

# Measuring Disability of the Upper Extremity: A Rationale Supporting the Use of a Regional Outcome Measure

**A. M. Davis, PhD, MSc, BScPT**  
*University Musculoskeletal Oncology Unit  
Division of Orthopaedic Surgery  
Mount Sinai Hospital;  
University of Toronto  
Toronto, Ontario, Canada*

**D. E. Beaton, MSc, BScOT**  
*The Institute for Work and Health;  
University of Toronto*

**P. Hudak, MSc, BScPT**  
*The Toronto Hospital Hand Program  
The Toronto Hospital (Western Division);  
University of Toronto*

**P. Amadio, MD**  
*Department of Orthopedic Surgery  
Mayo Clinic  
Rochester, Minnesota*

**C. Bombardier, MD, FRCPC**  
*The Institute for Work and Health;  
Department of Medicine  
University of Toronto*

**D. Cole, MD**  
*The Institute for Work and Health;  
McMaster University  
Toronto, Ontario, Canada*

**G. Hawker, MD, FRCPC**  
*Department of Rheumatology  
Women's College Hospital;  
University of Toronto*

**J. N. Katz, MD**  
*Division of Rheumatology and Robert B. Brigham  
Multipurpose Arthritis & Musculoskeletal  
Disease Center  
Brigham & Women's Hospital  
Harvard Medical School  
Boston, Massachusetts*

**M. Makela, MD**  
*Department of Health and Disability  
National Public Health Institute  
Helsinki, Finland*

**R. G. Marx, MD, MSc, FRCSC**  
*The Institute for Work and Health;  
University of Toronto*

**L. Punnett, ScD**  
*Department of Work Environment  
University of Massachusetts-Lowell  
Lowell, Massachusetts*

**J. G. Wright, MD, MPH, FRCSC**  
*Departments of Orthopaedic Surgery and Clinical  
Epidemiology  
Hospital for Sick Children;  
University of Toronto*

**ABSTRACT:** *Objective:* Many existing upper extremity outcome measures have been designed for a specific anatomic site (e.g., shoulder) or a specific disease entity (e.g., carpal tunnel syndrome). The purpose of this paper is to examine whether questionnaire items taken from very specific measures are considered relevant only to that specific region or are applicable to the whole extremity. *Methods:* Fifteen practicing clinicians categorized a sample of 132 items from existing questionnaires according to whether the items reflected disability specific to an anatomic site or were relevant to the whole extremity. *Results:* Seventy-two percent of the items were categorized as relevant to the extremity as a whole, while only 21% of the items were categorized as specific to an anatomic site. *Conclusion:* Items in existing specific upper extremity questionnaires are also relevant to other regions and conditions. This finding is in agreement with kinesiological and biomechanical theories that the upper extremity acts as a single functional unit. Questionnaires designed for the whole extremity could provide a more practical and still valid measure of upper extremity disability.  
J HAND THER 12:269-274, 1999.

The effectiveness of treatment should be evaluated using outcomes that are relevant to patients. Since the relief of symptoms and the reduction of disability are the main reasons that patients with upper extremity musculoskeletal disor-

ders seek treatment, clinicians and researchers often select outcomes that reflect these aspects of health. Several measures that may be used in the evaluation of upper extremity function have been developed.<sup>1-12</sup> Most of these measures are labeled as being joint-specific<sup>2,7-9</sup> (i.e., focusing on a particular joint such as the shoulder) or disease-specific<sup>11</sup> (i.e., focusing on a particular disorder such as carpal tunnel syndrome). Others<sup>4-6,10,13</sup> are intended to evaluate the function of the entire upper extremity (regardless of the specific joint or disease involved) using a region-specific measure.

When evaluating upper extremity function, clinicians must decide between these two types of measures. Such decisions are guided by consideration of the patient population, the way the mea-

This work was supported in part by a PhD fellowship to Ms. Beaton and a scholarship to Dr. Wright from the Medical Research Council of Canada. The research was sponsored by the American Academy of Orthopaedic Surgery and the Institute for Work and Health. The Institute for Work and Health, an independent, not-for-profit research organization, receives support from the Ontario Workplace Safety and Insurance Board.

