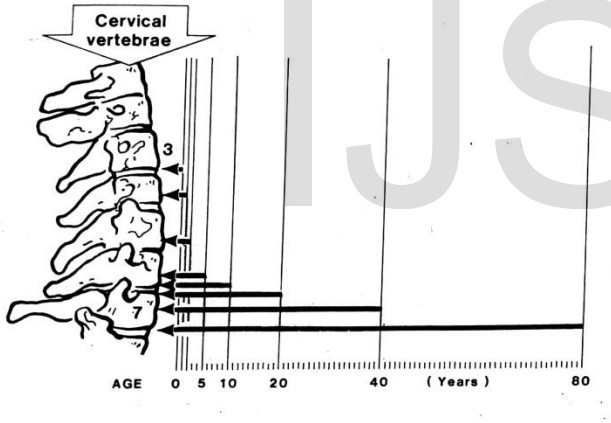
1.1 Critical Periods of vocal change

The acoustic output of the vocal tract is closely associated with underlying physiological mechanisms, and it forms a bridge to human speech perception ″[12], [13]''. ''Aronson [2]'' stated that by the third month of fetal life the larynx has the same features as recognizable at the birth for both the gender. However, only gross vertical movements of the larynx are possible during the neonatal cry. At birth, the neonate's larynx occupies a position higher in the neck, relative to the skull, than at any other time in life. Almost immediately after birth, it begins its descent in the neck. Figure 1, [14] shows that at birth the lower border of the cricoid cartilage is level between cervical vertebrae three and four (C3 and C4). By age five, the larynx has descended almost to the level of C7. Between ages 15 and 20, it remains at C7. After that, it continues to descend throughout life.

Figure 1: Vertical descent of the larynx during life. Shows relationship of lower border of cricoid cartilage to cervical vertebrae at various ages.



(Taken from Wind J [14])

At birth the thyroid is contiguous with the hyoid bone. The laryngeal skeleton then separates in a craniocaudal direction. The infant's epiglottis is bulky at this stage when seen superiorly. Together with the aryepiglottic folds, it is omega-shaped and lies over the dorsum of the tongue. The configuration of the alae of the thyroid cartilage changes from a rounded shield during fetal life to an angle of about 110 degrees in the male and 120 degrees in the females at birth. During puberty, the angle in the male thyroid alae narrows to 90 degrees, whereas in the female it remains the same. Ossification of the hyoid begins by age two years; the thyroid followed by the cricoid cartilage ossifies between ages 20 and 23 years; and the arytenoid cartilages ossify in the late 30s. By age 65 years, all the laryngeal cartilages except the cuneiforms and corniculates have ossified. [2]

The changes in the anatomy of larynx differ with respect to age and gender. So, the acoustic voice parameters will also differ with respect to age and gender.

1.2 Acoustic changes related to voice throughout the life span

Life begins with a voice fundamental frequency 300 to 400 Hz and no difference has been found between male and female voices from birth until puberty with respect to the measures of average fundamental frequency and frequency range. Pitch distinction between male and female begins during puberty and continues throughout adolescence. These voice changes are the result of the appearance and development of the secondary sex characteristics during puberty. The pitch and quality changes that occur at puberty are much more apparent in males than in females because of the greater magnitude of the pitch drop.

1.3 Vocal Perturbation Measures

Vocal perturbation is the cycle to cycle variability in the vocal signal. A small amount of cycle–to-cycle variability is expected in the normal voice. It results from aperiodic vibration of the vocal folds. Vocal perturbation is aimed at identifying the short term, cycle to cycle non-volitional variability, not the longer-term, volitional word or utterance (prosodic) trends. Therefore, sustained vowels or steady-state portions of vowels extracted from connected speech are typically used to determine vocal perturbation. Two vocal perturbation measures commonly obtained are jitter and shimmer. [3]

Jitter is the short term variability in fundamental frequency, while shimmer is the short term variability in the amplitude. [3] ''Maryn et al [15]'' reported that statistically significant difference for RAP between the 2 systems which were Computerised Speech Lab (CSL) system and the PC system is present with the CSL system's RAP values were consistently higher (Mean= 1.16 SD= 0.10) than those of the PC system (Mean= 0.45 SD= 0.04). For comparison of the programs (MDVP vs Praat) statistically significant difference for RAP was found between the 2 programs [MDVP (Mean= 1.16 SD= 0.10), Praat NHR (Mean= 0.33 SD= 0.03)]. ''Oğuz, Kiliç and Şafak [16]'' reported that no statistically significant difference for NHR ($p < 0.001$) is present between Praat

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and MDVP**.** The mean value of NHR was significantly higher with MDVP (Mean= 0.144SD= 0.050) than with Praat (Mean= 0.028 SD= 0.045). Hence, the results regarding norms of different parameters with respect to different instruments are inconclusive.

