Dysphagia
DOI 10.1007/s00455-017-9825-z

ORIGINAL ARTICLE

How Swallow Pressures and Dysphagia Affect Malnutrition and Mealtime Outcomes in Long-Term Care

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Received: 13 February 2017 / Accepted: 14 July 2017

Abstract Malnutrition is a major cause of hospitalization for residents of long-term care facilities (LTC). Dysphagia is thought to contribute to malnutrition. Tongue weakness is suggested to predict poor food intake, longer meals, and dysphagia. We explored the relationships between tongue strength, dysphagia, malnutrition and mealtime outcomes in LTC residents. Data were collected from 639 LTC residents (199 male), aged 62–102 (mean 87). Maximum isometric tongue pressures (MIPs) and saliva swallow pressures (MSPs) were measured using the Iowa Oral Performance Instrument. Participants also completed the Screening Tool for Acute Neuro Dysphagia. Nutrition status was assessed using the Patient-Generated Subjective Global Assessment. A series of repeated meal observations provided measures of meal duration and calories consumed. Mean MIPs were 33 kPa (95% CI 29–37) and MSPs were 26 kPa (95% CI 23–29). The odds of showing signs of dysphagia were 3.7 times greater in those with MSPs less than 26 kPa ($p < 0.05$). The odds of being malnourished were almost double in those showing signs of dysphagia. Co-occurrence of dysphagia and malnutrition was seen in 29%. Residents with low MSPs also had significantly longer mealtime durations (MTD) ($p < 0.05$). Moreover, those with both low swallowing pressures and suspected dysphagia consumed fewer calories/minute ($p < 0.05$) and had significantly longer MTDs ($p < 0.05$). This study confirms associations between tongue weakness, signs of dysphagia, mealtime outcomes and malnutrition among LTC residents. These findings suggest that saliva swallow pressure measures may be helpful for early identification of dysphagia and nutritional risk in this population.

Keywords Deglutition · Dysphagia · Nutrition · Elderly · Tongue · Nursing home

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Introduction

The fastest growing segment of the population in Canada is the elderly [1], and they have the highest rate of illnesses, disability, and admission to hospital. Malnutrition plays both a contributing and complicating role in these conditions, but this is often under-recognized by healthcare professionals [2–4]. Nutrition-related factors such as weight loss, undereating, obesity, diabetes and sarcopenia can precipitate admission to long-term care homes (LTC) [5–7]. The estimated prevalence of malnutrition in LTC ranges from 12 to 54%; the broad range for this estimate is attributed to the paucity of high-quality literature, lack of standard definitions [8], and diversity in homes (e.g., public vs private, rural vs urban, cultural vs multicultural). Several resident-level risk factors for malnutrition in LTC have been cited, including social isolation, depression, dementia, poor dentition, multiple medications and dysphagia (swallowing impairment) [9]; however, how each of these factors contributes to malnutrition is not well understood.

Dysphagia is another concern for seniors living in LTC, independent of malnutrition, as it is a known comorbidity of dementia [10] which afflicts the majority of LTC residents albeit at varying degrees of severity. Dysphagia has been reported to hinder medical recovery in the elderly, leading to longer hospitalizations and an increased need for LTC [11]. A common sequela of dysphagia, aspiration pneumonia, is also associated with a significant risk of morbidity and mortality [12]. When present, dysphagia is commonly assumed to contribute to malnutrition risk, but there is little direct evidence of this relationship in the literature. A recent systematic review on malnutrition and dysphagia in LTC found some evidence of co-occurrence, with estimated prevalence of the co-occurrence ranging from 3 to 28%. However, a lack of standard definitions and measures for both malnutrition and dysphagia limited the ability to draw objective conclusions [8]. If we can establish the extent and nature of the relationship between dysphagia and malnutrition in LTC, this will determine whether screening for both conditions should be recommended and whether assessment for one condition should be recommended as a rule in individuals recognized to have the other condition. It is also possible that interventions to treat or prevent dysphagia may have secondary benefits of helping to prevent malnutrition, or vice versa.

The tongue plays a primary role in swallowing, contributing to the formation, placement, and manipulation of the bolus within the oral cavity, and generating the forces that propel a bolus into and through the pharynx [13]. Several studies suggest that tongue strength declines with age [14–16], and in adults with dysphagia [17–21]. Associations have been made between tongue weakness and aspiration (i.e., entry of food or drink into the airway during swallowing) in healthy community dwelling seniors [22], and this same relationship may exist for older adults living in LTC. In one preliminary study performed in LTC, correlations were found between low tongue strength and several measures of mealtime function, including longer mealtime durations (MTDs), reduced food and drink intake, and increased prevalence of mealtime difficulties [23]. In another study, tongue strength was shown to decline over the course of a meal in seniors [24]. Reduced tongue strength may, therefore, be a factor contributing both to dysphagia and to malnutrition.

The purpose of the current study was to study the associations between: (a) nutritional status; (b) mealtime measures of food intake; (c) clinical signs suggesting the presence of dysphagia; and (d) reduced tongue strength in a large sample of older adults living in LTC. We hypothesized that signs of dysphagia would be associated with malnutrition, and that reduced tongue strength would be associated with signs of dysphagia. Based on a previous pilot study [23], we expected to find that tongue weakness would be associated with longer MTDs and reduced food intake. Given the hypothesis that reduced tongue strength would be associated with the presence of dysphagia, we expected that similar findings for MTD and food intake would be seen in individuals with suspected dysphagia.