Correspondence and reprint requests to Aileen M. Davis, PhD, MSc, BScPT, Suite 476, Mount Sinai Hospital, 600 University Avenue, Toronto, Ontario, Canada M5G 1X5.

sure performs statistically (i.e., its reliability and validity) in relation to the intended application, and the practical aspects of the measure (face validity, time, and ease of use). By face validity, we mean that "the instrument appears to be assessing the desired qualities."<sup>14</sup> Content validity is defined as "whether the instrument samples the important content or domains."<sup>14</sup> The purpose of this paper is to focus on the practical aspects—specifically face validity and content validity as they relate to this choice between a joint- or disease-specific measure and a regional (entire upper extremity) measure.

We conducted a study to examine whether items (i.e., questions) from existing joint- or disease-specific measures and regional measures can be identified as pertaining to only the intended joint or disease when taken out of the context of their original measure. For example, can an item from a shoulder measure be identified as being unique to the shoulder? We hypothesized that items, although selected from a joint- or disease-specific measure, would be relevant to other parts of the upper extremity; that is, the items would not be considered unique to the joint or disease for which the measure was originally intended. Such a finding would support the use of a regional measure rather than a joint- or disease-specific one.

A region-specific measure is advantageous because it can be used for the evaluation of upper extremity outcomes for patients with different diseases and with involvement of different or multiple anatomic sites. Hence, busy clinicians might need only one measure, rather than several different measures, to assess all their patients with upper extremity disorders.

## METHODS

A literature review identified 13 self-completed instruments that were designed to measure upper extremity function or had a specific section on upper extremity function.<sup>1-8,10,11,14,15,24</sup> Items from 13 existing instruments (Table 1) were pooled, resulting in a total of 821 items. These items were reduced to 577<sup>13</sup> by eliminating those considered redundant or obviously unrelated to the upper extremity (e.g., walking one block). These 577 items were used as the item pool for the development of a new upper extremity measure, the DASH (Disabilities of the Arm, Shoulder and Hand).<sup>13</sup> For the purposes of this study, it was not feasible to rate all 577 items, because of time constraints; therefore, one author (D.B.) chose from the 577 a sample of 132 items to be rated in the study. The 132 items were chosen from all 13 existing measures with the intent of sampling items specific to symptoms and function in each joint or disorder as indicated by their inclusion in a joint- or disease-specific instrument or by their specific content (e.g., handling small change). The second column in Table 1 shows the number of items selected from each of the 13 measures. Some of these items (e.g., doing up buttons) appeared in more than one measure. In this situation,

the item was selected from the measure whose wording was felt to use the least amount of attribution to a specific region (i.e., it did not refer specifically to a joint). The wording of items selected for the exercise remained as it was in the original questionnaire. The 132 selected items were then used for the categorization exercise on which this study is based.

The categorization exercise took place at a meeting of the American Academy of Orthopaedic Surgeons Outcomes Committee and Council of Musculoskeletal Specialty Societies (in Tarpon Springs, 1994). Three of the investigators (C.B., M.M., and P.A.) facilitated a workshop attended by 15 clinicians—two trauma surgeons, six hand surgeons, five shoulder surgeons, one arthroscopist, and one rheumatologist. These clinicians became the "expert" raters.

Each of the selected items was typed in a similar format on a 3" × 8" file card. The 15 raters worked in seven groups (six pairs and one group of three). The raters in each group were asked to assign each item, worded exactly as in the original instrument, to one of the following categories—1) specific to the shoulder; 2) specific to the elbow; 3) specific to the wrist/hand; 4) relevant to the upper extremity but not specific to an anatomic region; 5) not specific to the upper extremity, that is, possibly relevant to both upper and lower extremity disability, such as "Do you need help taking a bath or shower?"; and 6) not related to upper extremity disorders at all. Each item, therefore, received seven

TABLE 1. Number of Items Selected for the Face Validity Exercise (N = 132) from Instruments That Measure Upper Extremity Function (Specific to a Joint or Disease or Pertinent to the Whole Extremity) or That Have Sections Dedicated to Upper Extremity Function

