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Comparison of shoulder strength assessment in scaption with an isometric dynamometer and a weighing machine: a pilot study

Philippe Collin, MD [a], B.H. Banarji, MD [b], Patrick J. Denard, MD [c,d], Omar Kherad, MD [e,f], Alexandre Lädermann, MD [f,g,h,*]

[a] Division of Orthopaedics and Trauma Surgery, Centre Hospitalier Privé Saint-Grégoire, Saint-Grégoire, France
[b] Division of Orthopaedics and Trauma Surgery, MS Ramaiah Memorial Hospital, Bangalore, India
[c] Southern Oregon Orthopedics, Medford, OR, USA
[d] Department of Orthopaedics and Rehabilitation, Oregon Health & Science University, Portland, OR, USA
[e] Division of Internal Medicine, La Tour Hospital, Meyrin, Switzerland
[f] Division of Orthopaedics and Trauma Surgery, La Tour Hospital, Meyrin, Switzerland
[g] Division of Orthopaedics and Trauma Surgery, Department of Surgery, Geneva University Hospitals, Geneva, Switzerland
[h] Faculty of Medicine, University of Geneva, Geneva, Switzerland

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Background: Strength testing is an important aspect of shoulder examination. To date, strength assessment has many limitations. There is no single standard instrument for measuring, and various current devices have problems in reliability, accuracy, and cost. This study compared the results of an innovative and simple method of strength testing (weighing machine) with an existing method (isometric dynamometer).

Methods: Shoulder strength was tested in 80 individuals, 60 with normal shoulders (group 1) and 20 with shoulder pathology (group 2). Strength was tested in the standard position of 90° of elevation in the scapular plane (scaption) with the elbow extended and forearm pronated while resistance was applied just proximal to the wrist. A weighing machine and an isometric dynamometer were used for strength testing.

Results: There was a mean difference of 0.26 kg in group 1 (95% confidence interval [CI], 0.16-0.36; $P < .0001$) and 0.30 kg in group 2 (95% CI, 0,04-0,72; $P = .0291$) between the weighing machine and the isometric dynamometer. Although statistically significant, these differences were not clinically significant.

Conclusions: This pilot study shows that strength assessment by an innovative and simpler technique with a weighing machine gives similar results as an isometric dynamometer.

Strength testing is performed to assess a patient's ability to maintain maximum voluntary muscle tension against a force or resistance. Evaluating muscle strength is an essential component of the physical examination of the shoulder and is used for diagnosis, monitoring treatment progress, and disability evaluation.[3,16,20,23,25] Although testing of shoulder strength is routine, accurately quantifying shoulder strength can be challenging.

Strength testing can be subjective or objective. Subjectively, muscle strength may be manually tested and graded on a scale of 0 to 5.[19] However, such subjective assessment is limited by the lack of intrarater and inter-rater reliability and cannot be expressed in standard units.[22]

Several methods of objectively quantifying muscle strength have been proposed, including the isometric dynamometer, spring balance, and cable tensiometer. These methods have been particularly applied to the clinical research setting as a component of functional outcome scores. For instance, in the Constant score,[9] which was adopted by the European Society for Surgery of Shoulder and Elbow as the primary functional outcome score for clinical research, 25% of the score is apportioned to strength assessment.[1,6-8,16] In the original description, the strength assessment portion of the Constant score was performed with a spring balance or cable tensiometer.[21] However, studies have questioned the reliability of the spring balance.[2,4] More recently, Gerber and Arneberg[12] developed an isometric dynamometer and defined a range of normal values for strength in scaption measured at the wrist. Various studies have proved the efficacy of such instrument of measure,[13,17,18] particularly during calculation of a Constant score. However, this device is expensive and not readily available in all centers.

The primary author (P.C.) has developed a simple method of assessing shoulder scaption strength with the use of a weighing scale.

Ethical approval was not applicable for this study.

