3. METHODOLOGY

This prospective research was developed in Audiology and Speech therapy department at C U Shah Medical College, Surendranagar in Gujarat. The study was carried out in two phases i.e. before and after speech therapy.

3.1 Participants

Total number of participants was two hundred in the age range of six to fifty years and they were divided into two groups. First group of one hundred persons with stuttering (PWS) (sixty male and forty female with mean age of 21.5 years), formed the study group (SG). SG was comprised of two subgroups based on age. The first subgroup G1 of adults with stuttering which was comprised of sixty adults with stuttering (thirty five male and twenty five female participants) in the age range of eighteen to fifty years (mean age 30.3 years). Forty children with stuttering (twenty five male and fifteen female participants) formed the second subgroup G2 in the SG in the age range of six to twelve years (mean age 8.4 years).

Second group of one hundred persons with no stuttering (PWNS) with mean age of 21.3 years, formed the control group (CG). CG also comprised of two subgroups G3 (adults with no stuttering) with mean age of 29.9 years and G4 (Children with no stuttering) with mean age of 8.3 years. Participants of CG were age and gender matched with the participants of SG.

3.1.1 Participants’ selection criteria: Participants included in SG and CG had hearing sensitivity within normal limits that is pure tone thresholds of up to 25 dB HL at frequencies from 250 to 8000Hz in both the ears. Also they had normal middle ear functions.

3.1.2 Exclusion criteria: Following were the exclusion criteria for the participants.

- History or present complaint of hearing loss or any other otological problem like acute or any chronic ear infection, tinnitus, vertigo etc.
- Any psychiatric problem
• History of a neurological disorder or gross neurological symptoms
• History of any medical impairment.
• History of learning disability or Dyslexia.

All of the hundred PWS reported gradual development of disfluencies during early childhood, family history for stuttering and none had previously undergone any kind of therapy.

In order to determine the distribution of the participants between the groups, the following inclusion criteria were used:

(A) SG – diagnosed with at least “moderate” stuttering on the Stuttering Severity Instrument (SSI-3) (Riley, 1994). All of the selected participants presented moderate to very severe stuttering on the SSI-3.

(B) CG – diagnosed with “normal fluency” on the SSI-3 (Riley, 1994).

All participants signed the Free and Informed Consent Form - in which all procedures performed were described - consenting participation in the study and dissemination of the results.

3.1.3 Speech samples and disfluency analyses:

A speech sample of each participant (i.e. SG and CG) was audio taped. A corpus containing 200 fluent syllables of conversational speech, based on an everyday life situation, with an unfamiliar listener was analyzed. Overall, SG presented speech samples ranging from 330 to 750 syllables (mean 556.67±168.03) and CG presented speech samples ranging from 207 to 260 syllables (mean 224.17±19.94).

Samples were evaluated according the Stuttering Severity Instrument (Riley, 1994) to estimate the level of stuttering severity. For SG, in order to verify fluency amelioration, this analysis was performed pre and post-treatment.

3.2 Instrumentation:

The present study was carried out using following instruments:

• A calibrated dual channel Madsen Orbiter – 922 clinical audiometer with TDH – 39 ear phones housed in MX/41 ear cushions and radio ear B71 bone vibrator for pure tone audiometry.
• A calibrated GSI Tymstar middle ear analyzer for tympanometry and acoustic reflex measurement.

• IHS smart EP, version 2.39 (Intelligent Hearing systems, Florida, USA) with Eartone 3A insert earphones to record and analyze auditory evoked potentials.

3.3 Procedures

After completion of a history questionnaire with the aim of collecting data on hearing complaints and eligibility criteria for the sample - each individual was subjected to inspection of the external ear canal with an otoscope to assess the conditions for conventional audiological assessment and electrophysiological performance.

A calibrated Madsen Orbits – 922 with TDH – 39 ear phones was used for pure tone audiometry. Pure tone Audiometry was conducted to ensure normal hearing sensitivity (thresholds below 25 dBHL) at octave frequencies from 250 Hz and 8 kHz in both the SG and CG.

