Palm-up test and range of motion in flexion and external rotation provide best correlation with disability and perceived pain in patients with shoulder complaints

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ABSTRACT

Objectives: The aim of this study was to find a reliable set of clinical tests to predict pain and disability in patients with shoulder pain.

Shoulder pain is the second most frequent musculoskeletal complaint in the primary care setting and has a great impact in work and leisure activities. Patient reported outcomes measuring pain and disability are available, but they are time-consuming, often biased by psychological and sociological factors and rely on patient collaboration.

Methods: This was an observational, cross-sectional study, including patients with shoulder pain aged 18 to 70 years. Patients filled in the questionnaires Disabilities of the Arm, Shoulder and Hand outcome measure (DASH) and Shoulder Pain and Disability Index (SPADI) pain scale. A Visual Analogue Scale (VAS) for current pain was applied and sociodemographic and clinical data were collected. Physical examination included the Jobe, Neer and palm-up signs, range of motion (ROM) of shoulder abduction, flexion and rotation (internal and external), both active and passive. An independent t-test to compare differences between groups and the Spearman's coefficient for evaluation of bivariate correlation were used. Linear regression analysis was applied to relevant predictors. Tests were two-tailed and p values < 0.05 were considered significant.

Results: A total of 127 patients were included. Female patients and those with a positive Jobe, Neer or palm-up tests, complaints on dominant side, no leisure activity involving shoulder effort, a history of previous shoulder tendinopathy or taking analgesics had significantly higher DASH scores. Age and all range of motion variables significantly correlated with DASH scores. A linear regression model with six independent variables (Palm-up test, range of motion in active flexion and external rotation, age, gender and complaints on dominant side) produced the highest correlation (R = 0.665), explaining 44% of the variance of DASH score.

Conclusion: A model based on few physical examination items and individual objective data like age, gender and dominancy, can help predict disability and perceived pain in shoulder disorders. Palm-up test and range of motion in active flexion, abduction and external rotation showed best correlation with the outcome, but abduction was found redundant for the obtained prediction model.

Keywords: Shoulder pain; Disability evaluation; DASH; Palm-up test; Range of motion; Physical examination.

INTRODUCTION

Shoulder pain is a relevant medical problem, with figures in literature pointing up to 66.7% for lifetime prevalence[1]. Women and patients aged 45 to 64 years old have the highest incidence[2]. In the general population aged ≥ 25 years, shoulder was reported to be the second most common location for musculoskeletal pain, after low back pain[3]. About half the patients consult their doctors only once for their complaints[2,4]. Doctors usually focus on history and observation, as well as on simple diagnostic tests, as screening tools to select the cas-

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es which require further investigation.

The causes of shoulder pain are diverse, but rotator cuff and subacromial disorders seem to account for most of the cases[5-7]; glenohumeral disorders, acromioclavicular joint pathology, and referred neck pain should also be included as probable etiologies. Many studies have previously addressed the clinical utility of shoulder specific physical examination tests. In a 2012 systematic review with meta-analysis[8], the sensitivity and specificity of tests for diagnosis of several shoulder pathologies were analysed, but the authors concluded that the use of any single test to make a pathognomonic diagnosis could not be recommended, based on the quality of the evidence and the summary estimates of accuracy.

Nevertheless, the absence of a specific diagnosis does not necessarily imply the need for further investigation. Measuring the impact on daily activities is essential to assess if anything more than simple pain-relieving medication would be necessary in such a frequent condition. It could also help to determine the ability to return to work and it is recognized to influence prognosis[9].

For the purpose of measuring that impact, various questionnaires are available and validated for different languages and cultures, like the Disabilities of the Arm, Shoulder and Hand outcome measure (DASH), the Shoulder Pain and Disability Index (SPADI) and the Oxford Shoulder Score (OSS) [10-15]. However, some difficulties are associated with their use in clinical practice. A questionnaire form must be available. The time to complete a questionnaire is quite variable with mean times published (for DASH) reaching 13 minutes to complete and 6 minutes to analyse[10]. Patient-based assessment of disability is often affected by psychological and sociological factors[11]. In addition, such questionnaires depend on patient full collaboration, and they can be subject to bias when conflicting interests exist, namely if litigation or compensation is in question, making a more objective assessment desirable.

