

Muscle strength and outcome measures for upper limb function in adults with Myotonic Dystrophy type 1: A cross-sectional study

Hanne Ludt Fossmo^{1,2}, Hilde Stendal Robinson², Karianne Grüner Bjåstad³, Kristin Nielsen Varhaug⁴, Jan C. Frich², Kristin Ørstavik¹

1 Section for rare neurological disorders and EMAN, Department of Neurology, Oslo University Hospital, Norway 2 Institute of Health and Society, Faculty of Medicine, University of Oslo, Norway, 3 Møre og Romsdal health Trust, Norway, 4 Haukeland University Hospital, Norway

Background and aims

Upper limb dysfunction has been noted since the first description of DM1, characterized by progressive muscle stiffness(myotonia), atrophy and weakness. Hand and upper limb function is particularly important for dexterity, and the ability for patients to perform daily tasks and stay independent.

However, few studies have focused on upper limb function and specifically how to measure function and progression of disease. This is reflected in limited focus on these aspects in the total of three workshops on Outcome Measures in Myotonic Dystrophy type 1 (OMMYD) in 2011, 2013, and 2015(1,2,3).

The **primary aim** of this study was to characterize upper limb muscle strength, functional performance, and self-reported symptoms in a heterogeneous cohort of adults with DM1, encompassing different subtypes and a range of disease severities.

Secondarily, we wanted to examine the relationships between muscle strength and functional performance, to evaluate the comparability of different strength measurement devices and methods, to explore correlations among functional outcome measures and to assess the influence of disease duration, age, and clinical subtype on upper limb impairment.

Material and methods

89 genetically confirmed adult DM1 participants from three different regions in Norway were included. Muscle strength was measured using handheld dynamometers, while fine motor function was assessed with the Nine-Hole Peg Test(NHPT) and Nut and Bolt task(NBT).

Functional impairment was rated with the Muscular Impairment Rating Scale (MIRS), Brooke Upper Extremity Scale, Revised Upper Limb Module (RULM) and Motor Function Measure 32 (MFM32).

Patient-reported outcome measures (PROMs) included ABILHAND-NMD, ACTIVLIM and the Myotonia Behavior Scale (MBS).

Table 1 Demographic and clinical data (n = 89)

	Total	Female	Male
Sex n (%)	89 (100)	54 (61)	35 (39)
Age (years), mean (SD)	45.2 (13.5)	44.6 (14)	46.0 (13.0)
Time since diagnosis (years), mean (SD)	11.7 (9.3)	11.6 (10)	12 (8.3)
Debut symptoms age (years), mean (SD)	25 (16.6)	22.5 (14)	26.5 (18)
Subtype n (%)			
Congenital	3 (3)	3 (5)	0 (0)
Childhood	34 (38)	21 (39)	13 (37)
Adult	37 (42)	22 (41)	15 (43)
Late onset	15 (17)	8 (15)	7 (20)
MIRS n (%)			
1	2 (2)	2 (4)	0 (0)
2	25 (28)	14 (26)	11 (31)
3	21 (24)	12 (22)	9 (26)
4	22 (25)	15 (28)	7 (20)
5	19 (21)	11 (20)	8 (23)
Brooke n (%)			
1	61 (69)	38 (72)	23 (66)
2	13 (15)	9 (17)	4 (11)
3	6 (7)	3 (5.5)	3 (9)
4	8 (9)	3 (5.5)	5 (14)
Work status n (%)			
Employed full/parttime	34 (38)	18 (33)	16 (46)
Unemployed/disability	49 (55)	32 (59)	17 (48)
Retired	6 (7)	4 (8)	2 (6)
Marital status n (%)			
Married/partner	51(57)	35 (65)	16 (46)
Partner but live alone	13 (15)	9 (17)	4 (11)
Single/alone	25 (28)	10 (18)	15 (43)
Living situation n (%)			
Lives alone independently	31 (35)	19 (35)	12 (34)
Lives with someone, is independent	30 (34)	18 (33)	12 (34)
Needs some assistance	23 (26)	14 (26)	9 (26)
Live in an institution	5 (5)	3 (6)	2 (6)

