The Validity, Reliability, Responsiveness, and Bias of the Manchester-Modified Disability of the Arm, Shoulder, and Hand Score in Hand Injuries

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Abstract The Manchester-Modified Disability of Arm, Shoulder and Hand questionnaire (M² DASH) was developed by the authors as a modification to the original DASH questionnaire. In this study, we assessed the validity, reliability, responsiveness, and bias of the M² DASH questionnaire for hand injuries using completed M² DASH,

Patient Evaluation Measure, and Michigan Hand Outcome questionnaires from 40 patients. The M² DASH scores showed significant positive correlations with the Patient Evaluation Measure and Michigan Hand Outcome scores suggesting validity. There was also no evidence of a statistical difference in the M² DASH scores when the condition had stabilized suggesting good test–retest reproducibility and reliability. The effect size and the standardized response mean for the M² DASH score were greater than those for the Patient Evaluation Measure and Michigan Hand Outcome scores establishing that the M² DASH is highly responsive. There was no gender, hand dominance, or dominant side injured bias for the M² DASH score. There was, however, a relatively weak association between age and the M² DASH score at presentation. We conclude that the M² DASH questionnaire is a robust region-specific outcome measure. It is a valid and responsive questionnaire with test–retest reliability proven for hand injuries in this study. Gender, handedness, and side injured did not cause bias in the responses.

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Introduction

Outcome measures are important as they allow clinicians to assess the severity of injuries and disease and allow a comparison between different forms of management. A patient-completed questionnaire is efficient in terms of time and resources and allows the assessment of outcome without the need to attend an outpatient clinic.

The original DASH questionnaire was developed as a measure specific to the upper limb, but recent studies have shown that it also takes lower limb function into account

Figure 1 The M² DASH questionnaire.

Manchester-Modified Disability of the Arm, Shoulder and Hand (M² DASH) questionnaire

Patient's Name/ Reference..... Date.....

Clinician's Name/ Reference.....

INSTRUCTIONS FOR PATIENT: This questionnaire asks about your symptoms as well as your ability to perform certain activities. Please answer every question, based on your condition in the last week. If you did not have the opportunity to perform an activity in the past week, please make your best estimate on which response would be the most accurate. It doesn't matter which hand or arm you use to perform the activity; please answer based on your ability regardless of how you perform the task.

Please rate your ability to do the following activities in the last week.	No difficulty	Mild difficulty	Moderate difficulty	Severe difficulty	Unable
1. Open a tight or new jar	1	2	3	4	5
2. Write	1	2	3	4	5
3. Turn a key	1	2	3	4	5
4. Prepare a meal	1	2	3	4	5
5. Place an object on a shelf above your head	1	2	3	4	5
6. Wash or blow dry your hair	1	2	3	4	5
7. Wash your back	1	2	3	4	5
8. Put on a pullover sweater	1	2	3	4	5
9. Use a knife to cut food	1	2	3	4	5
10. Recreational activities which require little effort (eg cardplaying, knitting, etc)	1	2	3	4	5
11. Sexual activities	1	2	3	4	5
	Not at all	Slightly	Moderately	Quite a bit	Extremely
12. During the past week, to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	1	2	3	4	5
	Not limited at all	Slightly limited	Moderately limited	Very limited	Unable
13. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	1	2	3	4	5
14. Tingling (pins and needles) in your arm, shoulder or hand	1	2	3	4	5
15. Weakness in your arm, shoulder or hand	1	2	3	4	5
16. Stiffness in your arm, shoulder or hand	1	2	3	4	5
	No difficulty	Mild difficulty	Moderate difficulty	Severe difficulty	So much difficulty I can't sleep
17. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand?	1	2	3	4	5
	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
18. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem	1	2	3	4	5

Thank you very much for completing all the questions in this questionnaire.