Methods

This study was conducted as a part of a larger study known as M3: Making the Most of Mealtimes. The larger M3 study was a cross-sectional, multi-site study involving data collection in four provinces across Canada: New Brunswick, Ontario, Manitoba, and Alberta. Human subjects ethics clearance was obtained from the Research Ethics Boards of the Universities of Alberta, Manitoba, Moncton, and Waterloo, as well as the University Health Network in Toronto. In some cases, approval was also required and received from review boards inside the individual LTC homes.

Participants

A total of 639 residents (199 male; mean age: 87 [range 62–107] years) were recruited from 32 LTC homes across Canada (8 homes per province). Within each province, LTC homes were purposively sampled in an attempt to recruit a diverse and representative sample with respect to facility size (minimum of 50 residents), model of care, profit-status (for profit = 10, not for profit = 22), cultural factors, rural/urban region and other home-level determinants that might impact food intake [25]. Within each LTC home, we recruited residents from up to three randomly selected care units, with a care unit defined as a geographic area in a LTC home, having a consistent, assigned group of direct care providers and, typically, its own dining area. In each home, we ensured the inclusion of at least one dementia specific unit, if such a designation existed for the home. All residents within these units, regardless of cognitive ability, were eligible to participate if they were over the age of 65 years; required at least 2 h per day of nursing care; had resided in the home for at least 1 month; and either they or their substitute decision maker provided consent to participate. Residents were excluded if they were currently medically unstable (i.e., within 1 month of acute care hospitalization); were on a short-term admission (e.g., respite care); required tube feeding; were not eating because they were at the end of life; or had advanced directives excluding them from research. Home staff identified those who met these criteria [26]. A random number table was used to determine the order in which eligible residents from each unit should be approached by home staff to inquire whether they were interested in hearing more about the study from research staff. For residents who were not considered competent, their alternative decision maker was approached. Informed written consent was obtained directly from residents who were identified by unit staff as having the capacity to consent, or from alternative decision makers from those considered to lack capacity. Continued assent to participate was confirmed throughout data collection, based on the willingness of residents to cooperate with data collection procedures [27].

Measures and Data Collection

Data were collected between January and December 2015. The data collection team in each province included a coordinator (a registered dietitian or individual with dietetics training and applied nutrition research experience) and two post-graduate research associates (RAs) who were trained to collect food intake and meal observation data.

Nutritional Status

Data on age, gender, cognition, health, nutritional status, and potential risk factors for poor food intake were collected at the resident-level. Nutritional status was assessed using the Patient-Generated Subjective Global Assessment (PG-SGA) [28, 29], tailored to the LTC environment, as described in the M3 protocol [30]. Residents were classified either as adequately nourished (diagnostic category A), mildly or moderately malnourished (diagnostic category B), or severely malnourished (diagnostic category C) [31]. The PG-SGA inquired about changes in weight, dietary intake, gastrointestinal symptoms, functional capacity, as well as a physical examination of subcutaneous fat, muscle wasting, edema, and ascites. Diagnostic categories B and C were collapsed, so that those who were determined to be in one of these two categories were deemed to be malnourished and residents falling under category A were deemed to have no nutritional concerns.

Food Intake and Mealtime Measures

Three nonconsecutive days of meal observation, including a weekend day, were used to measure the food intake of participants, with residents observed at 3 meals each day, for a total of 9 meal observations per resident. Estimates of caloric intake were based on nutrient analysis of the facility menu, using *The Food Processor Software* from ESHA Research (version 10.14.2). This process is further described in the M3 protocol [30]. Estimates of additional food and fluid intake at snack times and between meals were included, based on inquiries with the residents, family and/or staff. Site staff were asked to report before-breakfast food consumption and were trained to record evening snacks and beverage intake on food intake assessment days. Other mealtime measures, such as MTD, were recorded at each meal. In addition, a more elaborate mealtime observation was conducted for each resident at one meal per observation day (three observations total). This detailed mealtime observation included the documentation of mealtime behaviors, such as coughing and choking.

Dysphagia Status

Dysphagia status was a composite variable, determined on the basis of three different input variables. First, individuals who were already receiving thickened liquids were considered to have possible dysphagia. Second, with the exception of residents already receiving thickened liquids, all other participants who were cognitively aware completed a swallow screen using the Screening Tool for Acute Neuro Dysphagia (STAND) [32]. Residents consumed three teaspoons of applesauce and drank 90 ml of water in a continuous fashion. If signs of dysphagia (i.e., coughing, wet voice quality, throat clearing) were noted at any point during the test, the test was stopped and it was noted that the resident was likely at risk of dysphagia. Third, any single observation of coughing or choking across any of the three meals where mealtime behaviors were observed for any resident was also sufficient to result in a code of risk of dysphagia. Documentation of a swallowing concern through any one of these three mechanisms resulted in a resident being classified as having suspected dysphagia.

Tongue-Strength

The investigation of tongue strength was conducted in a subset of the larger study, comprising the 8 LTC homes located in the province of Ontario. M3 participants were included in this portion of the study if they (1) had a diet prescription that permitted them to drink thin liquids at mealtimes; (2) were alert and responsive; (3) were able to sit upright; and (4) were able to follow simple one-step directions. Residents were excluded if they were already receiving thickened liquids at meals or were unable to follow commands. Of the 160 Ontario residents included in the national study, the subset meeting the inclusion criteria for tongue strength measurement comprised 80 residents (20 male; mean age: 87.3 ± 7.04, range 72–102). Measures of tongue strength were taken using the Iowa Oral Performance Instrument (IOPI). The IOPI is a handheld pressure bulb system that consists of a small air-filled bulb, which is placed in the mouth and squeezed between the tongue and the hard palate (see Fig. 1). A strain gauge sensor inside the device measures the amount of air displaced from the bulb in kilopascals (kPa). For this study, we used a custom LabView software program to register a digital pressure waveform from the analog output of the IOPI device at 250 Hz (see Fig. 2). This enabled us to display a biofeedback screen view of the tongue-pressure waveform to the participant throughout data collection, and to extract detailed measures of tongue-pressure amplitude from the recorded signal. Maximum isometric tongue-pressures (MIPs) were recorded across a series of three bulb squeezes, with the bulb held in an anterior position, just behind the teeth (see Fig. 3). Saliva swallows were recorded across a series of three cued tasks, with the bulb held in the same anterior position. Tongue-pressure tasks were cued with a 10-s rest between task repetitions. In total, 2 min were required to collect the tongue-pressure measures. A clean, individually wrapped, single-use tongue-pressure bulb was used for each participant, and discarded immediately after use.

