# Impact of Body Mass Index on the Accuracy of Physical Examination and MRI of the Shoulder

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**Background:** The physical examination of overweight patients can require specific adaptations. Orthopaedic literature on the impact of body mass index (BMI) on the physical examination of the shoulder is virtually nonexistent.

**Purpose:** To assess whether BMI affects the sensitivity and specificity of common shoulder tests, using arthroscopy as a gold standard. We also examined the effects of BMI on the sensitivity and specificity of magnetic resonance imaging (MRI) of the shoulder for reference.

**Study Design:** Cohort study (diagnosis); Level of evidence, 2.

**Methods:** We analyzed the data of 116 consecutive patients who underwent shoulder arthroscopy for the treatment of rotator cuff tears, Bankart lesions, and superior labral anterior-posterior (SLAP) lesions. Preoperative BMI, physical examination of the shoulder findings, and MRI findings were extracted. Contingency tables and receiver operating characteristic curves were used to evaluate the sensitivity and specificity of provocative tests of the shoulder and MRI as well as their relationship to BMI.

**Results:** The sensitivity and specificity of the Jobe supraspinatus test were 77.8% and 72.7% in patients with BMI ≤25, 82.6% and 70.6% in those with 25 < BMI ≤ 30, and 81.3% and 55.6% in those with BMI >30, respectively ($P < .001$). The apprehension and relocation tests demonstrated higher sensitivity and specificity for the overweight patients (25 < BMI ≤ 30) compared with the other BMI groups, with a sensitivity and specificity of 83.3% and 100% for the apprehension test and a sensitivity and specificity of 75% and 100% for the relocation test, respectively. The O'Brien, Speed, and Ebinger tests for SLAP tears had low accuracy and did not yield statistically significant results. MRI interpretation was found to be influenced by BMI in obese patients, especially when SLAP lesions were assessed.

**Conclusion:** Counterintuitively, tests for shoulder instability had greater specificity in overweight patients and should be encouraged, particularly in obese patients, in whom the specificity of shoulder MRI for the detection of a Bankart lesion is lower. The Jobe test was more sensitive but less specific in overweight patients. These findings may assist care providers in improving the interpretation of the shoulder examination of overweight patients and consequently lead to better treatment-related decisions.

**Keywords:** overweight; obesity; shoulder; physical examination; BMI; rotator cuff; instability; SLAP

As time goes on, humans are getting bigger. The notion of the default 70-kg patient taught in medical school is no longer relevant for many Western countries.[27] The prevalence of obesity in the United States has risen by more than 12% since 1994, reaching approximately 35.3% in 2012.[24] The mean body mass index (BMI) values for American men and women are 28.6 and 28.7, respectively.[7] The physical examination of obese patients can be quite challenging, requiring specific training and adaptations.[27] While obesity prevalence has been rising for almost a century, the physical examination of shoulder patients has yet to adapt.

A physical examination is performed at every patient encounter and can be immensely helpful in assessing the pretest probability of a diagnosis as well as the subsequent interpretation of tests ordered. Correct patient selection relies on the validity of the physical examination and can determine the fate of the procedure. Several studies outside the field of orthopaedics have demonstrated that obesity can affect the reliability of the physical examination.[3,4,6,11,22,33]

Orthopaedic literature on the effect obesity has on physical examination is scarce. Anthropometric measurements of midarm circumference, subscapular, and triceps skinfold thicknesses are on the rise in concurrence with the increase in mean BMI and obesity rates.[7,21] The use of assistance has been suggested for positioning obese patients when performing the anterior drawer test or flexion-abduction–external rotation test.[27]

It is also imperative to emphasize that the majority of the orthopaedic physical examination tests performed today were introduced decades ago, when obesity was far less prevalent. For example, details of the Jobe "empty can" test were published in 1982, when obesity prevalence in the US population was only 15% to 20%.[15,18]

The primary aim of our study was to assess whether a patient's BMI affects the sensitivity and specificity of provocative tests of the shoulder, using arthroscopy as the gold standard. Our secondary aim was to evaluate the impact BMI has on the sensitivity and specificity of preoperative shoulder magnetic resonance imaging (MRI) for reference. We hypothesized that an increased BMI would decrease the reliability of the shoulder physical examination.