''Brockmann, Bauser and Drinnan [17]'' stated that standardization is almost non-existent when it comes to vocal perturbation measures which make them potentially less clinically useful, particularly when comparing research results across sites, clinicians, and various equipment manufacturers. ''Behrman [18]'' stated that because a coherent database of normative vocal perturbation values does not exist, vocal perturbation cannot be used to differentiate reliably between normal and abnormal voice. ''Titze [19]'' stated that a jitter of less than 1.0% and shimmer of less than 0.5 dB are considered normal.

Frequency Perturbation (Jitter)

Frequency (or period) perturbation, commonly called jitter, is the variability of the fundamental frequency or, reciprocally, of the fundamental period. When measured during running speech, variability is reflected in pitch sigma. Jitter measurements, however, are concerned with short term variation i.e. jitter is a measurement of how much a given period differs from the period that immediately follows it, and not how much it differs from a cycle at the other end of the utterance. Jitter, then, is a measure of the frequency variability not accounted for by voluntary changes in fundamental frequency. ''Sorensen, Horii and Leonard [20]'' stated that perturbation resulted from diminished control over the phonatory system.

Relative Average Perturbation

Changes of fundamental frequency are of two types, the ones that are relatively slow and steady that increases or decreases and the other that are abrupt and rapid, quasi-random shifts. In most cases the first ones are related to linguistic variables and hence are volitional. They are best evaluated by measures such as pitch sigma. Whereas, the sudden, involuntary changes are perturbational. In running speech, the two types of fundamental frequency modulation occur simultaneously.

1.4 Vocal Noise Measures

The human voice is not a pure tone [3]. That is, it is made up of harmonic (periodic) and inharmonic (aperiodic) components. This is because vocal fold vibration is naturally aperiodic (irregular). In a voice with normal voice quality, the harmonic components should dominate, that is, have more energy (as measured in dB). In the dysphonic voice, the harmonic component is less dominant. In attempting to quantify the relationship between the harmonic and inharmonic components, researchers have proposed three ratios; the harmonics- to-noise ratio (HNR), the noise-to-harmonics ratio (NHR) and the signal-to-noise ratio (SNR). Signal to noise ratio (SNR) and harmonics to noise ratio (HNR) are useful for quantifying the amount of noise in the voicing signal [21], [22], [23]. The voice with normal quality is characterised by a high HNR or SNR and low NHR, whereas the dysphonic voice is characterized by a low HNR or SNR and a high NHR.

2. AIMS AND OBJECTIVES

2.1 Aims of the study:

The present study aims at:

To obtain and compare the normative values of Relative Average Perturbation (RAP), Noise to Harmonic Ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI) in young adults.

2.2 Objectives of the study:

1. To obtain and compare the normative values for Relative Average Perturbation (RAP) for the young adults.
2. To obtain and compare the normative values for Noise to Harmonic Ratio (NHR) for the young adults.
3. To obtain and compare the normative values for Soft Phonation Index (SPI) for the young adults.
4. To obtain and compare the normative values for Voice Turbulence Index (VTI) for the young adults.

2.3 Operational definition:

YOUNG ADULT: is a person in the age range from 18 to 40 years. [24]

2.4 Research Question:

1. Do normative voice values of RAP of young adult males differ from young adult females?
2. Do normative voice values of NHR of young adult males differ from young adult females?
3. Do normative voice values of SPI of young adult males differ from young adult females?
4. Do normative voice values of VTI of young adult males differ from young adult females?

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3. METHODOLOGY

The aim of the present study was to obtain and compare the normative values of Relative Average Perturbation (RAP), Noise to Harmonic ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI) in young adults.

This chapter describes the nature of the sample chosen, the tools and the equipment used, the procedure in depth and the methods used for the statistical analysis of the data obtained.

3.1 Research Design:

The study used an Exploratory design with Convenient sampling.

3.2 Participants:

The sample consisted of 200 individuals which are further divided into two groups with 100 individuals in each group.

Group 1: Young adult males (YM) with age range between 18-40 years (n=100).
Group 2: Young adult females (YF) with age range between 18-40 years (n=100).

3.3 Setting (location of the study):

The study was done in Mumbai (Maharashtra)

3.4 Duration of the study:

The study took 1 year to be completed.

Inclusion criteria:

Subjects within the age range 18-40years of both Gender with no voice complaints at the time of the study, with no ear related complaints**,** with no difficulty following speech at conversational level, with no history of any head and neck surgery, with no history of voice therapy or singing training, with no history of neuro-motor deficit, laryngeal pathology, psychological illness, endocrinal disorders and respiratory disorders.

