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The Dysphagia Stress Test for Rapid Assessment of Swallowing Difficulties in Esophageal Conditions

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Abstract

Background: Esophageal dysphagia is a common symptom in gastroenterology practice. Current rapid assessment tools are limited to oropharyngeal dysphagia and do not translate well to esophageal conditions. We aim to create a novel tool, the dysphagia stress test (DST), to evaluate swallowing in patients with esophageal disease characterized by dysphagia.

Methods: Adults with eosinophilic esophagitis (EoE), gastroesophageal reflux disease (GERD), achalasia, and dysphagia not-otherwise-specified (NOS) participated. Patient controls with non-esophageal diagnoses and healthy controls were also recruited. Participants completed the DST with 5 bolus challenges: water, applesauce, rice, bread, barium tablet and rated their swallowing difficulty and pain. A study clinician observed and documented water use and refusal of any challenges. Participants also completed measures of esophageal symptoms, hypersensitivity, and symptom anxiety to evaluate the DST validity. Collinearity of bolus challenges guided item reduction.

Results: 132 subjects participated. Both control groups and GERD patients had the best swallowing ability, while achalasia, EOE, and dysphagia NOS scored poorer. 90% of patients were able to attempt or pass each of the bolus challenges, suggesting high acceptability. Construct validity of the DST is evidenced by modest negative correlations with symptom severity, hypersensitivity, and anxiety. The DST does not appear to be influenced by brain-gut processes. Applesauce, rice, and bread demonstrated collinearity; thus, the DST was reduced to 3 challenges.

Conclusions: The DST is the first rapid assessment tool designed for gastroenterology clinics with direct observation of swallowing ability across several conditions to mitigate issues related to patient self-report of esophageal symptoms.

Graphical Abstract

Abbreviated abstract: Clinical evaluation of esophageal dysphagia that relies on patient self-report can be inaccurate. The Dysphagia Stress Test is a novel rapid assessment tool designed to aid in

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the evaluation of dysphagia through direct observation of patient swallowing ability across esophageal diseases.

Keywords

esophagus; dysphagia; assessment; deglutition disorders

Introduction

Esophageal dysphagia is a common symptom in gastroenterology practice¹. Determining its etiology includes obtaining a careful history to distinguish oropharyngeal disorders from esophageal. Once esophageal dysphagia is suspected, several diagnostic tools are available including barium esophagography², gastroesophageal endoscopy³, and manometry⁴ to confirm pathophysiology. Physiological reasons for esophageal dysphagia include mechanical obstruction (e.g. esophageal stricture), neuro-muscular disorders (e.g. achalasia), an inflammatory condition (e.g. eosinophilic esophagitis), or hypersensitivity to bolus transit (e.g. functional dysphagia)⁵.

Careful assessment of swallowing during clinical encounters is imperative for newly presenting patients with dysphagia and for those with established diagnoses⁵. Assessment of the patient's ability to swallow liquids and solids of varying consistencies can yield important information to corroborate, or contradict, self-report of dysphagia symptom location and severity, which can be inaccurate^{6, 7}. Although assessments of swallowing abilities exist⁸⁻¹⁴, rapid methods are limited to oropharyngeal dysphagia in non-GI patient populations. A review of these tools found most lack consistent sensitivity to identify dysphagia and are limited in generalizability due to homogeneous samples¹⁵. To date, there is no validated, standardized protocol to evaluate esophageal dysphagia in gastroenterology practice.

We propose a novel tool to gauge esophageal dysphagia severity at the clinical encounter, the Dysphagia Stress Test (DST). The aims of this study include: 1) assess acceptability of the DST using well defined controls and esophageal dysphagia patient sub-populations, 2) determine relationship between the DST and dysphagia symptom severity when controlling for symptom anxiety and hypersensitivity, 3) evaluate construct validity of the DST to identify dysphagia patients compared to existing self-report measures.

