An investigation of the relationship between measures of pain intensity, pain affect, and disability, in patients with shoulder dysfunction

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Objectives: Numerous outcomes measures can be used to capture and differentiate change in different constructs comprising recovery. Consequently, patients are often burdened by completing a number of measures which involves considerable time and effort. The purpose of this longitudinal, observational study was to identify the number of dimensions in a battery of self-report findings in a patient population who received shoulder injections to investigate the association of the instruments.

Methods: Ninety-nine subjects, with diagnoses of adhesive capsulitis, labral injuries, rotator cuff injuries, and osteoarthritis completed outcomes measures including five different forms of pain intensity measures, the McGill Short Form Questionnaire, and the Disabilities of the Arm, Shoulder, and Hand Questionnaire. Change scores were calculated at 4 weeks and an exploratory factor analysis (EFA) with varimax rotation was used to analyze dimensionality. The relationship between the raw scores of the seven measures was investigated using a correlation matrix.

Results: The EFA yielded only one factor and the raw score correlations demonstrated very strong, significant associations. The finding of a single factor suggests that in this sample of patients, only one dimension of change, most likely a change in pain, is represented by the seven individual outcomes measures.

Discussion: In this isolated example, one outcomes measure would have been sufficient in determining outcome and could have reduced the administrative burden to the caregivers and the patients.

Keywords: Shoulder, Outcomes measures, Factor analysis

Introduction

Outcomes measures are used by regulatory agencies, health care practitioners,¹ and third party payers to evaluate the success and cost effectiveness of specific treatment regimens,^{2,3} and may include: (1) biological indicators such as pain, joint laxity, range of motion, or strength, (2) functional indicators that include patients' ability to perform activities of daily living (ADLs) such as walk, climb stairs, bath, or self-dress, or (3) disability indicators, with disability being a multidimensional construct involving overlap of psychological, sociological and functional measures.³ Outcomes measure may be directly observed, process

related (length of stay, costs of care), or collected through self-report mechanisms.²

Self-report outcomes are based on measurement of latent constructs, rather than observable phenomena.⁴ In essence, many elements associated with disability are unobservable and require a proxy measure as an inference to the actual individuals standing.¹ Self-report outcome measures may take the form of multidimensional questionnaires involving health related quality of life, pain, or function² or may be specific in their structure in order to capture only one dimension. What is known is that these dimensions are variably related but are independent in construct.²

Evaluating each of the dimensions to fully reflect the changes associated with a patient's condition⁵ is critically important. As a result, when utilizing

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self-report outcomes measures, a number of considerations are imperative. First, proper use of a validated outcome measure is essential to capture meaningful and useful information. Second, a number of questionnaires may be necessary to capture the targeted and desired constructs (e.g., pain, weakness, and functional limitations). Third, maintaining a balance between administrative burden of the assessment and the data that are gathered during the assessment is imperative. Collecting too little data may leave the clinicians uninformed, whereas collecting too much information may burden the respondent unnecessarily. Consequently, the purpose of this study was to identify the number of dimensions in a battery of self-report findings associated with the shoulder and investigate the association between instruments. Identifying the number of dimensions may improve our ability to appropriately assign outcomes measures for the efficient and useful collection of data.

Materials and Methods

Design

The study involved data captured from a longitudinal observational study performed in three outpatient physician clinics in the southeast aspect of the United States.⁶ The study was approved by the Mary Black Health Systems and the Greenville Health Systems institutional review and ethics boards. The original design of the study⁶ involved a comparative analysis of injection accuracy in experienced versus inexperienced physicians. In that study, consecutive patients with symptomatic glenohumeral arthritis, adhesive capsulitis, or other intra-articular pathology, such as labral tears or articular-sided rotator cuff conditions, were targeted. Those excluded were allergic to the anesthetic, corticosteroid, or iodinated dye/ioxhexal in the dye, had a history of documented severe steroid flare, demonstrated clinical evidence of infection, had surgery within the past 6 weeks, were pregnant, had clinical evidence of a full thickness rotator cuff tear, or indicated a history of uncontrolled diabetes.

