Relating Physiologic Swallowing Impairment, Functional Swallowing Ability, And Swallow-Specific Quality Of Life

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R. Jordan Hazelwood[1] · Kent E. Armeson[2] · Elizabeth G. Hill[2] · Heather Shaw Bonilha[3] · Bonnie Martin-Harris[4,5,6]

Abstract
Many studies include functional swallowing ability and quality of life information to indicate a response to a specific swallowing intervention or to describe the natural history of dysphagia across diseases and conditions. Study results are difficult to interpret because the association between these factors and actual swallowing impairment is not understood. We set out to test the associations between components of physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life using standardized and validated measurement tools: Modified Barium Swallow Impairment Profile (MBSImP), Functional Oral Intake Scale (FOIS), Eating Assessment Tool (EAT-10), and Dysphagia Handicap Index (DHI). We specifically aimed to understand which factors may contribute to the overall relationships between these measurement tools when analyzed using total scores and item-level scores. This study included a heterogeneous cohort of 273 outpatients who underwent a modified barium swallow study (MBSS). We found significant correlations between MBSImP total scores and FOIS scores and DHI total scores, but not between MBSImP total scores and EAT-10 total scores. Significant correlations were also found between MBSImP item-level component scores and FOIS scores, EAT-10 total scores, and DHI total scores. Detailed item-level analyses revealed the MBSImP components of bolus transport/lingual motion, oral residue, and tongue base retraction were correlated with EAT-10 item-level scores and DHI item-level scores. The clinically modest associations between physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life reveal different factors that uniquely contribute to patients' overall dysphagic profile, emphasizing the clinical impact of a comprehensive swallowing assessment.

Keywords Deglutition · Deglutition disorders · Dysphagia · Assessment · Modified Barium Swallow Impairment Profile · Functional Oral Intake Scale · Eating Assessment Tool-10 · Dysphagia Handicap Index · Quality of life

✉ R. Jordan Hazelwood
hazelwoodrj@appstate.edu

[1] Department of Rehabilitation Sciences, Beaver College of Health Sciences, Appalachian State University, Boone, NC, USA

[2] Department of Public Health Sciences, College of Medicine, Medical University of South Carolina, Charleston, SC, USA

[3] Department of Health Sciences and Research, College of Health Professions, Medical University of South Carolina, Charleston, SC, USA

[4] Roxelyn and Richard Pepper Department of Communication Sciences and Disorders, Northwestern University, Evanston, IL, USA

[5] Department of Otolaryngology-Head and Neck Surgery and Radiation Oncology, NorthwesternUniversity Feinberg School of Medicine, Chicago, IL, USA

[6] Edward Hines, Jr. VA Hospital, Hines, IL, USA

Introduction

Dysphagia, a condition resulting from impairment in swallowing physiology, safety, and efficiency, can lead to devastating consequences for health and wellbeing [1–3]. Given that the prevalence of dysphagia is estimated to be nearly 37% in the hospital setting and as high as 50% in nursing homes, the impact of dysphagia is substantial [4]. While dysphagia management has historically aimed to prevent airway invasion and mitigate negative health outcomes by assessing swallowing physiology, measures that may drive care decisions, such as functional swallowing ability and swallow-specific quality of life, should, in addition to safety indicators, be considered as an integral part of comprehensive swallowing assessment [5–7]. Recent evidence has established that, in combination with components of

physiologic swallowing impairment, functional swallowing indicators of oral intake status, feeding tube status, and maximum penetration–aspiration scale score significantly aided in differentiating dysphagia severity levels [8].

Understanding the relationship between physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life is important for many aspects of clinical practice: screening and evaluating patients, determining treatment goals and plans, and assessing treatment outcomes. The proximal–distal causal continuum of health-related outcomes outlined by Brenner et al. [9] describes the modest correlation between system physiology and quality of life measurement tools, which are more removed from the medical condition [9]. This relationship is also shown in the swallowing literature. Studies relating physiologic swallowing impairment and functional swallowing ability, as measured by the Functional Oral Intake Scale (FOIS), and swallow-specific quality of life, as measured by the Eating Assessment Tool-10 (EAT-10), report varied results [10–17].

