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# THORACIC MOVEMENT SCREENING IN ADULTS WITH CYSTIC FIBROSIS: RELIABILITY OF THE MANCHESTER MUSCULOSKELETAL SCREENING TOOL.

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7

## 8 Abstract

9 **Objectives:** 

10 The Manchester Musculoskeletal Screening Tool (MMST) is used internationally to screen 11 for pain, postural changes and urinary incontinence in adults with cystic fibrosis (CF). The 12 tool has been validated for the outcome measures of pain and incontinence but not for the 13 thoracic movement section. The aim of this study was to assess intra (single rater) and inter-

14 rater (between rater) reliability of the thoracic movement screen section of the MMST.

### 15 Methods:

16 This is a prospective reliability study. Digital videos of thoracic movement were taken of

adults with CF during their annual musculoskeletal screen at a large UK Adult CF Centre.

18 Twelve physiotherapists independently watched the videos and scored the movements on two

19 occasions, two weeks apart, using the MMST. Cohen's kappa and Krippendorff alpha were

20 used to establish intra and inter-rater reliability.

#### 21 **Results:**

22 Intra-rater reliability using Cohen's kappa calculation ranged between 0.35 - 0.93. 11 out of

23 12 physiotherapists had a moderate-substantial reliability score as assessed by Landis Koch

criteria (1977). Percentage agreement for each physiotherapist ranged from 67%-97%.

25	Inter-rater reliability	was poor (Krippend	lorff alpha score = 0	).422 (	(CI: 0.24-0.6	50)).
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## **Conclusion:**

27	The thoracic section of the MMST is reliable in adults with CF to highlight changes in
28	posture and thoracic mobility that may go undetected or under-reported by the patient when
29	repeated by the same clinician. However, the inter-rater variability is high, and it should not
30	be considered reliable when carried out by different clinicians over time.
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35	Keywords:
36	Thoracic
37	Screening
38	Reliability
39	Musculoskeletal
40	Cystic fibrosis
41	Physiotherapy
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#### 54 Introduction

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56 Cystic fibrosis (CF) is the most common lethal genetic disease in the developed world (Davies, 2006). It is a multisystem disease but advances in medical management have resulted in 57 significant improvements in life expectancy and the majority of CF patients in the UK are now 58 adults. These patients present increasingly with musculoskeletal (MSK) problems (Sandsund, 59 Roughton, Hodson and Pryor, 2011). The prevalence and frequency of pain amongst patients 60 61 with CF is difficult to establish as studies have used different parameters and assessment tools for pain (Havermans et al, 2013). However, incidence of back pain has been quoted to be as 62 high as 94% (Parasa and Muffulli, 1999). 63

Adults with CF are at an increased risk of developing MSK problems such as postural changes, pain and urinary incontinence (Massery, 2005). The reasons for this are multifactorial, but include changes in respiratory mechanics, posture, reduced bone mineral density and a reduced muscle mass (Cystic Fibrosis Trust, 2017; Schindel et al, 2015). Even in patients with only mild reduction in lung function, postural changes are found when compared to healthy controls (Schindel et al, 2015).

Postural changes become more prevalent in the adult CF population due in part to ageing and 70 a decline in respiratory function and hyperinflation (Tattersall and Walshaw, 2003; Botton et 71 72 al, 2003). Nutritional deficiencies and low bone mineral density (Schindel et al, 2015) both of which may worsen as the person ages and the disease progresses, probably also play a role. 73 The most common postural change observed in adults with CF is increased thoracic kyphosis 74 (Cystic Fibrosis Trust, 2017; Schindel et al, 2015; Tattersall and Walshaw, 2003). A reduction 75 in thoracic mobility has been observed linked to altered rib angles with hyperinflation and 76 77 shoulder girdle changes (Laghi and Tobin, 2003; Mandrusiak et al, 2010). It is hypothesised that the dual role of the abdominal and trunk muscles to support both respiration and postural
control means that, in a situation of declining respiratory function, these muscles work harder
to support respiration, resulting in less postural support, in turn, increasing the risk of postural
deformities and secondary MSK complaints such as back pain (Hodges et al, 2002).

