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Original Article

Dentistry Section

Gender Variation in the Prevalence of Decreased Tongue Strength and Tongue Endurance among Institutionalised Geriatric Population in Chennai, India: A Cross-sectional Study

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ABSTRACT

Introduction: Ageing is associated with progressive loss of muscle mass and function, which also includes the orofacial muscles. The tongue is a vital organ that helps in various oral functions; maintaining the muscular structure of the tongue is essential for normal deglutition and breathing. Such a state can be achieved when the tongue strength and endurance are adequate, which makes it essential to measure as age advances.

Aim: To assess gender variation in the prevalence of decreased tongue strength and tongue endurance among the Institutionalised geriatric population in Chennai and to evaluate the correlation between these parameters.

Materials and Methods: A cross-sectional study was conducted among 256 aged people who were Institutionalised and living in old age homes in Chennai, Tamil Nadu, India, from January 2025 to June 2025. Tongue strength and endurance were measured using the TM1010 Tongueometer device with disposable bulbs. Tongue strength was recorded in kilopascals (kPa), and endurance was measured in seconds. Statistical analysis was performed using the Chi-square test to assess associations, and Pearson's correlation coefficient was used to evaluate the relationship between tongue strength and endurance. A p-value<0.05 was considered statistically significant.

Results: The prevalence of decreased tongue strength was 55.5%, with a significantly higher proportion observed in females compared to males (p=0.005). Decreased tongue endurance was observed in 193 (75.4%) participants, with males showing a higher prevalence compared to females (p<0.05). Age-wise analysis demonstrated a significant increase in reduced tongue strength with advancing age (p<0.001), while tongue endurance showed a high prevalence across all age groups. Correlation analysis revealed a weak but statistically significant positive correlation between tongue strength and endurance in females, whereas no significant correlation was observed in males.

Conclusion: The study demonstrated a high prevalence of reduced tongue strength and endurance among the Institutionalised geriatric population, with significant gender-based differences. While females exhibited greater reductions in tongue strength, males showed a higher prevalence of decreased endurance. A modest association between tongue strength and endurance was observed in females. These findings highlight the importance of routine assessment of tongue function in elderly individuals for early identification and management of functional decline.

Keywords: Ageing, Dysphagia, Muscle mass, Swallowing

INTRODUCTION

The inexorable process in humankind is ageing. Ageing is a physiological process that leads to a decline in overall health due to functional and anatomical changes in an individual's body. Healthy ageing refers to being disease-free [1]. According to the World Health Organisation (WHO), "It is the process of developing and maintaining functional ability that enables well-being in older age" [2].

India, the most populous country with approximately 1.45 billion inhabitants, has an elderly demographic constituting 12.4%, with Tamil Nadu exhibiting a higher percentage of 17.1%; the elderly population is projected to increase significantly, reaching approximately 138 million by 2031 and 19.4% by 2050 [3-5].

Among several systemic effects of ageing, the musculoskeletal system exhibits substantial age-related changes that include loss of muscle mass, strength, and endurance, which can be broadly termed "sarcopenia". In general, sarcopenia refers to a decrease in the number of muscle fibres, which are replaced by fat and connective tissues [6,7]. These changes not only affect the appendicular muscles but also the muscles of the craniofacial region [8].

The tongue is a dynamic muscular organ that plays a pivotal role in stomatognathic functions such as speech, deglutition, sucking, and breathing. It also plays a crucial role in the biomechanics of swallowing, from chewing food and forming the bolus to propelling it into the pharynx [7]. Age-related muscular atrophy and fatty infiltration of the tongue contribute to reduced tongue strength and endurance. The muscular alteration in the tongue affects this process and leads to oropharyngeal dysphagia [9]. Although there is no proven direct relation between muscle loss and dysphagia, it could be a disadvantage to the functional ability of the oral cavity [8]. Several studies in the literature emphasise that reduced tongue pressure can lead to impairment in normal swallowing, which can cause aspiration of solids or liquids into the lungs, causing aspiration pneumonia commonly seen in the elderly under long-term care [10-12]. Additionally, oral dysphagia can lead to nutritional deficiency, improper hydration, and typically intolerance to any consistencies that can be swallowed safely and effectively, which creates a potential loss of socialisation, self-esteem, and independence for a healthy ageing individual [13].

This highlights that measuring the tongue strength and endurance is essential in elderly people for the purpose of maintaining proper

function. Conventionally, tongue strength assessment relied on subjective clinical evaluation using tongue blades and functional swallowing tests [14]. However, observer variability, lack of quantification, and restricted accessibility in routine clinical settings limit these methods.

