Normalization of the subscapularis belly-press test

Brian Gilmer,[a] Thomas Bradley Edwards, MD,[a] Gary Gartsman, MD,[a] Daniel P. O'Connor, PhD,[b] and Hussein Elkousy, MD,[a] *Houston, TX*

The purpose of this report is to document the normal range of the subscapularis belly-press test and to define factors that influence it to aid in the assessment of subscapularis function in relevant shoulder pathology and procedures. Both shoulders in 204 patients with no history of shoulder problems were tested with an Isobex machine. Patients were educated on proper technique before testing. Height, weight, age, hand dominance, and gender were all recorded. All measured values were recorded in kilograms. Women had a mean belly-press strength (mean of both arms) of 5.1 ± 1.9 kg, which was significantly less than the men's strength of 8.4 ± 2.5 kg (P < .001). The mean difference in belly-press strength between the dominant arm (6.7 kg) and nondominant arm (6.5 kg) was small (95% confidence interval, 0.05-0.4 kg). Multiple regression analysis revealed that mean belly-press strength was significantly related to gender (P = .001), height (P = .006), and weight (P < .001) but not age (P = .320). The belly-press test evaluation for subscapularis strength can be normalized across an average population by gender, height, and weight. Hand dominance and age do not factor in significantly. This test can be useful in evaluating the preoperative and postoperative status of the subscapularis in relevant shoulder injuries and procedures. (J Shoulder Elbow Surg 2007;16:403-407.)

The subscapularis is the largest and strongest rotator cuff muscle.[7] It functions primarily to rotate the humerus internally, but it also acts in shoulder flexion, extension, abduction, and adduction.[7] Beyond these motor functions, the subscapularis also plays a small role in the stability of the shoulder.[7]

In the past, subscapularis injuries have been uncommon, unrecognized, or underappreciated. Most injuries are partial-thickness tears associated with other rotator cuff injuries, with only rare reports of isolated or full-thickness tears.[7,9] Perhaps for this reason, reports of subscapularis repair are sparse in the older literature. However, as more subscapularis injuries are being diagnosed by magnetic resonance imaging, ultrasound, and arthroscopy, deficits in function are becoming more apparent and emphasis has been placed on management, particularly surgical treatment.

Imaging studies and arthroscopy have allowed several investigators to develop physical examination tests that can detect subscapularis injuries. These tests assist with diagnosis and functional assessment. They include increased passive external rotation, the belly-press angle, the belly-press test, the belly-off sign, and the liftoff test.[2,4,5,10] However, these tests are interpreted subjectively and may differ among individuals and even between sides in the same person.

The belly-press test, also called the Napoleon test, has emerged as a simple test of subscapularis function that can be easily reproduced, is generally not limited by pain, and correlates highly with full-thickness tears.[1,7,11] For these reasons, we chose it as the subject of this study. We assumed that the belly-press test would yield measurable and reproducible results if controlled by key demographic variables. Specifically, we hypothesized that gender, weight, height, and arm dominance would influence subscapularis function and belly-press measurements. These data would be useful in assessing subscapularis muscle function after injury and after surgical repair.

MATERIALS AND METHODS

Subjects were consecutively chosen from the sports medicine practice of one of the authors. They were only asked to participate if they were being evaluated for a nonshoulder problem and if they had no history of shoulder pain, injury, or surgery. A total of 204 subjects were tested.

All subjects were instructed on the proper technique for the belly-press test maneuver. The examiner demonstrated proper technique and allowed the subject a practice attempt (Figure 1). All subjects were tested while standing with their feet flat on the floor and shoulder-width apart. This is the position in which we test patients routinely in the clinic. The subjects were instructed to keep the elbow forward and the wrist in a neutral position and to press the hand toward the abdomen.[7] Both arms were then tested

From [a]Fondren Orthopedic Group and [b]Joe W. King Orthopedic Institute.

Reprint requests: Daniel P. O'Connor, PhD, Joe W. King Orthopedic Institute, 7401 S Main St, Houston, TX 77030 (E-mail: *dano@jwkoi.com*).