INSTRUCTIONS FOR CLINICIAN: The questionnaire can only be used if at least 16 out of the 18 questions have been answered. Using the formula below, you get a score out of 100.

$$\left(\frac{\text{SUM OF TOTAL SCORE}}{\text{NUMBER OF QUESTIONS ANSWERED}} \right) \text{SUBTRACT 1} \left. \vphantom{\frac{\text{SUM OF TOTAL SCORE}}{\text{NUMBER OF QUESTIONS ANSWERED}}} \right) \text{MULTIPLY BY 25} = \dots\dots\dots$$

Reference: Khan WS, Jain R, Dillon B, Clarke L, Fehily M, Ravenscroft M (2008). Hand; 3(3): 240-244.

[5, 6]. This implies that the original DASH questionnaire is not suited for patients with additional lower limb pathologies, or patients with polyarthropathies. The original DASH questionnaire is also limited by a high

internal consistency suggesting redundancy in questions [4], difficulty with reproduction of the four pages it spans, time restraints for the patient and the clinician, and confusion over optional modules. These issues prompted

the authors to create a modified shorter version, the Manchester-Modified Disability of Arm, Shoulder, and Hand questionnaire (M² DASH) that is more sensitive and specific for the upper limb [1, 6]. The M² DASH has a simple one-page layout and is easy to understand and complete for the patient. For the researcher, it is easy to enter into a database and to calculate and analyze the score.

It is important to establish the validity, reliability, responsiveness, and bias of any outcome measure. The validity establishes whether the outcome measure actually measures what it was designed to. An outcome tool is reliable if the same result is obtained when tested at different time points once the condition has stabilized. The responsiveness is the ability to detect clinically important changes in disability at various intervals. Bias can occur when assumed independent variables such as age and gender affect responses.

There are many patient-completed questionnaires available for the assessment of outcomes in the upper limb. The Patient Evaluation Measure (PEM) questionnaire was developed in the UK in 1995 [7], and the Michigan Hand Outcome (MHO) questionnaire was developed in the USA in 1998 [3]. Both questionnaires are region-specific outcome measures commonly used for hand injuries and, like the M² DASH, are patient-completed questionnaires.

Previously, the only assessment of the validity of the M² DASH questionnaire was by comparison with the original DASH questionnaire from which the M² DASH scores had been extrapolated. It is important that a more thorough evaluation of this questionnaire is performed. In this study, we assessed the validity, reliability, responsiveness, and bias of the M² DASH questionnaire for hand injuries using completed M² DASH, PEM, and MHO questionnaires.

Patients and Methods

Between October 2006 and August 2007, we studied 59 patients who attended the fracture clinics of two local district general hospitals with hand injuries. Patients under 18 years of age, with preexisting disorders of the upper limb, with cognitive impairment preventing the completion of the questionnaires, or with language difficulties, were

excluded. The M² DASH (Fig. 1), PEM, and MHO questionnaires were completed by the patients at their first clinic visit, on discharge following their last visit, and at 6 months following discharge. The M² DASH was also completed by the patients 12 months following discharge. Thirteen patients who started completing the questionnaires at presentation but failed to complete all sets of questionnaires at the various time points were excluded from the study. This included four patients where there were omissions from the questionnaires invalidating them. Six patients who started completing the questionnaires but sustained a further upper limb injury or had to seek further medical advice for their original injury following discharge were also excluded.

The completed questionnaires from 40 patients at the different time points were used to assess the validity, reliability, responsiveness, and bias of the M² DASH questionnaire. Of the 40 patients for whom all sets of questionnaires were available, there were 24 men and 16 women. Their mean age was 43 years (standard deviation (SD) 18 years, range 18 to 85). Thirty-one were right-handed and nine were left-handed. Twenty-six patients had injured their dominant hand and 14 patients their nondominant hand. The M² DASH, PEM, and MHO scores were then calculated as previously described [1, 3, 4, 7] giving a score out of 100.