## METHODS

### Patient Population

This was a retrospective evaluation of prospectively collected data on patients undergoing shoulder arthroscopy at our institution between 2013 and 2016. Included in this study were adult patients (>18 years of age) with shoulder complaints and well-documented physical examinations of the shoulder, performed by a single senior orthopaedic surgeon specializing in shoulder surgery, before undergoing primary shoulder arthroscopy of the affected shoulder. Exclusion criteria were patients who had a prior surgery of the index shoulder, previous proximal humeral fractures, and inflammatory arthropathy of the index shoulder. This study was approved by an institutional review board before study initiation.

### Physical Examination

All patients underwent a complete physical examination of both shoulders. Patients were examined in an undressed state above the waist to allow inspection of the shoulder. Female patients were covered up in a fashion similar to that of a strapless dress. Inspection was followed by palpation, a range of motion examination, provocative tests, and a neurovascular examination. Provocative tests included the Jobe supraspinatus test,[17] apprehension test,[20] relocation test,[20] O'Brien test,[25] Speed test,[14] and Ebinger test.[5] Of note, the Jobe supraspinatus test was considered positive if either pain, weakness, or both were appreciated during the test.[17,23] When indicated, disorders of the cervical spine and other causes of referred pain to the shoulder were also evaluated.

### Magnetic Resonance Imaging

Patients underwent a shoulder MRI arthrogram before surgical intervention. MRI examinations were performed using a 3.0-T Siemens Magnetom Skyra (Siemens Medical Solutions). As a result of the major role of MRI in the diagnosis of shoulder pathologies and preoperative planning, MRI findings were analyzed to assess the impact of BMI on sensitivity and specificity and provide reference to the physical examination analysis. Interpretation of the MRI results was performed by senior musculoskeletal radiologists as standard of care. MRI pathologies were classified in a binary fashion as being either injured or intact.

### Operative Technique

The indication for surgical intervention was determined by senior orthopaedic shoulder specialists according to the patient's history, clinical findings, and imaging. The decision to undergo surgery followed a thorough discussion between the patient and operating surgeon and the provision of written informed consent. Arthroscopies of the shoulder were performed with the patient in the beach-chair position. All arthroscopies began with a primary diagnostic survey of the shoulder through a standard posterior viewing portal, using the Southern California Orthopedic Institute 15-point evaluation system.[28]

The surgeon noted the presence of a rotator cuff tear (complete or partial) or its absence, superior labral anterior-posterior (SLAP) lesion (of any type), and Bankart lesions as well as any other intra-articular pathology. Finally, treatment was performed as indicated by the encountered pathology.

### Statistical Analysis

We assessed the diagnostic sensitivity and specificity of the provocative tests for shoulder pathologies using arthroscopy as the gold standard. The sensitivity and specificity of the Jobe supraspinatus test were determined according to the presence of a supraspinatus rotator cuff tear during arthroscopy. The sensitivity and specificity of the apprehension test and relocation test were determined according to the presence of a Bankart lesion during arthroscopy. The sensitivity and specificity of the O'Brien, Speed, and Ebinger tests were determined according to the presence of a SLAP lesion during arthroscopy. We assessed sensitivity and specificity separately for 3 groups of patients by BMI according to the World Health Organization classification[34]: patients with BMI ≤25 (normal weight), 25 < BMI

TABLE 1
Characteristics and Injury Patterns of Patients (N = 116)[a]

|  | Value |
| --- | --- |
| Mean age, y | 43.1 ± 19.1 (15-77) |
| Sex, male/female, n | 85/31 |
| Side, right/left, n | 70/46 |
| Mean weight, kg | 79.4 ± 16.8 (50-160) |
| Mean height, cm | 171.9 ± 8.5 (147-194) |
| Mean BMI | 26.8 ± 4.8 (18.82-44.32) |
| BMI group |  |
| BMI ≤25 | 51 (44.0) |
| 25 < BMI ≤ 30 | 40 (34.5) |
| BMI >30 | 25 (21.6) |
| Trauma[b] | 47 (43.1) |
| Dislocation[c] | 46 (41.4) |
| Overhead activity pain[d] | 50 (64.9) |
| Supraspinatus tear on arthroscopy | 57 (49.1) |
| Bankart lesion on arthroscopy | 45 (38.8) |
| SLAP diagnosis on arthroscopy[29] | 72 (62.1) |
| SLAP tear type |  |
| Type 1 | 25 (21.6) |
| Type 2 | 43 (37.1) |
| Type 3 | 3 (2.6) |
| Type 4 | 1 (0.9) |

[a]Data are reported as mean ± SD (range) or n (%) unless otherwise indicated. BMI, body mass index; SLAP, superior labral anterior-posterior.
[b]n = 109 patients.
[c]n = 111 patients.
[d]n = 77 patients.