* Corresponding author. Alexandre Lädermann, MD, Division of Orthopaedics and Trauma Surgery, La Tour Hospital, Av. J.-D. Maillard 3, Meyrin, CH-1217 Switzerland.
E-mail address: Alexandre.laedermann@gmail.com (A. Lädermann).

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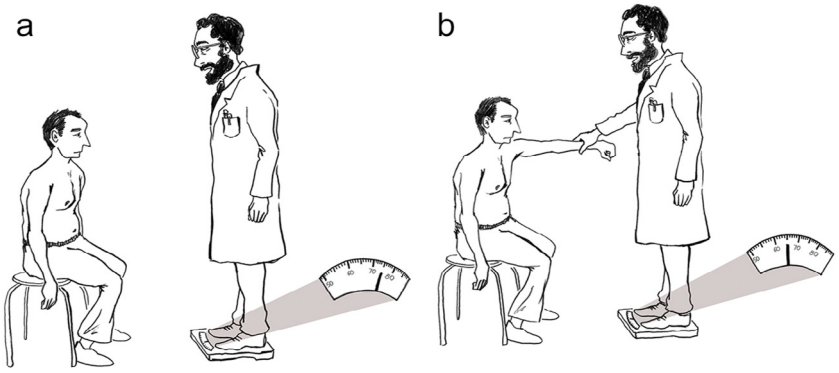

Figure 1 (**A**) The weight of the examiner is recorded (75 kg in this example). (**B**) With the elbow extended, the hand pronated, and the torso not stabilized, the patient's arm is elevated 90° in the plane of the scapula. The examiner positions 1 hand just proximal to the wrist. The patient is asked to maintain the position of the upper extremity for at least 5 seconds while a downward force is applied. The new weight is noted (65 kg in this example). The strength that has to be reported in the Constant score is the difference between the 2 measurements, in this example, 10 kg (75 kg – 65 kg).

This method is affordable and readily available in most clinics. The purpose of the study was to compare shoulder scaption strength measured with an isometric dynamometer and a weighing scale.

Materials and methods

This was a prospective pilot study of patients evaluated in an orthopedic clinic from September 2010 to December 2010. All volunteers were informed routinely about the study and agreed to participate. The study consisted of a volunteer group with healthy shoulders and a patient group with shoulder pathology.

Group 1 consisted of 15 consecutive men and 15 consecutive women (60 shoulders) without any known shoulder pathology. These patients were recruited from an orthopedic clinic where they were being treated or evaluated for nonshoulder complaints. Exclusion criteria for this group included shoulder pain, neck pain, a history of shoulder surgery elucidated during a history and physical examination, or pathology of the ipsilateral elbow and forearm.

Group 2 consisted of 20 consecutive postoperative shoulder patients (20 shoulders) who had undergone an arthroscopic shoulder procedure or open instability reconstruction at least 6 months before the evaluation. Exclusion criteria for this group included placement of an arthroplasty, the inability to actively elevate the arm above 90°, or pathology of the ipsilateral elbow and forearm.

All participants underwent strength testing with 2 different instruments in sequence: (1) an isometric dynamometer (Dynamometer, Hoggan Health Industries, West Jordan, UT, USA) and (2) a weighing scale (TPRO 3100, Terraillon, Croissy-sur-Seine, France). All measurements were taken by a single examiner.

With the elbow extended and the hand pronated, the arm was elevated 90° in the plane of the scapula.[1,8] The torso was not stabilized.[14] For the isometric dynamometer, a strap was applied just proximal to the wrist.[1,23] Patients were asked to maintain the position of the upper extremity for at least 5 seconds while a downward force was applied. The maximum resistance generated by the patients was recorded in kilograms by an independent examiner. Strength measurements obtained with the weighing scale methods are detailed in Fig. 1. For each device, 3 measurements were taken at least 1 minute apart, and the mean of the 3 values was recorded.[12,18] In group 1, the contralateral shoulder was assessed before proceeding to the next instrument. An interval of 5 minutes was taken before testing the same shoulder with another instrument[1] to allow full muscle recovery.[11]

Statistical analysis methods

Variables for baseline characteristics are reported as mean ± standard deviation or proportions. Between-group comparisons were performed using the Wilcoxon test for baseline characteristics and the paired *t* test for comparison in strength measurements. Results are presented as the mean difference and 95% confidence intervals (CIs). *P* values <.05 were considered statistically significant. A difference of >0.5 kg was considered clinically significant. Statistical analyses were performed with IBM SPSS Statistics for Windows 20.0 software (IBM, Armonk, NY, USA).

