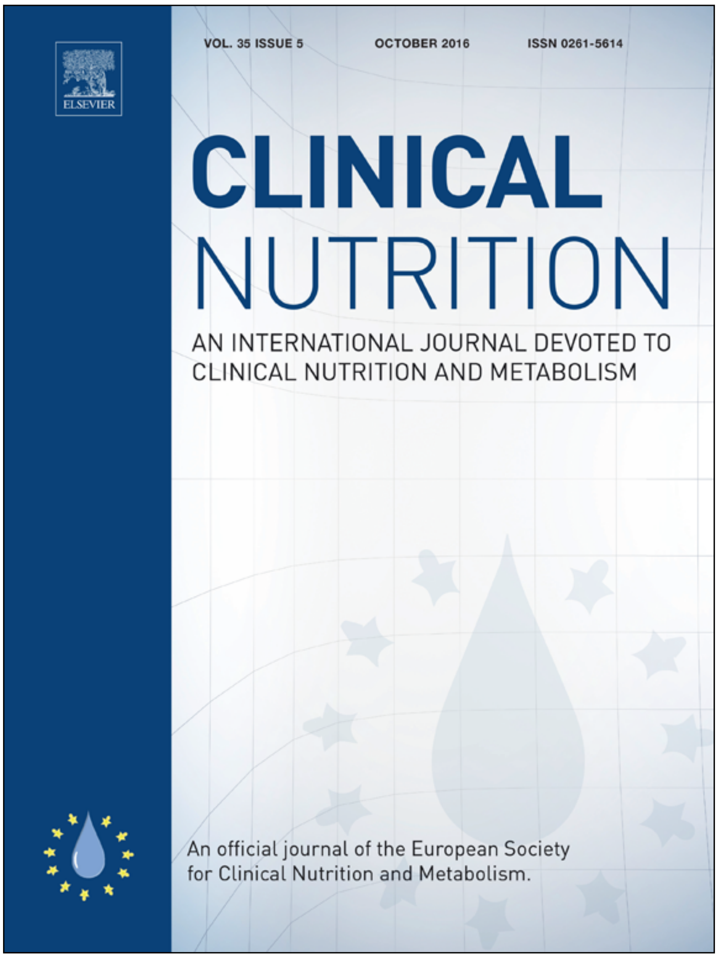
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Original article

# The effect of tongue strength on meal consumption in long term care

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SUMMARY

*Purpose:* As many as 74% of residents in long-term care (LTC) are anticipated to have swallowing difficulties (dysphagia). Low food intake is commonly reported in persons with swallowing problems, but food intake may also be affected by fatigue in the swallowing muscles. As fatigue sets in during mealtimes, the strength of the tongue may decline. Tongue strength is also known to decline with age but it is unclear how this functional change may influence food intake. In this pilot study, we explored the relationship between tongue strength and meal consumption in persons not previously diagnosed with dysphagia.
*Methods:* The Iowa Oral Performance Instrument was used to collect maximum anterior isometric tongue-palate pressures from 12 LTC residents (5 male; mean age: 85, range 65–99). Residents were also screened for dysphagia with applesauce and a water swallow test. Each resident was observed at three different meals to record the length of time taken to eat the meal, amount of food consumed, and any indication of overt signs of swallowing difficulty (e.g. coughing).
*Results:* Residents who displayed observable swallowing difficulties at mealtimes had significantly lower tongue strength than those without swallowing difficulties ($p < 0.01$). Those with lower tongue strength took significantly longer to complete meals ($p < 0.05$) and consumed less food. Tongue strength was not predictive of performance on the water screen and the water swallow test was not a good predictor of which participants were observed to display mealtime difficulties.
*Conclusion:* Among seniors in long term care, reduced tongue strength is associated with longer meal times, reduced food consumption, and the presence of observable signs of swallowing difficulty. Further exploration of these relationships is warranted.