1058-2746/2007/$32.00
doi:10.1016/j.jse.2006.09.014

Figure 1 Belly-press test technique as demonstrated to study participants. **A**, Testing of right arm. It should be noted that the elbow is placed forward. **B**, Testing of left arm. It should be noted that the wrist is in a neutral position.

once by use of the Isobex muscle strength analyzer (Medical Device Solutions, Burgdorf, Switzerland) (Figure 2). The device measures mean muscular strength and fatigue over a period of 3 to 5 seconds and yields a mean value in kilograms. Demographic data were collected from the patient's office chart or by asking the patient directly for this information. These data included current height, current weight, hand dominance, and gender.

Means and SDs were calculated for all numeric variables. The reliability of the belly-press test was estimated by use of an intraclass correlation coefficient. Multiple regression was used to test our hypothesis that gender, weight, height, and arm dominance were related to belly-press test strength. Normative tables of belly-press test strength were constructed for both genders. All statistics were computed with SPSS software, version 13.0 (SPSS, Chicago, IL), and statistical significance was set at .05.

RESULTS

There were 112 women (mean age, 42.2 ± 13.5 years) and 92 men (mean age, 41.7 ± 14.7 years). Of the subjects, 45 were aged 20 to 29 years, 44 were aged 30 to 39 years, 56 were aged 40 to 49 years, and 59 were aged 50 years or older; there was no difference in gender distribution across these age groups ($P = .890$). The women averaged 163.1 ± 6.4 cm in height and 73.1 ± 16.9 kg in weight. The men averaged 179.3 ± 7.4 cm in height and 92.5 ± 17.4 kg in weight. Most subjects (91%) were right hand–dominant.

The women had a mean belly-press strength (mean of both arms) of 5.1 ± 1.9 kg, which was significantly less than the men's strength of 8.4 ± 2.5 kg ($P < .001$). The mean difference in belly-press strength between the dominant arm (6.7 kg) and nondominant arm (6.5 kg) was small, with a 95% confidence

Figure 2 Isobex muscle strength analyzer (Medical Device Solutions).

Table I Ranges of normal values by height and body weight for belly-press test in adult women (aged ≥20 years)

	Belly-press strength (kg)				
Height	**Body Weight of 50 kg (110 lb)**	**Body Weight of 60 kg (132 lb)**	**Body Weight of 70 kg (154 lb)**	**Body Weight of 80 kg (176 lb)**	**Body Weight of 90 kg (198 lb)**
155 cm (61 in)	0.3-6.6	0.8-7.1	1.3-7.6	1.8-8.1	2.3-8.6
160 cm (63 in)	0.6-6.9	1.1-7.4	1.6-7.9	2.1-8.4	2.6-8.9
165 cm (65 in)	0.9-7.1	1.4-7.7	1.9-8.2	2.4-8.7	2.9-9.2
170 cm (67 in)	1.2-7.4	1.7-7.9	2.2-8.4	2.7-9.0	3.2-9.5
175 cm (69 in)	1.4-7.7	1.9-8.2	2.5-8.7	3.0-9.2	3.5-9.7
180 cm (71 in)	1.7-8.0	2.2-8.5	2.7-9.0	3.2-9.5	3.7-10.0
185 cm (73 in)	2.0-8.3	2.5-8.8	3.0-9.3	3.5-9.8	4.0-10.3

Table II Ranges of normal values by height and body weight for belly-press test in adult men (aged ≥20 years)

	Belly-press strength (kg)				
Height	**Body Weight of 70 kg (154 lb)**	**Body Weight of 80 kg (176 lb)**	**Body Weight of 90 kg (198 lb)**	**Body Weight of 100 kg (220 lb)**	**Body Weight of 110 kg (242 lb)**
165 cm (65 in)	3.3-9.6	3.8-10.1	4.3-10.6	4.8-11.1	5.3-11.6
170 cm (67 in)	3.6-9.8	4.1-10.3	4.6-10.9	5.1-11.4	5.6-11.9
175 cm (69 in)	3.8-10.1	4.4-10.6	4.9-11.1	5.4-11.6	5.9-12.2
180 cm (71 in)	4.1-10.4	4.6-10.9	5.1-11.4	5.7-11.9	6.2-12.4
185 cm (73 in)	4.4-10.7	4.9-11.2	5.4-11.7	5.9-12.2	6.4-12.7
190 cm (75 in)	4.7-11.0	5.2-11.5	5.7-12.0	6.2-12.5	6.7-13.0
195 cm (77 in)	5.0-11.3	5.5-11.8	6.0-12.3	6.5-12.8	7.0-13.3