The validity of the M² DASH was assessed by determining how well the score at various time points correlated with the PME and MHO scores. The reliability was assessed by performing test–retest reproducibility analyses on the M² DASH scores at 6 and 12 months after discharge; 6 months after discharge, as the patients had not sustained a further injury or sought further medical advice, it was assumed that their condition had stabilized. A paired *t* test was used to check if the patients score had changed significantly over this time period.

Responsiveness was assessed by correlating the changes in the M² DASH score with changes in the PEM and MHO scores and was measured by calculating the effect size and the standardized response mean. The effect size was calculated by considering the two periods between the three time points where there were changes in the scores: initial presentation, discharge, and 6 months following discharge. The effect sizes were calculated by dividing the mean of change in the score during the periods by the standard deviation of the baseline score. The standardized response mean was calculated by dividing the mean of change in the

Table 1 The correlations of PEM and MHO scores with the M² DASH scores.

Time of score	PEM score correlation		MHO score correlation	
	Coefficient	<i>p</i> value	Coefficient	<i>p</i> value
At presentation	0.96	<0.001	0.85	<0.001
At discharge	0.96	<0.001	0.88	<0.001
6 months following discharge	0.60	<0.001	0.54	<0.001

Table 2 The effect sizes and standardized response means for the M² DASH, PME, and MHO scores.

	M ² DASH score	PEM score	MHO score
Effect size between presentation and discharge	1.45	1.26	1.23
Effect size between discharge and 6 months following discharge	1.07	0.96	0.6
Standardized response mean	2.21	1.80	1.50

scores between initial presentation and 6 months following discharge by the standard deviation of the change in score.

The bias in the M² DASH score was investigated by performing correlation studies for assumed independent variables including age, gender, hand dominance, and the side injured. Lastly, the values for the three questionnaires were plot against one another on scatter plots to further understand the relationships between them. All statistical analyses were performed on SPSS version 12.0 (SPSS Inc., Chicago, IL, USA) and a *p* value of <0.05 was taken as statistically significant.

Results

All the scores were normally distributed when assessed using histograms and Pearson correlations were used to compare them and assess validity of the M² DASH score. The correlation between the M² DASH scores and each of the PEM and MHO scores was calculated at presentation, at discharge and 6 months following discharge. The M² DASH scores compared well with the PME and MHO scores. Table 1 shows that the M² DASH scores showed highly significant positive correlations with both the PEM and MHO scores at all three time points (*p*<0.001). The

magnitude of the correlation coefficient was slightly lower with the MHO scores and at 6 months following discharge.

Comparison of the M² DASH scores 6 and 12 months after discharge shows no significant change over this period (*p*=0.53). The mean change over the 6 months was −0.2 (−0.84, 0.44). This is less than 5% of the mean M² DASH scores at 6 [4.83 (3.92, 5.73)] and 12 months [5.03 (4.19, 5.86)]. These results suggest good test–retest reproducibility and reliability.

Table 2 shows that the effect sizes for the M² DASH were 1.45 and 1.07 for the time periods between presentation and discharge and between discharge and 6 months following discharge, respectively. These were greater than 0.8 indicating that they were valuable. The effect sizes for the two periods were greater than those for the PME (1.26 and 0.96) and MHO (1.23 and 0.60). The effect size for the MHO scores was not valuable for the second period, i.e., between discharge and 6 months following discharge. The standardized response mean for the M² DASH score was 2.21. The standardized response mean for the PME and MHO scores were 1.80 and 1.50, respectively. These analyses establish that the M² DASH is a highly responsive scale.

There was evidence of a relatively weak association between age and the M² DASH score at presentation (*p*=0.02) but the correlation coefficient was not large (*r*=0.37).

Table 3 The association between the M² DASH score and gender, dominance, and injury to dominant side.