The aim of this study was to find an easy to execute and reasonably reliable set of clinical tests which could predict significant pain and disability derived from clinical history and observation.

METHODS

STUDY DESIGN AND SUBJECTS

This was an observational, cross-sectional study whose data collection prospectively took place for eighteen months, between February 2018 and July 2019.

Patients aged between 18 and 70 years old were consecutively recruited from those referred for shoulder ultrasound in the radiology department at Hospital de Santa Maria, CHULN, during that period. Patients referred for bilateral shoulder examination or whose exam was requested in the setting of occupational medicine, by a court of law or intending to define compensation or absence from work, were excluded in order to avoid measurement bias. Other exclusion criteria were: previous surgery or local invasive therapy on the examined shoulder, glenohumeral arthrosis (radiologically confirmed), pregnancy or who have given birth in the previous month, systemic inflammatory or infectious disease or an oncologic disease diagnosed in the past five years. The study also excluded minors, non-imputable or subjects unable to understand and accept informed consent or answer the study questionnaire.

The study was approved by the ethics committee of our institution and is in with the Declaration of Helsinki, as amended in Fortaleza, 2013. All patients signed an informed consent document. All the information was anonymously recorded in an electronic database.

MEASUREMENTS

Participants autonomously answered a questionnaire, asking for the above specified exclusion criteria, the duration of complaints (in years, months and days), and if there was an accident or a physical effort that concurred with the beginning of symptoms. The DASH, a Visual Analogue Scale (VAS) for current pain and the SPADI pain scale were also included in the form.

The DASH score was calculated as previously described[15]. The VAS[16] and SPADI pain scale[17,18] were assessed using 100mm linear segments and directly measured with a scale. All those variables were considered continuous, with a theoretical range from 0 to 100.

Sociodemographic and clinical data (age, gender, laterality of complaints and dominant side, professional or recreational shoulder efforts, pain evolution, prior shoulder pathology, medication) were further collected by interview. Work status was recorded, with occupation classified according to the International Standard Classification of Occupations (ISCO 08)[19].

Two rheumatology residents properly trained in musculoskeletal examination performed physical exams. Range of motion (ROM) of shoulder abduc-

tion, flexion, internal and external rotation, both active and passive (without patient effort), was registered in degrees. Jobe, Neer and palm-up signs, were collected as binary variables, classified as either 0 (negative) or 1 (positive). Jobe test was considered positive if shoulder pain was elicited applying resistance to active abduction starting with the arm in 30º flection, 60º abduction and internal rotation. In the Neer test, the shoulder was elevated in passive forward flexion while the scapula was depressed forcing the greater tuberosity and the rotator cuff against the acromion producing shoulder pain in the presence of impingement. Palm-up test was considered positive if the patient reported anterior shoulder pain when performing resisted flection with the arm supine in 45º flection and the elbow in extension.

The DASH questionnaire score was defined as the primary outcome, and VAS and SPADI pain scale were established as secondary outcomes. All other variables were considered potential predictors.

STATISTICAL ANALYSIS

Demographic and clinical variables were described with central tendencies and dispersion measures or frequencies as appropriate. Dispersion of each continuous variable was tested for normality with Shapiro-Wilks statistics and visual assessment of data in histograms and Q-Q (quantile-quantile) plots.

Regarding outcomes with a normal distribution, an independent t-test was applied to compare differences between groups defined by dichotomous variables, and one-way analysis of variance (ANOVA) was employed for other categorical data predictors. For outcomes without a normal distribution, non-parametric tests such as Mann-Whitney and Kruskal-Wallis were used.

For evaluation of bivariate correlation, the Spearman's coefficient was used, to allow non-parametric data. A correlation matrix was constructed to search for the most significant factors and a correlation between predictors.

Linear regression models were applied to possible relevant predictors in bivariate analysis (stepwise method, with listwise exclusion of missing values) in order to find a prediction model of shoulder disability. To test the assumptions required for multiple linear regression, independence of observations was tested using Durbin-Watson statistic, multicollinearity was checked by correlation coefficients and variance inflation factor (VIF) values, and residuals distribution was analysed for normality and homogeneity of variance.

All tests used were two-tailed and p values < 0.05 were considered significant.

Data was analysed with SPSS software, version 24.