There is emerging evidence of the potential to prevent or reverse some of these postural 82 83 changes seen in adults, and children with CF (Sandsund, Roughton, Hodson and Pryor, 2011; Massery, 2005), via aerobic exercise and stretches over a three-month period (Schindel et al, 84 2015). These postural changes require monitoring (Mandrusiak et al. 2010) and preventative 85 strategies need to be implemented to limit the impact on the MSK system, Therefore, it is 86 important to screen and monitor this population at least annually to detect any changes as they 87 occur (Massery, 2005; Cystic Fibrosis Trust, 2017; Tattersall and Walshaw, 2003; Cystic 88 Fibrosis Trust, 2011). 89

The Manchester Musculoskeletal Screening Tool (MMST) was developed to improve monitoring of adults with CF by improving identification of MSK problems requiring physiotherapy intervention (Ashbrook, Taylor and Jones, 2011). This was in response to the publication of the National Standards of Care for people with Cystic Fibrosis (Cystic Fibrosis Trust, 2011; 2017), recommending all patients have at least one MSK and postural assessment per year.

96 The MMST is split into three sections (appendix 1). Section one contains three questions 97 related to patient reported concerns of pain, urinary incontinence and posture. Section three 98 includes the Short Form McGill Pain Questionnaire (SF-MPQ) and the International 99 Consultation on Incontinence Questionnaire (ICIQ), which have demonstrated reliability and 100 validity and are suitable for use in research and clinical practice (Grafton, Foster and Wright, 101 2005; Strand et al, 2008; Avery et al, 2004).

Section two of the MMST includes physical examination of the patient's thoracic movement. 102 A trained physiotherapist may identify developing postural signs, or reduced movement before 103 the patient develops symptoms or deformity, but the reliability of this physical examination 104 section has not been tested and is the focus of this study. Confidence in reliability of section 105 two of the MMST would enable its use to guide the patient care pathway, facilitate MSK 106 treatment, monitor the prevalence of MSK issues within and between adults with CF, (in the 107 108 same centre and between centres) and also guide whether the MMST or process needs to be adapted. 109

The aim of this study was to establish whether the MMST has intra- and inter-rater reliability in order to determine if it is a valuable tool in the monitoring of MSK health in CF patients. Intra-rater reliability measures agreement between assessments made by the same physiotherapist on two separate occasions. Inter-rater reliability compares the level of agreement between physiotherapists.

115

#### 116 Materials and methods

This was a prospective reliability study. It was approved by Manchester Metropolitan
University Faculty Ethics Committee (Ref: Phys/17/2) and Manchester Foundation NHS Trust.
The Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were used (Kottner
et al, 2011).

#### 121 Sample

Participants included a sample of 14 physiotherapists from an NHS trust: 8 with a respiratory
background and 6 with an MSK background. They worked in the MSK outpatient department
(n=5) or the adult cystic fibrosis centre (n=9). Participants had a range of between 3- and 26-

years post qualification experiences. Participants were invited to participate via a trust emailadvert.

Fifteen patients were recorded, using digital video for the study to provide standardised thoracic assessments for the participants to score. The videos were recorded by the researcher using a Windows Pro tablet computer. Standardised instructions were provided to each patient prior to filming. Movements were demonstrated to patients then recorded with the researcher reading out the standardised instructions. The video was then re-watched by the researcher to check for accuracy and standardisation.

The MMST thoracic assessment is designed as a quick, easy to do posture and thoracic 133 movement screen, that requires no equipment. The thoracic assessment section consists of four 134 elements of observation, if the participant is unable to achieve one of the sections 'yes' is 135 136 checked and if they are able to achieve 'no' is checked. Part one: Sitting posture and thoracic kyphosis in the sagittal plane with judgement made as to whether the patient can actively 137 correct any increased kyphosis. Part two: Bilateral shoulder flexion (arms above head level 138 with ears) is measured to assess the ability of the thoracic spine to extend to produce terminal 139 shoulder flexion. Part 3: Thoracic rotation in sitting is assessed to determine whether 45 140 degrees can be achieved in each direction. Part 4: Thoracic lateral flexion in sitting is assessed 141 to determine whether 30 degrees can be achieved in each direction. If the patient is unable to 142 143 achieve any part of the thoracic section they do not pass this section, and therefore no do not pass the overall screening tool 144