Exclusion Criteria:

Subjects who have irritation and/or pain in the throat or any voice problem at the time of the study, who have cold, cough or ear related complaints at the time of the study, who works in noisy environment, who have habit of smoking, chewing pan, gutkha or tobacco on a daily basis, who are trained or untrained singers, who are pregnant or taking birth control pills or taking Hormone Replacement Therapy (HRT).

3.5 Tools

1. Case history questionnaire:

The case history questionnaire was developed in English language and was translated and validated in Hindi and Marathi languages by three individuals proficient in English, Hindi and Marathi languages, for gathering demographic data, preliminary information that was required to satisfy the selection criteria of participants for the study.

2. Sound Level Meter (SLM):

Digital Sound Level Meter Model MECO 970P was used to measure ambient noise levels in the room where the voice samples will be collected.

3. Digital recorder:

SONY Digital Recorder ICD Px333 was used for recording voice sample.

4. WavePad Audio Editing Software

NCH wave pad audio editing software was used to convert MP3 recordings of the IC Recorder ICD Px333 (SONY Corporation) digital voice recorder into wav files with sampling rates of 16 bits, 44100 Hz mono recording for saving the phonation while analysing on the MDVP software module of VISI PITCH IV.

5. Visi Pitch IV KayPENTAX Analysis System Model 3950B

Visi-Pitch IV (Model 3950B; KayPENTAX Corp., Montvale, New Jersey) is a widely used clinical instrument for measuring habitual pitch and loudness, frequency and intensity variability, and MPFR (Maximum Phonational Frequency Range) and dynamic range, among other things. The Visi-Pitch IV extracts acoustic parameters during speech production and presents these in real time, providing clients with clear, intuitive visual displays. Target vocalizations provided by a clinician can be compared to client attempts, both graphically and with auditory playback. Monitoring important speech/voice behaviours with concrete visual displays helps clients reach therapy goals more easily.

a.) MDVP Software module

MDVP is a software module under VISI PITCH IV. It has thirty-three parameters including voice quality parameters, noise parameters, etc. It is a powerful clinical and teaching tool that provides highly versatile

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information for voice assessment and therapy features including voice profile (RAP, NHR, VTI, SPI etc.).

3.6 Parameters assessed in the present study

1. Relative Average Perturbation (RAP):
RAP is the short term variability in fundamental frequency or, reciprocally of the fundamental period. RAP is a measure that evaluates the variability of the pitch period at smoothing factor 3 periods. It measures how a given period differs from the period that immediately follows it. It is useful in the evaluation of laryngeal and vocal pathology [6].

2. Noise to Harmonic Ratio (NHR):
NHR is an average ratio of energy of the inharmonic components in the range 70-4200Hz to the harmonic components in the range 70-4200Hz. It is a general evaluation of the noise presence within analysed signal in the form of amplitude and frequency variations, turbulence noise, sub harmonic components and/or voice breaks [6]. It provides objective information about the presence of roughness [25].

3. Soft Phonation Index (SPI)
SPI is the average ratio of the lower frequency harmonic energy in the range 70-1600Hz to the higher frequency harmonic energy in the range 1600-4200Hz. It is an indicator of how completely or tightly the vocal folds are adducted during phonation [7].

4. Voice Turbulence Index (VTI)
VTI is a ratio of the spectral inharmonic high frequency within the range 1800-5800Hz to the spectral harmonic energy in the range 70-4200Hz, obtained from a single 1024 point block of the signal where the influence of the frequency and amplitude variation, voice breaks and sub harmonic components are minimal [6]. VTI measures relative energy of high frequency noise. It correlates with the turbulence caused by incomplete or loose adduction of the vocal folds [7].

3.7 Procedure

1. Case history:
Prior to the initiation of procedure, the participants were explained in detail about the research study. An informed consent was taken from the clients willing to participate in the study. Participation in the study was at the discretion of the participants. Care was taken not to disturb the participant's schedule or performance for the data collection. Procedure was done in a comfortable well lit and quiet room with low background noise (less than 50dB level). The subjects were made to sit on a comfortable chair and table to fill case history questionnaire to gather all the relevant information needed to help decide whether the client can be included for the study.

2) Noise level measurement:
The ambient noise level was measured with the help of MECO 970P Digital Sound Level Meter and was found to be under 50 dB.

3) Obtaining voice samples:
The voice samples were obtained using IC Recorder ICD Px333 digital recorder. The subject was made to sit comfortably in a well-lit and quiet room with the noise level below 50 dB which was measured with the help of MECO 970P Digital Sound Level Meter. The task was first demonstrated to the subject and was asked to practice before the actual recording takes place. The microphone was held by the researcher at a mouth-to-microphone distance of 6 cm, at an angle of 45 degrees. The subjects were requested not to engage in any other activity simultaneously during voice recording that may affect the voice sample. The subject was made to perform the following task. The subjects were asked to phonate /a/ at comfortable pitch and loudness for 6 seconds. Three voice samples were taken and the best was chosen for assessment.