Results

The baseline characteristics of the study groups are presented in Table I. The 2 groups were similar with respect to sex distribution, height, weight, and limb dominance, but the mean age was significantly lower in the healthy volunteer group.

The difference between the strength measurements obtained with the isometric dynamometer compared with the weighing scale was 0.26 kg in group 1 (95% CI, 0.16-0.36; $P < .001$) and 0.38 kg in group 2 (95% CI, 0.04-0.72; $P = .029$; Table II). These differences were statistically significant but did not meet the definition of clinically significant.

Discussion

Many outcome scores are used for evaluating shoulder function, and strength assessment is an important part of most of them.[24] The European Society for Surgery of Shoulder and Elbow considers the Constant score[9] to be the most appropriate for assessing overall shoulder function.[1,6-8,16] This score, with a minimum of 0 and

Table I
Baseline characteristics according to groups

Variable	Group 1 (n = 60)	Group 2 (n = 20)	*P* value
Male sex	61.6	50.0	.092*
Age, yr	37.6 ± 12	49.2 ± 10	<.001*
Height, m	1.72 ± 0.10	1.68 ± 0.09	.333*
Weight, kg	70 ± 12	70 ± 12	.395*

Categoric data are shown as the percentage and continuous data as mean ± standard deviation.
* Wilcoxon test.

Table II
Comparison of strength measurements between the 2 methods

Group	Isometric dynamometer	Weighing scale	*P* value
	Mean ± SD (range)	Mean ± SD (range)	
Group 1	7.82 ± 2.56 (3.8-14.7)	7.56 ± 2.52 (3.6-14.3)	<.0001
Group 2	6.71 ± 2.33 (4.1-12)	6.33 ± 2.54 (3.0-12.3)	.0291

SD, standard deviation.

a maximum of 100, is divided into 4 subscales, including pain, activities of daily living, range of motion, and strength. The latter represents 25% of the score (25 points maximum). The University of California, Los Angeles Shoulder Rating Scale includes the factor of strength as well as pain, motion, function, and patient satisfaction in its assessment.[10] In these scores, a major source of error is the measurement of strength.[8]

The subjective assessment by manual muscle testing was first introduced by Lovett and Martin.[19] To objectively quantify muscle strength, the handheld dynamometer was introduced. These devices had certain limitations, such as upper limit of recording muscle force and difficulty in maintaining the device perpendicular to the limb.[2,5] Later, Hislop and Perrine[15] introduced the first isokinetic device, followed by several other isokinetic devices. These devices were not portable, required elaborated setups and stabilization procedures, and were not suitable for clinic setups.[20]

The data of the present study show encouraging similar results in scaption strength between an isometric dynamometer and our new method, which uses a weighing scale. The presented method with a weight machine meets the required standard[8] because it is reproducible and is easy and quick to use in a clinical or research setting without the need for sophisticated equipment. The isometric dynamometer remains a validated alternative, but in comparison, there is a price difference in favor of the former.

The major limitation of this study is lack of an intrarater and interrater reliability analysis. However, the goal of this prospective pilot study was simply to perform a comparison to current validated methods in asymptomatic individuals and in those with documented shoulder pathology. Further study is needed, including a reliability analysis and examination of the weighing scale methods in a larger population with different shoulder pathologies and in different shoulder positions.

Conclusion

This pilot study shows that strength assessment by an innovative and simpler technique with a weighing machine gives similar results as an isometric dynamometer. Further studies are warranted to confirm the reliability of this new method.

Disclaimer

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