The present study was performed using the TM1010 Tongueometer device with disposable bulbs, procured from Cranio Mandibular Rehab, Inc., USA. This device comprises pressure-sensitive air-filled, disposable bulbs with a biofeedback interface [15]. This helps in evaluating the tongue strength in kilopascals (kPa) and endurance in seconds (s), and the value is reflected in the tongueometer mobile application connected using Bluetooth. Although the Iowa Oral Performance Instrument (IOPI) is considered the gold standard in measuring tongue pressure [16], the TM1010 Tongueometer device offers a valid and practical alternative, providing objective measurements with the advantages of cost-effectiveness and portability, making it suitable for the current study.

The current manuscript forms part of a larger PhD research study conducted among Institutionalised geriatric people in Chennai. The translation and validation of the Tamil version of the Gerotranscendence Scale was a separate part of the project and has been published [17]. The present study is primarily focused on tongue strength and tongue endurance, and there is no overlap of objectives, data analysis and outcome measures with the published work. Amidst the innumerable studies in the literature with a dilemma of whether there is a correlation between age, gender and tongue pressure [16,18,19], the present study aims to assess gender-based variation in the prevalence of decreased tongue strength and tongue endurance and the correlation between them among the Institutionalised geriatric population in Chennai.

MATERIALS AND METHODS

A cross-sectional study was conducted among aged people who were Institutionalised and living in old age homes in Chennai, Tamil Nadu, India, from January 2025 to June 2025. The research was conducted after approval from the Institutional Ethics Committee (Ref No. MADC/IEC/I/08/2025).

Inclusion criteria:

- An elderly population aged above 65 years, ambulant and able to respond to the questionnaire, regardless of any underlying medical conditions;
- The elderly population who are residing in both free and paid residential homes;
- Elderly population with good orientation.

Exclusion criteria:

- Elderly individuals with cognitive impairments that affect communication, such as Alzheimer's disease and who are unable to comprehend the Tongueometer procedure will be excluded from the study.
- Participants who were unresponsive or unwilling to take part in the study were excluded.

Sample size calculation: The sample size was calculated using G*Power software, version 3.1. The calculation was performed to test two independent proportions with a one-sided hypothesis assuming the proportions were 0.5 and 0.3. The statistical power was also set at 95% and the alpha error probability at 5%. According to these factors, the sample size for each group was calculated to be 128 persons, resulting in a total sample size of 256 persons. The research power that was actually attained was 95.1%.

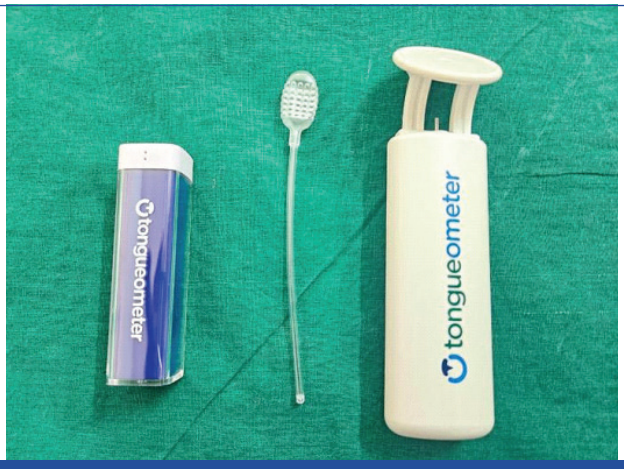
Participants were selected through a method of cluster random sampling. In Chennai, a list of old-age homes that provide free and paid residential services was prepared. All of the retirement communities were organised into clusters, and the clusters were randomly selected. All required permissions were obtained from the respective authorities of the selected Institutions. Then, eligible residents were selected sequentially until the required sample size of 256 persons was achieved. A total of 128 males and 128 females were included in the research sample based on the inclusion and exclusion criteria.

Questionnaire assessment: All participants completed a standardised questionnaire before the assessment of their tongue function. The questionnaire was available in English and translated into Tamil and included demographic details such as age and gender; questions related to medical history, past surgeries of the oral cavity, tongue, head or neck, denture use, pain or discomfort of the tongue in the past three months, self-perceived difficulty in tongue mobility, and self-perceived tongue strength during mastication. Participants were also assessed for their understanding of the Tongueometer procedure instructions and their willingness to participate in the evaluation. The questionnaire was primarily used to determine participant eligibility according to inclusion and exclusion criteria and to collect baseline information on oral and tongue functional status.

Study Procedure

Recruitment of participants was undertaken following the provision of a full description of the research through a participant information sheet and subsequent signed informed consent. For better understanding, the participant information sheet and the informed consent form were made available in both English and Tamil.

