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

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Abstract

Objectives:

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

Methods:

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. Twelve physiotherapists independently watched the videos and scored the movements on two occasions, two weeks apart, using the MMST. Cohen's kappa and Krippendorff alpha were used to establish intra and inter-rater reliability.

Results:

Intra-rater reliability using Cohen's kappa calculation ranged between 0.35 - 0.93. 11 out of 12 physiotherapists had a moderate-substantial reliability score as assessed by Landis Koch criteria (1977). Percentage agreement for each physiotherapist ranged from 67%-97%.

Inter-rater reliability was poor (Krippendorff alpha score = 0.422 (CI: 0.24-0.60)).

Conclusion:

The thoracic section of the MMST is reliable in adults with CF to highlight changes in posture and thoracic mobility that may go undetected or under-reported by the patient when repeated by the same clinician. However, the inter-rater variability is high, and it should not be considered reliable when carried out by different clinicians over time.

Keywords:

Thoracic

Screening

Reliability

Musculoskeletal

Cystic fibrosis

Physiotherapy

Introduction

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 significant improvements in life expectancy and the majority of CF patients in the UK are now adults. These patients present increasingly with musculoskeletal (MSK) problems (Sandsund, Roughton, Hodson and Pryor, 2011). The prevalence and frequency of pain amongst patients 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 high as 94% (Parasa and Muffulli, 1999).

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 a decline in respiratory function and hyperinflation (Tattersall and Walshaw, 2003; Botton et 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. The most common postural change observed in adults with CF is increased thoracic kyphosis (Cystic Fibrosis Trust, 2017; Schindel et al, 2015; Tattersall and Walshaw, 2003). A reduction in thoracic mobility has been observed linked to altered rib angles with hyperinflation and 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 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, 2015). These postural changes require monitoring (Mandrusiak et al, 2010) and preventative strategies need to be implemented to limit the impact on the MSK system, Therefore, it is important to screen and monitor this population at least annually to detect any changes as they occur (Massery, 2005; Cystic Fibrosis Trust, 2017; Tattersall and Walshaw, 2003; Cystic Fibrosis Trust, 2011).

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.

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

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

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.

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).

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 email advert.

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 movement screen, that requires no equipment. The thoracic assessment section consists of four elements of observation, if the participant is unable to achieve one of the sections 'yes' is 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 correct any increased kyphosis. Part two: Bilateral shoulder flexion (arms above head level with ears) is measured to assess the ability of the thoracic spine to extend to produce terminal shoulder flexion. Part 3: Thoracic rotation in sitting is assessed to determine whether 45 degrees can be achieved in each direction. Part 4: Thoracic lateral flexion in sitting is assessed to determine whether 30 degrees can be achieved in each direction. If the patient is unable to achieve any part of the thoracic section they do not pass this section, and therefore no do not pass the overall screening tool

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

149 screening at Manchester Adult Cystic Fibrosis Centre. The sample of patients was screened by
150 an independent exercise physiologist in the CF team to ensure a spread of disease severity
151 (mild, moderate, severe, and very severe) (GOLD, 2008). Age, disease severity and presence
152 of pulmonary exacerbation were collected for each subject (Table 1).

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

159 ***Procedure***

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

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

168 Questions 1, 2, 3, 4 of section one relates to pain, urinary incontinence, and concerns about
169 posture and require a yes/no answer. These questions were not included in the videos as they
170 were not related to the study objectives to assess thoracic movement section. Participants
171 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?
7. With arms across chest is patient unable to rotate upper body to 45°?
8. With arms above head is patient unable to lean to 30°?

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).

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.

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 inter-rater 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. Percentage agreement between measures was also calculated.

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 (Landis and Koch, 1977). Percentage agreement ranged from 67%-97%.

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, 2004).

The kappa statistic was used to determine agreement of individual questions. No question was superior in agreement when compared to each other (Table 3).

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).

Discussion

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 physiotherapists are consistent in their scoring and we would recommend that the same physiotherapist repeats a patient's annual screen.

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.

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 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. For example:

- 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'.

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.