Data Analysis

Before analysis, the data were cleaned, noting any discrepancies, missing data, and irregular data points. RAs and paper data collection forms were consulted to rectify errors when possible. Frequency statistics were calculated for the categorical variables (PG-SGA result; dysphagia status input variables; dysphagia status composite variable). Frequencies were then cross-tabulated to determine the co-occurrence of malnutrition and suspected dysphagia, and an odds-ratio was calculated to measure the association between these two variables.

Descriptive statistics (means and 95% confidence intervals) were calculated for continuous parameters (MTD; food intake in calories). For the subset of residents from Ontario, descriptive statistics were also calculated for

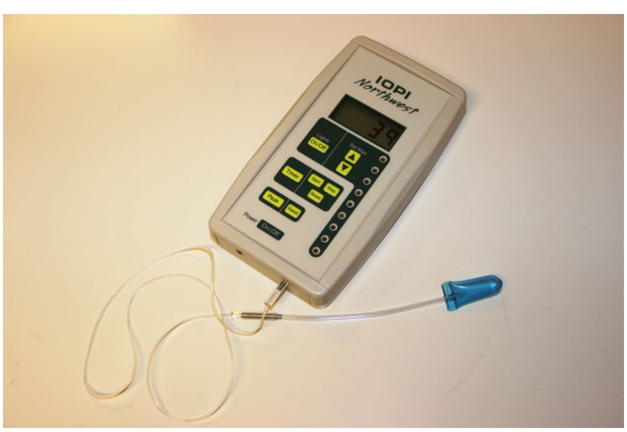

Fig. 1 The Iowa Oral Performance Instrument

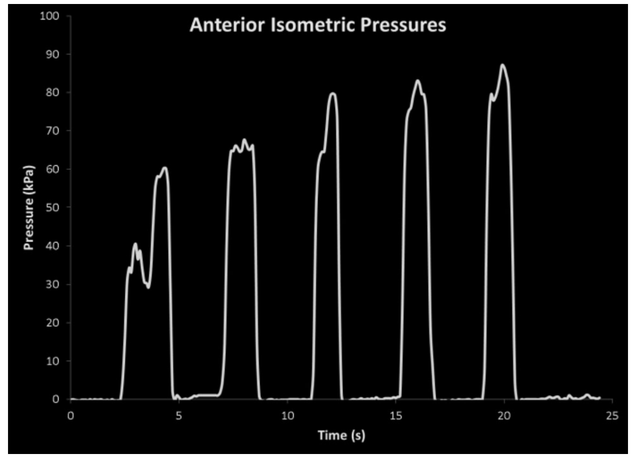

Fig. 2 Sample of a waveform from maximum anterior isometric tongue pressures

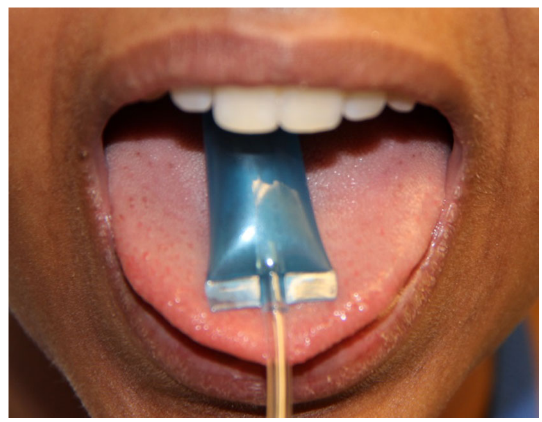

Fig. 3 Anterior placement of an IOPI tongue pressure bulb

maximum anterior isometric tongue pressure (MIP), maximum saliva swallow pressure (MSP), and for swallow pressure expressed as a percent of MIP. Pearson correlations were run to determine whether tongue pressures varied as a function of age. Differences in MTD and caloric intake were explored between participants classified with versus without suspected dysphagia using univariate analysis of variance (ANOVA). Univariate ANOVAs were also used to explore differences in MIPs and MSPs between participants classified with suspected dysphagia and those who were not. Additional post hoc analyses of the tongue pressure data were performed between dichotomized subgroups of participants with MSPs $\leq$ or $>$ the overall group mean MSP (normal; reduced swallow pressures), as well as performed for subgroups of participants who swallowed at $\leq$ or $>$100% of their MIP. Differences between these tongue strength subgroups were explored using univariate ANOVAs for the mealtime measures of MTD, weight of food and drink intake, caloric intake, and calories consumed per minute. Frequencies were cross-tabulated to determine the co-occurrence of low swallow pressure and malnutrition, low swallow pressure and suspected dysphagia, as well as swallows >100% of MIP and malnutrition and swallows >100% of MIP and cognitive impairment.

Results

Nutritional Status

As shown in Table 1, of the 639 residents included in the nationwide dataset, 638 had complete data for malnutrition. A total of 281 residents (44.0%) were found to be malnourished. Of these, 244 residents (38.2% of the total sample) were considered to be mildly/moderately malnourished as per the modified PG-SGA and 37 (5.8% of the total sample) were considered to be severely malnourished. Of the 80 residents recruited in Ontario, 21 (26.3%) were considered to be malnourished, and of these residents 20 (28.1% of the Ontario sample) were moderately malnourished and 1 was severely malnourished.