Assessment of the strength and endurance of the tongue was performed using the TM1010 Tongueometer (CranioMandibular Rehab, Inc., USA) with disposable air-filled bulbs [Table/Fig-1]. To record and store measurements, the device was connected to a smartphone application through Bluetooth technology.

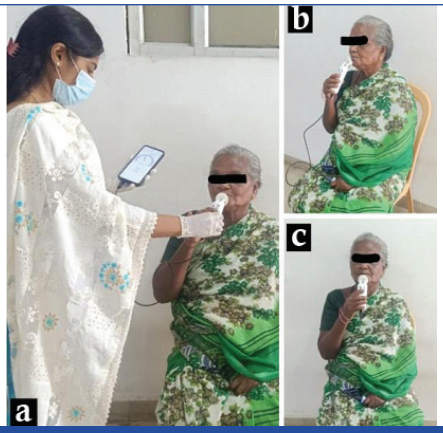


[Table/Fig-1] Tongueometer containing a sterile disposable air-filled bulb.

Maximum tongue strength was measured with the Tongueometer maximum strength module. The participants were instructed to push the posterior part of the tongue against the roof of the mouth as strongly as possible for 2 seconds. During this test, the mandible was kept stable. The bulb, full of air, would be pressed against the palate. The highest pressure produced was recorded using kilopascals (kPa) measurements. Values of tongue strength less than 34 kPa were considered to be significant as a sign of decreased tongue strength [20].

To measure tongue endurance, the time that participants were able to sustain a tongue pressure between 60% and 80% of their maximal tongue strength was recorded. Less than ten seconds of endurance was thought to indicate decreased tongue endurance and weaker oral muscles, both of which were associated with an increased risk of dysphagia [21,22].

Tongue strength and tongue endurance were measured three times, with a 1-minute rest period between measurements. The maximum value obtained was considered for analysis [Table/Fig-2].



[Table/Fig-2]: TM1010 Tongueometer clinical assessment of tongue function: (a) Assessment of maximum tongue strength, real-time pressure monitoring by means of the mobile application; (b) Evaluation of tongue endurance by maintaining tongue pressure against the roof of the mouth; (c) Standardised testing position used during assessment of tongue function in an institutionally living elderly participant.

STATISTICAL ANALYSIS

The collected data were entered into Microsoft Excel, and analysis was performed using the Statistical Package for Social Sciences (SPSS) program version 24.0. Descriptive statistics were used to give a brief overview of the research variables. The Chi-square test was used to determine the extent to which categorical variables are associated with one another. Pearson's correlation coefficient was used to evaluate the relationship between tongue endurance and tongue strength. Statistical significance was established as a p-value of less than 0.05.

RESULTS

Analysis of the tongue strength across the age group showed a progressive increase in the prevalence of reduced tongue strength with advancing age. Conversely, the percentage of individuals with normal tongue strength showed a steady decrease across these age groups. Chi-square test shows a statistically significant reduction in tongue strength as age progresses among the study population (p<0.001) [Table/Fig-3].

Age group (in years)	Total (n)	Decreased tongue strength (<34 kPa) n (%)	Normal tongue strength (≥34 kPa) n (%)	p-value
65-70	44	12 (27.3%)	32 (72.7%)	<0.001
71-75	68	30 (44.1%)	38 (55.9%)	
76-80	66	38 (57.6%)	28 (42.4%)	
>80	78	49 (62.8%)	29 (37.2%)	
Total	256	129 (50.4%)	127 (49.6%)	

[Table/Fig-3]: Shows distribution of tongue strength across the different age groups.
*kPa - kilopascal; % - Percentage; p- Probability value; n- Number

The analysis of the tongue strength based on gender revealed marked differences among the study population. A total of 82 (64.1%) females showed decreased tongue strength compared to males, with 60 (46.9%) males. In totality, more than half of the participants, 142 (55.5%), demonstrated reduced tongue strength. The association between gender and tongue strength was significant (p=0.005) [Table/Fig-4].

An age-wise analysis of tongue endurance revealed no potential decline in reduced endurance as age increased. The percentage of decreased tongue endurance was highest in the 65-70 years group (84.1%), followed by 79.4% in 71-75 years, 74.2% in 76-80 years and 67.9% in those above 80 years of age. Overall, only 24.6% of study participants showed normal tongue endurance, which strongly indicates the statistical significance of age groups and tongue endurance. (p=0.029) [Table/Fig-5].