In a group of outpatients evaluated for dysphagia at a university clinic, Kendall et al. [5] assessed the correlation of quantitative swallowing measures for videofluoroscopy, including spatial and temporal measures, with EAT-10 total scores [5]. These analyses were only completed for 20 cc thin liquid boluses with no significant findings. However, a trend was reported with more impaired EAT-10 total scores associated with an increased delay in airway closure. Arrese et al. [12] explored the relationship between swallowing physiology and functional swallowing ability in a group of patients with head and neck cancer [12]. They found strong relationships between Modified Barium Swallowing Impairment Profile (MBSImP) total scores and EAT-10 total scores, but only for participants who were within one year of cancer treatment. Additional analyses for this same group of participants, which considered correlations between MBSImP total scores and EAT-10 item-level scores, revealed moderate to strong relationships for EAT-10 items describing quality of life and effort for swallowing pills and liquids. Even though the results of this study included EAT-10 item-level analysis, specific contributions of swallowing physiology were not discernible as the MBSImP component scores were not analyzed at the item-level. Another study conducted by Arrese et al. [13] comparing FOIS scores to only five of the 17 MBSImP physiologic components found no significant relationships in a small, heterogeneous group of patients with head and neck cancer [13]. Dewan et al. [14] studied a cohort of patients with various dysphagia-related etiologies and found patients with impaired MBSImP total scores had significantly lower FOIS scores and significantly higher EAT-10 total scores than those without impairment [14]. They concluded that, despite these relationships, patient reports alone did not offer sufficient information to adequately describe the full relationship between physiologic swallowing impairment and swallow-specific quality of life [14]. The findings of these studies were focused on utilizing total scores of the measurement tools; however, the specific factors (item-level scores) that may have contributed to the overall relationships were not accounted for. Like the EAT-10, the Dysphagia Handicap Index (DHI) can be used in clinical practice to elucidate information about the impact of swallowing on quality of life [18]. However, to our knowledge, there are no studies to date that have investigated the relationship between physiologic swallowing impairment and the widely used DHI.

The purpose of this study was to explore associations between physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life in a heterogeneous cohort of outpatients with dysphagia. We specifically aimed to understand which factors may contribute to the overall relationships between measurement tools when analyzed using total scores and item-level scores. Our scientific premise is that while swallowing physiology, function, and quality of life are correlated, each contributes distinctly to the overall condition of dysphagia and should be included in a comprehensive swallowing assessment. As such, one alone is not sufficient for describing the condition of dysphagia; rather, each should be considered as a related, but unique, contributor. Based on previous literature, we hypothesized there would be clinically modest associations between physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life when item-level associations were explored.

Methods

Procedures

This study represents a secondary data analysis of 312 adult modified barium swallow studies (MBSSs) consecutively conducted in response to physician referral at the Ralph H. Johnson VA Medical Center (VAMC) in Charleston, SC over a 27-month period. Assessment data were included for 1) outpatient visits for Veterans who participated in an initial MBSS, 2) studies for which FOIS scores were recorded; and 3) studies for which EAT-10 and DHI scores were collected at the time of the MBSS. A total of 273 MBSSs were included in this study; 19 studies were conducted with Veterans who received care as inpatients and 20 studies represented repeat MBSSs. MBSS data were recorded and scored as part of regular clinical care during offline frame-by-frame analysis. Each of the research team members completed training in the MBSImP approach including passing testing to ensure a good threshold of scoring reliability. Results for EAT-10 and DHI were reviewed for completeness and were

only considered for analysis if responses were given for all items. This study was approved by the Research and Development IRB at the Ralph H. Johnson VAMC.

Participants

The majority of the 273 outpatient Veterans who participated in our study were referred from general medical or oncology services. Most of the participants were white males in their mid 60s, though there was a wide age range (25 to 95 years old), Table 1.

Modified Barium Swallow Impairment Profile (MBSImP™©)

The MBSImP approach assesses 17 physiologic components of swallowing across 12 swallowing tasks in both the lateral and anterior–posterior viewing planes during MBSSs [11]. MBSImP scores can be reported in two ways: 1) as MBSImP item-level scores using overall impression (OI) scoring, or 2) as MBSImP total scores [19]. Administering the full MBSImP protocol of all 12 swallowing tasks results in an OI score for each of the 17 physiologic components. OI scores range from "0" to "4" depending on the physiologic component being assessed. Higher OI scores indicate the worst, or extreme, impairment at the item-level for each of the 17 physiologic components of swallowing [19]. MBSImP total scores are the summation of the individual OI scores from the oral and pharyngeal domains of swallowing, resulting oral total (OT) scores and pharyngeal total (PT) scores, respectively. OT scores range from "0" to "22" and PT scores range from "0" to "29," with higher OT or PT scores indicating increased physiologic impairment across the oral or pharyngeal domains. The esophageal domain of swallowing is comprised only one physiologic component, resulting scores ranging from "0" to "4" [19].