## 1. Introduction

Elderly adults living in long term care (LTC) facilities (including nursing homes and assisted living), are nutritionally vulnerable. Inadequate food and fluid intake leads to malnutrition. Malnutrition is estimated to be present in 30–60% of those living in LTC, with negative consequences for health, well-being, quality of life (QOL) and health care costs [1]. Malnutrition can also lead to serious illnesses, which may call for hospitalization. In Canada, admissions from LTC account for approximately 10% of all acute care hospital visits [2]. As the baby-boomers age, an increased demand for LTC beds is anticipated [3]. In the European Union (EU), elderly people currently account for approximately 18% of the population [4] and the old-age dependency ratio (i.e., the number of people over 65 divided by the number of people aged 15–64) is expected to reach 53% by 2050 (up from 25% in 2007) [5]. These demographic changes will place serious pressures on the healthcare system, which will be exacerbated by malnutrition unless effective solutions for poor food intake in LTC are found. In order to limit and mitigate the costs associated with malnutrition, it is critical that we determine the factors associated with and contributing to poor food intake and malnutrition among those residing in LTC.

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Poor food and fluid intake is the primary cause for LTC malnutrition; average consumption has been estimated at 50% of food offered [[6] 2003]. Dysphagia (swallowing difficulty) is also a known comorbidity for those in LTC, and estimated to be present in as many as 74% of residents [7,8]. There is an even higher prevalence of dysphagia in those with dementia [9], who comprise a large proportion of LTC residents. Residents with dysphagia are at increased risk for inadequate food intake, leading to malnutrition [10]. Food intake may also be affected by eating-related fatigue [11] and this may be of particular concern in seniors with dysphagia, who are reported to take longer to eat [12].

The tongue is a critical organ in swallowing, providing the driving forces that transport food and liquid through the mouth and pharynx. Fatigue in the tongue muscles may contribute to incomplete food clearance (residue), prolonged time to complete a meal and reduced intake. In a study by Kays and colleagues [13] the tongue strength of older, healthy adults (aged 65–82) was measured twice at baseline and once following consumption of a meal. The results showed that the activity of eating a meal can be tiring enough to cause a reduction in post-meal measures of tongue strength compared to pre-meal measures. Previous studies have also shown that tongue pressures are generally lower in healthy older adults when compared to healthy younger adults [14–18], and reduced tongue strength is associated with aspiration (i.e., entry of material into the airway, contributing to the risk of respiratory consequences) [19]. However, we do not know the extent to which tongue strength impacts food intake in elderly individuals living in LTC. If an age-related reduction in tongue strength increases the demands of dining for those in LTC, we may see longer mealtimes, leading to reduced intake and contributing to malnutrition risk.

The goal of the current pilot study was to explore tongue strength in elderly residents in a LTC facility and to measure its association with: (a) signs of swallowing impairment based on a dysphagia screening tool; (b) length of time to eat a meal; (c) signs of swallowing impairment observed during meals; and (d) amount of food consumed. The study was also conducted to establish feasibility of collecting these measures in a larger, future study. We hypothesized that those with reduced tongue strength would be more likely to demonstrate signs of swallowing impairment on the dysphagia screening tool, take longer to finish eating, show signs of swallowing impairment during meals, and eat less than residents with tongue strength within the reported norms.

## 2. Materials and methods

### 2.1. Participants

A pilot sample of 20 elderly residents (8 male, 12 female; mean age: 85, range 65–99) was recruited from a LTC facility in Waterloo, Canada as part of a larger project exploring predictors of malnutrition. Informed written consent was obtained directly from LTC residents who had the capacity to consent as identified by unit staff. For residents who did not have the capacity to provide informed consent, unit managers or designates approached substitute decision makers using a standard script for permission to provide their contact information to the researchers. In the cases where a substitute decision maker provided consent for participation, assent to participate in the study was evaluated by the willingness of residents to cooperate with data collection procedures. The inclusion and exclusion criteria for participants can be found in Table 1.

A subset of these 20 pilot participants was recruited to perform the swallowing screening and tongue strength measures. In total, twelve elderly adults (5 male, 7 female; mean age: 85, range 65–99) made up this smaller group of residents. The inclusion criteria for this subset can be found in Table 2.