4) Editing:
The MP3 recordings of the were converted into '.wav' files with sampling rate of 16 bits, 44100 Hz mono recording for saving the phonation was used by the NCH WavePad Editing Software. The mid 4-second segment of the 6 second voice sample was used for analysis.

5) Parameters of Analysis:
The parameters for acoustic analysis using VISI PITCH software are:

a. Relative Average Perturbation (RAP)
b. Noise to Harmonic Ratio (NHR)
c. Voice Turbulence Index (VTI)
d. Soft Phonation Index (SPI)

3.8 Ethical Considerations:

1. An informed written consent was taken from the subject.

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2. No invasive procedure was used.

3. Data has been kept confidential throughout the study and made available to the subjects only if required.

3.9 Statistical Analysis:

For dependent variables Relative Average Perturbation (RAP), Noise to Harmonic ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI), the data set has one independent variable i.e. Gender (with two levels Males and Females). The normality check is done by Shapiro-Wilk test separately for each of the four dependent variables of each of the two groups to know whether the data comes under normal distribution or not. Then, accordingly for normal data, parametric test i.e. paired t-test and for the data which is deviated from normal, non-parametric test i.e. (Mann-Whitney U test) is used to achieve the best statistical results.

4. RESULTS

The aim of the present study was to obtain and compare the normative values of Relative Average Perturbation (RAP), Noise to Harmonic Ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI) in young adults. For this purpose, 200 individuals were taken and divided into two groups, group 1 young males (age range 18-40 years) and group 2 young females (age range 18-40 years). The data obtained was analysed with the statistics software Statistical Package for the Social Sciences (SPSS) Statistics Version 25.

4.1 NORMALITY TEST RESULTS

The normality check was done separately for the two groups for each of the four parameters by using Shapiro-Wilk test. Due to inter group variability in the distribution of population, in all sets of comparison Mann- Whitney U test was applied. The data set has one independent variables i.e. gender (males and females) and four dependent variables- Relative Average Perturbation (RAP), Noise to Harmonic Ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI).

Young Males

The result of normality check for Young Males is presented in Table 5.1. It can be seen from the Table 5.1 that the data has some deviation from normality for each of the four parameters.

Young Females

The results of normality check for Young Females is presented in Table 5.2. It can be seen from the Table 5.2 that the data is normally distributed for all the parameters except for SPI.

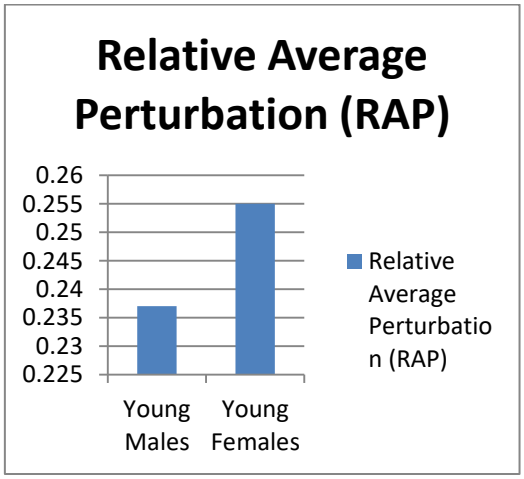
4.2 ACOUSTICAL FINDINGS

Comparison between Young Males and Young Females

Relative Average Perturbation (RAP)

The data for RAP was not normally distributed for young males but was under normal distribution for young females. Hence, non-parametric test i.e. Mann Whitney U test was applied. The descriptive statistics is presented in the Table 5.1.1. It can be seen from the Table 5.1.1 and Figure 18 that the mean of RAP values is higher for young females (0.255) than for young males (0.237). The result of Mann-Whitney U test indicated that there is significant difference between young males and young females (p= 0.013).

