SUMMARY & CONCLUSIONS

The present research investigated the swallowing characteristics in adults and geriatrics using qualitative and quantitative measures. Eight hundred individuals without dysphagia, divided into four groups based on their age 18 to 40 years (adults), 41 to 59 years (adults), 60 to 75 years (geriatrics), and 76 years and above (geriatrics), were included in the study. Each group consisted of 100 males and 100 females. None of these individuals had history/presence of any speech, language, neurological and swallowing disorders. The study was carried out in two phases. The first phase was devoted for developing a swallowing assessment protocol and the second phase comprised of quantitative assessment of swallowing.

Qualitative measures:

- The tasks for the swallowing assessment were derived from the available literature input on swallowing and also from the standardized and non-standardized clinical assessment tools.
- Final components comprised of assessment of structure, sensory assessment, motor assessment and the assessment involving trial feeds.
- The sensory assessment revealed that sensory skills were affected in geriatric groups when compared to adult groups and these impairments were observed only on the posterior one third of the tongue (gag reflex). There was no gender difference.
- The motor assessment revealed that motor skills related to swallowing were affected in geriatric groups as against the adult groups. This was observed in both the genders with significant difference between males and females.
suggesting that motor skills related to swallowing were affected more in females in comparison to males.

- Trial feeds (dry swallow, thick liquids, thin liquids and solids) assessment revealed that swallowing measures were intact in adult groups and affected in geriatric groups i.e., with increasing age, swallowing problems also increased. This was observed in both the genders with no significant difference between males and females suggesting that swallowing phases were not affected by gender.

- The sensitivity of the qualitative protocol was ascertained by administering it on twenty five individuals with dysphagia. The obtained results were also compared with Videofluoroscopy. The results revealed Sensitivity - 77%; Specificity - 67%; Positive predictive value - 71%; Negative predictive value - 73%; and Efficiency - 72% suggesting the accuracy of the test in identifying aspiration in individuals with dysphagia.

- Follow up evaluations with the protocol after therapeutic intervention also revealed the ability to detect changes from baseline measurement.

- To conclude, the developed qualitative protocol would be a valuable tool in the dysphagia assessment. It enables the clinicians to identify the presence of dysphagia, to establish possible etiology for dysphagia in relation to swallowing physiology, to assess the ability to identify aspiration, to determine the possibility for oral feeding, to make recommendations regarding the alternative feeding methods and to determine the need for further instrumental evaluation.
Quantitative measures:

- Quantitative measures adopted for the present study included surface EMG, nasal airflow monitoring, and cervical auscultation, which were performed using the Kay Digital Swallowing Workstation and Swallowing Signals Laboratory (Model 7120, Kay PENTAX, Montwale, NJ).
- All the measurements were done during dry swallow, thick liquid swallow (rice flakes mixed with water) and thin liquid swallow, with two different bolus volumes (5ml and 10ml).

**Surface EMG**: It was used to measure the submental muscle activity during swallowing. Surface electrodes were placed on the submental muscles and the parameters such as amplitude and temporal measures were investigated across the age, gender, bolus consistency and volume.

**Amplitude measures**:

- With increase in the age, peak and mean amplitude of submental muscle activity decreased and this change was evident from 60 years onwards.
- Amplitude of submental muscle with respect to mean and peak amplitude during swallowing did not vary with gender.
- The amplitude of submental muscle activity (mean and peak amplitude) varied with bolus consistency i.e., as the thickness of the bolus was reduced, submental EMG amplitude was also reduced.
- The amplitude of submental muscle activity (mean and peak amplitude) varied with bolus volume i.e., as the volume increased, amplitude of submental muscle activity also increased.
Temporal measures:

- With the increase in age, duration of the submental muscle activity increased.
- The changes in the duration of submental muscle activity with ageing was observed from 41 year onwards suggesting that the temporal measures were more sensitive in the identification of swallow deviations compared to amplitude measures.
- Duration of the submental muscle activity did not vary with gender.
- The duration of submental muscle activity varied across the bolus consistency i.e., as the thickness of the bolus consistency decreased, duration of the submental muscle activity increased.
- The duration of submental muscle activity varied across the bolus volume i.e., as the volume increased, the duration of the submental muscle activity decreased.
- More demand on the pharyngeal and laryngeal control mechanism is reflected in terms of increased muscle amplitude. However, the time duration did not increase indicating a trade-off relationship between the amplitude and the temporal measures in the submental EMG amplitude.
- To conclude, submental muscle functions such as amplitude and temporal measures varied with age, bolus consistency and volume.