Food Intake and Mealtime Duration

The average MTD across residents from all four provinces was 40.04 ± 17.4 min, and the average number of calories consumed at a meal was 1571 ± 421 calories, as shown in Table 1. In Ontario, average MTD was 38.44 ± 10.43 min and average calorie consumption was 1631 ± 411 calories.

Dysphagia Status

As shown in Table 1, in the larger, nationwide data set, only 68 residents (10.6%) were found to have existing prescription for thickened fluids; of these, two-thirds (i.e., $n = 46$) were on nectar-thick fluids, 19 were receiving honey-thick liquids, and three residents were on the most restrictive modification, pudding-thick liquids. Signs of coughing during at least one observed meal were recorded for 243 residents (38.3% of the national sample) and choking was observed in 19 residents (3%). The STAND was completed in a total of 427 residents across the country and 192 of these residents (45%) showed signs of dysphagia. Closer inspection of the data revealed that almost equal numbers displayed signs of swallowing difficulty on the puree swallow portion of the test ($n = 78$) and on the 90-ml water swallow portion ($n = 79$). The remaining residents either displayed difficulties while performing the dry swallows, or did not complete the test for a variety of reasons. As per the protocol for the STAND (32), those who failed the puree swallow portion did not move on to the water swallow portion of the test. In total, 378 unique residents in the nationwide data set (i.e., 59.2%) met the composite criteria for being classified as having suspected dysphagia.

Table 1 Demographics and health characteristics of study participants

	All provinces		Ontario subset	
N	639		80	
Age, mean (SD)	86.8 (7.83)		87.3 (7.04)	
	n	%	*n*	%
Gender, men, *n* (%)	199	31.1	20	25.0
Malnutrition total	281[a]	44.0	21	26.3
Moderately malnourished	244	38.2	20	28.1
Severely malnourished	37	5.8	1	1.25
Suspected dysphagia total[b]	378	59.2	25	31.3
Thickened liquids	68	10.6	1	1.25
Swallowing difficulties on STAND	192[c]	30.0	23	28.8
Observed coughing at meals	243	38.3	2	2.50
Observed choking at meals	19	2.97	1	1.25
Mealtime duration (min), mean (SD)	40.0 (17.4)		38.4 (10.4)	
Caloric intake, mean (SD)	1571 (421)		1631 (411)	

[a] $n = 638$

[b] Suspected dysphagia total is the unique number of residents presenting with at least one of the conditions that make up the composite variable

[c] Only performed on $n = 427$

In the Ontario subset, a single resident had a prescription for thickened liquids at meals. Two residents were observed to cough at least once during the meal observations, and one of these two residents was also observed to choke at least once. Signs of swallowing difficulty were observed during the STAND screening test in 23 residents (28.8%), of whom 17 failed the 90-ml water swallow portion of the screening test. In total, 25 residents of the 80 in the Ontario subset (31.3%) were classified as having suspected dysphagia.

Association Between Nutritional and Dysphagia Status

Of the 281 residents in the nationwide dataset who were considered to be malnourished, 184 (65% of malnourished) were also classified as having suspected dysphagia. Therefore, an overall co-occurrence rate of 29.0% (184/638) was found for malnutrition and suspected dysphagia. Residents with suspected dysphagia had a higher prevalence and greater odds of malnutrition than those without dysphagia ($\chi^2(1) = 8.520$, $p < 0.05$; odds ratio = 1.62, 95% confidence interval 1.17–2.24).

Association Between Mealtime Measures, Intake, and Dysphagia Status

In the nationwide sample, average MTD was significantly longer in those classified with suspected dysphagia versus those without ($F(1,363) = 16.320$, $p < 0.001$; Cohen's $d = 0.4$ [small]). LTC residents without suspected dysphagia took on average 38.65 ± 12.51 min to eat, while those with suspected dysphagia took an average of 44.02 ± 12.04 min to eat. However, the number of calories consumed did not change significantly based on dysphagia risk ($F(1,363) = 1.364$, $p = 0.244$). Residents with suspected dysphagia ate on average 1544.69 ± 385.67 kcal, whereas residents without suspected dysphagia ate on average 1705.77 ± 472.08 kcal.

Tongue-Strength

Complete tongue pressure data were only available for 64 of the 80 residents in the Ontario subset. Table 2 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. There was little correlation between maximum swallowing pressures and age ($r^2 = 0.024$), and between maximum isometric pressures and age ($r^2 = 0.029$) (see Figs. 4, 5, respectively). On average, participants used 88.2% of their total tongue MIP range during saliva swallowing (95% CI 79.8–96.6%). As shown in Fig. 6, swallowing pressures were notably lower in residents classified as having suspected dysphagia compared to those without (mean = 22 kPa, 95% CI 17–26; vs mean = 28 kPa, 95% CI 25–32 respectively), and this difference was statistically significant: $F(1,62) = 5.152$, $p < 0.05$; Cohen's $d = 0.6$ [medium]. However, no difference in MIPs was found between those with and without suspected dysphagia ($F(1,78) = 1.442$, $p = 0.233$); those who were at risk for dysphagia had a MIP of 29 kPa (95% CI 24–34), and those without signs of dysphagia had a mean MIP of 33 kPa (95% CI 29–38). There were also no differences in swallow pressures as a percent of MIP for residents with and without suspected dysphagia ($F(1,62) = 0.280$, $p = 0.599$).