RESULTS

The characteristics of the 127 patients which fulfilled the predetermined selection criteria and did not meet any of the exclusion criteria are displayed in Tables I and II. Female gender was by far more common (78.7%) than male. The median age was 56 years (range: 24-70) and the distribution showed a negative skewness, denoting the cut-off selection limit at 70 years. The length of symptoms variable revealed a positive skewness, with a predominance of shorter duration cases but with scattered patients reporting extremely long continuous pain (up to forty years). Most patients came from the departments of orthopedics and physical and rehabilitation medicine. Participants exhibited in most of the instances a normal/maximum ROM, and only tests for active abduction, active flexion and active external rotation registered less than 80% normal results (tests with lower kurtosis). Only DASH score allowed an assumption of a normal distribution.

The subgroups of patients with a female gender, a positive Neer or palm-up test or a previous clinical hypothesis of adhesive capsulitis had higher DASH scores than their counterparts did, with a particularly significant difference ($p < 0.001$). Patients with complaints on dominant side, no leisure activity involving shoulder effort, a history of previous shoulder tendinopathy, a positive Jobe test or taking analgesics also had significantly higher DASH scores (Table III).

Non-parametric tests (Mann–Whitney U test) were performed to compare subgroups for VAS and SPADI pain scale means. Significant positive differences were found in patients with previous clinical hypothesis of adhesive capsulitis (respectively median values 95.0 *vs* 52.0, $p = 0.027$ for VAS and 95.3 *vs* 68.6, $p = 0.040$ for SPADI pain scale) and with a positive Jobe test (58.0 *vs* 50.0, $p = 0.001$ and 71.3 *vs* 62.2, $p = 0.001$), Neer test (60.5 *vs* 50.0, $p = 0.008$ and 72.7 *vs* 63.4, $p = 0.006$) or palm-up test (57.0 *vs* 50.0, $p = 0.012$ and 72.7 *vs* 59.8, $p < 0.001$). SPADI pain scale mean was also higher in female (71.2 *vs* 56.4, $p = 0.002$) and in patients not enrolled in leisure activities with shoulder effort (70.3 *vs* 59.0, $p = 0.028$) or taking at least an anti-inflammatory drug (71.4 *vs* 63.6, $p = 0.022$).

There was a statistically significant difference of

TABLE I. PATIENT SOCIO-DEMOGRAPHIC CHARACTERISTICS AND PREVIOUS HISTORY

Patient characteristics	Frequency / Distribution	N
Gender		127
Female	100 (78.7%)	
Male	27 (21.3%)	
Age (years) †	56.0 (16)	127
Dominant side		127
Right	119 (93.7%)	
Left	8 (6.3%)	
Complaints on dominant side	82 (64.6%)	127
Work status and occupation		127
Professionals	17 (13.4%)	
Technicians and Associate Professionals	15 (11.8%)	
Clerical Support Workers	6 (4.7%)	
Services and Sales Workers	24 (18.9%)	
Craft and Related Trades Workers	11 (8.7%)	
Plant and Machine Operators & Assemblers	3 (2.4%)	
Elementary Occupations	8 (6.3%)	
Unemployed	6 (4.7%)	
Home duties	11 (8.7%)	
Retired	26 (20.5%)	
Usual shoulder effort		127
Professional	79 (62.2%)	
Recreational	15 (11.8%)	
Any	86 (67.7%)	
Previous shoulder pathology	40 (31.5%)	127
Age of first symptoms (years) †	46.5 (15)	
Dislocation	4 (3.1%)	
Tendinopathy	31 (24.4%)	
Rotator cuff tear	5 (3.9%)	

Notes: Continuous variables (†) expressed as median (IQR); all other variables are categorical and expressed as frequency and percentage, n (%)
N - Total number of valid observations; IQR - Interquartile range

DASH scores between work status and occupation groups as demonstrated by one-way ANOVA ($p < 0.001$). A Bonferroni post-hoc analysis showed that retired patients had higher scores than professionals (mean values 62.2 *vs* 39.7, $p = 0.001$) and craft and related trades workers (62.2 *vs* 41.3, $p = 0.028$), and as well that services and sales workers had higher scores than professionals (59.0 *vs* 39.7, $p = 0.016$). A significant difference between work status and occupation groups was additionally found for VAS ($p = 0.022$) and SPADI pain scale ($p = 0.024$), demonstrated by Kruskal-Wallis test.