Figure 18: Column Chart for Comparison of Mean of RAP values between Young Males and Young Females



Noise to Harmonic Ratio (NHR)

The data for NHR was not normally distributed for young males but was under normal distribution for young females. Hence, non-parametric test i.e. Mann-Whitney U test was applied to check for statistical significance. The descriptive statistics is presented in the

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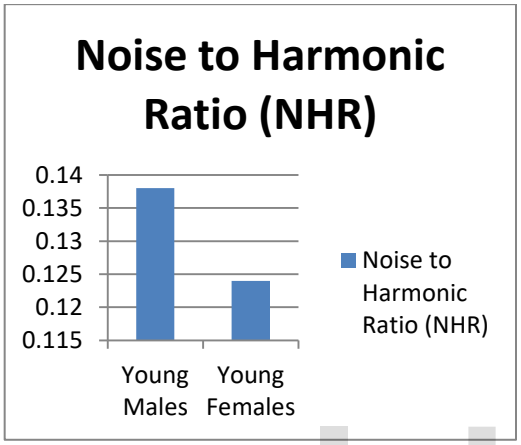
Table 5.1.1. It can be seen from the Table 5.1.1 and Figure 19 that the mean of NHR values is higher for young males (0.138) than for young females (0.124). The result of Mann-Whitney U test indicated that there is significant difference between young males and young females, p= 0.000.

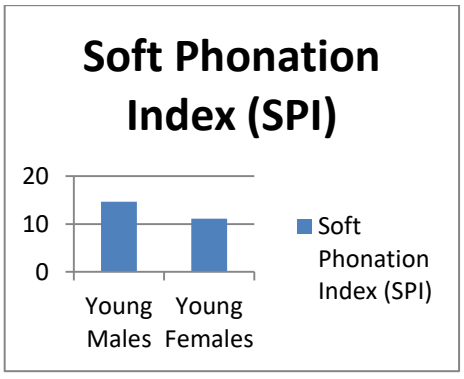
Figure 19: Column Chart for Comparison of Mean of NHR values between Young Males and Young Females



Soft Phonation Index (SPI)

The data for SPI was not normally distributed for both young males and young females. Hence, non-parametric test i.e. Mann-Whitney U test was applied to check for statistical significance. The descriptive is statistics presented in the Table 5.1.1. It can be seen from the Table 5.1.1 and Figure 20 that the mean of SPI values is higher for young males (14.635) than for young females (11.089). The result of Mann-Whitney U test indicated that there is significant difference between young males and young females, p= 0.000.

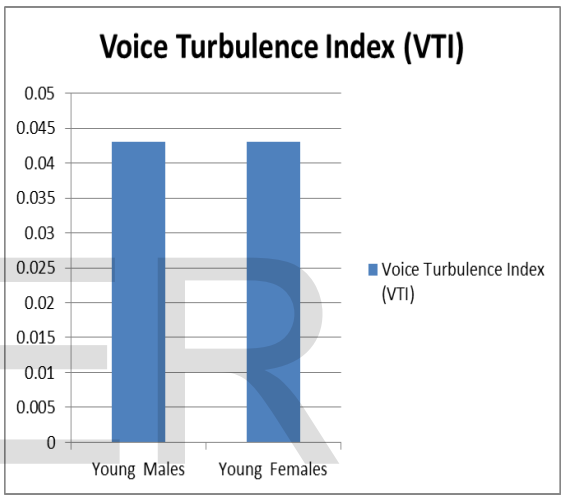
Figure 20: Column Chart for Comparison of Mean of SPI values between Young Males and Young Females



Voice Turbulence Index

The data for VTI was not normally distributed for young males but was under normal distribution for young females. Hence, non-parametric test i. e. Mann-Whitney U test was applied to check for statistical significance. The descriptive statistics presented in the Table 5.1.1. It can be seen from the Table 5.1.1 and Figure 21 that the mean of VTI values is equal for young males (0.043) and young females (0.043). The result of Mann-Whitney U test indicated that there is no significant difference between young males and young females, p= 0.629.

Figure 21: Column Chart for Comparison of Mean of VTI values between Young Males and Young Females



Therefore, from the above results it is evident that the VTI is the only parameter which has not shown significant difference with respect to gender.

5 DISCUSSION

5.1 FINDINGS OF ACOUSTICAL PARAMETERS

Comparison between Young Males and Young Females

The mean of all the four parameters i.e. Relative Average Perturbation (RAP), Noise to Harmonic Ratio (NHR), Soft Phonation Index (SPI) and Voice Turbulence Index (VTI) were obtained and compared in Young Males and Young Females.

Relative Average Perturbation (RAP)

As RAP is an indicative of short term variability in fundamental frequency or reciprocally of the fundamental period. It is useful in the evaluation of laryngeal and vocal

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pathology [6]. The mean of RAP values were obtained and found to be lower for Young Males [Mean= 0.237 (SD= 0.114)] than for Young Females [Mean= 0.255 (SD= 0.087)] which revealed that **statistically significant difference was found for RAP values between Young Males and Young Females (P= 0.013) at p= 0.05.** This indicates that there is significantly more short term variability in the fundamental frequency of Young Females in comparison to the Young Males.