≤ 30 (overweight), and BMI >30 (obese). The $\chi^2$ test was used to assess the association between shoulder pathology as indicated by the physical examination and shoulder arthroscopy findings as viewed by the surgeon. A similar assessment was performed to assess the impact of BMI on the sensitivity and specificity of shoulder MRI findings to properly diagnose rotator cuff tears, Bankart lesions, and SLAP lesions. $P <.05$ for the $\chi^2$ test was considered statistically significant. SPSS Statistics for Windows (Version 26.0; IBM) was used to make these calculations.

## RESULTS

### Characteristics

A total of 116 consecutive patients (mean ± SD age, 43.1 ± 19.1 years) met the inclusion criteria for the study. There were 31 (26.7%) women and 85 (73.3%) men, and the mean patient BMI was 26.79 ± 4.8. Patient characteristics are detailed in Table 1.

### Rotator Cuff Tear

During arthroscopy, a supraspinatus rotator cuff tear was discovered in 57 patients. The sensitivity and specificity of the Jobe test in detecting a supraspinatus tear are shown in Table 2. The correlation between rotator cuff integrity as indicated by the Jobe test during physical examination and

TABLE 2
Sensitivity and Specificity of the Jobe Test in the Diagnosis of Rotator Cuff Tear, Stratified by BMI Group[a]

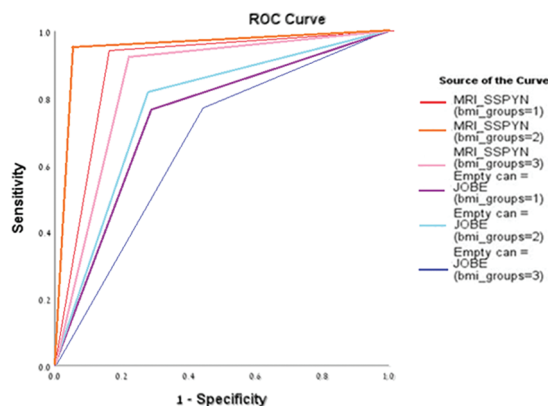| Jobe Test | Sensitivity, % | Specificity, % | Positive Likelihood Ratio | $\chi^2$ (P Value) |
| --- | --- | --- | --- | --- |
| Overall | 80.7 | 69.5 | 2.646 | 31.403 (<.001) |
| BMI ≤25 | 77.8 | 72.7 | 2.850 | 12.112 (.002) |
| 25 < BMI ≤ 30 | 82.6 | 70.6 | 2.810 | 14.2 (.002) |
| BMI >30 | 81.3 | 55.6 | 1.831 | 3.586 (.058) |

[a]BMI, body mass index.



**Figure 1.** Receiver operating characteristic (ROC) curves for supraspinatus tear diagnosis by Jobe test and magnetic resonance imaging (MRI), stratified by body mass index (BMI) group (group 1: BMI ≤25; group 2: 25 < BMI ≤ 30; group 3: BMI >30). SSPYN, supraspinatus tear (yes/no).

shoulder arthroscopy findings as viewed by the surgeon was statistically significant ($P < .001$). When stratified by BMI group, the correlation was significant for the normal weight and overweight groups ($P = .002$ for both), but there was only a trend toward statistical significance ($P = .058$) for the overweight group (BMI >30). The area under the curve (AUC) for patients with a BMI >30 was the lowest (AUC, 0.662) of all the receiver operating characteristic (ROC) curves (Figure 1).