Table 1 Participant Demographics

	n	%
Referring Service		
General Medicine	116	42.5%
General Otolaryngology	80	29.3%
Neurology	31	11.4%
Head and Neck Oncology	14	5.1%
Pulmonology	14	5.1%
Gastroenterology	11	4.0%
Cardiothoracic	7	2.6%
Sex		
Male	257	94.1%
Female	16	5.9%
Race		
White	198	72.5%
Black or African American	73	26.7%
Native Hawaiian or Other Pacific Islander	2	0.7%
Other	0	0.0%
Unknown or Unreported	0	0.0%
Ethnicity		
Non-Hispanic/Non-Latino	272	99.6%
Hispanic/Latino	0	0.0%
Not known/Not reported	1	0.0%
	Mean	*Range*
Age (Years)	67.4	25–95

Functional Oral Intake Scale (FOIS)

The FOIS is a 7-point ordinal scale used to rate functional swallowing ability. This measurement tool results only in a single score ranging from "1" to "7" on an ordinal scale, with lower scores associated with increased dysphagia severity [16]. While the FOIS scale was initially validated on stroke patients, its authors have seen no difference in the scale's validation when used with patients who have head and neck cancer and dysphagia. The FOIS has been shown to have a clinically meaningful improvement in a heterogeneous population of patients with stroke and head and neck cancer if the FOIS scores increase by two or more points on the scale [20].

Eating Assessment Tool (EAT-10)

The EAT-10 is a measurement tool used to document disability and impact of swallow-specific quality of life due to changes oral intake secondary to dysphagia [17]. The EAT-10 is scored using an ordinal scale, with ten items providing a response ranging from "no problem" (score of "0") to "severe problem" (score of "4"). EAT-10 total scores range from "0" to "40," with higher scores indicating a higher level of self-perceived impairment secondary to dysphagia. EAT-10 scores greater than three indicate increased risk for dysphagia [21].

Dysphagia Handicap Index (DHI)

The DHI is a swallow-specific quality of life measurement tool for patients with dysphagia [18]. The DHI is scored using an ordinal scale, with 25 items providing a response ranging from "never" (score of "0") to "sometimes" (score of "2") to "always" (score of "4"). DHI total scores range from "0" to "100," where higher scores indicating a higher frequency of experiencing the effects of dysphagia. DHI scores can also be reported using subscale scores for physical, functional, and emotional domains. A self-perceived severity for dysphagia rating is also recorded on a 7-point

Likert scale from "normal" (score of "1") to "severe problem" (score of "7") with a middle-anchored score of "moderate problem" (score of "4"). Changes in clinical severity of dysphagia are associated with changes in DHI severity category.

Analyses

Descriptive statistics were conducted to summarize the demographics and describe the characteristics of this outpatient cohort, Figure 1. The associations between swallowing physiology (MBSImP total scores and MBSImP item-level scores), functional swallowing ability (FOIS scores), and swallow-specific quality of life (EAT-10 total scores and EAT-10 item-level scores; DHI total scores; and DHI item-level scores) were tested using Spearman's rank order correlation coefficient based on the ordinal level data in the MBSImP, FOIS, EAT-10, and DHI measurement tools. Statistical significance was set at $p < 0.05$, with weak correlations defined as coefficients between − 0.50 and 0.00 or 0.00 and 0.50, moderate correlations defined as coefficients between − 0.70 and − 0.50 or 0.50 and 0.70, and strong correlations defined as coefficients between − 1.0 to − 0.7 or 0.7 to 1.0 [22]. Analyses were completed using SPSS for Macintosh software version 22.0 (IBM Corp., Armonk, NY, USA).

Results

MBSImP Scores

The median MBSImP OI scores skewed toward decreased severity, with scores of less than or equal to "1" for 12 of 17 of the physiologic components, Table 2. Scores were generally minimal or mild impairment for all components, with the exception of bolus transport/lingual motion and initiation of pharyngeal swallow, hence the use of median rather than mean summary statistics. Median MBSImP scores of "2" for the components of bolus transport/lingual motion, oral residue, initiation of pharyngeal swallow, pharyngeal residue, and esophageal clearance, which all have maximum scores of "4", indicated only moderate physiologic impairment. One participant was missing a score for tongue control during bolus hold due to a data omission error. Seventeen participants were missing scores for bolus preparation/mastication due to safety concerns ($n = 16$) and unexpected expectoration of the bolus ($n = 1$). Pharyngeal contraction, a physiologic component that requires visualization in the anterior–posterior (A/P) position for scoring, was not scored for 16 participants as only the lateral view was captured. Lastly, esophageal clearance was not scored for 19 participants due to capture of only the lateral view ($n = 16$), no esophageal follow-through ($n = 2$), and technical issues ($n = 1$).