Methods

This study used a cross-sectional approach to accomplish the three aims. Adult patients of a university based outpatient gastroenterology practice were screened via an a priori electronic medical record review based on ICD-10 diagnoses between 2014 and 2015. Patients are grouped as: 1) patient controls (no symptoms of esophageal dysphagia, no gastroesophageal reflux disease (GERD) symptoms, no prior esophageal disease diagnosis), or 2) dysphagia patients with confirmed diagnosis of GERD, achalasia, EoE, or dysphagia NOS (dysphagia as primary presenting symptom without other diagnosis) per ICD-10 medical record documentation. Once identified, patients were approached at their next outpatient visit to the

gastroenterology clinic to participate in the study. An additional cohort of healthy controls (no gastrointestinal diagnosis) were recruited from the community, including adults attending the patient's medical visit and university staff. The diagnosis of GERD was determined using the Porto consensus¹⁶, EoE using the 2011 consensus guidelines¹⁷, and achalasia and dysphagia NOS via the Chicago Classification (v3)¹⁸.

A priori power analyses indicated a necessary sample size of 135 to adequately power ($\beta = 0.8$) the planned statistical analyses with an effect size of 0.3 and $P < .05$. We aimed to stratify participants for equal numbers in each esophageal patient group (minimum $n=17$ per diagnosis) and a 2:1 ratio for each esophageal patient group to patient controls (minimum $n=34$) and also to healthy controls (minimum $n=34$). After obtaining informed consent, participants completed the DST with one of three study personnel (EK, KS, JC) and several previously validated questionnaires.

Dysphagia Stress Test:

The DST evaluates swallowing difficulty and pain during 5 bolus challenges. Patients are first screened for food allergies or dietary restrictions. Foods are presented in a sequential hierarchical process based on assumed difficulty with swallowing: 10 cc of water (single swallow), 5 cc of applesauce (single swallow), 1 teaspoon of Essential Everyday™ instant white rice, cooked in product's microwave bag for 60 seconds (swallow after 10 seconds of chewing), 2×2×1 cm piece of Udi's™ Gluten Free white bread (swallow after 10 seconds of chewing), and one 13 mm EZ-Disk™ barium sulfate tablet (swallow with water sips). Each challenge is performed twice except the barium tablet. For each attempt, a trained study coordinator coded how many swallows were required as follows: 1 swallow = 10, > 1 swallow = 5, water required = 1 (for applesauce, rice, bread). If the patient failed to swallow the item or refused the challenge, the attempt was coded 0. Following each attempt, participants rated how difficult it was to swallow the bolus (0=Very difficult to 10=No difficulty) and how much pain, if any, they experienced (0=Severe pain to 10=No pain). The 0–10 rating scale for patients was based on widely used, thus familiar to most patients, pain rating scales in medical practice; a 0–10 scale also yields greater variance for statistical analyses. Rating scales for the clinician (0, 1, 5, 10) were chosen for consistency with the 0–10 scale chosen for patients. Specific values were established to prevent variability in clinician ratings for each swallowing event. Patients completed challenges until the end of the DST or if the patient failed or did not attempt a challenge (e.g. refused to attempt the bread), the DST was concluded and scored from that point. The DST yields 3 sub-scale scores: swallow score, difficulty with swallows, and pain experienced. The swallow score is obtained by adding each swallow rating and dividing by the number of swallows completed, the difficulty score is obtained by adding each difficulty rating and dividing by the number of ratings completed, and the pain score is obtained by adding each pain rating and dividing by the number of ratings completed. The total DST score is calculated by summing the swallow, difficulty with swallows, and pain experienced scores (Appendix A). Higher scores indicate better swallowing ability.

Mayo Dysphagia Questionnaire (MDQ):

The MDQ is a 27-item questionnaire to assess both liquid and solid dysphagia, reflux symptoms, and food impaction. Total scores are calculated by summing all items^{19, 20}. Because of its stem-and-leaf format, a minimum of 13 and maximum of 27 items may be answered.

Gastroesophageal Reflux Disease Questionnaire (GERDQ):

The GERDQ is a 6-item questionnaire measuring symptom severity and differentiating dyspepsia from GERD²¹. Questions are rated based on frequency (Never to 4–7 days per week). A score of > 6 is supportive of a diagnosis of GERD. Maximum score is 18.

Visceral Sensitivity Index (VSI):

The VSI is a 15-item self-report questionnaire evaluating anxiety associated with gastrointestinal sensations, symptoms, or contexts in which symptoms may appear²². VSI appears to be distinct from general anxiety²³. The VSI was modified for the esophagus rather than bowel for this study (e.g. “When I feel discomfort in my esophagus, it frightens me.”). Maximum score is 90.