When the maximum swallow pressure parameter was dichotomized into a categorical variable ($\leq$ vs $>$ the overall mean MSP value of 26 kPa), 37 residents were classified as having low swallowing pressures. These individuals were more likely to be classified as having dysphagia than those with higher MSPs ($\chi^2(1) = 5.56$, $p < 0.05$; odds ratio: 3.694, 95% CI 1.21–11.24). When swallow pressure status (low; high) was cross-tabulated against nutritional status, no differences were found in the frequency of malnutrition between groups ($\chi^2(1) = 0.094$, $p = 0.759$). Similarly, no significant differences were found between swallow pressure groups and caloric intake ($F(1,62) = 0.10$, $p = 0.921$). However, as seen in Fig. 7, significant differences were found in MTD between swallow pressure groups ($F(1,62) = 6.65$, $p < 0.05$; Cohen's $d = 0.46$ [small]). Group differences in calories consumed per minute narrowly missed significance ($F(1,62) = 3.932$, $p = 0.05$).

The maximum swallow pressure parameter was also dichotomized into another categorical variable; mean swallow pressure greater than 100% of MIP and mean swallow pressure equal to or less than 100% of MIP. Twenty residents were classified as having swallow pressures that were greater

Table 2 Summary of tongue pressure parameters

	Mean	Lower confidence interval boundary	Upper confidence interval boundary
Maximum tongue strength (kPa)	34 (16)	29	37
Maximum saliva swallow pressure (kPa)	26 (12)	23	29

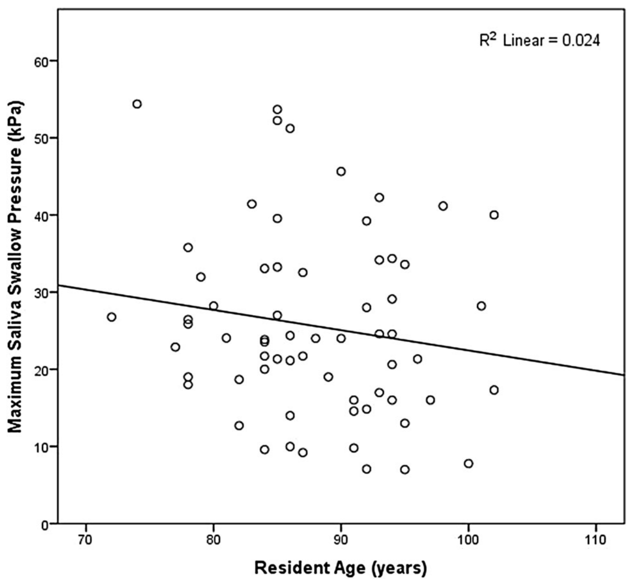

Fig. 4 Scatterplot displaying association between resident age and maximum swallow pressure

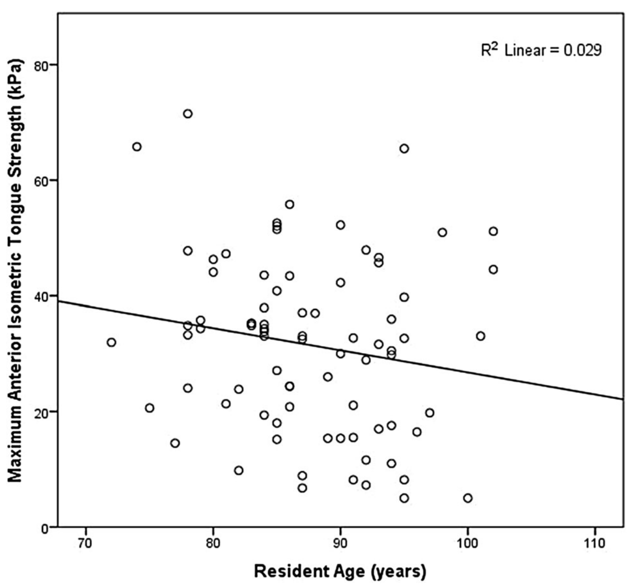

Fig. 5 Scatterplot displaying association between resident age and maximum anterior isometric pressure

than 100% of MIP. These participants were no more likely to be malnourished than those with swallow pressures less than 100% of MIP ($\chi^2(1) = 0.190, p = 0.66$), nor were they more likely to be more cognitively impaired ($\chi^2(1) = 0.509$, $p = 0.475$). However, significant differences were found between residents with swallow pressures less than or equal to 100% of MIP versus those with pressures greater than 100% of MIP and amount of food and drink intake in grams (2103.41 ± 595.01 vs 1782.23 ± 452.40 g, respectively; $F(1,62) = 4.60$, $p < 0.05$), MTD (36.13 ± 10.20 vs 41.93 ± 9.48 min, respectively; $F(1,62) = 4.65, p < 0.05$),

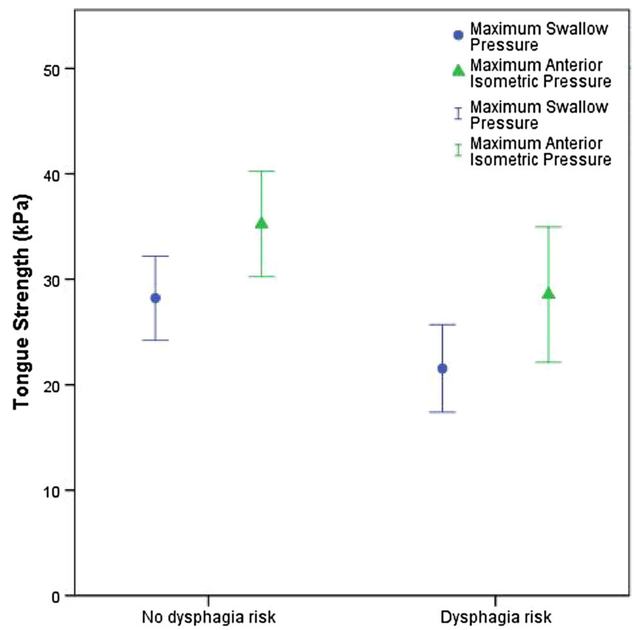

Fig. 6 Graph showing that swallowing pressures were significantly lower in residents classified as having suspected dysphagia compared to those without. No differences in maximum anterior isometric pressures were found between those with and without suspected dysphagia