Gender	Total (n)	Decreased tongue strength (<34 kPa) n (%)	Normal tongue strength (≥34 kPa) n (%)	p-value
Male	128	60 (46.9%)	68 (53.1%)	0.005
Female	128	82 (64.1%)	46 (35.9%)	
Total	256	142 (55.5%)	114 (44.5%)	

[Table/Fig-4]: Distribution of tongue strength between the genders.
*kPa - kilopascal; % - Percentage; p- Probability value; n- Number

Age group (in years)	Total (n)	Decreased tongue endurance (<10 sec) n (%)	Normal tongue endurance (≥10 sec) n (%)	p-value
65-70	44	37 (84.1%)	7 (15.9%)	0.029
71-75	68	54 (79.4%)	14 (20.6%)	
76-80	66	49 (74.2%)	17 (25.8%)	
>80	78	53 (67.9%)	25 (32.1%)	
Total	256	193 (75.4%)	63 (24.6%)	

[Table/Fig-5]: Distribution of tongue endurance among the age groups.
*sec - Seconds; n- Number; %- percentage; p- probability value

The gender-based analysis of tongue endurance between the genders revealed that males exhibited a higher percentage of decreased tongue endurance compared to females. A significant association was observed between gender and tongue endurance (p=0.042) [Table/Fig-6].

Gender	Total (n)	Decreased tongue endurance (<10 sec) n (%)	Normal tongue endurance (≥10 sec) n (%)	p-value
Male	128	104 (81.2%)	24 (18.8%)	0.042
Female	128	89 (69.5%)	39 (30.5%)	
Total	256	193 (75.4%)	63 (24.6%)	

[Table/Fig-6]: Distribution of tongue endurance between genders.
*sec- Seconds; n- Number; %- percentage; p- probability value

Correlation analysis between tongue strength and endurance among different age groups revealed age-specific variations. A weak negative correlation was observed between the age groups of 65-70 years and 71-75 years. A moderate positive correlation was identified among the age group of 76-80, which showed statistical significance (p=0.007). For the individuals aged above 80 years, a weak positive correlation was observed; however, it was not statistically significant (p>0.05) [Table/Fig-7].

Age group (in years)	Variables compared	Pearson's correlation (r)	p-value
65-70	Tongue strength (kPa) vs Tongue endurance (seconds)	-0.172	0.264
71-75	Tongue strength (kPa) vs Tongue endurance (seconds)	-0.073	0.552
76-80	Tongue strength (kPa) vs Tongue endurance (seconds)	0.332	0.007
>80	Tongue strength (kPa) vs Tongue endurance (seconds)	0.127	0.269

[Table/Fig-7]: Shows Pearson's correlation between tongue strength and endurance among age groups.
*kPa - kilopascal; sec - Seconds; n- Number; %- percentage; p- probability value;

A very weak positive correlation was observed between tongue strength and endurance in males, which was statistically insignificant; contrarily, a weak positive significant correlation was observed in females (r=0.181, p=0.041) [Table/Fig-8].

Gender	Variables compared	Pearson's correlation (r)	p-value
Male	Tongue strength (kPa) vs tongue endurance (seconds)	0.047	0.595

Female	Tongue strength (kPa) vs tongue endurance (seconds)	0.181*	0.041

[Table/Fig-8]: Shows Pearson's correlation between tongue strength and endurance between genders.

DISCUSSION

The ageing process is marked by a series of anatomical and functional changes in the neuromuscular system, significantly affecting skeletal muscle function. The tongue, a unique muscular hydrostat made up of interlaced intrinsic and extrinsic muscle fibres, is subject to age-related alterations [8,23]. The incessant motion of the tongue is essential for functions such as deglutition, articulation, and maintaining airway patency. However, as one ages, there is a reduction in lingual muscle thickness, a decline in contractile efficiency, and impaired coordination, which may hinder its functional performance. Furthermore, sensory decline and delayed neural feedback mechanisms due to ageing may exacerbate these functional impairments [24]. The present study aimed to determine the decline in tongue strength and endurance as age advanced, as well as the variation in gender among Institutionalised individuals aged 65 years and above in Chennai, with a sample size of 256, comprising 128 males and 128 females.

In the present study, there was an evident decline in tongue strength across the age groups as age advanced. This shows a strong prevalence of decreased tongue strength, with 27.3% in 65-70 years and 62.8% in individuals above 80 years of age. In the literature, several studies also had similar findings, where there were instances of decreased tongue strength as age increased [6,25,26]. A recent study conducted by Siqueira AV et al., on a healthy Brazilian population in 2026 showed similar trends of reduced tongue strength as age progressed [27]. In 2012, a study was conducted by Clark HM and Solomon NP on the American population's measured tongue strength. Strength in young adults, middle-aged adults, and the elderly. The study revealed that elderly individuals exhibited reduced tongue strength, which shows correspondence to the current study [28]. A meta-analysis conducted by Adams V et al., stated that individuals younger than 60 years of age showed significant tongue strength compared to individuals over 60 years of age, which coincides with our study [29].