Anxiety Sensitivity Index (ASI):

16-item self-report questionnaire whereby respondents indicate the degree to which they are concerned about social and somatic consequences of anxiety^{24, 25}. Maximum score is 64.

Eosinophilic Esophagitis Activity Index (EESAI):

The EESAI is a 35-item measure of EoE symptom severity, including dysphagia, and eating behavior²⁶. A subset questions were used as follows: Food tolerance (Maximum = 8) measured by “Do you eat the following foods (Yes or No): solid meat, soft foods, dry rice, ground meat, white bread, grits/porridge/rice pudding, raw fibrous foods, French fries”; dysphagia symptom severity (Maximum = 13) graded using 4 questions “How often do you have trouble swallowing in the past 24 hours,” “How often have you had trouble swallowing in the past 7 days,” “How long did an episode of trouble swallowing last in the past 24 hours?” and “How long did an episode of trouble swallowing last in the past 7 days?” No other items from EESAI were used.

Statistical Analyses

All data were exported to SPSS v. 25 for Macintosh (Chicago, IL) for analyses. Evaluation for normal distribution using accepted cutoffs for skewness and kurtosis (± 2.0) identified the need for non-parametric tests as control subjects exhibited a positive skew in DST scores. For normally distributed variables, mean plus standard deviation (SD) and percentages (frequency) are presented. For non-normal data, median with range are presented.

Differences in demographic variables between study groups were evaluated via Chi Square (gender, race) or one-way ANOVA (age). For questionnaire data (GERDQ, MDQ, EESAI, ASI, VSI), which was normally distributed, a series of one-way ANOVA determined

between-group differences for HC, PC, and each patient diagnosis. Separate Kruskal-Wallis tests determined between-group differences for each DST score (Swallow, Difficulty, Pain, Total), including sub-analyses for each of the 5 bolus challenges for HC, PC, and each patient diagnosis. Each bolus challenge on the DST was also evaluated for percentage of non-control subjects with failed/refused swallows by diagnosis to assess acceptability of the DST.

To evaluate construct validity of the DST, Spearman's Rho correlations determined relationships between DST scores and dysphagia symptom severity, GERD symptom severity, symptom anxiety, and visceral hypersensitivity for non-control group participants only. Non-control group participants were then dichotomized as "Good Performance" and "Poor Performance" on the DST via median split (Median = 140). Mann-Whitney U evaluated differences in DST scores between the dichotomized groups.

Three separate stepwise linear regression models evaluated the potential influence of symptom anxiety or visceral hypersensitivity in DST performance (Total DST, Pain Score, Difficulty Score). The MDQ score was entered with the anxiety and hypersensitivity scores to control for dysphagia symptom severity. Adjusted R^2 are reported as percentage variance of each DST score explained ($\text{Adjust } R^2 \times 100$).

Additional Pearson's correlations evaluated multicollinearity for the five DST challenges for the sample with control group participants excluded. The threshold for collinearity was set to correlations of 0.70 or greater²⁷. Items exceeding this cutoff were considered for removal from DST via consensus from study authors.

Discriminate ability of final DST was assessed via three separate Receiver Operating Characteristic (ROC) curve analyses. Participants were coded into dichotomous groups for the state variable to compare patient group (achalasia, EoE, and dysphagia NOS) with 1) healthy controls, 2) patient controls, 3) GERD patients. A minimum acceptable area under the curve (AUC) was set for 0.70. Cut points with sensitivity (true positive) and specificity (false positive) values are reported with optimal cut point based on the Youden index, or the point on the curve where sensitivity and specificity are maximized.

Results:

One hundred thirty-two patients participated (Table 1). The primary reason for non-participation in the study was due to timing of recruitment done during the clinical visit and patients and/or the physician did not have time to accommodate the study process. The sample was primarily Caucasian with a relatively even distribution between males and females. Patient controls were all diagnosed with a digestive disorder (i.e. irritable bowel syndrome, inflammatory bowel disease, functional diarrhea/constipation/abdominal pain) without associated esophageal symptoms or diagnosis. 53% of GERD patients scored at or above the clinical cutoff of 6 for the GERDQ, suggesting half of patients had some degree of symptomatic control. The EoE sample was small and differed from typical trends as our EOE sample was >50% female, despite the disease being more prevalent in men. The GERD and Dysphagia NOS groups were significantly older than controls, EoE, and achalasia.