Measure	No. of Items Selected
Instruments specific to a joint or disease:	
American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) <sup>2</sup>	8
Shoulder Pain and Disability Index (SPADI) <sup>7</sup>	4
Shoulder Severity Index (SSI) <sup>6,14</sup>	4
Subjective Shoulder Rating Scale (SSRS) <sup>6,14,25</sup>	2
Simple Shoulder Test (SST) <sup>8</sup>	3
Symptom severity and functional status scales for carpal tunnel syndrome (Brigham) <sup>11</sup>	7
	28
Instruments applicable to the whole extremity:	
Musculoskeletal Function Assessment Questionnaire (MFA) <sup>4</sup>	25
Neck and Upper Limb Index (NULI) <sup>5</sup>	36
St. Michael's questionnaire (M-ASES) <sup>6,14,25</sup>	5
Toronto Extremity Salvage Score (TESS) <sup>10</sup>	11
	77
Instruments containing a section on upper extremity function:	
Arthritis Impact Measurement Scales (AIMS2) <sup>1</sup>	15
Health Assessment Questionnaire (HAQ) <sup>3</sup>	7
Short Form 36 (SF-36) <sup>15</sup>	5
	27

**TABLE 2. Twenty-eight Items Related Only to One Specific Joint (Shoulder, Elbow, or Wrist/Hand)**

Shoulder:	
Describe your ability to lift 10 lbs above your shoulder. (ASES <sup>2</sup> )	Are you able to get enough of a grip on a jar to open it? (HAQ <sup>3</sup> )
Do you have pain in your shoulder at night? (ASES <sup>2</sup> )	Is it necessary to hold or grip tools or parts of other objects very tightly for stretches of time? If yes, how much difficulty do you have with that now? (NULI <sup>5</sup> )
How severe is your pain reaching for something on a high shelf? (SPADI <sup>1</sup> )	Do you have difficulty with the grasping and use of small objects such as keys or pens? (Brigham <sup>11</sup> )
Could you easily scratch your low back with your hand? (AIMS2 <sup>1</sup> )	Considering the amount of difficulty that you are having with your arm, describe your ability to pick up small items over the past week. (TESS <sup>10</sup> )
Can you place your hand behind your head with the elbow straight out to the side? (SST <sup>8</sup> )	On a typical day during the past two weeks, have hand/wrist symptoms caused you to have any difficulty with household chores? (Brigham <sup>11</sup> )
Rate your ability to reach a shelf above your head. ((M-ASES <sup>6,14,24</sup> )	Can you make a fist? (MFA <sup>4</sup> )
How is your shoulder motion? (SSRS <sup>6,14,24</sup> )	How often do you have hand or wrist pain during the day-time? (Brigham <sup>11</sup> )
Does your shoulder feel unstable? (ASES <sup>2</sup> )	How often did hand or wrist pain wake you up during a typical night in the past two weeks? (Brigham <sup>11</sup> )
Do you think you can toss a softball overhand 20 yds with the affected extremity without bending your elbow? (SST <sup>8</sup> )	Do you do sewing, knitting, embroidery, crocheting, needle-point, or other crafts? If yes, how much difficulty do you have with that now? (NULI <sup>5</sup> )
Elbow:	Do you have tingling sensations in your hand? (Brigham <sup>11</sup> )
Do you straighten and/or bend your arm completely? (MFA <sup>4</sup> )	Do you have weakness in your hand or wrist? (Brigham <sup>11</sup> )
Hand/wrist:	Is it necessary to repeatedly bend or twist your wrists up, down, to either side or make circling movements with them? If yes, how much difficulty do you have with that now? (NULI <sup>5</sup> )
Do you have a difficult time cutting your own fingernails? (MFA <sup>4</sup> )	Could you easily write with a pen or pencil? (AIMS2 <sup>1</sup> )
Could you easily tie a knot or a bow? (AIMS2 <sup>1</sup> )	
Is it necessary to move your fingers quickly and repeatedly or do fine, precise handwork for prolonged periods of time? If yes, how much difficulty do you have with that now? (NULI <sup>5</sup> )	
Are you able to open a new milk carton? (HAQ <sup>3</sup> )	
Are you able to turn faucets on and off? (HAQ <sup>3</sup> )	