	<i>N</i>	Mean	SD	<i>N</i>	Mean	SD	<i>p</i> value
Association between M ² DASH score and gender							
	Male			Female			
At presentation	24	52.3	18.7	16	47.9	23.8	0.52
12 months following discharge	24	4.8	2.7	16	5.4	2.5	0.49
Association between M ² DASH score and dominance							
	Right			Left			
At presentation	31	51.9	20.8	9	45.8	20.8	0.44
12 months following discharge	31	5.2	2.7	9	4.4	2.2	0.45
Association between M ² DASH score and injury to dominant side							
	Dominant injury			Nondominant injury			
At presentation	26	48.2	21.2	14	54.9	19.8	0.34
12 months following discharge	26	4.9	2.6	14	5.2	2.6	0.74

At 12 months following discharge, there was no correlation between age and the M² DASH score ($r=-0.09$, $p=0.57$). Table 3 shows that there was no evidence of an association between the M² DASH scores and gender, dominance, and injury to dominant side when we looked at the scores at presentation and 12 months following discharge.

When the scores were plot against each other (Fig. 2), the M² DASH and PEM scores showed a fairly linear relationship. The MHO score, when compared to the other two scores, had a more sigmoid curve.

Discussion

The M² DASH is an upper limb outcome assessment tool that is not pathology or region specific within the upper limb. Previously, the only assessment of the validity of the M² DASH questionnaire was by comparison with the original DASH questionnaire. In this study, we assessed the validity, reliability, responsiveness, and bias of the M² DASH questionnaire for hand injuries using completed M² DASH questionnaires and comparing it with the PEM and MHO questionnaires.

In this study, criterion validity testing showed strong correlations between the M² DASH scores and the PME and MHO scores suggesting that the M² DASH score measures what it is designed to and confirmed that the questionnaire is valid for injuries to the hand. The construct validity of the M² DASH questionnaire appears sound as the questionnaire retains at least half of the questions from each of the six domains of the original DASH questionnaire [6]. Each individual question contributes to the complete evaluation of hand function. The M² DASH includes some questions not routinely addressed in the objective assessments of the hand, suggesting good content or face validity of the M² DASH questionnaire.

We have established that the M² DASH is reliable with good test–retest reproducibility as there was no significant change in the scores at 6 and 12 months following discharge. Our study has also established that the M² DASH questionnaire is responsive to change compared with the PME and MHO questionnaires over a period of time, from initial presentation following injury through discharge from the fracture clinic and to follow-up at 6 months.

Our study confirmed that no gender, hand dominance, or dominant side injured bias existed for the M² DASH score at presentation or at 6-month follow-up. There was, however, a relatively weak association between age and the M² DASH score at presentation. The positive correlation implies that older people tend to have high DASH scores when they present with hand injuries. This could be due to older patients sustaining more severe hand injuries or sustaining injuries of similar severity but suffering a greater

Figure 2 Scatter plots for M² DASH and PEM scores (a), M² DASH and MHO scores (b), and PEM and MHO scores (c).

disability. Although the latter one is more likely, further work is needed to explore this in more detail.

When the scores were plot against each other, the relationships of the MHO score with the other two scores

was more sigmoid shaped than linear suggesting that at the extremes, the MHO scores were clustered and not spread out like the M² DASH and PEM scores. This implies that the MHO score is less sensitive at both extremes.

The QuickDASH questionnaire is a shorter version of the DASH questionnaire developed using the concept-retention method [2]. The QuickDASH questionnaire remains limited in terms of sensitivity and specificity for the upper limb with only six of its 11 questions being present in the M² DASH questionnaire [6]. Unlike the PEM and MHO questionnaires, the QuickDASH has not been validated for hand injuries and was not included in this study.

We conclude that the M² DASH questionnaire is a robust region-specific outcome measure. It is a valid and responsive questionnaire with test–retest reliability proven for hand injuries in this study. Gender, handedness, and side injured did not cause bias in the responses. We acknowledge the need for further studies looking beyond hand injuries before a more complete picture on the validity of the M² DASH for all upper limb pathologies could be drawn.

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