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

Strengths of the study include the use of video which provide a standardised assessment for 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 subjects or difficulties organising appointment around the microbiological subgroups. Also, it avoided the need for multiple thoracic movements which could have influenced the results obtained due to a warmup effect. Multiple independent trained personnel were included to reduce the possibility of bias, an adequate sample size and interval between tests was included to prevent a learning effect.

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 for instance.

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

As a result of this study a training video has been developed to describe the correct use of the tool. It is freely accessible on YouTube https://www.youtube.com/watch?v=sAOdNPSYm9M 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 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.

Conclusion

The thoracic movement screening section of the MMST demonstrates good intra-rater but 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, incontinence and postural changes are screened for. The tool may also be applicable to other respiratory diseases that encounter similar musculoskeletal issues.

Declaration of interest statement

Ethical Approval was granted by the Manchester metropolitan University ethics committee (ref: Phys/17/2). This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. There is no conflict of interest.

354 **Table 1: Characteristics of patients in the digital videos:**

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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

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

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

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Rater	Kappa	Classification Landis and Koch [26] (Appendix 2)	Bootstrapped 95% Confidence Interval	P =	Physiotherapist speciality	Work on the CF Unit	% agreement
A	0.521	Moderate	0.319 - 0.731	<0.001	Respiratory	Yes	77
B	0.931	Substantial	0.826 - 1.000	<0.001	Musculoskeletal	Yes	97
C	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
E	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
H	0.507	Moderate	0.286 - 0.729	<0.001	Musculoskeletal	No	77
I	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
K	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	

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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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374 **REFERENCES**:

375

376 Ashbrook JE, Taylor J, Jones A. 2011 The development of a musculoskeletal screening tool
377 for adults in cystic fibrosis. Journal of Cystic Fibrosis 10: Supplement 1. S6

378

379 Avery K, Donovan J, Peters TJ, Shaw C, Gotoh M, Abrams P 2004 ICIQ: a brief and robust
380 measure for evaluating the symptoms and impact of urinary incontinence. Neuro-urology
381 Urodynamics 23: 322-320.

382

383 Botton E, Saraux A, Laselve H, Jousse S, Goff P 2003 Musculoskeletal manifestations in Cystic
384 Fibrosis. Joint Bone and Spine 70: 327-335

385

386 Bowers D 1998. Medical statistic from scratch. (2nd Ed) West Sussex: John Wiley

387

388 Button BM, Yamin J, Holland A, Wilson J 2012 Evaluation of musculoskeletal and postural
389 function in cystic fibrosis using a physiotherapy screening tool. Journal of Cystic Fibrosis; sup
390 22 https://www.cysticfibrosisjournal.com/article/S1569-1993 (12)60069-1/pdf

391

392 Cohen J. 1960 A coefficient of agreement for nominal scales. Education Psychological
393 measurement 20: 37-46.

394

Cystic Fibrosis Trust. 2011 Standards of care and good clinical practice for the physiotherapy management of cystic fibrosis. https://www.cysticfibrosis.org.uk/the-work-we-do/clinical-care/consensus-documents

Cystic Fibrosis Trust. 2017 Standards of care and good clinical practice for the physiotherapy management of cystic fibrosis. https://www.cysticfibrosis.org.uk/the-work-we-do/clinical-care/consensus-documents.

Davis PB 2006 Cystic fibrosis since 1938. American Journal Respiratory Critical Care Medicine 173: 475-82

Dennis R, Finch C, Elliott B, Farhart, P 2008 The reliability of the musculoskeletal screening test used in cricket. Physical Therapy in Sport 9: 25-33.

Gabbe B, Bennell K, Wajswelner H, Finch C 2004 Reliability of common lower extremity musculoskeletal screening tests. Physical Therapy in Sport 5: 90-97.

Global Initiative for chronic obstructive lung disease (GOLD) Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease (2008). https://goldcopd.org/gold-2017-global-strategy-diagnosis-management-prevention-copd/

416 Grafton K, Foster N and Wright C. 2005 Test-retest reliability of the Short-Form McGill Pain
417 Questionnaire. Clinical Journal of Pain 21: 73-82.