Procedure

The study involved six different physicians who performed the injections and two experienced radiologists who were involved in determination of accuracy of the injection in or outside of the joint. There were three orthopedic surgeons who had been in practice for at least 5 years, one primary care sports medicine physician, one primary care sports medicine fellow, and one orthopedic sports medicine fellow. The physicians were responsible for enrolling, providing care and tracking the outcomes of the patients. The radiologists were responsible for evaluating video fluoroscopic images to determine the accuracy of a specific injection.

Pre-injection demographic data were captured on each subject including age, weight, height, duration of symptoms, and gender, in addition to seven distinct outcome measures. Patients were asked to complete all outcome measures pre-injection, 5–10 minutes after the injection, and at a 4-week follow-up appointment. All providers remained blinded to all of their results until the end of the study.

The seven distinct measures included the Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH), a Short-Form McGill Pain Questionnaire (SF-MPQ), and five variations of the visual analog scale (VAS). The DASH was targeted for its role as a measure of disability. The SF-MPQ was selected to capture the descriptive quality of pain and change of that quality. The five variations of the VAS were captured to identify intensity of pain. The first VAS involved general, overall pain intensity; the second involved pain during sedentary activities; the third queried pain during ADLs; the fourth involved pain during work; and the fifth questioned the level of pain during sport. All VAS forms were 10 cm in length.

The DASH

The DASH was developed to measure physical disability and symptoms in the whole upper extremity including the shoulder.⁷ The DASH is a commonly used region-specific scale and has demonstrated both reliability, responsiveness, and validity in capturing levels of pain and disability in various shoulder conditions.^{7,8} The DASH has been identified as having the strongest psychometrics among functional assessment tools of the shoulder⁹ and is generally considered to be a single dimensional questionnaire (disability); although others have identified more than one dimension.^{10,11}

The SF-MPQ

The SF-MPQ is shortened version of the McGill Pain Questionnaire and was originally designed by Melzack.¹² Similar to the original version, the SF-MPQ has two dimensions (sensory and affective)¹³ and is designed to capture the affective (emotional response to pain) and sensory components of pain (descriptive characteristics) and has demonstrated reliability¹⁴ and validity.¹⁵

VAS for pain

The VAS for pain intensity has demonstrated reliability only^{16,17} and specific measures of intensity during ADLs, sedentary activities, work, and sport remain untested. In theory, the constructs associated with intensity differ from those associated with the SF-MPQ, although, to our knowledge, this remains untested.

Statistical analyses

All analyses were run using SPSS 14.0 (SPSS, Chicago, IL, USA). Descriptive statistics including the mean, standard deviation, and range were calculated for all continuous data and frequencies for categorical variables were measured.

Pre-injection to 4 weeks' post-injection change scores for each outcome measure was calculated and inputted for factor analysis. An anti-image correlation matrix was run to determine whether correlations were high enough to retain factors for the factor analysis. Values below 0.5 were excluded from the analysis. Once the retained variables were captured, an exploratory factor analysis with varimax rotation was run on the change score variables to determine the dimensions of the cluster of seven outcome measures. Factor analysis is often used to detect structure in the relationships between multiple variables to give meaning to large amounts of data or to identify clusters of cases in data.¹⁸ Factor analysis condenses a number of variables that are typically similar in latent construct and allows categorization by name for further clarification and appropriate statistical modeling.¹⁹ Further, the analysis is useful in determining whether single or multiple concepts are present within the data collected, to better understand the concepts behind the gathered information.

Varimax rotation was chosen to identify each variable with a single factor by maximizing the variance of the squared loadings of a factor on all the variables.¹⁷ To determine the strength of the factor analysis, a Kaiser Meyer Olin statistic was used to determine if the sum of partial correlations was greater than the sum of correlations.¹⁹ A Bartlett's test for sphericity, which is a test for normalization of the sample and the potential relationship it may yield, was also calculated.