### Shoulder Instability

During arthroscopy, a Bankart lesion was discovered in 44 patients. The sensitivity and specificity of the apprehension and relocation test are shown in Table 3. Overall, the sensitivity and specificity of tests for shoulder instability were statistically significant. For the apprehension test, the areas under the ROC curves for BMI ≤25, 25 < BMI ≤ 30, and BMI >30 were 0.727, 0.917, and 0.775, respectively. For the relocation test, the areas under the ROC curves were 0.733, 0.875, and 0.775, respectively (Figure 2).

TABLE 3
Sensitivity and Specificity of Tests for Shoulder Instability in Diagnosis of a Bankart Lesion, Stratified by BMI Group[a]

| | Sensitivity, % | Specificity, % | Positive Likelihood Ratio | $\chi^2$ (*P* Value) |
|---|---|---|---|---|
| Apprehension test | | | | |
| Overall | 68.9 | 91.5 | 8.106 | 49.203 (<.001) |
| BMI ≤25 | 67.9 | 78.3 | 3.129 | 10.963 (.004) |
| 25 < BMI ≤ 30 | 83.3 | 100.0 | — | 31.111 (<.001) |
| BMI >30 | 60.0 | 95.0 | 12.000 | 9.003 (.003) |
| Relocation test | | | | |
| Overall | 62.2 | 94.4 | 11.107 | 47.481 (<.001) |
| BMI ≤25 | 57.1 | 87.0 | 4.392 | 13.529 (.001) |
| 25 < BMI ≤ 30 | 75.0 | 100.0 | — | 27.097 (<.001) |
| BMI >30 | 60.0 | 95.0 | 12.000 | 9.003 (.003) |

[a]BMI, body mass index. Dashes indicate unmeasurable value (occurs when specificity is 100%, which in turn causes division by zero in the formula and thus incalculable).
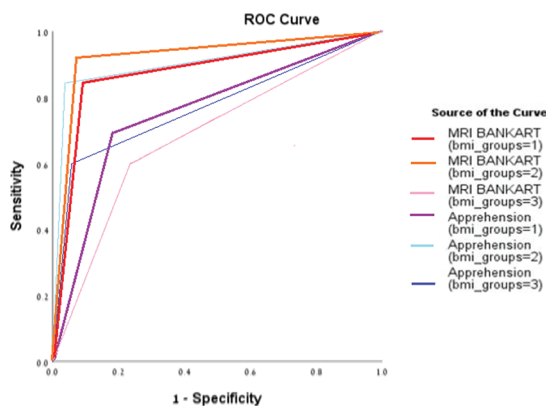


**Figure 2.** Receiver operating characteristic (ROC) curves for Bankart lesion diagnosis by apprehension test and magnetic resonance imaging (MRI), stratified by body mass index (BMI) group (group 1: BMI ≤25; group 2: 25 < BMI ≤ 30; group 3: BMI >30).

## SLAP Lesion

A SLAP lesion was present in 72 patients. The sensitivity and specificity of the O'Brien test, Speed test, and Ebinger test for diagnosing the SLAP lesion are shown in Table 4. Overall, the sensitivity and specificity of the SLAP tests were not statistically significant. Of note, the sensitivity and specificity of the Speed test for normal weight patients were statistically significant (*P* = .044).

## Sensitivity and Specificity of MRI Stratified by BMI

The overall sensitivity and specificity for the detection of a supraspinatus tear by MRI were 94.2% and 86.2%, respectively (*P* < .001). Obese patients (BMI >30) had the lowest sensitivity and specificity for the detection of a supraspinatus tear by MRI (92.3% and 77.8%, respectively; *P* < .001) (Figure 1 and Table 5). The MRI sensitivity and specificity in the diagnosis of Bankart lesions were lower in obese patients (60% and 76.5%, respectively) when compared with normal weight and overweight patients (sensitivity, 85.2% and 91.7%; specificity, 91.3% and 92.6%, respectively; *P* < .001). Overall, MRI demonstrated a sensitivity of 54.9% and a specificity of 84.6% for the detection of SLAP lesions (*P* < .001). No significant differences were found between the sensitivity and specificity of MRI for the detection of a SLAP lesion based on BMI (Tables 5 and 6). The areas under the ROC curves are shown in Table 7. In general, we found higher AUC values for MRI in the detection of shoulder pathologies compared with the AUC values of respective provocative physical examination tests. Interestingly, the AUC for the detection of a Bankart lesion by MRI was only 0.5.