NOTE: These items were determined by a majority vote of rater groups; that is, by agreement of four or more of the seven rater groups. ASES indicates American Shoulder and Elbow Surgeons Standardized Shoulder Assessment; SPADI, Shoulder Pain and Disability Index; AIMS2, Arthritis Impact Measurement Scales; SST, Simple Shoulder Test; M-ASES, St. Michael's questionnaire; SSRS, Subjective Shoulder Rating Scale; MFA, Musculoskeletal Function Assessment; HAQ, Health Assessment Questionnaire; NULI, Neck and Upper Limb Index; Brigham, Symptom severity and functional status scales for carpal tunnel syndrome; TESS, Toronto Extremity Salvage Score.

independent ratings. The group facilitators and raters were blinded to the measure from which the items originated.

An a priori decision was made to assign an item to a category if a simple majority of rating groups (i.e., at least four of the seven rating groups) assigned the item to the same response category.

## RESULTS

Twenty-eight of the 132 items (21%) were identified as pertaining only to a specific joint—the shoulder, the elbow, or the wrist/hand (Table 2). Forty-five (72%) of the items were considered to be applicable to the upper extremity but not to a specific joint. Two items were considered to be unrelated to upper extremity disorders. Only seven items had no clear majority rating. Table 3 summarizes the frequency of the ratings for all the items; Table 4 provides examples of items relevant to the upper extremity but not to a specific joint (shoulder, elbow, or hand/wrist); and Table 5 shows the categorization, by rater group, of the seven items for which no majority rating was ob-

tained. It can be seen that the trend among the ratings of these seven items was toward rating them as being relevant to the whole extremity or the whole person rather than to specific joints. Thus, the total number of items favoring nonspecific categorization could be considered to be 79% (104 of 132) if these items were added to the previous group.

**TABLE 3. Number of Items (N = 132) Assigned to Each Rating Category**

Rating Category	No. of Items
Shoulder	9
Elbow	1
Wrist/hand	18
Applicable to more than one region in the upper limb	45
Not specific to upper limb	50
Not related to upper limb	2
No majority assignment achieved*	7

NOTE: An item was assigned to a rating category if four or more of the seven rater groups agreed on the assignment.

\*See Table 5 for details of the categorization of these items by the rater groups.

**TABLE 4. Examples of Items Categorized as "Applicable to More than One Joint in Upper Limb"**

Item (Source)	No. of Rater Groups*
Describe your ability to brush your teeth (TESS <sup>10</sup> )	6
Describe your ability to prepare and serve meals (TESS <sup>10</sup> )	5
Could you easily put on a pullover sweater (all days-no days) (AIMS2 <sup>1</sup> )	4
Do you need help eating? (MFA <sup>4</sup> )	6
Overall, how much difficulty have you had in the past week when looking after yourself with washing, dressing, grooming or eating, because of your (NUL) problem? (NULI <sup>5</sup> )	5
Are you able to open car doors? (HAQ <sup>3</sup> )	4
How severe is your pain pushing with the involved arm? (no pain-worst pain imaginable) (SPADI <sup>7</sup> )	7
Describe your ability to put on make-up or shave (TESS <sup>10</sup> )	7
How much difficulty do you have pushing yourself up with your arms, for example, when getting up from bed, from a low chair, or getting out of the bath tub? (NULI <sup>5</sup> )	7
Can you work overhead (without problems to impossible)? (SSRS <sup>6,14,24</sup> )	4

NOTE: TESS indicates Toronto Extremity Salvage Score; AIMS2, Arthritis Impact Measurement Scales; MFA, Musculoskeletal Function Assessment; NULI, Neck and Upper Limb Index; HAQ, Health Assessment Questionnaire; SPADI, Shoulder Pain and Disability Index; and SSRS, Subjective Shoulder Rating Scale.

\*Numbers indicate the number of rater groups ( $n = 7$ ) that assigned the item to this category.