FOIS Scores

The median FOIS score was 7 with scores ranging from 1 to 7. The functional swallowing ability of this outpatient cohort as measured by FOIS scores was skewed, with more than 75% of the scores greater than or equal to 6. This aggregation toward higher scores affirms less functional impairment in this participant cohort, overall.

EAT-10 Total Scores and DHI Total Scores

Of the 273 outpatients who participated, 241 EAT-10 scores and 220 DHI scores were completed in their

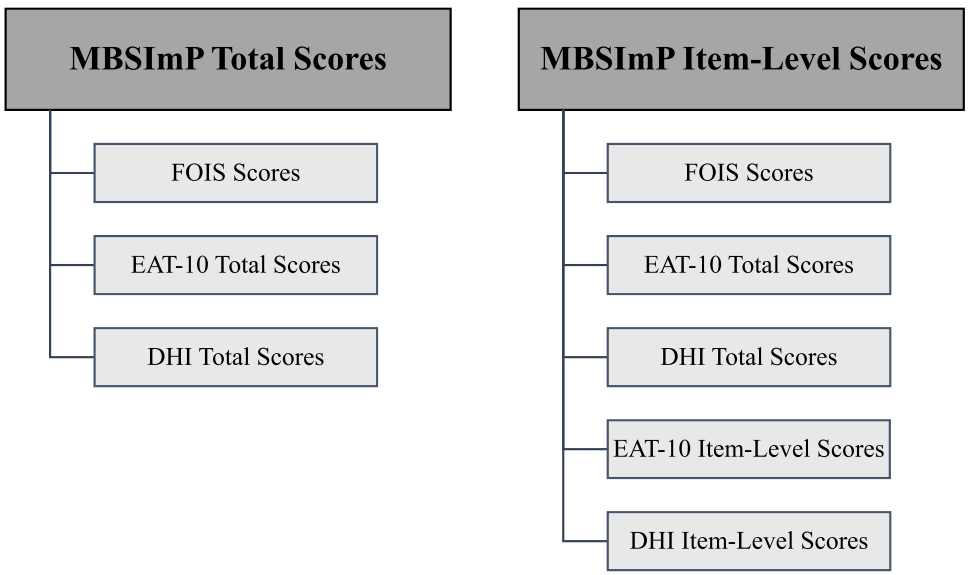

Fig. 1 Associations Between Physiologic Swallowing Impairment, Functional Swallowing Ability, and Swallow-Specific Quality of Life

Table 2 MBSImP Overall Impression Scores by MBSImP Component

MBSImP Component	*n*	MBSImP Overall Impression Scores					Median
		0	1	2	3	4	
Lip Closure	273	79	175	13	4	2	1
Tongue Control/Bolus Hold	272	149	62	56	5		0
Bolus Preparation/Mastication	256	33	206	15	2		1
Bolus Transport/Lingual Motion	273	34	83	70	84	2	2
Oral Residue	273	3	26	237	6	1	2
Initiation of Pharyngeal Swallow	273	45	79	17	132	0	2
Soft Palate Elevation	273	263	7	2	1	0	0
Laryngeal Elevation	273	90	169	14	0		1
Anterior Hyoid Excursion	273	22	203	48			1
Epiglottic Movement	273	134	38	101			1
Laryngeal Vestibular Closure	273	150	116	7			0
Pharyngeal Stripping Wave	273	122	134	17			1
Pharyngeal Contraction	257	230	4	23	0		0
PES Opening	273	112	147	13	1		1
Tongue Base Retraction	273	52	168	45	7	1	1
Pharyngeal Residue	273	3	22	232	14	2	2
Esophageal Clearance	254	47	73	121	12	1	2

entirety and were included in the final analysis. Findings from both measurement tools indicated that outpatients perceived and reported swallowing ability negatively impacted quality of life. EAT-10 total scores ranged from 0 to 40 with a mean EAT-10 total score of 13.13 (SD 9.4). The majority (73%) of EAT-10 total scores were greater than 3 (out of 40), the cut-off score indicating risk for dysphagia. DHI total scores ranged from 0 to 94 with a mean DHI total score of 32.46 (SD 21.0), indicating an overall moderate impact on quality of life. Comparison of EAT-10 total scores and DHI total scores were strongly, positively correlated ($r_s = 0.817$, $p < 0.001$) indicating possible redundancy in the measurement tools; the negative impact on swallow-specific quality of life increased as total scores increased for both tools.