as well as mean calories per minute (50.16 ± 19.09 cal/min vs 39.03 ± 13.33 cal/min, respectively; $F(1,62) = 5.54$, $p < 0.05$). No significant differences were found between swallow pressure groups and resident age ($F(1,62) = 0.15$, $p = 0.70$) and caloric intake ($F(1,62) = 1.11, p = 0.30$).

Residents with the combination of suspected dysphagia and low swallowing pressures had similar calorie consumption to those with higher swallow pressures and/or no signs of dysphagia ($F(3,60) = 0.799$, $p = 0.500$), and neither condition on its own resulted in significantly lower calorie consumption (swallowing pressures: $F(1,60) = 0.012$, $p = 0.913$; dysphagia risk: $F(1,60) = 1.396$, $p = 0.242$). Residents with the combination of low swallowing pressures and suspected dysphagia took an average of 43.90 min to eat (95% CI 39.48–48.31), which was significantly longer than those without dysphagia and/or with higher swallow pressures, who took an average of 33.77 min to eat (95% CI 29.57–37.98) ($F(3,60) = 3.861, p < 0.05$; Cohen's $d = 0.59$ [medium]). When compared separately, the group with reduced swallow pressures had significant longer MTDs, but this was not seen for residents who had signs of dysphagia (swallow pressures: $F(1,60) = 4.432$, $p < 0.05$, Cohen's $d = 0.46$ [small]; dysphagia risk: $F(1,60) = 2.548$, $p = 0.116$). When calorie consumption and MTD were combined, the number of calories consumed per minute was significantly lower in the group with both reduced swallow pressures and signs of dysphagia ($F(3,60) = 3.114$, $p < 0.05$; Cohen's $d = 0.35$ [small]). Analyzed separately,

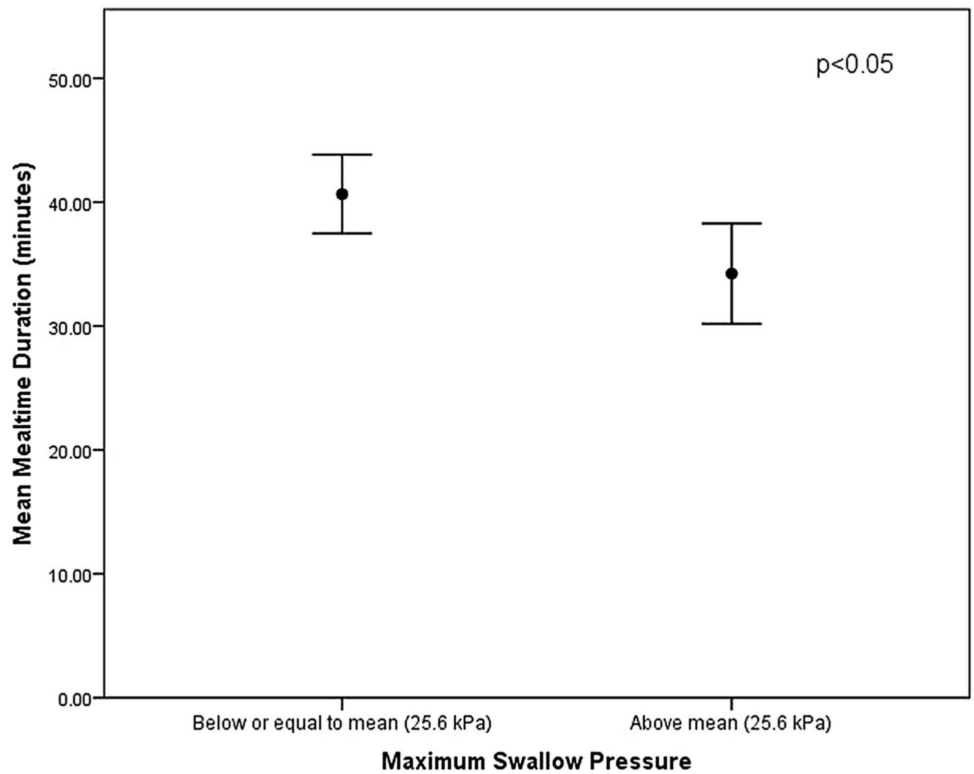

Fig. 7 Graph showing differences between mealtime duration for residents with swallow pressures above versus equal to or below the mean (26 kPa)

neither swallow pressures nor dysphagia risk significantly influenced the mean number of calories consumed per minute (swallow pressure: $F(1,60) = 3.225$, $p = 0.078$; dysphagia risk: $F(1,60) = 1.658$, $p = 0.203$). Those with low swallow pressures and suspected dysphagia ate an average of 36.61 calories per minute (95% CI 28.67–44.55) while those without dysphagia and/or higher swallow pressures ate an average of 51.75 calories per minute (95% CI 44.20–59.30) (see Fig. 8).