Normative values of RAP for **Young Males and Young Females in the present study are lower than that given in the MDVP manual** for males [Mean= 0.345 (SD = 0.333)] and females [Mean= 0.378 (SD= 0.214)] [6]. The probable reason could be due to the difference between the Indian and Western population with respect to vocal tract (i.e. length, mass and volume). In the present study, for males standard deviation (SD) is more (0.114) in comparison to females (0.087). Also, SD for RAP in the present study [SD= 0.114 for young males and SD= 0.087 for young females] is lower than that given in the western norms [SD= 0.333 for males and SD= 0.214 for females] in MDVP manual.

The present study is in agreement with the study done by ''Hema, Mahesh and Pushpavathi [25]'' which aimed to establish normative values of RAP for young adults in Indian population and reported higher values of RAP for adult females [Mean= 0.58 (SD= 0.32)] than for adult males [Mean= 0.44 (SD= 0.21)] and the same trend is seen in the present study. However, the present study is in contrast with the study with respect to the comparison between the Indian norms with the Western norms given in MDVP manual. The study reported that the Indian norms of RAP for young males and young females were significantly higher than the western norms [with Male's Mean= 0.34 (SD= 0.21) and Female's Mean= 0.37 (SD= 0.21)] which is in contrast with the present study where the opposite trend is seen. The study gave the reason for increase in RAP measurements of their Indian norms would be due to difference in the vocal tract (length, mass and tension). The reason of contrast in the findings between their study and the present study can be attributed to the methodological differences such as small sample of 60 subjects in the study. Whereas, large sample size i.e. 200 subjects with 100 Young Males and 100 Young Females was included in the present study. Also, they have taken adult subjects of a narrow age range i.e. from 18 to 25 years. Whereas, a wide age range i.e. 18 to 40 years for young adults and 41 to 60 years for old adults is considered in the present study. Also, they have used microphone to take voice samples and placed it at a distance of 2 inches (5.8 cm) from the mouth i.e. real time analysis was performed. Whereas, SONY digital recorder was used and placed at a distance of 4cm from the mouth i.e. recorded data was analysed in the present study.

Noise to Harmonic Ratio (NHR)

NHR is a useful parameter for quantifying the amount of noise in the signal. Presence of noise in the voice signal is perceived as hoarseness. Laryngeal pathology may lead to the poor adduction of the vocal folds resulting in increased amount of random noise (hoarseness). Greater the NHR, higher will be the hoarseness [6]. The mean of NHR values were obtained and found to be higher for Young Males [Mean= 0.138 (SD= 0.019)] than that for Young Females [Mean= 0.124 (SD= 0.012)] which revealed that **statistically significant difference was found for NHR values between Young Males and Young Females (P= 0.000) at p= 0.05**. This indicates that Young Males have more random noise in their voice resulting in more hoarseness than young females.

Normative values of **NHR for Young Males and Young Females in the present study are higher than that given in the MDVP manual** for males [Mean= 0.122 (SD = 0.014)] and females [Mean= 0.112 (SD= 0.009)]. The probable reason could be due to the difference between the Indian and Western population with respect to vocal tract (length, mass and volume). In the present study, for males standard deviation is more (0.019) as comparison to females (0.012). Also, standard deviation in the present study [SD= 0.019 for young males and SD= 0.012 for young females] is higher than that in the western normative [SD= 0.014 for males and SD= 0.009 for females] given in MDVP manual.

In the present study, the mean of NHR values for Young Females is higher [Mean= 0.124 (SD= 0.012)] than that present in the control group consisted of females [Mean= 111(SD= 0.008)] in the study done by ''Lazic et al [26]''.

The present study is in agreement with the study done by ''Rowan and Gore [27]'' which reported significant higher mean of NHR values in the younger men [Mean= 0.14 (SD= 0.03)] than younger women [Mean= 0.12 (SD= 0.17)].

Soft Phonation Index (SPI)

SPI indicates the degree to which the vocal folds adduct completely or tightly during phonation. Increased value

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of SPI usually indicates loosely or incompletely adducted vocal folds during phonation. SPI is an evaluation of the weakness of the high frequency harmonic components that may be an indicator of loosely adducted vocal folds during phonation [7]. The mean of SPI values were obtained and were found to be higher for Young Males [Males= 14.635 (SD= 5.986)] than for Young Females [Mean= 11.089 (SD= 5.043)] which revealed that **statistically significant difference was present for SPI values between Young Males and Young Females (P= 0.000) at p= 0.05.** This indicates that there is more weakness of the high frequency harmonic components in Young Males than the Young Females which indicated that vocal folds of Young Females are more tightly adducted during phonation than the vocal folds of Young Males.