MBSImP Total Scores and FOIS Scores

A weak negative correlation ($r_s\,(271) = -0.271$, $p < 0.001$) was found between MBSImP OT scores and FOIS scores. This means that as MBSImP OT scores increased, FOIS scores decreased, indicating a more restricted diet with increased oral impairment. The association between MBSImP PT scores and FOIS scores also revealed a weak negative correlation ($r_s\,(271) = -0.313$, $p < 0.001$). This means that as the MBSImP PT scores increased, FOIS scores decreased, indicating a more restricted diet with increased pharyngeal impairment.

MBSImP Total Scores and EAT-10 Total Scores

No significant associations were found between MBSImP OT scores and EAT-10 total scores or between MBSImP PT scores and EAT-10 total scores.

MBSImP Total Scores and DHI Total Scores

The MBSImP OT scores and DHI total scores were weakly, positively correlated ($r_s\,(232) = 0.133$, $p = 0.042$). This means that as the MBSImP oral total scores increased, DHI total scores increased, indicating a negative impact on swallow-specific quality of life with increased oral impairment. The association between MBSImP PT scores and DHI total scores was not significant.

MBSImP Item-Level Scores and FOIS Scores

Eight MBSImP components were weakly, negatively correlated with FOIS scores. These included lip closure ($r_s\,(271) = -0.178$, $p = 0.003$), tongue control during bolus hold ($r_s\,(271) = -0.207$, $p = 0.001$), bolus preparation/mastication ($r_s\,(271) = -0.237$, $p < 0.001$), bolus transport/lingual motion ($r_s\,(271) = -0.259$, $p < 0.001$), pharyngeal stripping wave ($r_s\,(271) = -0.280$, $p < 0.001$), pharyngoesophageal segment opening ($r_s\,(271) = -0.198$, $p = 0.001$), tongue base retraction ($r_s\,(271) = -0.376$, $p < 0.001$), and pharyngeal residue ($r_s\,(271) = -0.235$, $p < 0.001$). Results indicate that as

physiologic swallowing impairment increased for each of the MBSImP components, functional swallowing ability was also more impaired.

MBSImP Item-Level Scores and EAT-10 Total Scores

Only one significant association was found when comparing EAT-10 total scores and MBSImP item-level scores. The MBSImP component tongue base retraction was weakly, positively correlated (r_s (239) = 0.220, p = 0.001) with EAT-10 total. This means that as tongue base retraction impairment increased, EAT-10 total scores also revealed more impairment.

MBSImP Item-Level Scores and DHI Total Scores

Tests for association between MBSImP item-level component scores and DHI total scores revealed weak, positive correlations for the MBSImP components oral residue (r_s (232) = 0.140, p = 0.032), laryngeal elevation (r_s (232) = 0.136, p = 0.038), and tongue base retraction (r_s (232) = 0.241, $p < 0.001$. This means that as oral residue, laryngeal elevation, and tongue base retraction scores increased, DHI total scores increased, indicating a negative impact on swallow-specific quality of life with higher levels of physiologic impairment.

MBSImP Item-Level Scores and EAT-10 Item-Level Scores

Several significant associations were revealed between MBSImP item-level component scores and EAT-10 item-level scores. The most MBSImP components were weakly, positively correlated with the EAT-10 item "My swallowing problem has caused me to loose weight": tongue control/bolus hold (r_s (244) = 0.203, p = 0.001), bolus transport/lingual motion (r_s (244) = 0.182, p = 0.004), oral residue (r_s (244) = 0.137, p = 0.032), and tongue base retraction (r_s (244) = 0.192, p = 0.003). The MBSImP component tongue base retraction was weakly, positively correlated with eight of the ten EAT-10 items. This means that as MBSImP item-level component scores increased indicating elevated impairment, EAT-10 item-level scores also revealed increased patient-reported difficulty. No significant associations were found for two of the EAT-10 items ("Swallowing is painful" and "When I swallow food sticks in my throat"), Table 3.