Esophageal patient groups exhibited similar levels of symptom anxiety and visceral hypersensitivity, with the exception of GERD patients reporting significantly lower levels of hypersensitivity than the other three esophageal disease groups.

Data for all questionnaires were normally distributed while DST scores were non-normal. Clinical questionnaire data for each group are presented in Table 2. As expected, healthy and patient controls reported lower dysphagia and GERD symptoms, symptom anxiety, and hypersensitivity than patient groups (all $p < .01$). Achalasia patients reported greatest dysphagia on the MDQ with scores significantly higher than dysphagia NOS and EoE (all $p < .01$).

Items on the DST demonstrated good acceptability in that >90% of non-control participants passed/attempted all bolus challenges, with the exception of the barium tablet (11% failed/refused). Only a very small percentage (<5%) of patients reported any difficulty or pain with the water challenge. As the DST items progressed, the percentage reporting no difficulty decreased while pain remained relatively consistent (Figure 1). Significant differences were not observed between time 1 and time 2 assessments for each bolus challenge (Supplementary Table 1).

DST Group Differences

Median scores, with range, for each DST score by subject group are presented in Table 3. Significant differences were found between groups, with EoE scoring the worst on the swallow and pain scores. Achalasia patients scored poorest for difficulty and total score, while GERD patients scored similarly across all DST scores as HC and PC. These differences remained consistent when evaluating each bolus challenge for the DST individually, with the exception of the pain rating for the water challenge becoming not significantly different between groups ($p=0.16$).

DST Relationships with Symptom Severity, Symptom Anxiety, and Hypersensitivity

Small to moderate correlations existed between the Total DST score and each of the study measures (Table 4). When evaluating each bolus challenge, some associations became non-significant, specifically for symptom anxiety (water difficulty, applesauce pain, barium tablet pain), GERDQ (water difficulty, barium tablet difficulty and pain), and VSI (water difficulty). The remaining bolus challenge difficulty and pain scores retained moderate, significant associations with study questionnaires (Rho Range: -0.21 to -0.65). When dichotomized by performance on the DST, better performance was associated with less symptom anxiety, less hypersensitivity, and fewer symptoms across symptom scales, further supporting the construct validity of the DST (Figure 2).

Next, we sought to determine the potential influence of brain-gut variables (symptom anxiety and visceral hypersensitivity) on DST performance. For the total DST score, dysphagia symptom severity accounted for 46% of the variance in score, while visceral hypersensitivity accounted for 3% and symptom anxiety was removed from the model as non-significant. Similar findings existed for the Difficulty scale (MDQ: 46%, VSI: 2%). The percentage variance of the Pain scale explained by dysphagia symptoms was reduced but remained the greatest predictor with VSI only contributing a small percentage and symptom

anxiety being non-significant (MDQ: 29%, VSI: 4%). Conversely, symptom anxiety and hypersensitivity accounted for 11% of the variance in MDQ score.

Item Analysis and Refinement of DST

The original five items of the DST demonstrated multicollinearity. Applesauce, rice, and bread exceeded the threshold for all DST scales ($r > 0.70$); water and barium tablet did not show collinearity with any other items. These findings remained after healthy and patient controls were excluded. The DST was reduced to 3 bolus challenges: water, bread, barium tablet based on these findings and consensus from study investigators (Appendix A). Of the 3 items demonstrating multicollinearity, bread was chosen for its ease of administration in a clinical setting over rice and applesauce. Repeat statistical analyses with the 3-item version identified no significant changes to results.

Discriminant Validity of the Final DST

The ROC curve analyses show 3-item DST discriminates well between patients with known dysphagic esophageal conditions and healthy controls, patient controls, and patients with GERD. The AUC was excellent for all ROC curves. The optimal cutoff of 126 on DST identifies an esophageal dysphagia patient from healthy controls with a sensitivity of 0.80 and specificity of 0.86 (AUC=0.91, 95%CI: 0.85–0.97, $p<.001$), from other GI non-esophageal dysphagia patients with a sensitivity of 0.80 and specificity of 0.80 (AUC=0.86, 95%CI: 0.78–0.94, $p<.001$), and from GERD patients with a sensitivity of 0.80 and specificity of 0.74 (AUC=0.85, 95%CI: 0.74–0.96, $p<.001$).