interval of 0.05 to 0.4 kg. Examination of the raw data revealed that 88% of the subjects had side-to-side differences of 2 kg or less. The nondominant arm was stronger in 42% of the subjects. Belly-press strength averaged across both arms was within 2 kg of the dominant and nondominant arm measures for all subjects. The reliability coefficient (intraclass correlation coefficient, 2,2) for agreement between the dominant and nondominant arms' strength measures was very high (0.94).

With simple linear regression, mean belly-press strength was significantly related to gender ($P < .001$), height ($P < .001$), and weight ($P < .001$) but not to age ($P = .249$). Thus, gender, height, and weight were entered into a regression analysis as predictors of mean belly-press strength.

Multiple regression analysis showed that gender ($P = .001$), height ($P = .006$), and weight ($P < .001$) each remained statistically significant predictors of mean belly-press strength ($R^2 = 0.52$, $P < .001$). Using the derived regression equation, we constructed tables of ranges of normal values for adult women (Table I) and men (Table II). Fewer than 5% of adults without shoulder pathology would be expected to have a belly-press strength above or below these ranges.

The results are applicable to either arm. The regression analysis was repeated for dominant arm strength and nondominant arm strength, and the results were indistinguishable from those using the mean of both arms.

DISCUSSION

Subscapularis tears account for 5% of all rotator cuff tears.[6] Injuries to the subscapularis muscle are rarely isolated, often being associated with supraspinatus tears, and they may be acute or chronic and partial or complete.[6,7] These injuries result in pain, weakness, and occasionally, instability.[7,9] For these reasons, they may require surgical treatment that relies on appropriate preoperative and postoperative evaluation. Consequently, several tests have been developed to assess subscapularis function, but these tests have not proven to be quantifiable.

The tests of subscapularis function include the increased external rotation test, the liftoff test, the belly-press test (Napoleon test), the belly-off sign, and the belly-press angle.[2,3,5,7,10] Another physical examination finding is weakness of internal rotation, but this can be masked by function of the pectoralis major, latissimus dorsi, and teres major.[7] The liftoff test and belly-press test are accurate, because they test internal rotation strength in a position of maximal extension and internal rotation.[11] This isolates the subscapularis from the other internal rotators. However, the liftoff test can often be more painful, because it requires more passive internal rotation than the belly-press test.[7] In these cases, the belly-press test is more useful.[11]

The belly-press test is performed by instructing the patient to keep the elbow forward, the wrist in neutral, and the hand on the abdomen.[7] It is usually only positive for full-thickness tears, whereas the liftoff test may be positive for partial tears.[1,7] In a study by Kreuz et al,[6] the liftoff test was positive in 13 of 21 partial subscapularis tears, and the belly-press test was positive in 3 of 21 partial tears. Both tests were positive in all 21 complete tears in that study.[6]

Our study measured the normal values for the belly-press test in a normal active population. The variables assessed were patient height, weight, age, gender, and hand dominance. The data yielded several findings. First, measuring subscapularis strength with an Isobex dynamometer is a reliable means of measuring subscapularis function with small measurement error (<1 kg). Second, height, weight, and gender are the key predictors for belly-press strength. Third, arm dominance did not have a significant effect on subscapularis strength. Finally, patient age did not play a significant role in subscapularis strength.

Qualitative testing of the subscapularis has flaws that make it difficult to assess subscapularis function accurately. For example, the belly-press test may be more specific in assessing the upper subscapularis, whereas the liftoff test is more specific to the lower subscapularis, based on electromyographic evaluation.[11] This study may present a simple means by which to assess subscapularis function objectively and reproducibly, based on parametric variables.

These data can be applied clinically in several ways. First, the normal ranges corrected for height, weight, and gender may be useful in determining if the subscapularis has been injured. Isolated tears fare better than combined tears, younger patients fare better than older patients, and a shorter interval between injury and surgery yields better results.[6] Accurate identification of subscapularis tears may result in a shorter delay to diagnosis and subsequent surgery, as well as appropriate counseling for expected restoration of function.