MBSImP Item-Level Scores and DHI Item-Level Scores

Several significant associations were revealed between MBSImP item-level component scores and DHI item-level scores. The most MBSImP components were correlated with the DHI item "I've changed my diet due to my swallowing problems": tongue control/bolus hold (r_s (242) = 0.129, p = 0.044), bolus transport/lingual motion (r_s (242) = 0.131,

Table 3 Significant Associations between MBSImP Components and EAT-10 Items

EAT-10 Items	MBSImP Components with Significant Associations	$p < .05$
My swallowing problem has caused me to loose weight	Tongue Control/Bolus Hold	$r_s(244) = .203$, $p = .001$
	Bolus Transport/Lingual Motion	$r_s(244) = .182$, $p = .004$
	Oral Residue	$r_s(244) = .137$, $p = .032$
	Tongue Base Retraction	$r_s(244) = .192$, $p = .003$
My swallowing problem interferes with my ablity to go out for meals	Oral Residue	$r_s(244) = .157$, $p = .014$
	Tongue Base Retraction	$r_s(244) = .162$, $p = .011$
Swallowing liquids takes extra effort	Bolus Transport/Lingual Motion	$r_s(244) = .172$, $p = .007$
	Oral Residue	$r_s(244) = .156$, $p = .015$
	Tongue Base Retraction	r_s (244) = .198, $p = .003$
Swallowing solids takes extra effort	Tongue Base Retraction	$r_s(244) = .213$, $p = .001$
Swallowing pills takes extra effort	Laryngeal Elevation	$r_s(244) = .140$, $p = .028$
	Tongue Base Retraction	$r_s(244) = .211$, $p = .001$
Swallowing is painful	N/A	
The pleasure of eating is affected by my swallowing	Oral Residue	$r_s(244) = .128$, $p = .046$
	Tongue Base Retraction	$r_s(242) = .141$, $p = .028$
When I swallow food sticks in my throat	N/A	
I cough when I eat	Tongue Base Retraction	$r_s(243) = .127$, $p = .047$
Swallowing is stressful	Tongue Base Retraction	$r_s(243) = .147$, $p = .022$

N/A No significant associations were found for this item

$p = 0.040$), soft palate elevation (r_s (242) = 0.138, $p = 0.031$), epiglottic movement (r_s (242) = − 0.142, $p = 0.027$), tongue base retraction (r_s (242) = 0.178, $p = 0.005$), and esophageal clearance in upright position (r_s (228) = 0.148, $p = 0.022$). Five MBSImP components were weakly, positively correlated with the DHI-10 item "I don't enjoy eating as much as I used to": tongue control/bolus hold (r_s (242) = 0.176, $p = 0.006$), bolus preparation/mastication (r_s (242) = 0.148, $p = 0.023$), bolus transport/lingual motion (r_s (242) = 0.151, $p = 0.019$), oral residue (r_s (242) = 0.172, $p = 0.007$), tongue base retraction (r_s (242) = 0.312, $p < 0.001$). The MBSImP component tongue base retraction was found to have weak, positive correlations with five of the nine DHI physical domain items, seven of the nine DHI functional domain items, and six of the seven DHI emotional domain items. This means that as MBSImP item-level component scores increased indicating elevated impairment, DHI item-level scores also revealed decreased quality of life related to swallowing. No significant associations were found for six of the DHI items ("I cough when I drink liquids," "I need to drink fluid to wash food down," "I feel a strangling sensation when I swallow," "I cough up food after I swallow," "I have changed the way I swallow to make it easier to swallow," "I get angry at myself because of my swallowing problem"), of which four were from the physical domain, Table 4.

Discussion

We explored associations between total scores and item-level scores for measurement tools of swallowing physiology, functional swallowing ability, and swallow-specific quality of life in a heterogeneous cohort of outpatients with dysphagia. This study was the first to explore these measurement tools in such a specific way and in a heterogeneous outpatient cohort. By using both total score and item-level analysis, we confirmed that while measures of functional swallowing ability and swallowing-specific quality of life are related to physiologic swallowing impairment, they provided information distinct from physiology, and as such, should not be used in place of instrumental swallow assessments as the only indicator of dysphagia. The clinical implication of this study is that associations between physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life revealed different factors that uniquely contributed to patients' overall dysphagic profile, emphasizing the need for a comprehensive swallowing assessment.