Factors were identified if eigenvalues were >1.0 , a cut-off relevant for the present sample size,¹⁹ and confirmed by parallel analysis and the scree test. Parallel analysis involves use of the scree test and identifying where the lines of the eigenvalues form an 'elbow' or leveling of the plot.^{18,20} Analysis performed in this fashion reduces the risk of over-estimating the number of dimensions in an analysis.

The final analyses involved assessment of association among the defined factor dimensions. For each factor, a regression coefficient was created for each subject. Although no guidelines exist to determine strength of relationship for correlational values we identified a strength of relationship of 0.4 or higher as fair to moderate with a *P*value of <0.05 required for significance.

Results

The study captured 99 eligible patients with various shoulder diagnoses who received injection and completed all pre-injection and 4-week follow-up forms. The 99 patients included mostly females and a majority of patients with a diagnosis of adhesive capsulitis. The mean age was 56 years and the mean duration of symptoms was nearly one half of a year (Table 1).

Change scores of the seven outcomes measures reflected the symptom variability of the patient pool. The mean changes were as follows: VAS for ADL=2.9 (SD=3.5), VAS for work=2.8 (SD=4.2), VAS for sport=2.6 (SD=4.7), VAS intensity=2.5 (SD=3.3), McGill short form=8.7 (SD=12.2), and the DASH=13.5 (SD=24.2). In all measures, group change scores demonstrated improvement in the 4 weeks.

There were no variables that were removed using the anti-image correlation 0.5 benchmark; thus, all variables were included in the exploratory factor analysis with varimax rotation. The factor analysis yielded only one distinct factor with eigenvalues over 1.0, which represented 60.1% of the cumulative variance in the study (Fig. 1). All component scores were >0.6 , ranging from a high value of 0.878 (VAS reflecting work) to a low value of 0.620 (DASH).

The Kaiser Meyer Olin statistic was 0.85 (0.5 and above indicates sample adequacy), which suggests that patterns of correlations are relatively compact and component analysis should yield a distinct and reliable factor or factors. The Bartlett's test for sphericity was significant ($P<0.01$, $\chi^2=398.6$; $df=21$), indicating that the sample did include relationships between variables, and therefore reinforcing that the analysis was appropriate.

Because only one regression coefficient was created (there was only one factor), a correlation matrix (a

Table 1 Descriptive statistics of the sample ($n=99$)

Characteristic	
Age (years), mean (SD)/range	56 (12.8)/20–70
Body mass index, mean (SD)/range	28.2 (6.6)/18.9–57.8
Duration of symptoms (months), mean (SD)/range	15 (24.9)/1–170
Diagnosis	51 adhesive capsulitis (52%) 21 osteoarthritis (21%) 18 labral tear (18%) 9 other (9%)
Gender	43 male (43%) 56 female (57%)

Figure 1 Scree plot of factor analysis of seven distinct self-report measures of the shoulder. The x-axis shows the principal components while the y-axis represents the total the proportion of variance explained by each component/outcomes measure. The scree plot demonstrates that the majority of the variance in scores between the outcomes measures can be explained by a single factor and that there is great redundancy among the other measures.

substitute analysis) of the raw data for each change score was run (Table 2). All raw scores of variables were significantly correlated ($P < 0.01$), and only the relationship between the DASH and VAS for pain intensity did not yield a correlation > 0.4 .

Discussion

This study found that the construct dimensionality of the DASH, the SF-MPQ, and five variations of pain intensity (designed to reflect dedicated activities and situations) were similar in a sample of patients with a variety of shoulder diagnoses who received an injection for pain. The seven distinct measures were significantly correlated, which suggests that the measures are highly reflective of similar content when change occurs in the shoulder. In our sample, the use of one of the items would have likely provided us with the necessary information to appropriately

reflect changes in the patient's condition. The use of all seven items was not beneficial and may have lead to unnecessary burden.