#### 2.1.1. Swallowing screening and tongue strength

Each participant in the study was screened for dysphagia by a licensed speech-language pathologist (SLP) using a modified version of the Screening Tool for Acute Neurological Dysphagia (STAND) [20]. This tool evaluates a participant's risk of dysphagia using pureed fruit (Mott's ® Fruitsations Unsweetened Applesauce) and water (Nestle ® Pure Life Bottled Water). The modifications adopted for the purposes of this pilot study were as follows:

1) Each participant was asked to repeat the initial task of swallowing a teaspoon of puree (applesauce) three times to ensure representative sampling of swallowing behavior. The puree task was discontinued if any difficulties were noted.
2) Two saliva swallows were elicited after completion of the puree trials, regardless of the number of puree trials completed. Thicker consistencies are known to cause increased residue [21]; therefore, these saliva swallows were included for the purpose of clearing any residue prior to the water swallow portion of the test.
3) A single 3-ounce water swallow trial was performed, requiring residents to drink water from a cup. The additional straw-drinking 3-ounce water swallow trial specified in the original STAND protocol was omitted.
4) Oxygen saturation levels were not monitored, and tearing in the eyes was not used as a sign of swallowing difficulty since these signs have not been found to be valid indications of swallowing impairment in the broader swallowing literature [22,23].
5) Lastly, the observation of more than two swallows per bolus was added as a sign of swallowing difficulty [24].

Measures of tongue strength were taken by the SLP using the Iowa Oral Performance Instrument (IOPI). The IOPI is a handheld manometry system that consists of a 2.7 ml air-filled bulb that is squeezed between the tongue and the hard palate (see Fig. 1). Pressures are displayed on the device LCD screen, in kilopascals. The bulb is attached to the IOPI machine with a small, clear connector tube, which also prevents the bulb from being swallowed accidentally. A clean, individually wrapped, single-use tongue pressure bulb was used for each participant, and disposed of immediately after use. In consultation with the manufacturer, we have developed a Microsoft Excel software program to register a digital pressure waveform from the analog signal generated by the IOPI at 250 Hz. This enables us to provide a biofeedback screen view of the tongue pressure measurement to the participant during data collection and to extract detailed measures of tongue pressure amplitude and timing from the recorded waveform (Fig. 2). Both maximum anterior isometric tongue strength pressures (squeezing the bulb between the front of the tongue and the hard palate as hard as possible) and saliva swallow pressures (keeping the bulb at the front of the tongue while swallowing saliva) were collected three times from each participant. Each participant was allowed to practice two times before any data were collected. Tongue pressure tasks were cued with a 10 s rest between each task repetition; total time to complete these tasks was three to 5 min.

Swallowing screening and tongue pressure tasks were completed in a single session for all residents. Measures were taken between meals and typically in the morning when residents were most alert. The unit kitchen served as the most accessible place to complete all of the tasks. Any participants who were unwilling or unable to follow the instructions to perform the tasks were excluded.

**Table 1**
Inclusion and exclusion criteria for larger pilot study exploring predictors of malnutrition.

| Inclusion | Exclusion |
|---|---|
| • 65 + years of age<br>• Required at least 2 h per day of nursing care due to dependence in activities of daily living<br>• Had resided in the home for at least two months<br>• Functional communication in English<br>• Either they or their substitute-decision maker could provide consent to participate. | • Medically unstable<br>• Required tube-feeding<br>• Not eating because they were receiving palliative care<br>• Had advanced directives excluding them from research |

**Table 2**
Inclusion and exclusion criteria for participants in swallow screening experiment.

| Inclusion | Exclusion |
|---|---|
| • Had a diet prescription that permitted them to drink thin liquids at mealtimes<br>• Alert and responsive<br>• Able to sit upright<br>• Able to follow simple, one-step directions | • Dysphagia diet (i.e. prescribed to drink thickened liquids during meals)<br>• Unable to follow commands |

### 2.1.2. Meal observations

Three separate meals were observed on the same day for the purposes of determining food intake for each participant. Two trained research assistants (RA) worked in tandem to collect meal observations from five residents per meal. Observations included:

- weighing all items individually on the main plate, before and after the resident was finished and estimating intake of other meal components based on the standard portions provided (e.g. beverages, side dishes);
- documenting mealtime processes (e.g. length of time to eat the meal, number of assistants helping the resident, etc.);
- documenting any eating assistance provided; and
- completing a checklist of mealtime behaviours of the resident and staff who interacted with the resident.