A calibrated GSI- Tymstar Middle ear Analyzer, version 3.1 was used to perform immittance audiometry. Impedance evaluation was performed on the subjects to check for normal middle ear functioning indicated by a static compliance pressure between -100 dapa and 100 dapa and presence of both ipsilateral and contra lateral reflexes at 100 dBSPL for the frequencies 500 Hz, 1kHz and 2 kHz.

AEP recording

Subjects were asked to lie on a table in an electronically shielded and acoustically treated room. A portable system from Intelligence Hearing Systems, model smart ep. 2.39 was used for AEP measurement. The measurement occurred after preliminary skin cleaning with abrasive paste and attachment of electrodes to the skin by means of electrolytic paste and adhesive tape. The electrode positions were pre-determined by the examination protocols. The electrodes impedance values were verified and they were below 5 kOhms. The acoustic stimulus was presented by a pair of insert earphones, which elicited the responses. The tests were conducted in quiet environment. The electrodes placement to capture the AEP followed the IES 10-20 (International Electrode System) standard.
The auditory evoked potentials were recorded in following order:
1. Auditory Brainstem Response (ABR)
2. Auditory Middle Latency Response (AMLR)
3. Late Latency response (LLR)

Details about each of these potentials are as follows:

3.3.1 ABR:
The ABR was recorded for each ear. The electrode sites chosen and their connections to the electrode box were made as shown in figure 3.1.
The patients were asked to lay comfortable on the table and relax. They were instructed to avoid extraneous movements of the head, neck and jaw during the course of recording the potentials. Table 3.1 shows the stimulus parameter for obtaining ABR in subjects.

Fig 3.1 Electrode placements for ABR recording
Table 3.1: Stimulus parameters for obtaining ABR

<table>
<thead>
<tr>
<th>Stimulus:</th>
<th>0.1 msec Click</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate:</td>
<td>11.1/sec</td>
</tr>
<tr>
<td>Polarity:</td>
<td>Rarefaction</td>
</tr>
<tr>
<td>Transducers:</td>
<td>Insert Earphones</td>
</tr>
<tr>
<td>Intensity:</td>
<td>80 dB HL.</td>
</tr>
<tr>
<td>Filters:</td>
<td>100 – 1500 Hz</td>
</tr>
</tbody>
</table>

3.3.2. AMLR:

The middle latency responses were recorded from both the ears. The electrode impedance was kept at less than 5 kohms.

For recording these potentials, the electrode placement (shown in fig 3.2), instructions and stimulus parameter were same as that used to record the ABR, but for the parameters mentioned below in table 3.2.

Fig. 3.2: Electrode placement to record AMLR waves

Site:
- Forehead (Fz)
- Vertex (Cz)
- Left ear mastoid (A1)
- Right mastoid (A2)

Head box:
- com.
- 1+2 (linked)
- 1-
- 2-
Table 3.2: Stimulus Parameter for obtaining AMLR

<table>
<thead>
<tr>
<th>Stimulus</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>7.1/sec</td>
</tr>
<tr>
<td>Polarity</td>
<td>Alternating</td>
</tr>
<tr>
<td>Transducers</td>
<td>Insert Earphones</td>
</tr>
<tr>
<td>Intensity</td>
<td>80 dB HL</td>
</tr>
<tr>
<td>Masking</td>
<td>No</td>
</tr>
<tr>
<td>Filters</td>
<td>10-1500 Hz</td>
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<tr>
<td>Notch Filter:</td>
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</tr>
<tr>
<td>Amplification</td>
<td>75x</td>
</tr>
<tr>
<td>Analysis Time Window</td>
<td>Overall 100 msec</td>
</tr>
<tr>
<td>Sweeps</td>
<td>1024</td>
</tr>
<tr>
<td>Electrode Montage</td>
<td>Fz-A1-A2 right auditory, Fz-A2-A1 left auditory</td>
</tr>
</tbody>
</table>

3.3.3 LLR:

Four electrodes were used for LLR testing. One was placed at vertex (cz), second on the forehead (FPz) and 3rd and 4th on the mastoid region behind auricle. The electrode at the vertex served as positive, one on the forehead served as common electrode and ones on the mastoid served as negative electrodes.