Discussion

We sought to create a rapid clinical assessment tool to evaluate swallowing difficulty as measured by bolus challenges rated by the patient and observing clinician. The DST shows potential to allow for direct observation of dysphagia symptoms across conditions often presenting with swallowing difficulties, thereby controlling for issues related to inaccurate symptom reporting by patients due to failure to account for compensatory mechanisms that the patient perceives as their normal eating habit. The overall construct validity of the DST was good as it was moderately correlated with symptom severity measured by established questionnaires, symptom anxiety, and visceral hypersensitivity. Discriminate validity of the DST to differentiate dysphagic patients from those without dysphagia was also excellent, with a recommended cut point score of 122. The DST also demonstrated acceptability due to only a small percentage of patients either failing or refusing any bolus challenges.

The DST may be superior to traditional questionnaire use in several ways. Primarily, the DST allows clinicians to quickly obtain a symptom severity score combined with an important and neglected feature of dysphagia workup – watching patients eat. DST scores for patients with EoE and achalasia, conditions with very different mechanisms for symptom production, were similar while achalasia patients scored higher on EESAI and MDQ. This may be explained by how a patient presents to a clinical visit. Patients with EoE can minimize dysphagia symptoms via dietary restrictions while achalasia patients generally experience dysphagia with most meals, depending on disease severity. Rather than relying

on self-report, DST puts the patient in a scenario to eat foods they may typically avoid and may generate a more accurate picture of dysphagia symptoms. As self-report of dysphagia symptom location and severity can be inaccurate^{6, 7}, use of the DST can improve a clinician's ability to make treatment decisions by allowing for objective observation of a patient's swallowing ability versus relying solely on traditional self-report of symptom experience. These objective data, along with the patient's own perceptions of their symptoms and disease impact, can provide a more detailed assessment of patient experience with these chronic esophageal diseases. We also anticipate clinicians to be able to administer the 3-item DST in 5 to 10 minutes, allowing time for the patient to pause between bolus challenges. While the results are promising, including minimal delivery time of the DST, this study uses a cross-sectional approach. As such, we are unable to state how the DST performs over time. Future studies should evaluate the DST at multiple time points, especially during the treatment of dysphagia, to further establish utility in clinical practice.

The DST also does not appear to be influenced by anxiety or hypersensitivity, which may enhance symptom reporting via traditional self-report measures. Brain-gut processes continue to be better understood in the pathophysiology of esophageal disease²⁸. Symptom-specific anxiety is present across esophageal diseases and not relegated simply to those of "functional" nature²⁹. With the DST, direct observation of patient swallowing by the clinician coinciding with patient self-report of difficulty and pain did not appear to be affected by these processes. It is unclear why this may be the case; as such, future research should explore this in larger patient cohorts.

Based on our findings, we also suggest the DST be used as a screening tool to guide additional diagnostic procedures in esophageal patients utilizing a recommended cutoff score of 126; further studies should confirm this recommendation. Specifically, GERD patients did not differ from control groups, those who score poorly on DST may have other co-morbid diagnoses and esophagogastroduodenoscopy or manometry may be necessary. For patients utilizing dietary therapies, DST may guide what food consistencies a patient can tolerate. Since applesauce was highly correlated with rice and bread, these findings suggest textured foods may be difficult for some patients and liquid diets or pureed foods may be optimal.

The original DST contained 5 bolus challenges; statistical overlap reduced the final version to water, bread, and barium tablet while maintaining findings. While bread and rice demonstrated collinearity, logistically, using bread is simpler for clinicians than rice thereby increasing the acceptability of DST and reducing burden to prepare bolus challenge items. Reducing DST to 3 items may help prevent a cumulative effect of filling the esophageal lumen, leading to false increases in later-item scores. While it is rare for patients with esophageal dysphagia to have difficulty swallowing water, this step may help identify those with additional oropharyngeal dysphagia presenting to a gastroenterology practice. Increasing water volume (e.g. 100 cc) may also improve DST's assessment of dysphagia in actual or suspected achalasia patients and should be tested in future studies. This may also be the case for EOE participants. Since EOE patients typically experience dysphagia to solids only, we would expect them to perform better on liquid swallows compared achalasia participants. However, our findings revealed similar DST scores. These results may be

supported by evidence suggesting 4% to 87% of EoE patients also have a secondary motility disorder³⁰.