Food weighing was completed by one research assistant, who was located next to the servery, with measures recorded in grams using a calibrated digital balance (Ohaus V22PWE3T, ITIN Scale Company, Brooklyn, NY). The second research assistant monitored other mealtime data collection while main dishes were being plated. When a resident finished their main plate, it was retrieved by the assistants and put aside for weighing of waste after the meal service was complete. The difference between plated and leftover food, was captured as the amount 'consumed' and the total weight of the main plate items only were used in this analysis. At each meal there were two choices for the main plate, choice of beverages and at least two different dessert options, therefore resident meals could have differed slightly.

The dining room was an open environment where residents could come as early or leave as late as they wanted for the meal. Researchers entered the dining area for observations before the scheduled start of the meal. Length of time at the meal was determined by identifying the difference between "start time" (defined as the latest of: a) the time when the resident arrived; or b) when food/beverages were made available for consumption at the table) and "end time" (defined as the earliest of: c) the time when the resident left the meal and did not return; or d) when all food provided to the patient had been consumed. Residents were made aware of these measurements at the time of consent. While residents were not specifically notified when mealtime observations were taking place, the RAs were in plain sight and wore nametags indicating that they were part of the study.

The Edinburgh Feeding Evaluation in Dementia (EdFED) scale was used to document mealtime eating skills and difficulties [25]. This validated instrument consists of ten questions which are scored as occurring 1 (never), 2 (sometimes) or 3 (often). An overall score of greater than 10 is considered indicative of mealtime difficulties. As this tool does not directly assess all mealtime challenges, including signs of swallowing difficulties, an additional nine questions were created (e.g. does the resident receive verbal prompting to eat). Two questions are focused on swallowing signs (Does the resident cough during the meal? Does the resident choke during the meal?). These additional items were scored to be consistent with the EdFED. A list of the questions can be found in Tables 3 and 4.


**Fig. 1.** The Iowa Oral Performance Instrument (IOPI), a hand-held device to measure tongue pressures is depicted on the left, and the anterior placement of an IOPI tongue pressure bulb is depicted on the right.

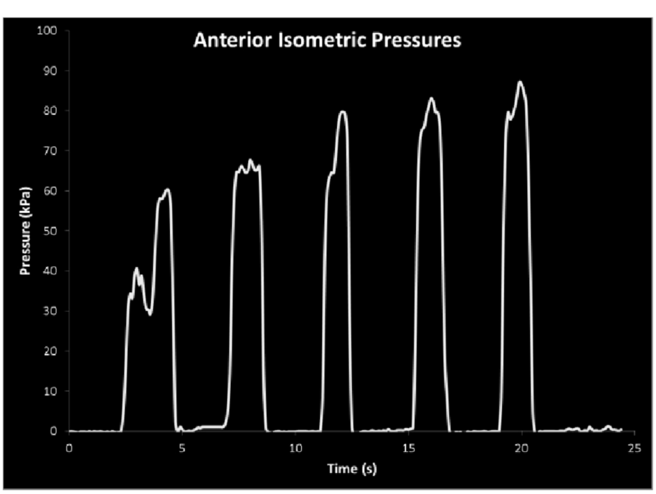


**Fig. 2.** Sample of a waveform from maximum anterior isometric tongue pressures.

### 2.2. Analysis

Descriptive statistics (means and 95% confidence intervals) were obtained for the tongue strength and saliva swallow pressure measures as well as for mealtime, and daily consumed food weight. Frequency statistics were calculated for the categorical variables of presence/absence of signs of swallowing impairment on the STAND dysphagia screening tool and the swallowing signs observed at meals. Any single observation of swallowing difficulty across any of the three meals was sufficient to result in a code of swallowing signs being 'present'. Differences in tongue strength were explored