Fig. 3.3: Electrode placement for LLR waves recording

The above fig. 3.2 illustrates the placement of the electrodes and their connection to the electrode box. The electrode and iner-electrode impedance were kept less than 5 kohms and 2 kohms respectively.
Instructions to the client:
The subjects were instructed to stay alert but relaxed throughout the recording. The subjects were asked to keep their eyes open and concentrate on a spot and to relax all neck and jaw muscles. The stimulus parameters for obtaining LLR have been listed in table 3.3.

Table 3.3: Stimulus parameters for obtaining LLR

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>0.1 milliseconds Click</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>1.1/sec</td>
</tr>
<tr>
<td>Polarity</td>
<td>Alternating</td>
</tr>
<tr>
<td>Transducers</td>
<td>Insert Earphones</td>
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<tr>
<td>Intensity</td>
<td>80dB</td>
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<tr>
<td>Filters</td>
<td>1-30 Hz</td>
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<td>Notch Filter:</td>
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<tr>
<td>Amplification</td>
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<tr>
<td>Analysis Time Window</td>
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<tr>
<td>Sweeps</td>
<td>512</td>
</tr>
<tr>
<td>Electrode Montage</td>
<td>Ipsilateral</td>
</tr>
</tbody>
</table>

3.4 Waveform analysis:
Waveform analysis was done offline and manually. Latency was recorded at the peak of the waves. If there was no sharp peak the latencies were recorded by placing the cursor at the center of the plateau. Amplitude was measured by placing two cursors at the center at one at the peak and other at the immediate trough.

Following measures were obtained from the waveforms of ABR.
- Absolute latencies for wave I, III and V.
- Interpeak latency differences between I-III, III-V and I-V
- Amplitude ratio between wave V and wave I

Latency values of waves Na, Pa and Nb and amplitude of Na and Pa peaks were studied in the waveform of AMLR.
For LLR, peak P1, N1, P2, and N2 were measured. The peak with the highest amplitude after the stimulus onset was considered as peak P1, the largest negative peak immediately after P1 was considered as N1, the positive peak after the N1 was marked as P2 and negative peak immediately after P2 was marked as N2. Replicability of peaks was considered to mark the peaks. 50 ms pre stimulus averaging was taken into consideration as baseline during recording and analysis and was subtracted from amplitude of peak N1 and P2 to get corrected amplitude. Absolute latencies of P1, N1, P2 and N2 and amplitude of N1P2 wave were studied.

All these electrophysiological measurements were made in pretherapy assessment as well as post therapy assessment, which were done after 3 months of regular speech therapy.

### 3.5 Speech therapy Program:
After the first AEPs measurements the SG (PWS) were enrolled in the speech therapy program in the speech therapy department at C U Shah Medical College and Hospital, Surendranagar. The therapy program was adapted from comprehensive speech therapy program for PWS (MN Hegde, 2001).

The goal of treatment was to reduce the rate of dysfluencies in conversational speech to less than 1% in clinic speech samples and no more than 5% in everyday situations by:

- Teaching the client to manage his speech related airflow properly.
- Teaching the client to initiate speech softly and gently.
- Teaching the client to prolong syllable durations to reduce the speech rate.
- Shaping normal prosodic features of speech and stabilizing fluency.
- Strictly managing the behavioral contingency by giving prompt positive and corrective feedback.
- Shifting significant others to manage the skills in the natural environment to promote maintenance of fluency over time and across situations.
- Following up the client periodically and giving booster therapy when needed.
3.5.1 Target Fluency skills: Three target fluency skills that are incompatible with stuttering were selected which are effective in establishing stutter free speech:

- Air flow management
- Gentle phonatory onset
- Rate reduction

3.5.1.1 Air flow management – For this skill the clinician provided the model first. The patients were asked to inhale a slightly deeper than usual amount of air through his nose. Then he/she was asked to exhale a slight amount of air through his open mouth as soon as inhaling the air without air being impounded in the lungs. Patient was asked to stop at the earliest sign of mismanaged air flow like taking too deep inhalation or impounding the air in the lungs and clinician provided the model again. The correct imitation was reinforced.

3.5.1.2 Gentle Phonatory onset skill - The clinician modeled gentle phonatory onset and contrasted that with hard glottal attacks using short and simple words. The patient was asked to initiate syllable softly, gently, slowly and in a relaxed manner. Correct imitation was reinforced. This technique was used until the client could, upon request and without modeling, initiated sounds softly while producing several words.

3.5.1.3 Rate reduction – For this skill clinician modeled a slow speech through syllable prolongation. Syllable duration was stretched and correct imitation of slow, prolonged speech was reinforced. Client was stopped as soon as clinician heard the sign of increased rate of speech, error was explained, and modeling was provided. This technique was used until the client could, on request and without modeling, stretch syllables in all the words being practiced.

Later all these fluency skills were combined and training was provided with single words initially modeled and later evoked by questions that led to one word utterances. Training on these three skills was continued until the client could, on request and without modeling, produce all three target behaviors and with stutter free speech at the word level with 98 to 100% accuracy.
3.5.2 Shifting the training to phrase level - For Phrase training the clinician chose two word phrases. Both words of the phrase were chosen on which the client was already trained. Later one new word and one trained word and in last stage both the new words were taken. Completely stutter free productions were reinforced.

3.5.3 Shifting the training to sentence level – For initial stage trained phrases were expanded to form sentences. The clinician provided model of stutter free speech and clients were reinforced and corrective feedback was provided.

3.5.4 Shape normal prosody – When the clients were able to produce stutter free speech at conversational speech level with 98 to 100% accuracy, normal prosody became the goal of therapy. The client was told that gradually increased speaking rate and typical intonations are keys to normal sounding speech. The clinician provided model at slightly increased rate of speech and the client was asked to imitate. If dysfluency appeared with increased rate of speech the rate was slowed down till the client regained stutter free speech. After some practice the client was again asked to increase the rate. Similar training was provided for pitch variation as well as vocal intensity variation.

3.5.5 Maintenance program – The client was taught the self monitoring skills by having him count the dysfluencies, increase in rate, production of target behavior, abrupt phonatory onset etc. The client was asked to judge appropriateness of airflow, gentle phonatory onset, rate reduction and prosody variations. Informal training sessions were held in naturalistic setting. The family members and friends and teachers were trained in prompting and reinforcing the production of target skills and fluency. A follow up schedule was given to bring the client back to the clinic periodically regardless of outcome.

All SG participants (PWS) were given therapy based on the above mentioned protocol. The frequency of speech therapy was twice a week and was for a duration of three months. All participants in SG completed this three month program. SG participants underwent a second electrophysiological evaluation after 24 speech therapy sessions
(three months). CG participants (PWNS) were also given second electrophysiological evaluation after three month period to ensure that any AEP results improvement observed in SG were due to speech therapy and not due to other external variable.

**Statistical analysis:** More than ±3 SD was taken as criteria for a value to be taken as deviant from the normal mean value of AEP measures. Pre and post assessments were compared using t test. t-test is the statistical test used to find the difference of mean between two groups. It is a test involving means of normal populations with unknown standard deviations and it is based on a variable ‘t’ equal to the difference between the mean of the sample and the mean of the population divided by a result obtained by dividing the standard deviation of the sample by the square root of the number of individuals in the sample. Differences between the group and subgroup responses were considered significant when p ≤0.05.