Nasal airflow monitoring: It was used to characterize the respiratory swallow coordination using a nasal cannula positioned at the entrance of each individual’s nares. Parameters such as swallow apnea duration and respiratory swallow phase relationship were investigated across age, gender, bolus consistency and volume.
**Respiratory swallow phase relations:**

- Expiration interrupting the swallowing was the predominant pattern observed in healthy adults across all the bolus consistencies and bolus volumes. The expiratory phase of breathing is linked to the paramedian position of the vocal fold during the pharyngeal swallow which assists in the airway closure during the pharyngeal swallowing.

- The occurrence of inhalation bracketing the swallow was observed to be high in individuals older than 60 years i.e., in group III and IV. Inhalation phase of respiration often presents with an abducted vocal fold position which may aid in the entry of food or liquid into the upper airway prior to or during the swallowing.

**Temporal measures:**

- As the age advanced, swallow apnea duration increased. The prolonged apnea duration was associated with an overall increase in total swallow duration in healthy aging individuals without dysphagia.

- Swallow apnea duration varied across the gender, with females exhibiting slightly higher duration than males.

- The swallow apnea duration varied across the bolus consistency i.e., as the thickness of the bolus increased, swallow apnea duration increased.

- The swallow apnea duration varied across the bolus volume i.e., as the volume of the bolus increased, swallow apnea duration increased.

- To conclude, the respiratory swallow phase relationship and swallow apnea duration varied with age, gender, bolus consistency and volume.
Cervical Auscultation: It was used to capture the swallow sounds by placing a stethoscope microphone on the thyroid lamina and the parameters such as amplitude and temporal measures were investigated across the age, gender, bolus consistency and volume.

Amplitude measures:

- As the age increased, the mean and peak amplitude of swallow sound decreased. Percentage of individuals who exhibited no swallow sound increased with the advancing age. This was pronounced during the dry swallow in comparison to thick and thin liquid swallow.

- Amplitude of swallowing sound varied across gender with females exhibiting lesser amplitude than males. This was observed for both mean and peak amplitude measures.

- The amplitude of swallowing sound varied across the bolus consistency i.e., as the thickness of the consistency increased, the peak and mean amplitude of swallow sound decreased which was statistically significant.

- Amplitude of swallow sound varied with the volume of the bolus swallowed i.e., as the volume increased, the peak and mean amplitude of swallow sound also increased significantly.

- On an average, 4-5 multiple swallow sounds were observed in the adult groups and the instances of multiple swallow sounds decreased in individuals over 60 years.

Temporal measures:

- As the age increased, duration of swallow sound decreased i.e., younger adults took longer duration and the older individuals exhibited lesser time duration of swallow sounds.
• Duration of the swallow sound did not vary across the gender.

• The duration of swallowing sound varied across the bolus consistency i.e., as the thickness of the bolus consistency increased, time duration decreased

• The duration of swallowing sound varied across the bolus volume i.e., as the bolus volume increased, duration of the swallow sounds also increased.

• To conclude, amplitude and temporal characteristics of swallow sound varied with age, bolus consistency and volume.

Clinical Implications

• The present study reported the normative database for swallowing in the Indian population using qualitative and quantitative measures across age, gender, bolus consistency and volume.

• The results of the present investigation provides the base for comparison against disordered swallowing behavior in adults and geriatrics.

• The present study also established a standard bolus consistency and volume for the qualitative and quantitative assessment of swallowing which is inexpensive, readily available and suitable for Indian population.

• The results of this study can be used to estimate treatment efficacy in individuals with swallowing disorders.

Limitations and Future directions

• The developed qualitative protocol needs to be administered on a larger sample of individuals with different types of dysphagia which might provide insight into the pattern of swallowing behavior across a range of swallowing problems in different clinical population.
• Quantitative measures investigated in the present study needs to be correlated with the invasive measures such as Videofluoroscopy and videoendoscopy to determine the risk for aspiration in individuals with dysphagia.

• Swallowing behavior measured on quantitative assessment may not be an accurate representation of the natural eating behavior during meal times. Future studies must address these issues.

• Though the present study established norms for adults and geriatrics, further studies are necessary to standardize these measures in children and adolescents.