**Table 3**
EdFED and additional questions to evaluate mealtime difficulties.

| EdFed questions |
|---|
| 1. Does the resident require close supervision while feeding/eating? |
| 2. Does the resident require physical help while feeding/eating? |
| 3. Is there spillage while feeding/eating? |
| 4. Does the resident tend to leave food on the plate at the end of the meal? |
| 5. Does the resident ever refuse to eat? |
| 6. Does the resident ever spit out his food? |
| 7. Is there spillage of food out of the mouth? |
| 8. Does the resident ever turn his head away while being fed? |
| 9. Does the resident refuse to open his mouth? |
| 10. Does the resident refuse to swallow? |
| **Additional questions regarding eating behaviours** |
| 1. Does the resident receive close supervision while feeding/eating? |
| 2. Does the resident receive verbal prompting to eat? |
| 3. Does the resident use adaptive utensils to eat? |
| 4. Does the resident appear distracted e.g. watching TV, or people, repetitive behaviours thereby seeming to forget the food in front of them? |
| 5. Does the resident treat the food in an unusual way e.g. repetitive behaviours of manipulating food without eating, doing strange things with food such a pouring liquid onto plate, etc.? |
| 6. Does the resident lack energy to eat? |
| 7. Does the resident appear to have chewing problems? |
| 8. Does the resident cough during the meal? |
| 9. Does the resident choke during the meal? |

between participants with and without signs of swallowing impairment using one-way analyses of variance (ANOVA) with repeated measures. Participants were then stratified into two groups according to whether their maximum tongue strength measures fell above or below the lower 95% confidence interval boundary (normal; reduced tongue strength). Differences between the two tongue strength groups were explored using univariate ANOVAs for the mealtime measures of: a) time required to complete a meal (averaged across the 3 meals); and b) daily amount of food consumed across the 3 meals. The relationship between meal duration and amount of food consumed was explored using scatter plots and linear regression.

## 3. Results

Tables 3 and 4 summarizes the means and 95% confidence intervals for the tongue-pressure parameters of interest, calculated based on three repetitions of each task obtained from each participant.

None of the participants showed difficulties on the puree (applesauce) or the saliva swallow components of the modified STAND. Two of the 12 participants failed the swallow screen based on the fact that they displayed difficulties on the 3-ounce water swallowing challenge. Maximum isometric tongue strength was notably lower in one of these two participants (13 kPa vs. overall mean of 35 kPa), however as a pair, these two participants did not display significantly lower tongue strength measures than those seen in participants who passed the water swallowing challenge: $F(1, 10) = 0.442$, $p = 0.52$.

**Table 4**
Maximum tongue pressure measures.

| | Mean | Lower confidence interval boundary | Upper confidence interval boundary |
|---|---|---|---|
| Maximum tongue strength (kPa) | 35 | 25 | 45 |
| Maximum saliva swallow pressure (kPa) | 29 | 20 | 38 |

Four participants displayed signs of swallowing impairment at mealtimes. As a group, these residents had reduced maximum isometric tongue strength (mean: 17 kPa, 95% confidence interval: 7–27) compared to those without swallowing difficulties (mean: 37 kPa, 95% CI: 29–44) (Fig. 3). This difference was statistically significant: $F(1, 10) = 12.97$, $p < 0.005$.

Those with lower tongue strength (less than 28 kPa, as displayed in Fig. 3) also took an average of 20 min longer than participants with normal tongue strength to complete meals: (82 min vs. 62 min; $F(1, 9) = 5.81$, $p = 0.04$. The estimated amount of food consumed, in grams, did not differ between individuals with reduced versus normal tongue strength ($p = 0.1$). However, meal duration showed a significant negative correlation with food consumption; reduced daily food intake of the main plate items was associated with significantly longer mealtimes, as illustrated in Fig. 4 ($r = -0.63$, $p = 0.04$; $r^2 = 0.39$).

## 4. Discussion

These results illustrate that reduced anterior maximum isometric tongue pressures may be a good predictor of dysphagia and mealtime difficulty for residents living in LTC. Based on the current study, there is a clear disparity in tongue strength between those who displayed observable swallowing difficulties at mealtimes and those who did not. The participants formed two discrete groups: one with anterior MIPs below 28 kPa and another group with anterior MIPs above 28 kPa. The group with lower tongue strength displayed difficulties at the meal, whereas the group with relatively higher tongue strength displayed no mealtime difficulties. The tongue plays a critical role in bolus transport from the oral cavity to the pharynx. Appropriate tongue strength is crucial to help avoid problems like residue and aspiration (entry of material into the airway). Given the tongue's significant contributions to swallowing, it is logical that reduced tongue strength might be predictive of mealtime difficulties.