Patient inclusion criteria were a diagnosis of Cystic Fibrosis, age 18 years and over, and those who had not yet had their annual MMST assessment. Exclusion criteria were significant MSK pathology, or recent abdominal/orthopaedic surgery and those undergoing MSK treatment for a thoracic movement restriction. Patients were randomly chosen during routine annual MSK screening at Manchester Adult Cystic Fibrosis Centre. The sample of patients was screened by
an independent exercise physiologist in the CF team to ensure a spread of disease severity
(mild, moderate, severe, and very severe) (GOLD, 2008). Age, disease severity and presence
of pulmonary exacerbation were collected for each subject (Table 1).

Patients were informed that it was possible they may be identified from the videos should the physiotherapist work on the CF unit. It was deemed that participants recognising patients was unlikely to affect the study results because assessment of thoracic spine is not routine and only part of the MSK annual screening undertaken by a select team. No other information regarding the patient was offered to the participants. The study was explained to all patients and participants, written information provided, and informed consent obtained.

#### 159 *Procedure*

Prior to the study, all participants were trained to complete the MMST using a standardised presentation with the opportunity to ask questions. Each participant independently watched the videos twice, with two weeks between each viewing, from a non-shared computer drive. Each video was sequentially numbered in date order.

Participants watched each video as often as they required, with no time limit to score the patients. Participants were allocated identifying letters provided in a sealed envelope to ensure blinding of the data analysis. Completed anonymised score sheets were entered into a sealed box.

Questions 1, 2, 3, 4 of section one relates to pain, urinary incontinence, and concerns about posture and require a yes/no answer. These questions were not included in the videos as they were not related to the study objectives to assess thoracic movement section. Participants scored each video using question 5-8 of the MMST. Questions posed were:

172 5. Is there a fixed thoracic kyphosis?

6. Is the patient unable to lift both arms straight above head level with ears?

- 174 7. With arms across chest is patient unable to rotate upper body to  $45^{\circ}$ ?
- 175 8. With arms above head is patient unable to lean to  $30^{\circ}$ ?
- 176

Question 5 determines whether the patient can correct any increased thoracic kyphosis. Question 6 determines if the patient can achieve full shoulder flexion and some thoracic extension, which occurs at the end of shoulder flexion. Question 7 and 8; determine any loss of rotation/side flexion in the thoracic spine. In questions 6, 7 and 8 the physiotherapists are asked if the patient is unable to perform certain movements to make answers consistent with earlier questions in the tool and therefore easier to score.

The order of the videos was kept the same for each participant and during data collection to maintain the maximum recommended time interval between sessions to limit recall (Steiner and Norman, 2003).

186

#### 187 Sample size

Previous literature was examined to determine the optimal sample size, but limited information was found on determining sample size calculations for reliability studies such as this (Jones, 2004). Previous studies testing the reliability of MSK screening have used 15 subjects and 2 raters in lower extremity (Gabbe, Bennell, Wajswelner, Finch, 2004), 10 subjects and 2 raters in cricketers (Dennis, Finch, Elliott and Farhart, 2008) and 26 subjects and 2 raters in kyphosis measurement in postmenopausal women with osteoporosis (Lundon, Li and Bibershtein, 1998). Depending on the subject there should be a balance between the number of raters examining
each subject and the number of subjects (Walter, Eliasziw and Donner, 1998). Therefore, it was
decided to use 15 patient videos and 14 participants (raters) for this study.

#### 198 Data Analysis

To calculate interrater reliability the Krippendorff Alpha test (Hayes and Krippendorff, 2007) was used because it can be used for multiple raters' and allows for missing data. Alpha ranges from 0= absence of reliability, to 1 = perfect reliability. Greater than 0.8 indicates strong interrater reliability, 0.67-0.8 indicates low reliability. Alpha less than 0.67 is very low inter-rater reliability (Krippendorff, 2004). A 95% confidence interval for alpha was used.