This study has limitations to consider. The sample is primarily Caucasian. Disease severity was not objectively measured via conventional physiological testing methods, such as high-resolution manometry or timed barium esophogram making it impossible to compare DST to these measures. At each assessment, only one study clinician was present and study clinicians were not blinded to the participants' diagnoses. Hence, observer bias may have influenced the scoring of swallows and we cannot provide interrater agreement. Clinician satisfaction was not gauged so we cannot report any negative experiences that could be barriers to implementation. As this is a cross-sectional study, we cannot determine the directionality of relationships between DST and other study measures. Finally, we did not assess secondary motility disorders in EOE, which may confound some results. Future studies should measure the presence of secondary motility disorders among EOE patients to determine if this factor influences DST scores.

In summary, we developed a simple method to assess esophageal dysphagia symptoms that incorporates observation of swallowing difficulty and food avoidance. The DST can be performed in under 5 minutes and our analysis supports it can be shortened even further by using only water, bread, and barium tablet for simple administration. Thus, DST can be incorporated easily into current clinical practice as it provides symptom assessment and an important physical exam component of swallowing function. We theorize that this tool could be added to the current physical examination to follow response to treatment as the ease of eating may be an important component not captured in current questionnaires. Future studies should further validate DST for feasibility, acceptability, sensitivity, and specificity before and after interventions in achalasia, EoE, and esophageal stricture.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments:

JP, PK, LK, BD designed the research study, KS, JC, BD, EK conducted the research, TT conducted the statistical analyses and interpreted the results, MC assisted in data management and analysis, TT, JP wrote the initial manuscript, all authors provided feedback on the final manuscript.

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Appendix A.: The Dysphagia Stress Test

10 cc water swallow: attempt in a single swallow			
	Swallow Score	Difficulty Score 0=Very Difficult 10=Not Difficult	Pain Score 0=No Pain 10 = Severe Pain
Attempt 1	<ul style="list-style-type: none"> 1 swallow [10] >1 swallow [5] 		

10 cc water swallow: attempt in a single swallow			
	Swallow Score	Difficulty Score 0=Very Difficult 10=Not Difficult	Pain Score 0=No Pain 10 = Severe Pain
	<ul style="list-style-type: none"> Failed [0] Did not attempt [0] 		
Attempt 2	<ul style="list-style-type: none"> 1 swallow [10] >1 swallow [5] Failed [0] Did not attempt [0] 		
<i>Water Scores</i>			
Bread (2×2X1 cm): swallow after 10 seconds of chewing			
Attempt 1	<ul style="list-style-type: none"> 1 swallow [10] >1 swallow [5] Needed water [1] Failed [0] Did not attempt [0] 		
Attempt 2	<ul style="list-style-type: none"> 1 swallow [10] >1 swallow [5] Needed water [1] Failed [0] Did not attempt [0] 		
<i>Bread Scores</i>			
Barium tablet with water sips			
Attempt 1	<ul style="list-style-type: none"> 1 swallow [10] >1 swallow [5] Failed [0] Did not attempt [0] 		
<i>Barium Scores</i>			

Scoring the DST

Swallow score: For each bolus, sum swallows attempted and divide by number of attempts.

Difficulty score: For each bolus, sum difficulty ratings and divide by number of attempts.

Pain score: For each bolus, sum pain ratings and divide by number of attempts.

Total score: Swallow score + Difficulty score + Pain score

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Key Points

1. Rapid clinical assessment for dysphagia is limited to the oropharyngeal type and does not translate well to esophageal dysphagia, a common symptom in gastroenterology practice. Direct observation of patient swallowing will meet this need while mitigating issues related to self-report.
2. The Dysphagia Stress Test (DST) is a reliable, valid, and feasible measure of patient swallowing that assesses difficulty with swallows, as well as any associated pain, during 3 separate bolus challenges: water, bread, barium tablet.
3. The DST fills a void in proper assessment of patient deglutition across several esophageal diagnoses, allowing for objective clinician observation of patient swallowing ability.

Figure 1.
Percentage of Esophageal Patients Reporting No Difficulty or Pain for Each Bolus Challenge

Figure 2.
Mean Difference Between Good Performers and Poor Performers on DST for Study Questionnaires

Table 1.