## DISCUSSION

Although many measures were developed to be "joint-specific," and are so labeled, a significant number of the items, as rated by clinicians, were felt to reflect disability in multiple parts of the upper extremity. Of the 132 items sampled from existing instruments, experts rated 72% relevant to the entire upper extremity and only 21% relevant to a specific joint. For the seven items that had no clear majority rating, most of the disagreement centered on whether an item was nonspecific to a joint of the upper extremity or nonspecific to the upper extremity as a whole (i.e., also applicable to other disabilities in the body, such as dressing and bathing). This finding supports our hypothesis that items may be relevant not only to the specific joint or disease for which their measure of origin was intended but also to other parts of the upper extremity. Therefore, a single upper extremity outcome measure might be able to describe the disability of the entire upper extremity without losing the ability to detect effects at each area or joint in the limb. We recognize that by removing items from the original instrument, the attribution imparted by that measure's instructions could be lost. However, our study is focused at the item-concept level. The original wording of the specific items, which may have included attribution, was retained.

There is also theoretical support for considering the upper extremity as one entity and, hence, for using a regional outcome measure rather than a joint- or disease-specific one. Writings in kinesiology and biomechanics support the view that the

**TABLE 5. Categorization by Rater Groups ( $n = 7$ ) of Items That Had No Clear Majority Rating**

Item (Source)	Rating Category					
	Shoulder	Elbow	Wrist/Hand	Applicable to More Than One Joint in Upper Limb	Not Specific to Just Upper Limb	Not Related to Upper Limb
Does your health limit you in bathing or dressing yourself? (SF-36 <sup>15</sup> )	0	0	0	2	3	2
Are you able to wash and dry your entire body? (HAQ <sup>3</sup> )	1	0	0	2	3	1
How much difficulty did you have carrying a heavy object of 10 lbs? (ASES <sup>2</sup> )	1	0	1	3	2	0
Overall, how much of a problem are you having with the changes in your money situation because of your neck and upper limb problem? (NULI <sup>5</sup> )	0	0	0	3	1	3
Overall, my mood and feelings are negative this week because of my neck and upper limb problem. (NULI <sup>5</sup> )	0	0	0	3	3	1
Describe your ability to sleep on your painful side. (ASES <sup>2</sup> )	2	0	0	3	1	1
This week I feel like my coworkers think less of me than before my neck and upper limb problem began. (NULI <sup>5</sup> )	0	0	0	3	3	1

NOTE: The numbers indicate the number of rater groups ( $n = 7$ ) that assigned each item to that category. SF-36 indicates Short Form 36; HAQ, Health Assessment Questionnaire; ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; and NULI, Neck and Upper Limb Index.

extremity functions as a unit.<sup>17,18</sup> A person uses the upper extremity to explore the environment<sup>19</sup> through what are classified as prehensile (grasp) and nonprehensile (push) activities.<sup>18,20</sup> Each segment of the upper extremity plays a unique role, through mobility or stability, or both, in positioning the hand for these activities. Ideally, stability of the spine frees a person to use the upper extremity to explore the environment.<sup>17</sup> Persons without axial stability, such as patients with spinal cord injuries, must use the upper extremity to stabilize the trunk (hooking around a chair, for instance) and therefore cannot use the arm to reach and grasp. Moving distally from the spine, each joint has a specific but complementary task. The shoulder, as the axis of the limb (in relation to the body), defines the extremes of the environment that the hand is able to reach. The elbow alters the length of the extremity by moving the hand toward and away from the shoulder. Thus, the shoulder and elbow define where the hand will be able to function.<sup>19,22</sup> The wrist puts the hand in the precise position required for a given task. Finally, the hand allows manipulation of the environment.<sup>17,19-23</sup> Each segment, performing its unique role, contributes to the integrated function of the upper extremity.