To calculate intra-rater reliability Cohen's kappa (Zapf, Castell, Morawietz and Karch, 2016) was used with first- and second-week scores. Bootstrapping was used as an estimation of accuracy of reliability across 1000 samples. It determines whether results can be inferred to the general population and is an acceptable alternative approach for the calculation of the confidence intervals for nominal data (Xu et al, 2011).

Statistical analysis was performed using SPSS 24. A significance level of p<0.05 was set.</li>
Percentage agreement between measures was also calculated.

211

#### 212 **Results**

14 participants completed the first round and 12 completed both rounds. Two (Raters F & O)
did not complete the second round of scoring because of pressure from clinical duties (Table
2).

Intra-rater reliability (agreement between assessments made by the same physiotherapist on
two separate occasions) demonstrated a moderate-substantial reliability (Kappa range =

- 0.492-0.931), with 1 outlier (clinician N, Kappa = 0.354, Table 2), using Landis Koch criteria
- 219 (Landis and Koch, 1977). Percentage agreement ranged from 67%-97%.

220 Inter-rater reliability (level of agreement between physiotherapists) was low (Krippendorff

alpha score 0.422). Further analysis of the Krippendorff alpha score of those therapists who

- work on the CF unit (n=9) was also low (Krippendorff alpha score 0.438) (Krippendorff,
- 223 2004).
- The kappa statistic was used to determine agreement of individual questions. No questionwas superior in agreement when compared to each other (Table 3).
- 226 It was felt that agreement might be higher in videos, where a patient had more obvious
- decreased or increased range of movement. No video showed better agreement than another(Table 4).

229

#### 230 Discussion

231 The aim of this study was to establish intra and inter reliability of the thoracic movement

screen section of the MMST. Intra-rater reliability was good demonstrating that the same

- 233 physiotherapists are consistent in their scoring and we would recommend that the same
- 234 physiotherapist repeats a patient's annual screen.
- 235 Inter-rater reliability was low and therefore this data indicates that, this section of MMST
- should not be used as a tool to monitor thoracic changes alone over time when comparing the
- results year on year, when assessed by different clinicians.
- 238 There was no difference in reliability when comparing physiotherapist who worked on the CF
- unit and those who did not. It may have been expected that those more accustomed with the
- 240 MMST would be more familiar with wording and scoring, but this effect was not observed.

Having several well-trained physiotherapists scoring this section of the MMST is important
and may improve both inter- and intra-rater reliability. Training could involve a standardised
video/training package so it can be easily and regularly accessed to ensure correct
standardised scoring.

The confidence intervals for the intra-rater reliability spanned multiple classifications (Landis
and Koch, 1977). A possible reason for this is that the sample size was too small (Bowers et
al, 1998).

A factor influencing the reliability of the tool could be the wording of the questionnaire. Forexample:

• Question 6: 'is patient **un**able to lift both arms straight above head level with ears?'

• Question 7: 'with arms across chest is patient **un**able to rotate upper body 45 degrees.

• Question 8: 'with arms above head is patient **una**ble to lean 30 degrees'.

253

They require a yes or no answer. Therefore, if the patient is unable to perform the task, a 'yes' is ticked. Answering a negative outcome with a positive response may have led to some confusion when scoring the patients in this study. It was worded this way to help the scoring of the tool. If all questions were scored no, no action was needed by the physiotherapist. If one question was a yes, the physiotherapist uses the flow chart at the back of the tool which shows which action is necessary, for instance referral to musculoskeletal physiotherapist or women's health physiotherapist.

Re-wording of questions within the tool from unable to able, may improve the reliability so that it is clear how to score patient movement. For example, question 6: 'Is the patient able to lift both arms straight above head level with ears?' However, this will impact the overall

scoring of the tool. It will mean that all 'no' answers do not result in a passed tool. Instead a
mixture or 'yes' and 'no's' will be a pass.

The patients in this study were opportunistically sampled. Disease severity does not always
coincide with poor thoracic movement (Schindel et al, 2015), a combination of
hyperinflation, nutritional and bone mineral problems (Schindel et al, 2015) are thought to be
the cause. As a range of disease severity was included. It is unlikely that a different spread of
disease severity would have affected results.