## DISCUSSION

We have found that BMI can have a major effect on the sensitivity and specificity of provocative tests for rotator cuff pathology and shoulder instability. The Jobe supraspinatus test was found to be more sensitive but less specific in overweight patients. Surprisingly, the specificity for the detection of a Bankart lesion was greater for provocative tests for shoulder instability and lower when using MRI. To the best of our knowledge, this is the first study to assess the relationship between BMI and physical examination of the shoulder. While previous studies have evaluated other factors that affect the precision of shoulder examination,[13,16,26] taking into account patient characteristics, including age, sex, and race, they did not address the potential influence of BMI on the accuracy of the tests.

A thorough physical examination of the shoulder is a cardinal part of the evaluation and treatment of patients with shoulder complaints. The reliability of routinely performed tests is crucial to the surgeon's ability to contemplate the importance of his or her findings, especially when surgery is considered. Previous studies outside the field of orthopaedics have demonstrated that obesity influences the reliability of the physical examination. Fink et al[6] demonstrated that greater abdominal girth is correlated with lower sensitivity in the detection of abdominal aortic aneurisms; BMI was found to be associated with nonpalpable breast cancer, suggesting a lower sensitivity of the clinical

TABLE 4
Sensitivity and Specificity of Tests for SLAP in Diagnosis of a SLAP Lesion, Stratified by BMI Group[a]

| | Sensitivity, % | Specificity, % | Positive Likelihood Ratio | $\chi^2$ (P Value) |
|---|---|---|---|---|
| O'Brien test | | | | |
| Overall | 45.9 | 70.5 | 4.011 | 3.907 (.142) |
| BMI ≤25 | 62.5 | 68.4 | 1.306 | 1.312 (.519) |
| 25 < BMI ≤ 30 | 33.6 | 68.8 | 5.179 | 4.798 (.091) |
| BMI >30 | 31.3 | 77.8 | 0.238 | 0.233 (.629) |
| Speed test | | | | |
| Overall | 62.5 | 56.8 | 1.447 | 4.358 (.113) |
| BMI ≤25 | 62.5 | 73.7 | 2.376 | 6.246 (.044) |
| 25 < BMI ≤ 30 | 54.2 | 43.8 | 0.964 | 0.093 (.955) |
| BMI >30 | 75.0 | 44.4 | 1.349 | 3.299 (.192) |
| Ebinger test | | | | |
| Overall | 41.7 | 68.2 | 1.311 | 1.212 (.546) |
| BMI ≤25 | 46.9 | 73.7 | 1.783 | 2.708 (.258) |
| 25 < BMI ≤ 30 | 41.7 | 62.5 | 1.112 | 0.218 (.897) |
| BMI >30 | 31.3 | 66.7 | 0.940 | 0.011 (.915) |

[a]BMI, body mass index. SLAP, superior labral anterior-posterior.

TABLE 5
Sensitivity and Specificity of MRI in Diagnosis of Shoulder Pathology, Stratified by BMI Group[a]

| | Sensitivity, % | Specificity, % | Positive Likelihood Ratio | $\chi^2$ (P Value) |
|---|---|---|---|---|
| Supraspinatus tear | | | | |
| Overall | 94.2 | 86.2 | 6.826 | 71.055 (<.001) |
| BMI ≤25 | 95.2 | 84.4 | 6.103 | 29.045 (<.001) |
| 25 < BMI ≤ 30 | 95.2 | 94.1 | 16.136 | 30.341 (<.001) |
| BMI >30 | 92.3 | 77.8 | 4.158 | 11.289 (<.001) |
| Bankart lesion | | | | |
| Overall | 84.1 | 88.1 | 7.067 | 57.355 (<.001) |
| BMI ≤25 | 85.2 | 91.3 | 9.793 | 29.066 (<.001) |
| 25 < BMI ≤ 30 | 91.7 | 92.6 | 12.392 | 26.542 (<.001) |
| BMI >30 | 60.0 | 76.5 | 2.553 | 2.369 (.124) |
| SLAP tear | | | | |
| Overall | 54.9 | 84.6 | 3.565 | 16.447 (<.001) |
| BMI ≤25 | 58.0 | 84.2 | 3.671 | 8.733 (.013) |
| 25 < BMI ≤ 30 | 54.2 | 85.7 | 3.790 | 5.886 (.011) |
| BMI >30 | 43.8 | 83.3 | 2.623 | 2.076 (.354) |