Second, the normal range of subscapularis strength may allow for monitoring or restoration of postoperative function. The subscapularis is disrupted and repaired with several surgical approaches. The results of these surgeries may be worse with transection of the subscapularis as opposed to splitting of the subscapularis, as shown in a study of the Latajet procedure by Mayou et al.[8] At follow-up, the subscapularis-splitting approach had less fatty infiltration and better function based on the liftoff test, and the subjective patient evaluation at 7.5 years was better.[8] These results may be specific to the Latarjet procedure, but the data from this study may be used to evaluate this more closely for the Latarjet or other procedures.

For example, the subscapularis is taken down and repaired to perform shoulder arthroplasty. In a study by Gerber et al,[4] all subscapularis repairs done with a lesser tuberosity osteotomy had excellent results. Almost 90% of patients had a negative belly-press test and 75% had a negative liftoff test. Despite these good results, fatty infiltration did increase postoperatively by 1 grade or more. The data from our study may be useful in comparing different approaches to repair of the subscapularis with shoulder arthroplasty, they may be used to assess postoperative subscapularis failure regardless of the approach, or they may be correlated with fatty infiltration to determine its clinical importance.

This objective data from this study can be corroborated with testing of the nondominant arm. This study validates the use of the nondominant arm as an internal control to assess individual subscapularis function. This was already shown in a study by Maynou et al,[8] in which the liftoff test in a control group was 8 kg in the dominant arm and 7 kg in the nondominant arm.

Although our findings are significant and, in our opinion, potentially clinically useful, there are some design flaws present. Most notably, subjects were tested in the standing position. It may be argued that this does not control for patient weight. This is a reasonable concern. We chose to test the subjects while standing because this is how we test patients routinely in the clinic. Subjects were coached and observed to ensure that they did not lean back or use their body weight to influence the results.

In summary, the belly-press test yields reproducible results across a normal population normalized by height, weight, and gender. Hand dominance and age do not appear to play a role in determining subscapularis strength, as measured by an Isobex dynamometer with the belly-press test. These data may be useful for future studies to assess subscapularis injuries, as well as function in the perioperative period.

REFERENCES

1. Burkhart SS, Tehrany AM. Arthroscopic subscapularis tendon repair: technique and preliminary results. Arthroscopy 2002;18: 454-63.

2. Gerber C, Hersche O, Farron A. Isolated rupture of the subscapularis tendon. J Bone Joint Surg Am 1996;78:1015-23.
3. Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle. Clinical features in 16 cases. J Bone Joint Surg Br 1991;73:389-94.
4. Gerber C, Yian EH, Pfirrmann CA, Zumstein MA, Werner CM. Subscapularis muscle function and structure after total shoulder replacement with lesser tuberosity osteotomy and repair. J Bone Joint Surg Am 2005;87:1739-45.
5. Kim SH, Oh I, Park JS, Shin SK, Jeong WK. Intra-articular repair of an isolated partial articular-surface tear of the subscapularis tendon. Am J Sports Med 2005;33:1825-30.
6. Kreuz PC, Remiger A, Erggelet C, Hinterwimmer S, Niemeyer P, Gachter A. Isolated and combined tears of the subscapularis tendon. Am J Sports Med 2005;33:1831-7.
7. Lyons RP, Green A. Subscapularis tendon tears. J Am Acad Orthop Surg 2005;13:353-63.
8. Maynou C, Cassagnaud X, Mestdagh H. Function of subscapularis after surgical treatment for recurrent instability of the shoulder using a bone-block procedure. J Bone Joint Surg Br 2005;87: 1096-101.
9. Neviaser RJ, Neviaser TJ. Recurrent instability of the shoulder after age forty. J Shoulder Elbow Surg 1995;4:416-8.
10. Scheibel M, Magosch P, Pritsch M, Lichtenberg S, Habermeyer P. The belly-off sign: a new clinical diagnostic sign for subscapularis lesions. Arthroscopy 2005;21:1229-35.
11. Tokish JM, Decker MJ, Ellis HB, Torry MR, Hawkins RJ. The belly-press test for the physical examination of the subscapularis muscle: electromyographic validation and comparison to the lift-off test. J Shoulder Elbow Surg 2003;12:427-30.