The literature suggests that healthy elderly adults should have anterior maximum isometric pressures (MIPs) of at least 40 kPa [14,15,26,27], and saliva swallow pressures between 20 and 30 kPa. The average anterior MIPs of the elderly residents in this study fell slightly below normative values, but the saliva swallow pressures for this group tended to fall within the normative range [15]. This is

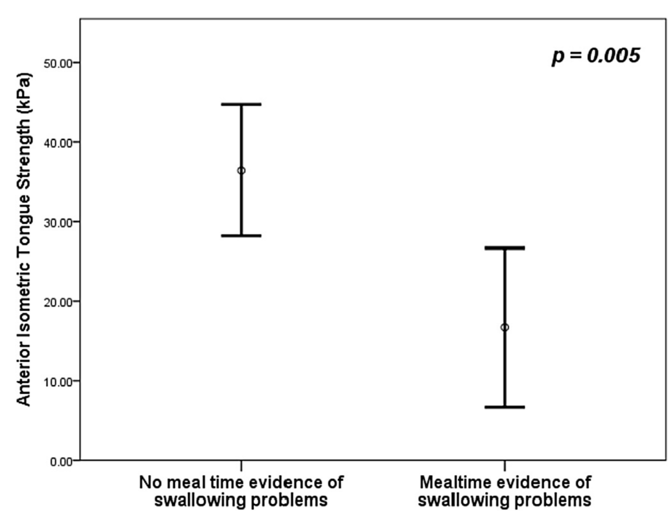


**Fig. 3.** Graph showing that those with mealtime evidence of swallowing problems had significantly lower tongue strength than those who displayed no evidence of mealtime difficulties.

consistent with previous literature that has reported a decrease in tongue pressure MIPs in elderly individuals [15,17,26–28]. These age-related decreases in tongue pressure may be indicative of sarcopenia of the tongue. Sarcopenia generally results from a decrease in the size and number of muscle fibers and an increase in noncontractile tissue, which could result in a less mobile tongue [27].

Anterior tongue strength also proved to be predictive of length of time to eat a meal and the daily amount of food consumed. Although seemingly logical, those who had lower tongue strength generally took longer to eat a meal and ate less than those with higher tongue strength. Food intake might also be affected by fatigue, as this is a commonly reported condition of older adults [11,13,29]. A major complaint of many seniors with dysphagia is that it takes them a longer time to eat than others, possibly due to fatigue; one result of this is limited food intake [12]. Considering that the muscles of the tongue are active participants in the swallowing process, it would be expected that as muscle fatigue sets in, the strength of these muscles will decline and eating may become a more arduous task. This could also lead to reduced ingestion, contributing to malnutrition over time. Previous research has shown that the activity of eating a meal can be tiring enough to cause a reduction in post-meal measures of tongue strength in healthy elderly individuals [13]. Therefore, if tongue strength is already low for LTC residents at baseline, then it is possible that tongue strength will decline further during mealtimes and directly impact the length of time to eat a meal and the amount of food consumed.

It is interesting to note that none of the residents in this pilot study had difficulty with the puree or saliva swallow components of the modified STAND dysphagia screening tool. Those that failed showed difficulties on the water swallow component of the test only, and only one of these two people showed any overt difficulties at meals. Furthermore, three persons with observable choking or coughing during meals were not identified by this screening task. Moreover, those with low tongue strength did not necessarily fail the water swallow screen. Although widely used, the water swallow screen does not appear to be helpful in predicting those with functional swallowing difficulties in a LTC setting. The 3-ounce water swallow test is typically used to determine if thin liquids and all other food consistencies can be taken safely (i.e., without aspiration), and is reported to have high sensitivity (100%) and low specificity (25%) in those with dementia [29], who make up approximately 70% of the LTC population [7]. Despite the small sample size in the current study, this same test was not found to be a good predictor of the more direct observation of mealtime difficulties. The study by Suiter & Leder [29] that reported high sensitivity and low specificity of the water test evaluated difficulties under strict testing conditions, after using a fiberoptic endoscopic evaluation of swallowing (FEES) to predetermine swallowing status. The testing environment and the presence of a scope through a naris and down the oropharynx may have skewed the results of their study. Further, the validity of Suiter and Leder's water test findings was potentially criterion biased by the fact that the FEES exam had already been completed and the results were known to the examiners.