Discussion

These results illustrate that suspected dysphagia and malnutrition co-occur in the LTC setting, and that the presence of dysphagia significantly increases a LTC resident's odds of becoming malnourished. Previous studies have suggested that malnutrition is a consequence of dysphagia, but this study establishes proof-of-principle regarding this association. We hypothesized that the co-occurrence of malnutrition would be greater than the range previously reported in a small pilot study of LTC residents (3–28%) [8]; however, we found the co-occurrence to only be slightly above previous reports, at 29%. It is important to note that the observed rate of co-occurrence may both under- or over-estimate the actual prevalence of dysphagia, given that the composite dysphagia status parameter was based on screening rather than objective instrumental examination.

It was somewhat surprising to discover that a relatively small proportion of residents in LTC across the country were on a prescription for thickened fluids, given that this is described to be one of the most common ways to treat dysphagia [10] and that a large proportion of residents were observed to be coughing at meals. If a thin liquid flows quickly through the mouth, it can spill into the pharynx prematurely and result in aspiration, which may trigger a cough response. Such circumstances may warrant the prescription of thickened fluids that flow more slowly through the oral cavity, and allow the swallowing mechanism more time to activate airway protection. Interestingly, almost equal numbers of residents failed the puree and 90-ml water swallowing portions of the STAND. In theory, purees are less likely to be aspirated because they move more slowly through the oral cavity and pharynx, similar to thickened liquids. However, thicker substances have been shown to cause more residue [33]. If residue remains in the pharynx post-swallow, it may cause post-swallow aspiration, which could lead to choking. Purees like applesauce are generally considered one of the easier consistencies to consume, so if residents are displaying issues with this consistency, it is quite likely that they are also having difficulties swallowing other consistencies. The results of this study underscore the importance of screening for

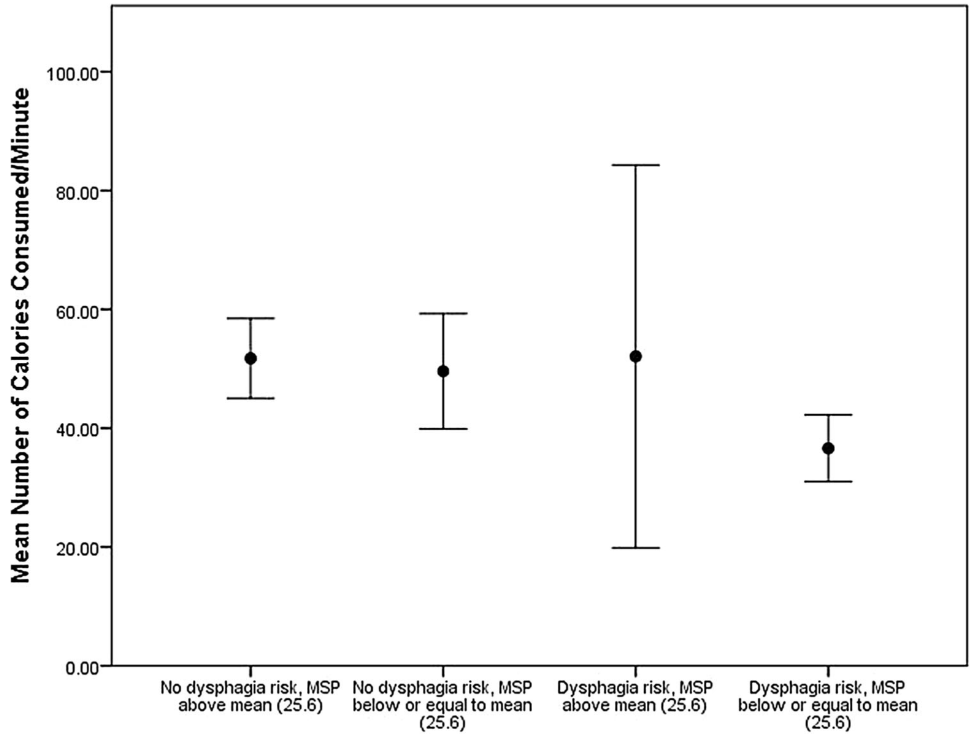

Fig. 8 Graph showing differences in mean number of calories consumed per minute for those with and without signs of dysphagia, as well as with swallow pressures equal to or below the mean versus above the mean (26 kPa)

dysphagia as a means of preventing malnutrition, considering the large proportion of residents who were found to have suspected dysphagia (59.2% of the national sample). With appropriate training, dysphagia screening can be conducted by any of the registered health care professional staff in a LTC home, and will help prioritize residents who need to be referred to speech-language pathologists for more detailed assessment and intervention.

MIPs values seen in the current study are similar to those previously reported for healthy elderly adults over the age of 80. Vanderwegen and colleagues reported that men over the age of 80 have mean anterior MIPs of 34 kPa and women over the age of 80 have mean anterior MIPs of about 28 kPa. We found mean anterior MIPs of 33 kPa (95% CI 29–37) for a group of both men and women. By contrast, the saliva swallow pressures measured in the current study fell below those previously reported in the literature. Nicosia [34] and Robbins [35] both performed similar studies looking at tongue strength during saliva swallowing with the IOPI but presented their data in graphic form without exact numbers, so results cannot be compared. Youmans and Stierwalt [13] also measured swallowing pressures but used a bolus rather than saliva. They found that older adults aged 60–79 had a mean swallow pressure of 30 kPa with a thin liquid bolus, compared to our group who had a mean saliva swallow pressure of 26 kPa (95% CI 23–29). Because of the differences between studies, including both subject attributes and materials swallowed, it is difficult to compare these numbers. The lower pressures observed in this study may be attributable to the increased age and vulnerability of the LTC population. Furthermore, increased prevalence of malnutrition in LTC, which may lead to frailty and sarcopenia, could plausibly contribute to weaker tongue pressures. Further investigation is warranted regarding pressures generated during swallowing in the elderly.