[a]BMI, body mass index; MRI, magnetic resonance imaging; SLAP, superior labral anterior-posterior.

breast examination in obese patients[3,27]; more studies have reported the obscuring effect of obesity in the diagnosis of ascites, pulmonary embolism, and aortic stenosis. Conversely, Chu et al[4] demonstrated that the predictive value of digital rectal examination for the detection of prostate cancer is significantly higher in obese patients. While these tests are mostly based on the examiner's perception, most shoulder tests are based on what the patient reports or demonstrates (ie, weakness or pain). Nevertheless, limb weight, soft tissue imbalance, examiner hand positioning and grasp, and other biomechanical mechanisms may support the effect of BMI on the reliability of provocative shoulder tests. The Jobe test is considered to be relatively highly sensitive (~81%) and specific (~89%) for the detection of rotator cuff pathology.[8,12] We found that the sensitivity of the Jobe test is increased in overweight patients, while the specificity is decreased when compared with patients with a

healthy BMI. Interpreting these results is challenging given the lack of prior evidence on this subject. However, obesity has been shown to alter the scapulothoracic kinematics and be correlated with an increased scapular upward rotation.[10] We can only speculate that this alteration in the obese patient's scapulothoracic movement may in part produce pain more readily during the Jobe test for causes unrelated to rotator cuff pathology, resulting in a higher sensitivity and lower specificity.

Lizzio et al,[19] in their review of the physical examination in patients with anterior shoulder instability, reported sensitivity and specificity values of 68% to 88% and 50% to 100%, respectively, for the apprehension test, and 57% to 85% and 87% to 100%, respectively, for the relocation test. Overall, we found sensitivity and specificity values for provocative tests for shoulder instability that were comparable with those of prior studies.[19] We found that provocative

TABLE 6
Sensitivity and Specificity of MRI in Diagnosis of SLAP
Lesions, Stratified by SLAP Type and BMI Groups[a]

|  | Total | Type 1 | Type 2 | Type 3 | Type 4 |
|---|---|---|---|---|---|
| SLAP tears on arthroscopy, n | 72 | 25 | 43 | 3 | 1 |
| Sensitivity, % |  |  |  |  |  |
| Overall | 54.9 | 25.0 | 69.7 | 66.7 | 100.0 |
| BMI ≤25 | 58.0 | 25.0 | 78.9 | NA | NA |
| 25 < BMI ≤ 30 | 54.2 | 16.7 | 66.7 | 66.7 | 66.7 |
| BMI >30 | 43.8 | 33.3 | 55.5 | NA | 100.0 |

[a]BMI, body mass index; MRI, magnetic resonance imaging; NA, not applicable; SLAP, superior labral anterior-posterior.

tests for instability have a higher specificity for the presence of Bankart lesions in overweight patients. Interestingly, the specificity of provocative tests for instability was greater than the specificity of shoulder MRI for the detection of a Bankart lesion. Obesity has been suggested to potentially negatively affect the control of rapid arm movement.[2] However, the exact pathophysiologic mechanism responsible for this effect of BMI on the examination of the unstable shoulder is unknown.

Provocative tests for SLAP lesions tend to be less sensitive and specific.[1,9,31,32] Ebinger et al[5] reported that the supine-flexion resistance test had a sensitivity of 80% and a specificity of 69%. O'Brien et al[25] reported the O'Brien test had a sensitivity and specificity of 100% and 98.5%, respectively. However, later studies have reported extremely lower sensitivities and specificities.[5,30] We found overall low sensitivity and specificity values for SLAP tests, but the results were not statistically significant for most tests. Of note, the sensitivity of MRI for the detection of SLAP appeared to decrease in overweight and obese patients.

Interestingly, positive likelihood ratios were generally higher for provocative shoulder tests assessing a Bankart lesion in obese patients, suggesting that the presence of a positive test presents a greater probability of disease in this patient population. Positive likelihood ratios were also relatively greater for MRI evaluations of all assessed pathologies in overweight patients, again suggesting that a positive MRI finding in these patients demonstrates an increased probability of disease.