Age and all ROM variables were found to have weak but significant correlation with DASH scores. Correlation matrix on Table IV displays the predictors found to have higher correlation coefficients. Stronger association was observed with ranges of active flexion, active abduction and active external rotation, and with palm-up test. The correlation of range of active abduction with active flexion and active external rotation is to be noted.

A linear regression analysis was performed taking DASH score as the dependent variable and including as independent variables all ROM variables, age, Jobe, Neer and palm-up tests, gender, pain on dominant side, leisure activity with shoulder effort, previous shoulder tendinopathy and analgesics consumption. Previous clinical hypothesis of adhesive capsulitis was not considered due to the small number of cases and the need for a previous examination. Lower limit of painful arc,

TABLE II. CLINICAL HISTORY, PHYSICAL EXAMINATION AND OUTCOMES

Characteristics	Frequency / Distribution	N
Duration of symptoms (days) †		
From beginning of the episode	365 (639)	127
With current intensity	122 (304)	127
Event at the beginning of complaints §		127
Accident	18 (14.2%)	
Shoulder effort	35 (27.6%)	
Clinical hypothesis §		127
Subacromial conflict	20 (15.7%)	
Tendinopathy	90 (70.9%)	
Rotator cuff tear	21 (16.5%)	
Adhesive capsulitis	2 (1.6%)	
Current medication §		127
Anti-inflammatory	69 (54.3%)	
Analgesics	55 (43.3%)	
Antispasmodics	23 (18.1%)	
Department of origin §		127
Orthopaedics	55 (43.3%)	
Physical medicine and rehabilitation	30 (23.6%)	
Neurosurgery	18 (14.2%)	
Rheumatology	5 (3.9%)	
Other	19 (15.0%)	
Positive shoulder tests §		
Jobe	94 (78.3%)	120
Neer	66 (54.1%)	122
Palm-up	78 (63.4%)	123
Range of motion - Active †		
Abduction	180 (60)	127
Flexion	180 (60)	127
Internal rotation	90 (20)	126
External rotation	90 (20)	126
Range of motion - Passive †		
Abduction	180 (0)	127
Flexion	180 (0)	127
Internal rotation	90 (0)	126
External rotation	90 (0)	126
DASH ‡	52.7 (18.1)	127
VAS) †	52 (27)	127
SPADI pain scale) †	69 (28)	127

Notes: DASH (‡) expressed as mean (SD) and other continuous variables (†) as median (IQR); categorical variables (§) expressed as frequency and percentage, n (%)
N - Total number of valid observations; DASH - Disabilities of the Arm, Shoulder and Hand outcome measure; VAS - Visual Analogue Scale; SPADI - Shoulder Pain and Disability Index; SD - standard deviation; IQR - Interquartile range

in degrees, which also showed significantly correlation (r = -0.284, p = 0.043) was only determined in 51 patients and was therefore not included.

Using a stepwise method, the sixth model found, described in Table V, produced the highest correlation (R = 0.665), with the coefficient of determination (R^2 = 0.442) pointing that 44% of the variance of DASH score can be predicted by this model. The adjusted value,