Youmans and Stierwalt [13] also reported swallow pressures as a percentage of MIP. They found that the older adults in their sample used 53.8% of their MIP-range to swallow. Robbins and colleagues [35] have also studied this parameter, reporting that older adults generally used 45.9% of their MIP-range to swallow. The results in our study are considerably higher, with elderly adults in LTC using 88.2% of their MIP-range to swallow. As previously acknowledged, the studies differed in many ways, including the fact that both prior studies used a bolus while measuring swallowing pressures, rather than saliva. It is also interesting to note that approximately one-third of the residents were using over 100% of their MIP-range to swallow, but this was unrelated to cognitive impairment. Our study suggests that functional reserve, i.e., the difference between MIPs and MSPs [20], is significantly reduced in the LTC population. Reductions in functional reserve have been argued to have possible clinical implications, putting patients at greater risk of developing functional swallow impairments, particularly in the case of decompensation [14, 34]. However, given that swallow pressures expressed as a percentage of MIPs had no bearing on suspected dysphagia within the current study and many residents had no functional reserve at all (i.e., when swallow pressures were greater than 100% of MIP), the clinical significance of functional reserve remains in question.

Initially, we hypothesized that the current study would show results similar to a previous pilot study performed in 12 residents from a single LTC home, which showed that residents with MIPs below 28 kPa took significantly longer to eat, ate less and displayed more mealtime difficulties than those who had MIPs above 28 kPa [23]. The current study did not corroborate these results; rather, differences in MIPs appeared to be less important than differences in swallow pressures. We found that residents were using a larger proportion of their MIP-range in order to produce a swallow, and swallow pressures were more predictive of both dysphagia risk and mealtime performance (MTD and number of calories consumed per minute). The results suggest that a reduction in swallow pressures generated by the tongue puts residents at a significantly increased risk for dysphagia. Suspected dysphagia, in turn, increases the risk of malnutrition. This was seen in the 29% of the LTC sample who presented with both malnutrition and suspected dysphagia. When low swallow pressures were combined with dysphagia risk, mealtime outcomes were also affected, with residents tending to take longer to eat and consuming fewer calories per minute. This increase in meal duration and decrease in caloric intake could reflect fatigue and reduced endurance. Previous research has shown that the act of eating a meal may be sufficient to cause fatigue and reduced post-meal measures of tongue strength in healthy elderly individuals [24]. These results may be exacerbated in a more vulnerable population, such as the elderly residing in LTC. The findings of the current study point to the possibility that interventions targeting improved tongue strength in LTC may reduce the risk of dysphagia, which in turn may help to mitigate malnutrition in this population.

Limitations

There are several limitations to note for the current study. First, the presence of dysphagia was determined based on a screening protocol rather than formal evaluation. The sensitivity of the STAND has been reported to be high for detecting both dysphagia and aspiration but the specificity of the screening tool was moderate; consequently, there is a chance that the number of residents considered to be at risk for dysphagia in this study was over-estimated. Additionally, an existing prescription for thickened fluids was accepted as a sign of dysphagia in this study. There are, however, several reasons why residents may be on thickened liquids, including poor oral health, so this may not be the best way to capture dysphagia risk. Swallowing impairment is also not the only reason why someone may cough or choke at a meal. A broad array of factors that can influence mealtime performance, including distractibility, availability of eating assistance, and palatability of the food [23], could also have influenced the occurrence of coughing and choking seen at mealtimes, leading to possible inflation of estimated dysphagia prevalence.

Another limitation of this analysis is the fact that medications were not considered; several medications are known to alter appetite and this may have influenced caloric intake, lethargy, and MTD. Measures of caloric intake may have also been confounded by imprecise estimates of food and drink intake between meals by RAs and LTC staff. Measures of mealtime function are also difficult to compare across facilities with different menus.

A further limitation of this study is the fact that only anterior MIPs were measured, rather than also looking at posterior MIPs. 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 would have been ideal to also assess the strength of the posterior tongue. Through this measurement, we may better understand whether weakness in the anterior or posterior tongue contributes more to mealtime difficulties, or whether both play an equal role. It would have also been beneficial to measure swallowing pressures using a bolus rather than saliva in order to draw comparisons to previous studies in the literature. However, it is particularly challenging to manage both a bolus and the IOPI bulb in the mouth at the same time; given the advanced age and prevalence of dementia in this sample, we decided to use the safer and less challenging option of measuring swallowing pressures with saliva.

Conclusion

The findings of our study have several significant implications. This is the first large study to quantify both malnutrition and risk of dysphagia among elderly residents of LTC, many of whom had dementia. We found that malnutrition occurs in 44% of LTC residents, risk of dysphagia occurs in 59% of residents, and the conditions co-occur in approximately 29% of the LTC population. We were also able to show that for residents living in LTC, having low swallow pressures significantly increases their odds of having dysphagia and in turn, if they present with signs or symptoms of dysphagia, their odds of becoming malnourished increase significantly. Moreover, those with low swallow pressures take significantly longer to eat and consume fewer calories per minute compared to those who do not have low swallow pressures. With these findings, we can move forward to explore feasible methods to improve tongue strength and reduce the risk of dysphagia in LTC. Further research is also warranted to confirm the prevalence of dysphagia in LTC using objective instrumental examinations, rather than screening, and to confirm how the presence of dysphagia affects nutrition.

Funding This study was funded by Canadian Institute of Health Research (Grant Number MOP-136888).

Compliance with Ethical Standards

Conflict of interest Heather Keller is a part of the Speaker's Bureau for Nestle Health Science, Abbott Nutrition and Fresenius Kabi, and receives salary support from the Schlegel-University of Waterloo Research Institute for Aging. The remaining authors declare that they have no conflicts of interest.

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