Normative values of **SPI for Young Males and Young Females in the present study are higher than that given in the MDVP manual for males** [Mean= 6.770 (SD = 3.784)] and females [Mean= 7.534 (SD= 4.133)]. The probable reason could be due to the difference between the Indian and Western population with respect to vocal tract (length, mass and volume). In the present study, for Young Males, standard deviation is more (5.986) as comparison to Young females (5.043). Also, standard deviation in the present study [SD= 5.986 for young males and SD= 5.043 for young females] is higher than that in the western normative [SD= 3.784 for males and SD= 4.133 for females] given in MDVP manual. Also, there is significant difference in SPI values between Young Males and Young Females. But, in MDVP there is not that much difference between males and females.

The present study is in agreement with the normative study done by ''Hema, Mahesh and Pushpavathi [25]'' on adults using MDVP which also reported higher SPI value in the Indian adult male [Mean= 17.59 (SD=10.82)] than female [Mean= 14.47 (SD= 4.60)]. They also compared their Indian norms with the Western norms given in the MDVP manual [Male's Mean= 6.77 (SD= 4.13) and Female's Mean= 7.53 (SD= 4.13)] and found that Indian norms were significantly higher than the Western norms and the same trend is seen in the present study. They considered that it may be due to difference in the manner of vowel phonation among the Indian and the Western population.

The normative mean of SPI values for Young Females found in the present study (Mean= 11.089) is in agreement with the SPI values found for females in the study done by ''Roussel and Lobdell [28]'' to find out the clinical utility of the soft phonation index in females to determine how consistently SPI tracks systematic changes in vocal fold adduction. Mean of SPI values for the normal voice condition (Mean= 13.05) is slightly higher in their study than that found in the present study.

Voice Turbulence Index (VTI)

VTI measures the relative energy level of the high frequency noise. It mostly correlates with the turbulence caused by the incomplete or loose adduction of the vocal folds. It is a good indicator of vocal fold mass lesions and vocal fold paresis or paralysis. It provides a quantitative analysis of breathiness [6]. The mean of VTI values were obtained and found to be same for both Young Males [Young Males= 0.043 (SD= 0.012)] and Young Females [Young Females= 0.43 (SD= 0.014)] which also revealed that **no statistically significant difference was found for VTI between Young Males and Young Females (P= 0.629) at p= 0.05.** This indicates that the relative energy level of the high frequency noise is same in both Young Males and Young Females.

The western normative value for VTI given in the MDVP manual is 0.052 (SD=0.016) for males and 0.046 (SD= 0.012) for females which is higher in comparison to the present study. In the MDVP norms, there is significant difference in the mean of VTI values between males and females which is not seen in the present study.

The present study is in agreement with a study done by ''Lazic et al [26]'' on females which reported similar mean of VTI values [Mean= 0.044(SD=0.014)] in their control group as the mean of VTI values for Young Females in the present study.

6. CONCLUSION

The following conclusions can be drawn from the present study:

Relative Average Perturbation (RAP)

- Normative values for RAP among **young males** (YM) and **young females** (YF) were found to be 0.237 (SD= 0.114) and 0.255 (SD= 0.087) respectively. The comparison of mean of RAP values between young males and young females with the Mann-Whitney U test were statistically significant (p=0.013).

Hence, it can be concluded that RAP values differ with respect to gender. Also, normative values of RAP as given in the MDVP manual which is based on western

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population is 0.345 (SD= 0.333) for males and 0.378 (SD= 0.214) for females. These western norms are found to be higher than the Indian norms established in the present study which are 0.237 (0.114) and 0.255 (0.087) for young males and young females respectively.

Noise to Harmonic Ratio (NHR)

- Normative values for NHR among **young males** and **young females** were found to be 0.138 (SD= 0.019) and 0.124 (SD= 0.013) respectively. The comparison of mean of NHR values between young males and young females with the Mann-Whitney U test were statistically significant (p= 0.000).

Hence, it can be concluded that NHR values differ with respect to gender. Also, normative values of NHR as given in the MDVP manual which is based on western population is 0.122 (SD= 0.014) for males and 0.112 (SD= 0.009) for females. These western norms are found to be lower than the Indian norms established by the present study which are 0.138 (0.019) and 0.124 (0.013) for young males and young females respectively.

Soft Phonation Index (SPI)

- Normative values for SPI among **young males** and **young females** were found to be 14.635 (SD= 5.986) and 11.089 (SD= 5.043) respectively. The comparison of mean of SPI values between young males and young females with the Mann-Whitney U test were statistically significant (p= 0.000).

Hence, it can be concluded that SPI values differ with respect to gender. Also, normative values of SPI as given in the MDVP manual which is based on western population is 6.770 (SD= 3.784) for males and 7.534 (SD= 4.133) for females. These western norms are found to be lower than the Indian norms established by the present study which are 14.63 (5.986) and 11.089 (5.043) for young males and young females respectively.