The concept that the upper extremity functions as one unit, or as a kinetic chain,<sup>22</sup> is the basis of many rehabilitation programs. Therapeutic exercise programs—such as proprioceptive neuromuscular facilitation patterning techniques, work hardening, stress loading, and functional activity programs—all aim to facilitate normal functional muscle patterns in the entire upper extremity, even if the pathology resides only in a single joint or segment. Recognition of the effects that one injured segment can have on other parts of the chain as they try to compensate for dysfunction is paramount. For example, when forearm pronation is limited, the shoulder is abducted as a compensatory movement to allow the positioning necessary for the hand to complete a task (e.g., typing or combing hair). In rehabilitation of the upper extremity, reintegration of the injured segment into its role in the kinetic chain is the ultimate goal. Thus, the measurement of upper extremity disability from a regional, whole-extremity perspective (rather than from a joint- or disease-specific one) is supported by both theory and clinical practice as well as by our findings (content ratings by clinicians).

This study has two main limitations. First, the items for review by the expert raters did not include a random sample of all possible items, because we deliberately picked items pertaining to symptoms and function of each joint from the existing joint-specific, disease-specific, or regional measures while also considering respondent burden. Because the experts rated only 132 of 577 possible items in the exercise, the results may not be generalizable to the entire content of the original 13 measures. Considering this possible lack of generalizability, the results of the current study must be interpreted with caution. However, the strength of the findings suggests that, while it would increase

the representativeness of the original measures, adding items would not have altered our conclusions.

Second, the subspecialties of the expert raters, although representative of the field of orthopedic and hand surgery, included only one medical specialist and did not include any occupational or physical therapists. This could lead to potential bias in the responses of the raters. However, the direction of this bias would probably have been to favor assignment of an item to a specific joint, reflecting a surgeon's area of specialization. Similarly, had we included more therapists, we might assume that their responses would have tended toward more regional assignments, reflecting their approach to treating the whole extremity. Thus, had a bias existed, the assignment of items to categories would have revealed a greater number of assignments to specific joints, a finding we did not observe. If the finding had been made, it would have diluted our conclusions rather than exaggerated the effect. Arguably, broadening the disciplines represented by the raters would have strengthened our argument in support of the use of a regional rather than a joint- or disease-specific measure to assess upper extremity disability.

One reason for using joint- or disease-specific measures is the assumption that these measures are more sensitive to clinical change than are region-specific measures. One study,<sup>15</sup> however, effectively used a disease-specific measure, the Brigham carpal tunnel scale,<sup>11</sup> for patients with another disorder (Colles fractures), suggesting that the items from a measure designed for a particular condition may be applicable to other conditions. Similarly, in a prospective cohort of shoulder surgery patients, a region-specific measure (St. Michael's questionnaire, or modified-ASES) had high correlations with shoulder-specific measures<sup>6,16</sup> and comparable responsiveness,<sup>24</sup> suggesting that region-specific measures may be as valid as joint- or disease-specific measures in at least one part of the extremity. Future studies may show similar findings for other joints. These two studies suggest that joint- or disease-specific measures are not necessary to identify disability and symptoms of a particular site in the extremity. Evidence is growing that existing measures are being used successfully outside their original disease or joint focus. The title of the measure does not necessarily reflect or limit its applicability.

In summary, existing measures designed to assess disability at a specific joint or in a relation to a specific disease (or multiple diseases) were judged by expert clinicians to include a significant proportion of items that are not related to a specific joint but are relevant to the entire upper extremity. The results of this study and kinetic chain theory from kinesiology support the measurement of disability in upper extremity disorders on the basis of a whole extremity measure. The use of a common measure would allow comparison of disability using a common metric across multiple upper extremity disorders and would be more practical than the use of several different measures in an upper ex-

tremity clinical setting. This is now being reflected in recently developed measures<sup>5,10,13</sup> and in the use of measures for patients outside their originally stated patient group.<sup>15</sup>