TABLE III. COMPARISON OF MEAN DASH SCORE BETWEEN DICHOTOMOUS GROUPS

	Yes		No		
Grouping variable	**Mean**	**SD**	**Mean**	**SD**	**p value†**
Gender, female	55.9	17.5	41.0	15.5	<0.001
Dominant side, right	52.6	18.1	55.0	20.2	0.714
Painful shoulder, right	55.0	16.8	49.3	19.6	0.079
Complaints on dominant side	55.2	17.2	48.1	19.0	0.033
Usual shoulder effort					
Professional	53.1	20.1	52.0	14.5	0.719
Recreational	40.8	15.2	54.3	17.9	0.006
Any	52.0	20.0	54.2	13.4	0.465
Event at the beginning of complaints					
Accident	57.1	17.5	52.0	18.2	0.267
Shoulder effort	52.3	19.0	52.8	17.9	0.887
Previous shoulder pathology					
Dislocation	45.7	18.0	52.9	18.2	0.436
Tendinopathy	59.0	15.7	50.7	18.5	0.026
Rotator cuff tear	58.9	18.6	52.5	18.1	0.437
Clinical hypothesis					
Subacromial conflict	47.6	15.3	53.7	18.5	0.171
Tendinopathy	52.8	17.7	52.4	19.4	0.895
Rotator cuff tear	59.1	17.8	51.4	18.0	0.075
Adhesive capsulitis	85.6	1.5	52.2	17.8	<0.001
Current medication					
Anti-inflammatory	53.7	17.3	51.5	19.1	0.486
Analgesics	56.3	19.2	49.9	16.8	0.047
Antispasmodics	54.0	14.0	52.4	18.9	0.706
Shoulder tests					
Jobe	53.7	17.4	44.7	16.0	0.019
Neer	57.1	17.6	45.8	15.8	<0.001
Palm-up	57.6	16.2	42.4	15.9	<0.001
Physical examiner, 1	51.3	17.4	54.1	18.6	0.380

DASH - Disabilities of the Arm, Shoulder and Hand outcome measure. SD - standard deviation
†independent-samples t-test

which reflects the number of variables and sample size, was also determined (adjusted R^2 = 0.412). The assumptions required for multiple linear regression, as described, were met.

DISCUSSION

A model with 6 clinical variables (age, gender, dominant side, palm-up test, active external rotation and active flexion) was found to predict 44% of DASH variability. DASH is not specific for shoulder disability, including also assessment of disability of the arm and hand and so some aspects of DASH variability were not assessed with a clinical evaluation focusing on the shoulder.

A higher frequency of female patients included in this study is in accordance with most[2,20], although not all[21] previous reports. Female patients also had significantly higher DASH scores and SPADI pain scale results, as compared to males. This can be related to differences between gender in pain sensitivity and in biological, social and psychological factors[2].

In our series, patients with shoulder complaints on the dominant side had more disability, expressed by higher DASH scores. However, pain was not signifi-

TABLE IV. SPEARMAN COEFFICIENT OF BIVARIATE CORRELATION BETWEEN OUTCOMES AND PREDICTORS

Variable	Age	Palm-up test	Neer test	Jobe test	ActROM Abduction	ActROM Flexion	PassROM Flexion	ActROM Extern. Rot.
DASH	0.241 *	0.407 **	0.310 *	0.195 *	-0.360 **	-0.413 **	-0.287 *	-0.345 **
SPADI pain scale	0.131	0.355 **	0.252 *	0.306 *	-0.359 **	-0.396 **	-0.238 *	-0.264 *
VAS	0.101	0.228 *	0.242 *	0.297 *	-0.244 *	-0.322 **	-0.101	-0.168
ActROM Extern. Rot.	-0.275 *	-0.036	-0.244 *	-0.161	0.521 **	0.583 **	0.306 *	
PassROM Flexion	-0.060	-0.239 *	-0.139	-0.140	0.608 **	0.654 **		
ActROM Flexion	-0.152	-0.235 *	-0.344 **	-0.263 *	0.767 **			
ActROM Abduction	-0.170	-0.154	-0.264 *	-0.126				
Jobe test	-0.065	0.355 **	0.369 **					
Neer test	0.041	0.16						
Palm-up test	0.036							

ActROM - Active range of motion; PassROM - Passive range of motion
*p<0.05; **p<0.001

TABLE V. MULTIPLE LINEAR REGRESSION MODEL FOR DASH SCORE WITH SIX PREDICTORS

Variable	Coefficient (95% CI)	p value
Palm-up test	11.4 (6.1; 16.7)	<0.001
ActROM Extern. Rot.	-0.2 (-0.4; 0.0)	0.037
Gender, female	9.4 (3.1; 15.6)	0.003
Dominant side	7.0 (1.8; 12.0)	0.008
ActROM Flexion	-0.1 (-0.2; 0.0)	0.016
Age	0.3 (0.0; 0.5)	0.032

Notes: R=0.665; Adjusted R^2=0.412
ActROM - Active range of motion

cantly higher in these patients as evaluated by VAS and the SPADI pain scale. This may be explained by a greater repercussion on daily activities when the dominant shoulder is involved, as previously reported[22].