Clinically, this reduced tongue strength has direct implications for swallowing efficiency, as inadequate lingual pressure may impair bolus propulsion and increase the risk of oropharyngeal dysphagia and aspiration [30]. Consequently, early identification of reduced tongue strength in elderly individuals becomes essential, as this condition may cause frailty in the whole body. As mentioned above, tongue pressure and swallowing functions are thought to be reduced due to systemic sarcopenia, although Chen KC et al., and Shimazaki Y et al., stated that systemic sarcopenia doesn't need to cause reduced tongue pressure [6,31], but a study conducted by Tashiro K et al., claimed that a decreased number of functioning teeth and remaining teeth are found to be in association with the reduced tongue strength [32].

In the present study, females showed a significant decrease in tongue strength compared to males; this result is consistent with the study conducted by Lin WY et al., where the mean maximum isometric tongue pressure was higher in males than in females [18]. These findings align with several other studies that show females have decreased tongue strength [24,29,32,33]. In contrast, several studies showed that there's no significant association between gender and tongue strength [27,33-35]. This disparity may be attributed to differences in muscle mass, hormonal influences, and overall physiological composition. Clinically, this finding signifies that elderly females may represent more vulnerable subgroups for developing oral functional deficits [36].

The significant prevalence of reduced tongue endurance across all ages in this study aligns with findings from Nicosia MA et al., and Crow HC and Ship JA, which indicated that the endurance capability of the lingual musculature diminishes with age due to neuromuscular fatigue and decreased oxidative capacity [33,34]. On the other hand, the observed gender differences in tongue endurance, wherein males demonstrated significantly lower endurance compared to females, are solely because of physiological composition, where females possess a higher proportion of type I muscle fibres, which confer greater resistance to fatigue [37,38]. This finding is in contrast to many studies where there was no significance of gender in the prevalence of tongue endurance [27,29,34,35].

Correlation analysis between tongue strength and endurance revealed a weak but statistically significant positive relationship in females, whereas no significant association was observed in males. This suggests that, in females, improving tongue strength may modestly contribute to enhancing endurance, indicating a degree of functional interdependence. In contrast, the lack of association in males suggests that these parameters may need to be dealt with independently during rehabilitation. Age-wise analysis demonstrated a significant positive correlation only in the age group of 76-80 years, which may represent a transitional phase wherein both strength and endurance decline concurrently before becoming functionally dissociated in advanced age.

Comprehensively, the prevalence of reduced tongue strength (55.5%) and endurance (75.4%) observed in this study emphasises the importance of routine screening of tongue function in elderly individuals, particularly in Institutionalised settings, to enable early diagnosis and intervention. Timely rehabilitative measures can significantly reduce complications such as dysphagia, malnutrition, dehydration, and aspiration pneumonia, thereby improving the overall quality of life [39].

Clinically, incorporation of objective assessment tools such as the IOPI and structured tongue-strengthening exercises has shown effectiveness in improving swallowing outcomes by increasing the tongue's strength [40,41]. An interdisciplinary approach involving oral physicians, speech-language pathologists, and geriatricians is essential for comprehensive management. Advanced techniques such as ultrasound- and MRI-based muscle assessment, along with emerging digital screening tools, offer promising opportunities for early detection and monitoring [42].

Limitation(s)

Nevertheless, the current study has a relatively small and geographically restricted sample selection, which limits causal inference, generalisability, and longitudinal follow-up. Future research should focus on longitudinal and multicentric studies and integration with gold standard swallowing assessments such as Videofluoroscopic Swallow Study (VFSS) and Fibreoptic Endoscopic Evaluation of Swallowing (FEES) and interventional trials to establish standardised rehabilitation protocols and improve clinical outcomes [43].

CONCLUSION(S)

The current study revealed substantial gender disparities in tongue function among elderly individuals, mostly residing in institutions. The findings suggested that females were more likely to have reduced tongue endurance and diminished tongue strength compared to males. A favourable association existed between tongue strength and endurance, particularly in females. This research underscores the need for regular evaluations of tongue function in the older population. Gender-specific assessments of tongue strength and endurance may facilitate the identification of early indicators of oral function decrease and possible dysphagia risk, hence enabling timely intervention.

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