n= Numbers, SD = Standard deviation, MIRS = Motor impairment rating scale

Results

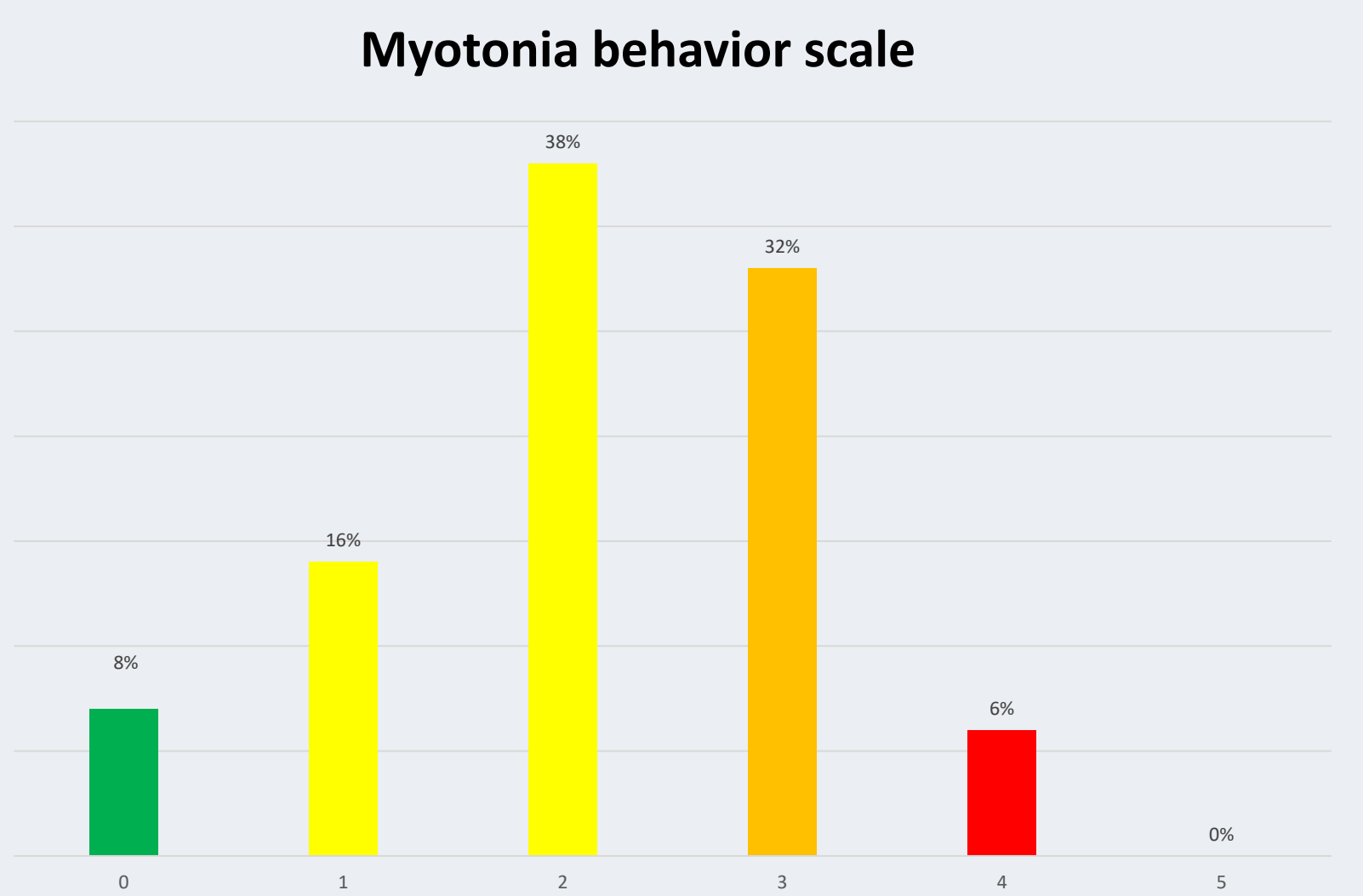


Table 3 Functional outcomes and PROMS

	Median	IQR 25%-75%
RULM (n=67) (0-37)	37	34.0-37.0
MFM32-D3 (n=86) (%)	100 (%)	90.5-100.0
NHPT dominant (n=88), s	21	18.6-24.8
NBT big dominant (n=45), s	30	24.0- 37.0
Abilhand-NMD (n=89) (0-36)	33	29.5-35
ACTIVLIM (n=89) (0-36)	31	26.0-35.0
MBS (n=87) (0-5)	2	2.0-3.0

IQR = interquartile range, RULM = Revised upper limb module, MFM32-D3 = Motor function measure 32, distal domain, NHPT = Nine-Hole Peg test, NBT= Nut and Bolt task, MBS = Myotonia Behaviour Scale

Table 4 Associations between function as measured by Nine-Hole Peg Test (NHPT) (seconds) and the results of muscle strength and self-reported myotonia

Independent variable	Dominant upper limb, mean (95%CI)	B (95% CI)	P-value
Myotonia (0-5)		2,3 (0,8– 3,8)	= 0,003
Grip strength kg	15.6 (14.2-19.1)	-0,3 (-0,4 – -0,1)	<0,001
Pinch strength kg	3.6 (3.2-4.1)	-1,1 (-1,8– -0,3)	=0,008
Wrist strength kg	7.5 (6.8-8.2)	-0,9 (-1,4 – -0,4)	<0,001
Elbow flexion kg	12.5 (11.2-13.8)	-0,4 (-0,7 - -0,1)	=0,004
Shoulder flexion kg	12.4 (11.2-13.5)	-0,7 (-1,1 - -0,3)	<0,001

Separate multivariable analysis for each independent variable with adjustment for sex, time with symptoms, s and subtype of DM1. kg = Kilogram, CI = Confidence Interval