Demographic & Clinical Characteristics of Study Sample by Group

N = 132	HC (22)	PC (35)	GERD (15)	Achalasia (19)	EoE (18)	Dysphagia NOS (19)	P
Gender							>.05
Male	36.4% (8)	37.1% (13)	33.3% (5)	31.6% (6)	43.8% (7)	26.3% (5)	
Female	63.6% (14)	62.9% (22)	66.7% (10)	68.4% (13)	56.3% (9)	73.7% (14)	
Race							>.05
White	77.3% (17)	54.3% (19)	73.3% (11)	64.7% (11)	93.3% (14)	94.7% (18)	
Non-White	22.7% (5)	25.7% (9)	20.0% (3)	11.8% (2)	6.7% (1)	5.3% (1)	
Unknown	-	20.0% (7)	6.7% (1)	34.0% (6)	16.7% (3)	-	
Age in years (Mean ± SD)							< .01
	37.6±16.1	43.7±15.3	58.1±18.8*	43.2±15.7	40.0±13.9	54.7±13.5*	

Table 2.

Mean (SD) Ratings for GERDQ, MDQ, Hypersensitivity, Symptom Anxiety, and EESAI by Group

	EESAI Dysphagia	EESAI Food Tolerance	Mayo Dysphagia	GERD Symptoms	Hyper-Sensitivity	Symptom Anxiety
Control Groups						
<i>HC</i>	0.14 (0.5)	0.0 (0.0)	1.27 (1.6)	0.36 (0.9)	7.32 (16.2)	9.36 (7.2)
<i>PC</i>	0.34 (1.2)	0.43 (1.3)	2.60 (3.9)	1.00 (2.0)	21.60 (22.3)	14.11 (11.8)
Patient Groups						
<i>GERD</i>	0.93 (1.7)	2.40 (3.0)	10.87 (6.4)	6.07 (3.4)	15.93 (16.6)	14.0 (10.4)
<i>Achalasia</i>	13.21 (5.2)	2.84 (2.1)	42.58 (16.6)	5.95 (4.2)	21.42 (17.7)	16.21 (8.2)
<i>EoE</i>	6.61 (5.5)	4.72 (2.27)	30.83 (16.0)	3.67 (2.9)	20.67 (16.3)	16.11 (7.1)
<i>D-NOS</i>	7.90 (5.6)	3.21 (2.5)	39.37 (11.2)	4.63 (3.8)	22.9 (23.2)	19.11 (11.8)

Notes: HC: Health Controls. PC: Patient Controls. EoE: Eosinophilic Esophagitis. D-NOS: Dysphagia Not Otherwise Specified.

Table 3.

Median DST Scores for Swallows, Difficulty, Pain, and Total by Diagnosis

	Swallow Score	Difficulty Score	Pain Score	Total Score
Control Groups				
<i>HC</i>	50.0 (40–50)	49.0 (40–50)	50.0 (45–50)	147.5 (132.5–150)
<i>PC</i>	50.0 (21–50)	50.0 (38–50)	50.0 (40–50)	149.0 (101–150)
Patient Groups				
<i>GERD</i>	50.0 (23–50)	50.0 (45–50)	50.0 (44–50)	149.0 (117–150)
<i>Achalasia</i>	30.0 (9–50)	40.0 (19.5–50)	48.0 (22.5–50)	112 (68.5–150)
<i>EoE</i>	25.8 (16–42.5)	43.0 (24.5–50)	46.8 (30–50)	117.8 (72.5–141)
<i>D-NOS</i>	33.0 (15.5–45)	42.0 (17.5–50)	50.0 (16–50)	119.0 (58.5–145)

Notes: Data non-normally distributed. Presented as Median (Range)

Table 4.

Spearman's Rho Correlations Between Total DST Score and Study Questionnaires

	1	2	3	4	5	6
1. DST Total	-					
2. Symptom Anxiety	-0.30 **	-				
3. EESAI	-0.60 **	0.32 **	-			
4. MDQ	-0.63 **	0.33 **	0.81 **	-		
5. GERDQ	-0.33 **	0.29 **	0.49 **	0.68 **	-	
6. VSI	-0.34 **	0.36 **	0.34 **	0.34 **	0.45 **	-

**
P < .01