We found that patients without leisure activities involving shoulder effort had higher pain and disability, both in DASH and SPADI pain scale. This in accordance with the literature as a protective, yet not significant, effect of regular leisure-time physical exercise was also found in a prospective study by Miranda *et al*.[23]

Patients taking analgesics and anti-inflammatory medication had respectively higher DASH and SPADI pain scale scores. A previous diagnostic hypothesis of adhesive capsulitis was also found to be associated with pain and disability in our cases.

Patients with a previous history of shoulder tendinopathy revealed higher disability. There was no association between disability and the duration of the current episode.

Occupation was found to be relevant. Services and sales workers, which included hairdressers, waiters and personal care workers, had high DASH scores; in these patients, light but continued shoulder effort could influence their higher disability. Previous studies have shown an elevated association of shoulder disorders with physical workload, and namely with repetitive movements and vibration[23,24].

A significant correlation was found between Jobe, Neer and palm-up tests and all the outcomes, and between all ROM variables and DASH scores. Correlation was slightly poorer for VAS and SPADI pain scale. Among ROM variables, active flexion, abduction and external rotation showed the best correlation, and active ROM was found to have a better correlation than passive evaluation. In a recent study[25], Answer et al also found flexion, abduction and external rotation to be more strongly associated with the total SPADI score than internal rotation and extension (extension was not measured in our study); they did not report passive ROM neither other clinical tests. Prior studies had described an association between ROM and disability, in different settings and using other outcome measures[26,28].

The linear regression model here presented allowed combining variables, explaining a higher proportion of outcome variance. The correlation coefficient obtained, $R = 0.665$, is considered moderately strong even under the more stringent criteria applicable in medicine previously defined by Chan[29,30]. Not all the best predictors are present in the model; for instance, adding active

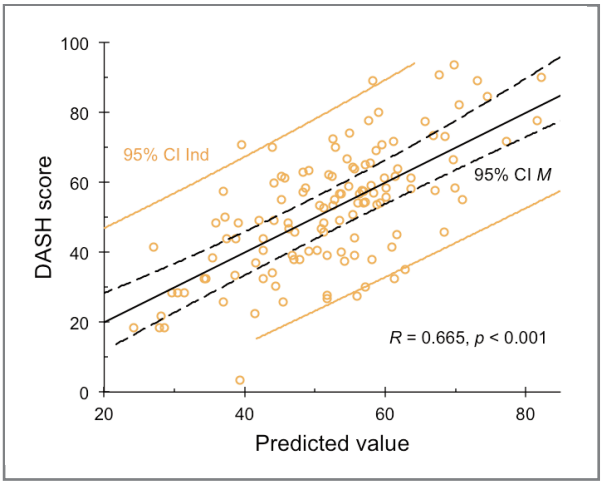

FIGURE 1. Scatterplot of actual obtained DASH scores vs. values predicted by the linear regression equation, represented by the solid central line. Also displayed are the 95% confidence intervals for individual observations (95% CI Ind, solid outer lines) and for the mean (95% CI M, dashed inner lines).

abduction did not strengthen the model, perhaps because it is related with active flexion and active external rotation, already in the regression equation. Jobe and Neer tests are equally absent from the model. This observation suggests that, when the goal of the physical examination is to predict disability, Jobe and Neer tests might be redundant.

More evidence, eventually with the control of psychosocial variables and testing for other clinical tests, will be necessary to achieve and validate the best model for the prediction of disability. Such model could be applied in the management of patients with shoulder complaints, namely in the decision for the need of further exams (particularly imaging). Longitudinal studies should be used to evaluate if such a strategy is adequate.

This study has some limitations. Even blinded to the outcome scores, it is difficult for the examiners to be blinded to patients' complaints when performing physical examination. Psychosocial factors, like general well-being, which can be a confounder[23,27], were not independently tested. Age was found to be a significant predictor of disability, but not for pain alone, and the extent of association between age and disability unrelated to the shoulder disorder was not explored.

CONCLUSIONS

A simple model, as the one proposed, based on few physical examination items and individual objective data like age, gender and dominancy, can help predict disability and perceived pain in shoulder disorders. Palm-up test and range of motion in active flexion, abduction and external rotation showed best correlation with the outcome, but abduction was found redundant for the obtained prediction model.

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