271 If reliability remains an issue despite these changes introducing thoracic movement

272 measuring tools such as the flexicurve or goniometry could be incorporated. It is beyond the

scope of this paper to make recommendations regarding which thoracic measurement to use.

However, this needs to be considered against the time and skill element required to avoid

adding significantly to work demands and if incorporated into the MMST risk the tool not

276 being completed at all.

The reliability of individual questions on the thoracic movement screen were analysed in this
study. The reliability was the same for all questions; no question was superior in agreement.
Additionally, the results also show no video was superior in terms of reliability, so no patient
video showed more agreement than others.

The poor inter-rater reliability of the tool means that different therapists may disagree on whether a patient's movement is limited or not; the potential outcome being not referred for intervention if movement is not deemed as limited. Therefore, if the patient passes the thoracic screen, but there are still concerns over their MSK health, the relevant referrals still need to be made.

There is currently a lack of appropriate musculoskeletal screening tools in use for adults with CF who have unique problems. The only other tool is the Alfred MSK Assessment tool for respiratory patients. This tool, developed in Australia, examines multiple items including
cervical, thoracic, scapulae position and muscle length (Button, Yamin, Holland and Wilson,
2012). The difference is the Alfred MSK assessment tool is an assessment tool used at annual
review rather than a screening tool to improve the identification of MSK problems requiring
physiotherapy intervention.

The value of the MMST is when repeated measurements are made by the same clinician, it shows good reliability. It is also useful to highlight changes in posture and thoracic mobility when this is unrecognised by the patient. The tool remains beneficial because it contains other reliable and validated outcome measures for pain (McGill) and incontinence (ICIQ). However, caution needs to be applied when interpreting the thoracic section of the tool.

298 Strengths of the study include the use of video which provide a standardised assessment for 299 reliability and was useful to reduce the requirement for patients to re-attend for repeated scoring or follow-up assessment two weeks later. This could have reduced the drop out of 300 301 subjects or difficulties organising appointment around the microbiological subgroups. Also, it avoided the need for multiple thoracic movements which could have influenced the results 302 obtained due to a warmup effect. Multiple independent trained personnel were included to 303 reduce the possibility of bias, an adequate sample size and interval between tests was 304 included to prevent a learning effect. 305

Limitations include that patient videos are different to a real-life assessment using the screening tool. Studies have successfully used videos to analyse posture and movement but using more specialist equipment (Xu et al, 2011). To our knowledge, there is no literature comparing video versus face to face assessment for thoracic movement assessment. However, in the real-life setting of using the screening tool the subjects may have changed between

rating sessions depending on whether they were experiencing a chest exacerbation forinstance.

The physiotherapists involved were aware of the aim of the study so may have been subjected to the Hawthorne effect (Kottner et al, 2011). The therapist's scores could have been affected because they knew their responses would be compared to others. Therefore, they could have spent longer time checking their responses than they would do in the real-life clinical setting. *Further work* 

318 As a result of this study a training video has been developed to describe the correct use of the

- 319 tool. It is freely accessible on YouTube
- 320 <u>https://www.youtube.com/watch?v=sAOdNPSYm9M</u> so it can be watched repeatedly to

ensure standardised use of the tool. A change to the wording in section two (questions 5, 6, 7,

8) from 'unable' to 'able' and scoring of the tool has been changed to using shaded boxes, if

323 all the ticks are in the shaded boxes the patient passes the tool. Future work includes re-

testing reliability of the thoracic section of the tool.

#### 325 Conclusion

326 The thoracic movement screening section of the MMST demonstrates good intra-rater but

327 poor inter-rater reliability; changes have been made to improve this which will need re-

testing. The MMST tool is important in CF to ensure under-reported symptoms of pain,

329 incontinence and postural changes are screened for. The tool may also be applicable to other

330 respiratory diseases that encounter similar musculoskeletal issues.