The main limitation of this current study is its retrospective nature. However, data were prospectively collected, and patients in our clinic routinely undergo physical examination before viewing of imaging studies. We also acknowledge the possible selection bias in our study, as only patients for whom a decision of surgical intervention was made were included in the study. The pathologies we focused on can be found in many asymptomatic patients and patients with only mild symptoms who do not necessitate surgical intervention. Additionally, power analysis was not performed for this study. Moreover, because of the sample size, we did not perform descriptive analysis of the characteristics for each pathology at each BMI group. Our database identified only 6 morbidly obese patients (BMI

TABLE 7
ROC Curve Analysis and AUC Values[a]

|  | AUC | SE | Asymptotic 95% CI |
|---|---|---|---|
| Jobe test |  |  |  |
| BMI ≤25 | 0.757 | 0.073 | 0.614 to 0.899 |
| 25 < BMI ≤ 30 | 0.790 | 0.077 | 0.640 to 0.940 |
| BMI >30 | 0.684 | 0.117 | 0.454 to 0.914 |
| Apprehension test |  |  |  |
| BMI ≤25 | 0.727 | 0.073 | 0.584 to 0.869 |
| 25 < BMI ≤ 30 | 0.917 | 0.065 | 0.790 to 1.044 |
| BMI >30 | 0.775 | 0.141 | 0.498 to 1.052 |
| Relocation test |  |  |  |
| BMI ≤25 | 0.733 | 0.071 | 0.594 to 0.872 |
| 25 < BMI ≤ 30 | 0.875 | 0.077 | 0.724 to 1.026 |
| BMI >30 | 0.775 | 0.141 | 0.498 to 1.052 |
| MRI: supraspinatus |  |  |  |
| BMI ≤25 | 0.894 | 0.050 | 0.797 to 0.992 |
| 25 < BMI ≤ 30 | 0.947 | 0.043 | 0.862 to 1.031 |
| BMI >30 | 0.850 | 0.094 | 0.665 to 1.035 |
| MRI: Bankart |  |  |  |
| BMI ≤25 | 1.000 | 0.000 | 1.000 to 1.000 |
| 25 < BMI ≤ 30 | 0.900 | 0.126 | 0.652 to 1.148 |
| BMI >30 | 0.500 | 0.323 | –0.133 to 1.133 |

[a]AUC, area under the curve; BMI, body mass index; MRI, magnetic resonance imaging; ROC, receiver operating characteristic.

>35), 2 of whom were identified as superobese (BMI >40). Because of the low numbers, we did not perform a separate subanalysis for these groups of patients. However, it is important to acknowledge the rising numbers of morbidly and superobese patients, which may necessitate a separate analysis. Concomitant pathologies were not evaluated and may have affected sensitivity and specificity. Also, results were not stratified according to grade of rotator cuff tears because of the limited size of this cohort.

This study also did not report other common physical findings, including pain localization, range of motion, and impingement signs. While these findings are fundamental to the physical examination, they are not intended to detect a specific pathology, and therefore, an analysis of sensitivity and specificity is not appropriate. While MRI is an important tool in the diagnostic process and for preoperative planning, the data are mostly presented and analyzed to provide reference to the reliability of the physical examination. Also, because of the retrospective nature of the study, we could not determine whether the same shoulder coil was used in all cases. However, MRI examinations evaluated for this secondary analysis were mostly of very high quality, and interpretation was not compromised. Last, investigations focusing on physical examination are prone to many inherent patient-, physician-, and researcher-related biases. However, these studies are unique and scarce and provide some of the most clinically useful data in the intimate day-to-day encounters of care providers and patients.

Even though it is not likely that our findings would significantly change common practice, they add to the knowledge of surgeons and physicians, helping them to better evaluate patients.

## CONCLUSION

Counterintuitively, tests for shoulder instability have greater specificity in overweight patients and should be encouraged, particularly in obese patients in whom the specificity of shoulder MRI for the detection of a Bankart lesion is lower. It appears that the Jobe test is more sensitive but less specific in overweight patients. These findings may assist care providers in improving the interpretation of the shoulder examination of overweight patients and consequently lead to better treatment-related decisions.

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