418

419 Havermans T, Colpaert K, Boeck K, Dupont L, Abbott J. 2013 Pain in CF: Review of the
420 literature. Journal of Cystic Fibrosis 12: 423-430.

421

422 Hayes AF, Krippendorff K. 2007 Answering the call for a standard reliability measure for
423 coding data. Communication Methods and Measures 1: 77-89.

424

425 Hodges PW, Gurfinkel VS, Brumagne S, Smith C, Cordo PC. 2002 Coexistence of stability
426 and mobility in postural control: evidence from postural compensation for respiration.
427 Experimental Brain Research 144: 293-302

428

429 Jones, M. 2004 Reliability of nutritional screening and assessment tools. Nutritional
430 Methodology 20: 307-311.

431

432 Kottner J, Audige L, Brorson, S, Donner A, Gajewski B, Hrobjartson A, Roberts C, Shoukri
433 M, Streiner D. 2011 Guidelines for reporting reliability and Agreement Studies (GRRAS) were
434 proposed. International Journal of Nursing Studies 48: 661-671.

435

436 Krippendorff K. 2004 Content analysis: An introduction to its methodology (2nd Ed)
437 Thousand Oaks, CA: SAGE.

438

439 Laghi F and Tobin M 2003 Disorders of the respiratory muscles. American Journal of
440 Respiratory Care Medicine 168:10-48.

441

442 Landis JR and Koch GG 1977. The measurement of observer agreement for categorical data.
443 Biometrics 33: 159.

444

445 Lundon K, Li A, Bibershtein S 1998 Interrater and inter-rater reliability in the measurement of
446 kyphosis in postmenopausal women with osteoporosis. Spine 23: 1978-1985.

447

448 Mandrusiak A, Giraud D, Macdonald J, Wilson C, Watter P 2010 Muscle length and joint range
449 of motion in children with Cystic Fibrosis compared to children developing typically.
450 Physiotherapy Canada 62: 141-146.

451

452 Massery M 2005 Musculoskeletal and neuromuscular interventions: a physical approach to
453 cystic fibrosis. Journal of the Royal Society of Medicine 98 (suppl.45):55-56

454

455 Parasa, RB, Muffulli, N 1999 Musculoskeletal involvement in Cystic Fibrosis. Bulletin
456 (Hospital joint diseases) 58: 37-44.

457

458 Sandsund CA, Roughton M, Hodson M, Pryor J 2011 Musculoskeletal techniques for clinically
459 stable adults with cystic fibrosis: a preliminary randomised controlled trial. Physiotherapy 97:
460 209–17

461

462 Schindel C, Hommerding P, Denizar M, Bapitista R, Marostica P, Donadio M 2015 Physical
463 exercise recommendations improve postural changes found in children and adolescents with
464 Cystic Fibrosis: A randomised controlled trial. The Journal of Paediatrics 166: 710-16
465
466 Steiner DL, Norman GR 2003 Health measurement scales: A practical guide to their
467 development and use. (3rd ed) Oxford: Oxford University press.
468
469 Strand LI, Ljunggren A, Bogen B, Ask T, Johnsen T 2008 The Short-Form McGill Pain
470 Questionnaire as an outcome measure: test-retest reliability and responsiveness to change.
471 European Journal of Pain 12: 917–25.
472
473 Tattersall R, Walshaw MJ 2003 Posture and cystic fibrosis. Journal of the Royal Society of
474 Medicine 96 (Supp 43):18-22
475
476 Walter SD, Eliasziw M, Donner A 1998 Sample size and optimal designs for reliability studies.
477 Statistics in Medicine 17: 101-110.
478
479 Xu X, Chang CC, Faber GS, Kingma I, Dennerlein 2011 The validity and interrater reliability
480 of video-based posture observation during asymmetric lifting tasks. Human Factors: The
481 Journal of the Human Factors and Ergonomic Society 53: 371.
482

Zapf A, Castell, S, Morawietz L, Karch A 2016 Measuring inter-rater reliability for nominal data- which coefficients and confidence intervals are appropriate? BMC Medical Research Methodology 16: 93.

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