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336	Declaration of interest statement
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338	Ethical Approval was granted by the Manchester metropolitan University ethics committee
339	(ref: Phys/17/2). This research did not receive any specific grant from funding agencies in the
340	public, commercial, or not-for-profit sectors. There is no conflict of interest.
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# **Table 1: Characteristics of patients in the digital videos:**

Video	Age (years)	CF lung disease severity	Exacerbation
1	29	Very severe	Yes
2	29	Severe	Yes
3	70	Moderate	No
4	19	Mild	No
5	36	Severe	No
6	47	Moderate	No
7	30	Severe	Yes
8	27	Severe	Yes
9	38	Severe	No
10	55	Severe	Yes
11	24	Severe	No
12	50	Severe	No
13	39	Very severe	No
14	32	Very severe	Yes
15	40	Very severe	Yes

56 Disease severity = mild/moderate/ severe/very severe [30]

# **Table 2: Intra-rater reliability**

Rater	Kappa	Classification	Bootstrapped	P =	Physiotherapist	Work	%
		Landis and	95%		speciality	on the	agreement
		Koch [26]	Confidence			CF	
		(Appendix 2)	Interval			Unit	
А	0.521	Moderate	0.319 - 0.731	< 0.001	Respiratory	Yes	77
В	0.931	Substantial	0.826 - 1.000	< 0.001	Musculoskeletal	Yes	97
С	0.662	Substantial	0.478 - 0.830	< 0.001	Respiratory	Yes	83
D	0.626	Substantial	0.414 - 0.825	< 0.001	Respiratory	Yes	82
Е	0.600	Moderate	0.394 - 0.768	< 0.001	Rotational	Yes	80
G	0.655	Substantial	0.458 - 0.826	< 0.001	Musculoskeletal	No	83
Н	0.507	Moderate	0.286 - 0.729	< 0.001	Musculoskeletal	No	77
Ι	0.586	Moderate	0.374 - 0.787	< 0.001	Musculoskeletal	No	79
J	0.582	Moderate	0.333 - 0.779	< 0.001	Respiratory	Yes	80
К	0.492	Moderate	0.261 - 0.708	< 0.001	Musculoskeletal	No	75
L	0.530	Moderate	0.311 - 0.728	< 0.001	Respiratory	Yes	76
N	0.354	Fair	0.112 - 0.586	.006	Musculoskeletal	No	67
F	-				Respiratory	Yes	
0	-				Respiratory	Yes	

# 367 Table 3: Intra-rater reliability of individual questions.

Question	Week	Kappa	P=	Agreement
5	1	0.06	0.01	Fair
5	2	0.09	0.00	Fair
6	1	0.09	0.00	Fair
6	2	0.02	0.28	Fair
7	1	-0.03	0.79	Poor
7	2	0.02	0.24	Fair
8	1	-0.03	0.87	Poor
8	2	0.06	0.02	Fair

## **Table 4: Intra-rater reliability of videos analysis**

V	Week	Kappa	P=	Agreement
1	1	0.07	0.26	Fair
1	2	0.00	0.51	Poor
2	1	0.22	0.02	Moderate
2	2	0.14	0.12	Fair
3	1	-0.18	0.94	Poor
3	2	0.03	0.41	Fair
4	1	-0.12	0.86	Poor
4	2	-0.17	0.93	Poor
5	1	-0.07	0.70	Poor
5	2	0.13	0.14	Fair

6	1	-0.12	0.85	Poor
6	2	-0.01	0.52	Poor
7	1	-0.05	0.66	Poor
7	2	-0.13	0.87	Poor
8	1	-0.06	0.70	Poor
8	2	-0.02	0.57	Poor
9	1	-0.12	0.86	Poor
9	2	-0.06	0.70	Poor
10	1	0.01	0.46	Fair
10	2	-0.14	0.89	Poor
11	1	0.13	0.12	Fair
11	2	0.12	0.15	Fair
12	1	-0.02	0.57	Poor
12	2	NA	NA	NA
13	1	-0.11	0.83	Poor
13	2	0.00	0.50	Fair
14	1	-0.03	0.62	Poor
14	2	-0.09	0.78	Poor
15	1	-0.03	0.59	Poor
15	2	-0.12	0.84	Poor

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