Table 2 Muscle strength upper extremity

	Shoulder flex (kg) (95% CI)		Elbow flex (kg) (95% CI)		Wrist flex (kg) (95% CI)		MyoGrip (kg) (95% CI)		MyoPinch (kg) (95% CI)	
	Dominant nt	Non dominant nt	Dominant nt	Non dominant nt	Dominant nt	Non dominant nt	Dominant nt	Non dominant nt	Dominant nt	Non dominant nt
To	12.3 (11.2-13.4)	11.1 (10.0-12.2)	12.4 (11.1-13.6)	11.6 (10.5-12.8)	7.5 (6.8-8.2)	7.8 (7.1-8.5)	17.2 (14.6-20)	16.7 (14.2-19.2)	3.6 (3.2-4.1)	3.5 (3.1-3.9)
Sex										
F	10.1(8.9-11.2)	9.3(8.2-10.5)	10.7(9.5-12.0)	10.6(9.3-11.8)	7.1(6.3-8)	7.6(6.7-8.5)	15.1 (12.9-17.3)	14.5 (12.4-16.6)	3.3 (2.9-3.7)	3.1 (2.7-3.4)
M	15.5 (13.7-17.3)	13.8(8.5-17.7)	14.2(12.2-16.1)	13.1 (11.1-15.1)	7.8(6.7-8.9)	7.9(6.7-9.2)	19 (13.6-24.3)	18.9 (13.8-23.9)	3.9 (3.2-4.6)	3.9 (3.2-4.6)
Years of symptoms										
0-9	16.4(14-18.8)	15.1(13.1-17.0)	15.5(13.4-17.6)	16.0(14.4-17.7)	9.8(8.2-11.4)	10.5(8.6-12.4)	32.6 (25.1-40.2)	31.9 (24.0-39.8)	6.3 (4.9-7.8)	5.6 (4.5-6.6)
10-19	12.8(10.4-15.2)	11.6(9.6-13.7)	13(10.6-15.5)	12.5(10.3-14.6)	7.1(5.6-8.6)	7.7(6.3-9.1)	16.7 (12.0-21.3)	15.6 (11.7-19.5)	3.6 (3.3-4.3)	3.2 (2.5-3.9)
20-30	10.4(8.4-12.3)	9.4(7.3-11.6)	10.5(8.5-12.4)	9.7(7.6-11.9)	6.6(5.5-7.8)	6.8(5.6-8.0)	11.4 (9.1-13.7)	11.0 (8.6-13.1)	2.8 (2.2-3.1)	2.8 (2.3-3.3)
>30	11.3(8.9-13.6)	9.7(7.3-12.0)	10.6(8.0-13.1)	9.7(7.5-12)	7.5(6.5-8.9)	7.4(5.8-8.9)	12.5 (9.3-15.7)	13.2 (9.9-16.5)	3 (2.3-3.7)	3 (2.3-3.6)

kg = Kilogram, CI = Confidence Interval

Table 5 The association between function as measured by Motor Function Measure 32 (MFM32) and the results of muscle strength and self-reported myotonia

Independent variable	Dominant upper limb, mean (95%CI)	B (95% CI)	P-value
Self-reported myotonia (0-5)		-3,7 (-7,2 - -0,1)	=0,04
Grip strength kg	15.6 (14.2-19.1)	0,9 (0,6 – 1,2)	<0,001
Pinch strength kg	3.6 (3.2-4.1)	4,1 (2,4-5,7)	<0,001
Wrist strength kg	7.5 (6.8-8.2)	2,5 (1,6-3,5)	<0,001
Elbow flexion kg	12.5 (11.2-13.8)	1,9 (1,1-2,8)	<0,001
Shoulder flexion kg	12.4 (11.2-13.5)	2,3 (1,6-2,9)	<0,001

Separate multivariable analysis for each independent variable with adjustment for sex, time with symptoms, age, and subtype of DM1. Kg = Kilogram, CI = Confidence Interval

Upper limb strength

Muscle strength is shown in table 2. Measurements obtained with MMT showed moderate to strong correlation with those obtained with handheld dynamometers.

Grip strength was substantially reduced compared with age-stratified Myo-Grip data.

Correlation between strength measures and **disease duration** showed moderate negative correlations regarding all strength measures (-0.37 to-0.48, all p<0.01). In contrast, correlations with **age** and **DM1 subtype** were low.

Upper limb function

Overall test-results are described in table 3. Significant correlations were found among all the functional outcome measures 0.46<r<0.60(p>0.001), except between RULM and NBT.

MIRS, Brooke, RULM and NBT were all moderately to highly correlated with all the strength measures including both the proximal and distal parts of the upper extremity. The total MFM32 score was correlated with all the strength scores (table 4 and 5).

Self-reported hand and arm function

We found moderate positive and negative correlation between Abilhand-NMD and ACTIVLIM and NMD scores (rho=0.67 and -0.45, resp. (p<0.01)).

Most patients reported mild to moderate myotonia (figure), median score 2. Myotonia showed only weak correlations with most functional and strength measures.

Conclusions

- Muscle strength assessment remains essential, both in the hand and fingers, as well as proximal segments of the upper limb.
- No single functional outcome emerged as the definite tool.
- NHPT and NBT is essential to capture aspects of dexterity.
- Myotonia is only weakly associated with strength and functional performance.