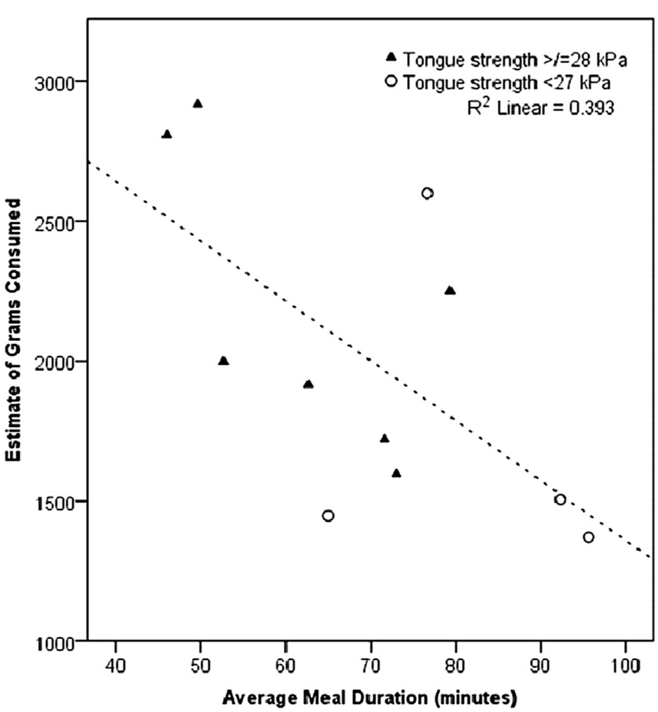


**Fig. 4.** Scatterplot displaying the relationship between time to eat a meal, daily amount of food consumed and tongue strength. Those with lower tongue strength tended to take longer to eat and ate less than those with higher tongue strength.

### 4.1. Limitations

There are some limitations to note for the current study. The first, is that this was a pilot study including a very small sample of the LTC population; results might vary with a larger sample size. Moreover, the LTC residence from which the pilot participants were recruited may not be representative of all LTC homes. The current study did not make comparisons based on cognitive impairment or oral health status, however all participants had sufficient cognitive function to follow study instructions. Medications were also not considered in this study, and these may have affected appetite, lethargy at meals and time for meal consumption. Meal duration measures did not subtract bathroom breaks or prolonged periods of time when the resident might not have been eating. This may have inflated the length of the mealtimes measured. The amount of food consumed and used in this analysis was simply the weight of the main plate that was eaten; it does not provide a complete picture of all of the foods and fluids provided at the meal. It would be interesting to further explore the types of food consumed in entirety (e.g. meat, pudding) as it can be hypothesized that foods that are more challenging to might contribute to greater fatigue and longer mealtimes.

A further limitation of this study is that only anterior maximum isometric tongue pressures were measured, as opposed to also looking at posterior maximum isometric tongue pressures. The anterior tongue is used for formation, placement and manipulation of the bolus in the oral cavity, whereas the posterior tongue is primarily responsible for containment of the bolus in the oral cavity and propulsion into the pharynx. Given the crucial role of the posterior tongue in the swallowing process, it may have been beneficial to also assess the strength of the posterior tongue. Through this measurement we may better understand if the anterior or posterior tongue contributes more to mealtime difficulties, or if both play an equal role.

## 5. Conclusions

In conclusion, in this pilot study, tongue pressure measurement has been shown to hold promise as an indicator of poor meal consumption for elderly residents in long term care. There was a clear difference in tongue strength between LTC residents who showed signs of swallowing difficulty at mealtimes and those who did not. Reduced tongue strength was also associated with longer meal times, reduced food intake and the presence of observable choking and coughing at the meal. Although widely used, the 3-ounce water swallow test does not appear to identify those who show these clinical signs of swallowing difficulties. Further exploration of these relationships and the potential to improve food intake using tongue strength training is warranted.

## Conflict of interest

None.

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