In this cohort of outpatients, the associations between both MBSImP total scores and item-level component scores and FOIS scores were weak. These findings, which are in direct contrast to the results of the Arrese et al. [13] study, may be explained by the etiologic heterogeneity of our outpatient cohort compared to their head and neck cancer cohort [13]. We did not find significant relationships between MBSImP total scores and EAT-10 total scores, which is consistent with previous findings [12–14], and correlations between MBSImP OT scores and DHI total scores were weak, but significant. Additionally, relationships between MBSImP item-level scores, EAT-10 total scores, and DHI total scores, though present, were modest. The modest associations we observed between physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life may be interpreted as reflecting more remote outcome measures which were less likely to be impacted if the medical condition is less severe, as seen in our mild outpatient cohort [9]. These findings are supported by prior studies that indicated outpatient Veterans report significantly lower health-related quality of life scores than their civilian counterparts, and that reported swallowing ability is often discordant with actual physiologic impairment [23]. Additionally, it is important to recognize that factors other than swallowing physiology unique to this study cohort, such as mental health or xerostomia due to polypharmacy, may have influenced EAT-10 and DHI scores [24–26].

Even though our findings are consistent with other studies that found strong correlations between EAT-10 total scores and DHI total scores, item-level analyses reveal some notable differences between these two measurement tools [27–29]. While three EAT-10 items inquire about increased swallowing effort ("Swallowing liquids/solids/pills takes extra effort"), a common symptom of dysphagia, this concept is not included in the DHI. Further, while the EAT-10 only includes one item inquiring about the pleasure of eating ("The pleasure of eating is affected by my swallowing"), five of the six DHI emotional domain items examine the pleasure of eating. Therefore, clinicians and researchers should carefully review both prior to selecting the swallow-specific quality of life measurement tool for their needs [30]. The relationships between the EAT-10 and the DHI with physiologic swallow impairment were similar and, thus, there is no evidence to support that one is a better contributor to dysphagia than the other.

Evidence showing how physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life are related can impact clinical practice by informing clinical diagnosis and treatment planning [31, 32]. A common weakness with all published studies exploring associations between physiologic swallowing impairment and tools measuring function and quality of life is that patient-reported factors are inconsistent and do not necessarily reflect actual swallowing impairment. The results of this study reconfirm tools to measure functional swallowing ability and swallow-specific quality of life should be used in addition to, and not as a replacement for, instrumental assessment of swallowing physiology.

Table 4 Significant Associations between MBSImP Components and DHI Items

DHI Domain	DHI Items	MBSImP Components with Significant Associations	$p < .05$
Physical	I cough when I drink liquids	N/A	
	I cough when I eat solid food	Tongue Base Retraction	$r_s(241) = .198, p = .002$
	My mouth is dry	Tongue Base Retraction	$r_s(243) = .175, p = .014$
	I need to drink fluids to wash food down	N/A	
	I've lost weight because of my swallowing problem	*Tongue Control During Bolus Hold	$r_s(242) = .146, p = .022$
		*Bolus Transport/Lingual Motion	$r_s(244) = .167, p = .009$
		Tongue Base Retraction	$r_s(242) = .155, p = .015$
	I have to swallow again before food will go down	Tongue Base Retraction	$r_s(241) = .155, p = .015$
	I choke when I take my medication	*Bolus Preparation/Mastication	$r_s(232) = .140, p = .032$
		Tongue Base Retraction	$r_s(242) = .200, p = .002$
	I feel a strangling sensation when I swallow	N/A	
	I cough up food after I swallow	N/A	
Functional	I avoid some foods because of my swallowing problem	Tongue Base Retraction	$r_s(242) = .204, p = .001$
	I have changed the way I swallow to make it easier to eat	N/A	
	It takes me longer to eat a meal than it used to	*Tongue Control During Bolus Hold	$r_s(242) = .171, p = .007$
		*Bolus Transport/Lingual Motion	$r_s(242) = .148, p = .021$
		Tongue Base Retraction	$r_s(242) = .185, p = .004$
	I eat smaller meals more often due to my swallowing problem	Tongue Base Retraction	$r_s(241) = .186, p = .004$
	I don't socialize as much due to my swallowing problem	*Tongue Control During Bolus Hold	$r_s(241) = .204, p = .001$
		*Bolus Transport/Lingual Motion	$r_s(241) = .131, p = .041$
		*Oral Residue	$r_s(241) = .152, p = .018$
		Tongue Base Retraction	$r_s(241) = .168, p = .009$
	I avoid eating because of my swallowing problem	*Oral Residue	$r_s(242) = .148, p = .021$
		Tongue Base Retraction	$r_s(242) = .175, p = .006$
	I eat less because of my swallowing problem	Tongue Base Retraction	$r_s(241) = .224, p < .001$
	I must eat another way (e.g., feeding tube) because of my swallowing problem	Laryngeal Elevation	$r_s(241) = .128, p = .046$
	I've changed my diet due to my swallowing problem	*Tongue Control During Bolus Hold	$r_s(242) = .129, p = .044$
		*Bolus Transport/Lingual Motion	$r_s(242) = .131, p = .040$
		Soft Palate Elevation	$r_s(242) = .138, p = .031$
		Epiglottic Movement	$r_s(242) = -.142, p = .027$
		Tongue Base Retraction	$r_s(242) = .178, p = .005$
		Esophageal Clearance in Upright Position	$r_s(238) = .148, p = .022$