## REFERENCES

- Meehan RF, Mason JH, Anderson JJ, Guccione AA, Kazis LE. AIMS2: the content and properties of a revised and expanded Arthritis Impact Measurement Scales health status questionnaire. *Arthritis Rheum.* 1992;35:1-10.
- Richards R, Kai-Nan A, Bigliani L, et al. for the Research Committee, American Shoulder and Elbow Surgeons: A standardized method for the assessment of shoulder function. *J Shoulder Elbow Surg.* 1994;3:347-52.
- Ramey DR, Raynauld JP, Fries JF. The Health Assessment Questionnaire: status and review. *Arthritis Care Res.* 1992; 5:119-29.
- Martin DP, Engelberg R, Agel J, Swiontkowski MF. Comparison of the Musculoskeletal Function Assessment Questionnaire with the Short Form 36, the Western Ontario and McMaster Universities Osteoarthritis Index, and the Sickness Impact Profile Health Status Measures. *J Bone Joint Surg.* 1997;79A:1323-35.
- Stock S, Streiner D, Reardon R, et al. The impact of neck and upper limb musculoskeletal disorders on the lives of affected workers: development of a new functional status index. *Qual Life Res.* 1995;4(5):491.
- Beaton DE, Richards RR. Selecting measures of disease-specific health-related quality of life in shoulder patients. *Qual Life Res.* 1995;4(5):395-6.
- Roach DE, Budiman-Mak E, Sonsiridej N, Lertratanakul Y. Development of a shoulder pain and disability index. *Arthritis Care Res.* 1991;4:143-9.
- Lippitt SB, Harryman DT II, Matsen FA III. A practical tool for evaluation of function: the simple shoulder test. In: Matsen FA III, Fu FH, Hawkins RJ (eds). *The shoulder: a balance of mobility and stability.* Rosemont, Ill: American Academy of Orthopaedic Surgery, 1993:501-18.
- Constant CR, Murley AHG. A clinical method of functional assessment of the shoulder. *Clin Orthop Rel Res.* 1987;214: 161-4.
- Davis AM, Wright JG, Williams JJ, et al. Development of a measure of physical function for patients with bone and soft tissue sarcoma. *Qual Life Res.* 1996;5(5):514-20.
- Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms in carpal tunnel syndrome. *J Bone Joint Surg.* 1993; 75A(11):1585-92.
- Ware J Jr. *SF-36 Health Survey Manual & Interpretation Guide.* Boston, Mass: Nimrod Press, 1993.
- Hudak PL, Amadio PC, Bombardier C, and the Upper Extremity Collaborative Group. Development of an upper extremity health status instrument: the DASH (Disabilities of the Arm, Shoulder, and Hand). *Am J Ind Med.* 1996;29:601-8.
- Streiner DL, Norman GR. *Health Measurement Scales: A Practical Guide to Their Development and Use.* 2nd ed. New York: Oxford Medical Press, 1995:5.
- Amadio PC, Silverstein MD, Ilstrup DM, Schleck CD, Jensen LM. Outcome after Colles' fracture: the relative responsiveness of three questionnaires and physical examination measures. *J Hand Surg.* 1996;21A(5):781-7.
- Beaton DE, Richards RR. Measuring shoulder function: a cross sectional comparison of five different questionnaires. *J Bone Joint Surg.* 1996;78A:882-90.
- Light TR. Kinesiology of the upper limb. In: *American Academy of Orthopedic Surgery.* (ed). *Atlas of Orthotics.* 2nd ed. Toronto, Canada: Mosby, 1985:126-38.
- Napier JR. The prehensile movements of the human hand. *J Bone Joint Surg.* 1956;38A:902-13.
- Morrey BF. *The Elbow and Its Disorders.* 2nd ed. Toronto, Canada: WB Saunders, 1993.
- Tubiana R. *Examination of the Hand and Upper Limb.* Toronto, Canada: WB Saunders, 1984.
- Flatt AF. Kinesiology of the hand. In: Reynolds FC (ed). *AAOS Instruction Course Lectures.* Vol 18. Toronto, Canada: Mosby, 1961.
- Kapandji IA. *The Physiology of Joints.* Vol 1: *The Upper Limb.* 5th ed. New York: Churchill Livingstone, 1982.
- Brand PW, Hollister A. *Clinical Mechanics of the Hand.* 2nd ed. Toronto, Canada: Mosby, 1993.
- Beaton DE, Richards RR. Assessing the reliability and responsiveness of five shoulder questionnaires. *J Shoulder Elbow Surg.* 1998;7:565-72.