Voice Turbulence Index (VTI)

- Normative values for VTI among **young males** and **young females** were found to be 0.043 (SD= 0.012) and 0.043 (SD= 0.014) respectively. The comparison of mean of VTI values between young males and young females with the Mann-Whitney U test were not statistically significant (p= 0.629).

Hence, it can be concluded that VTI values do not differ with respect to gender. Also, normative values of VTI as given in the MDVP manual which is based on western population is 0.052 (SD= 0.016) for males and 0.046 (SD= 0.012) for females. These western norms are found to be higher than the Indian norms established by the present study which are 0.043 (0.012) and 0.043 (0.014) for young males and young females respectively.

In comparison between **young males and young females** with respect to all the four parameters studied, **the mean values obtained for young males are higher for NHR and SPI, lower for RAP and equal for VTI.**

It can **also** be **concluded** that there is **vast difference between the western norms given in the MDVP manual and the Indian norms established in the present study** for the four MDVP parameters which are RAP, NHR, SPI and VTI mentioned in the Table 7.1. Visi Pitch IV KayPENTAX is a voice analysis instrument manufactured in a foreign country and standardized on foreign population. Hence, it is necessary to collect the Instrument specific normative data before assessing and diagnosing clients using MDVP.

Implications of the study

The study provides gender specific normative data on Indian population with respect to different vocal parameters which can be used as reference to differentiate pathological voice in Indians.

Limitations

1. This study does not provide Indian normative data for children and elderly population.

2. Only one stimulus i.e. the vowel /a/ was used for taking voice samples. The vowels /i/ and /u/ may also be useful stimulus and can be taken for future studies.

3. Out of thirty-three parameters of MDVP, only four parameters have been chosen for obtaining normative data on Indian population.

Suggestions for Future Research

Future studies should be done to overcome these limitations and design research which could yield more

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precise information about Instrument specific normative data on Indian population.

TABLES

ACOUSTICAL FINDINGS

Table 5.1: Normality result for Young Males

Parameter	Shapiro-Wilk Statistics	Degree of Freedom	p- value
RAP	0.805	100	0.000*
NHR	0.876	100	0.000*
SPI	0.916	100	0.000*
VTI	0.973	100	0.040*

* Value significant at 0.05 level.

Table 5.2: Normality result for Young Females

Parameter	Shapiro-Wilk Statistics	Degree of Freedom	p- value
RAP	0.981	100	0.159
NHR	0.980	100	0.131
SPI	0.932	100	0.000*
VTI	0.985	100	0.335

* Value significant at 0.05 level.

Comparison between Young Males and Young Females

Table 5.1.1: Estimated Means, Standard Deviations, Minimum, Maximum and Significance of comparisons of Means of RAP, NHR, SPI and VTI values between Young Males and Young Females.

Parameter	Age Group	Mean	Std. Deviation	Minimum	Maximum	p-value (Mann-Whitney U test)
RAP	**Young Males**	0.237	0.114	0.096	0.691	0.013*
	Young Females	0.255	0.087	0.090	0.520	
NHR	**Young Males**	0.138	0.019	0.094	0.208	0.000*
	Young Females	0.124	0.013	0.090	0.164	
SPI	**Young Males**	14.635	5.986	4.905	43.070	0.000*
	Young Females	11.089	5.043	4.020	28.829	
VTI	**Young Males**	0.043	0.012	0.018	0.087	0.629
	Young Females	0.043	0.014	0.012	0.084	

Note: N was 100 for Young Males and Young Females.
*The significance level is 0.05.

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Table 7.1: Comparison of Acoustic Parameters between MDVP Western norms and Present Study's Indian norms.

Parameters	MDVP Western Norms		Present study Norms		
	M	F	YM (N= 100)	YF (N= 100)	F (N= 200)
RAP ($\bar{X}$)	0.345	0.378	0.237	0.255	0.243
RAP (SD)	0.333	0.214	0.114	0.087	0.094
NHR ($\bar{X}$)	0.122	0.112	0.138	0.124	0.125
NHR (SD)	0.014	0.009	0.019	0.013	0.014
SPI ($\bar{X}$)	6.770	7.534	14.635	11.089	11.687
SPI (SD)	3.784	4.133	5.986	5.043	5.033
VTI ($\bar{X}$)	0.052	0.046	0.043	0.043	0.044
VTI (SD)	0.016	0.012	0.012	0.014	0.013

$\bar{X}$ - Mean
SD – Standard Deviation

Table: 8.1: Summary Table

PARAMETER	YM vs YF
RAP	Significant
NHR	Significant
SPI	Significant
VTI	Not Significant

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