The findings are unique in that they outline the dimensionality of longitudinal findings (change scores) rather than cross sectional results (single point pre-injection or post-injection). The results outline the comparable nature of the changes in each of the outcome measures and more closely reflects the true variability in the outcome measures' qualities. Although outcome measures are used to describe a condition at a given point, the use of change scores allow us to measure whether the change in one outcome measure is unique to other outcome measures. Our findings suggest that the changes in this sample reflect similar constructs and involve only one dimension, a dimension that we feel is associated with pain perception.

The influence of pain on the self-perceived assessment of function has been reported previously by others^{21,22} who indicated that although function may not improve when assessed objectively through a physical performance, self-perceived function improves concomitantly with reduction of pain. Others have found similar findings when selected disease related symptoms, including pain, were evaluated with function.²³ Pain appears to be a significant mediator of function and disability and must be considered when identifying changes over time.

Our selection of pain intensity measures with and without selected activities or situations reflects our efforts to examine the supposed multidimensionality associated with pain. The SF-MPQ has two defined dimensions and reportedly captures the emotional responses associated with pain. The tool has been widely used on various chronic conditions or central mediated pain conditions.²⁴ The SF-MPQ was designed as a measure to capture pain adjectives endorsed by patients who experienced various types of severe pains (e.g., labor, cancer, dental pain) and the affective elements that correspond to those conditions.¹² We argue that the comprehensive

Table 2 Correlation matrix across the seven self-report measures for the shoulder

	VAS for ADLs	VAS for work	VAS for sport	VAS sedentary activities	VAS intensity	Short-form McGill	DASH
VAS for ADLs	1						
VAS for work	0.717**	1					
VAS for sport	0.636**	0.875**	1				
VAS for sedentary activities	0.507**	0.503**	0.459**	1			
VAS intensity	0.430**	0.424**	0.447**	0.488**	1		
Short-form McGill	0.668**	0.655**	0.617**	0.558**	0.422**	1	
DASH	0.586**	0.470**	0.392**	0.457**	0.272**	0.458**	1

Notes: VAS: visual analog scale; DASH: disabilities of the arm shoulder and hand; ADL: activity of daily living.

*Significant at $P < 0.05$.

**Significant at $P < 0.01$.

nature of the SF-MPQ may be less pronounced at capturing the finite elements of subacromial shoulder pain and this may be one of the reasons the outcome measure correlated with the VAS measures.

Internal weaknesses of the DASH may be another reason for correlations between disability and pain. The questions associated with the DASH are somewhat generic and can involve holistic complications or problems outside shoulder, arm or hand pathology. The score of the DASH is also influenced by lower extremity disorders, since many of the items are associated with activities that require efforts beyond upper extremity use.²⁵

Limitations

There are a number of limitations in this study. We were unable to break down the measures by items, thus we lost a large portion of the sensitivity of the data. Another limitation is our sample, which consisted of subjects who received a number of different diagnoses, but only one specific intervention. In addition, our sample size of 99 limits the external validity of our study results.

Conclusion

Change scores among VAS measures, SF-MPQ, and the DASH demonstrated only one unique factor, suggesting that in this population, only one tool is required to capture the dimensions of patient change over time. Further studies should examine different populations, populations with different interventions, and should capture individual item scores from each metric.

Research Ethic Statement

This study was approved by the Mary Black Health Systems and the Greenville Health Systems Institutional review and ethics boards. Each research subject gave their informed consent.

Conflict of Interest Notification

The lead author (Chad E Cook) is editor-in-chief of JMMT and the second author (Eric J Hegedus) is an associate editor of JMMT. None of the other authors has a conflict of interest.