Table 4 (continued)

DHI Domain	DHI Items	MBSImP Components with Significant Associations	$p < .05$
Emotional	I'm embarrassed to eat in public	Laryngeal Vestibular Closure	$r_s(240) = .132, p = .040$
		Tongue Base Retraction	$r_s(240) = .129, p = .046$
	I feel depressed because I can't eat what I want	*Tongue Control During Bolus Hold	$r_s(242) = .174, p = .007$
		*Bolus Transport/Lingual Motion	$r_s(242) = .146, p = .022$
		*Oral Residue	$r_s(242) = .181, p = .005$
		Tongue Base Retraction	$r_s(242) = .175, p = .006$
	I don't enjoy eating as much as I used to	*Tongue Control During Bolus Hold	$r_s(242) = .176, p = .006$
		*Bolus Preparation/Mastication	$r_s(232) = .148, p = .023$
		*Bolus Transport/Lingual Motion	$r_s(242) = .151, p = .019$
		*Oral Residue	$r_s(242) = .172, p = .007$
		Tongue Base Retraction	$r_s(242) = .312, p < .001$
	I am nervous because of my swallowing problem	Initiation of Pharyngeal Swallow	$r_s(242) = .138, p = .031$
	I feel handicapped because of my swallowing problem	*Tongue Control During Bolus Hold	$r_s(241) = .145, p = .024$
		Initiation of Pharyngeal Swallow	$r_s(241) = .137, p = .033$
		Tongue Base Retraction	$r_s(241) = .205, p = .001$
	I get angry at myself because of my swallowing problem	N/A	
	I'm afraid that I'll choke and stop breathing because of my swallowing problem	Tongue Base Retraction	$r_s(242) = .150, p = .019$
Self-Perception		Laryngeal Vestibular Closure	$r_s(225) = .140, p = .035$
		Tongue Base Retraction	$r_s(225) = .136, p = .041$

N/A No significant associations were found for this item

*Oral domain MBSImP components

Limitations and Future Directions

The generalizability of the results of this study may be limited as the demographics of the participants in this retrospective convenience sample may not be representative of outpatients who undergo MBSSs. Our participant cohort was mostly white males, outpatient Veterans with quite mild physiologic swallowing impairment. When compared to inpatient Veteran cohorts or to the general population, outpatient Veterans' self-perception of health status significantly contributes to delays in seeking treatment and may negatively impact dysphagia assessment measures [25, 33]. This is especially relevant to acknowledge given the concern for decreased malnutrition, dehydration, and psychosocial difficulties from having dysphagia for outpatient Veterans [24, 34]. Additionally, we acknowledge that dysphagia is a multi-factorial condition, with many considerations beyond the scope of this study that may contribute to perception of health and wellbeing. Specific participant factors important for clinical practice that may impact swallowing physiology, function, and swallow-specific quality of life still remain unexplored. Future studies should include a larger sample size, more statistical power, and a general inpatient cohort as this may help in detecting other relationships at the item-level that were not revealed in this study.

Conclusions

This study revealed only weak correlations between swallow-specific quality of life and physiological swallow impairments. Thus, while item-level analysis may be helpful to shape individual patient care or address other relationships, it did not reveal strong enough relationships between physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life to provide evidence for inferring physiologic impairments from the measurement tools. Thus, the results confirmed that while

swallowing-specific quality of life measurement tools (such as the EAT-10 and the DHI) provide distinct information from that gained from videofluoroscopic studies (MBSImP), they should not be used in place of instrumental swallow assessments. Therefore, physiologic swallowing impairment, functional swallowing ability, and swallow-specific quality of life should not be considered in isolation, but rather each should be included during comprehensive swallowing assessment.

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Declarations

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