References

- Atkinson MJ, Lennox RD. Extending basic principles of measurement models to the design and validation of patient reported outcomes. *Health Qual Life Outcomes* 2006;4:65.
- Carey T, Mielenz T. Measuring outcomes in back care. *Spine* 2007;32:S9–14.
- Irrgang JJ, Anderson A. Development and validation of health-related quality of life measures for the knee. *Clin Orthop Rel Res* 2002;402:95–109.
- Nunnally J, Burstein I. *Psychometric theory*. 3rd ed. New York: McGraw Hill; 1994.
- van den Akker-Scheek I, Zijlstra W, Groothoff JW, Bulstra SK, Stevens M. Physical functioning before and after total hip arthroplasty: perception and performance. *Phys Ther* 2008;88:712–19.
- Tobola A, Cook C, Cassas KJ, Hawkins R, Wienke J, Tolan S, et al. Accuracy of glenohumeral joint injections: comparing approach and experience of provider. Platform presentation, The American Orthopedic Society for Sport Medicine, New Orleans, LA, USA, 13 March 2010.
- Roy JS, MacDermid J, Woodhouse LJ. Measuring shoulder function: a systematic review of four questionnaires. *Arthritis Rheum* 2009;61:623–32.
- Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med* 1996;29:602–8.
- Bot SDM, Terwee CB, van der Windt D, Bouter LM, Dekker J, de Vet HCW. Clinimetric evaluation of shoulder disability questionnaires: A systematic review of the literature. *Ann Rheum Dis* 2004;63:335–41.
- Cheng H, Sampaio R, Mancini M, Fonseca S, Cotta R. Disabilities of the arm, shoulder, and hand (DASH): factor analysis of the version adapted to Portuguese/Brazil. *Disabil Rehabil* 2008;30:1901–9.
- Fayad D, Lefevre-Colau MM, Gautheron V, et al. Reliability, validity, and responsiveness of the French version of the questionnaire Quick Disability of the Arm, Shoulder and Hand in shoulder disorders. *Man Ther* 2009;14:206–12.
- Melzack R. The short-form McGill Pain Questionnaire. *Pain* 1987;30:191–7.
- Mason ST, Arceneaux LL, Abouhassan W, Lauterbach D, Seebach C, Fauerbach JA. Confirmatory factor analysis of the Short Form McGill Pain Questionnaire with burn patients. *Eplasty* 2008;8:e54.
- Grafton KV, Foster NE, Wright CC. Test-reliability of the Short-Form McGill Pain Questionnaire: assessment of intra-class correlation coefficients and limits of agreement in patients with osteoarthritis. *Clin J Pain* 2005;21:73–82.
- Melzack R, Katz J. The McGill Pain Questionnaire: appraisal and current status. In: Turk DC, Melzack R, editors. *Handbook of pain assessment*. New York: Guilford Press; 2001.
- Revill SI, Robinson JO, Rosen M, Hogg MI. The reliability of linear analogue for evaluating pain. *Anaesthesia* 1976;31:1191–8.
- Zusman M. Spinal manipulative therapy: review of some proposed mechanisms, and a new hypothesis. *Aust J Physiother* 1986;32:89–99.
- Garson GD. Factor analysis. Statnotes: topics in multivariate analysis [cited 2009 July 18]. Available from: <http://www.faculty.chass.ncsu.edu/garson/pa765/statnote.htm>
- Field A. *Discovering statistics: using SPSS for Windows*. London: Sage Publications; 2001.
- Thompson B. *Exploratory and confirmatory factor analysis: understanding concepts and applications*. Washington (DC): American Psychological Association; 2004.
- Stratford PW, Kennedy D. Does parallel item content on WOMAC's pain and function subscales limit its ability to detect change in functional status? *BMC Musculoskel Disorders* 2004;5:17.
- Kennedy D, Stratford PW, Pagura SMC, Wessel J, Gollish JD, Woodhouse LJ. Exploring the factorial validity and clinical interpretability of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). *Physiother Can* 2003;55:160–8.
- Whitson HE, Sanders LL, Pieper C, Morey MC, Oddone EZ, Gold DT, et al. Correlation of symptoms to function in older adults with comorbidity. *J Am Geriatr Soc* 2009;57:676–82.
- Wright KD, Asmundson G, McCreary D. Factorial validity of the short-form McGill pain questionnaire (SF-MPQ). *Eur J Pain* 2001;5:279–84.
- Khan WS, Jain R, Dillon B, Clarke L, Fehily M, Ravenscroft M. The 'M² DASH'-Manchester Modified Disabilities of Arm Shoulder and Hand score. *Hand* 2008;3:240–4.