Received: 15 September 2020 | Revised: 28 January 2021 | Accepted: 30 March 2021

DOI: 10.1002/erv.2839

WILEY

BRIEF REPORT

The Sit Up Squat Stand test and Hand Grip Strength: What is the role of tests of muscle power in risk assessment in Anorexia Nervosa?

Sara Etemadi[1] | **Grey Xiaoliai Sun**[1] | **Sum-Ping Leung**[1] | **Arshad Siddique**[1] | **Steven Cooper**[2] | **Nwabunma Christiana Ezenwa**[2] | **Janet Treasure**[3] | **Paul Robinson**[1]

[1]Department of Medicine, University College London (UCL), London, UK

[2]Department of Research, Barnet, Enfield and Haringey Mental Health Trust (BEHMHT), London, UK

[3]Neuroscience Division of Academic Psychiatry, Institute of Psychiatry Psychology, King's College London (KCL), London, UK

Correspondence
Paul Robinson, Department of Medicine, University College London, The Rayne Building, 5 University Street, London WC1E 6JF, UK.
Email: p.robinson@ucl.ac.uk

Abstract

Objectives: To investigate the validity and reliability of two variants of the Sit Up Squat Stand Test (SUSS) and Hand Grip Strength (HGS) in predicting BMI and BMI risk level in hospitalised patients with Anorexia Nervosa (AN).

Methods: 25 inpatients with AN were tested roughly weekly for up to 16 weeks. Muscle power was assessed by two independent researchers.

Results: Intra-class coefficients (ICCs) indicated high Inter-Rater Reliability (IRR) for the HGS (10 participants). Cohen's Kappa showed moderate IRR for the SUSS test (25 participants). Stepwise multiple regression showed that the SUSS tests plus HGS predicted BMI and BMI risk level explaining about two-third of the variance. Each test individually had lower predictive value. There was a little difference between the two versions of the SUSS tested.

Conclusions: HGS and SUSS are valid and reliable measurements of muscle power in AN. Together, the SUSS tests and the HGS represent a useful and effective measure of muscle power and hence one aspect of physical risk in Anorexia Nervosa. In the light of Covid restrictions, the SUSS test is one way that physical state can be monitored on video link in a way that is hard to falsify.

KEYWORDS
anorexia nervosa, hand grip strength, muscle power, risk assessment, SUSS test

Abbreviations: AN, Anorexia Nervosa; BMI, Body Mass Index; DSM 5, Diagnostic and Statistical Manual of Mental Disorders, 5th edition; ED, Eating Disorder; HGS, Hand Grip Strength; ICC, Intra-Class Coefficient; MRC, Medical Research Council; NRES committee, National Research Ethics Service Committee; rmANOVA, Repeated Measures Analysis of Variance; SMR, Standardised Mortality Ratio; SS, Squat Stand; SU, Sit Up; SUSS, Sit Up Squat Stand.

1 | INTRODUCTION

1.1 | Risk in anorexia nervosa

With Anorexia Nervosa (AN) having the highest Standardized Mortality Ratio (SMR) (around 5.9) of any psychiatric condition (Arcelus et al., 2011, Quadflieg et al., 2019), risk assessment is essential in treating the disorder and preventing a fatal outcome which occurs in around 5% of cases (Fichter & Quadflieg 2016; Steinhausen, 2002) In the MARSIPAN guidance (Royal College of Psychiatrists 2014), muscle power using the sit up squat stand test (SUSS) is one of the recommended measures when assessing risk.

1.2 | Muscle power and starvation

Muscle mass is reduced in AN, by 13% in one study (Polito et al., 1998). McLoughlin et al. (1998) demonstrated that AN is characterised by selective muscle type II fibre atrophy. Moreover, McLoughlin et al. (2000) found proximal muscular weakness, diminished lactate response to ischaemic exercise, and a reduction of serum carnosinase (a muscle enzyme) in AN. Bratland-Sanda et al. (2010) found that muscular strength and bone mineral density are lower in patients with AN but not Bulimia Nervosa.

While a reduction of muscular strength probably contributes to increased mortality in AN, muscle power, measured using Hand Grip Strength, was also found to play a part in all-cause mortality in an apparently healthy population (García-Hermoso et al., 2018).

1.3 | Muscle strength as a risk factor

Patients with eating disorders (EDs) are known to appear deceptively well, sometimes sabotaging treatment, by, for example, falsifying their own weight by water loading up to 9 litres (Robinson & Rhys Jones, 2018). The MARSIPAN guideline advises that risk assessment for AN should include a range of observations, which includes the Sit-Up-Squat-Stand test of muscle power to increase the detection of patients whose weight is falling and who may be attempting to conceal that fact.

1.4 | The sit-up squat-stand test of muscle power

The SUSS test of muscle power initially originated by one of the authors (Robinson, 2006). However, the Maudsley Eating Disorders Service has since published a variant of the test, which we are calling the SUSS-VARIANT, as part of a guide to a multifactorial medical risk assessment for EDs (Treasure, 2009). We decided while examining the SUSS test to compare it with the SUSS-VARIANT to identify any differences in performance between the two.

Core findings

- The SUSS (SITUP-SQUAT STAND) test is a test of muscle function in Anorexia Nervosa which has face validity and good test retest and inter-rater reliability.
- The HGS (Hand Grip Strength) also has good validity and reliability in Anorexia Nervosa with performance somewhat better than the SUSS.
- The two tests together add significantly to tests of muscle function in Anorexia Nervosa and we recommend they form part of clinical evaluation, monitoring and risk assessment.

1.5 | Clinical assessments of muscle power

Muscles, if considered as a single entity, constitute the largest organ in the body, and a 70 kg fasting man loses 434 g of protein per week, through gluconeogenesis (Daniel et al., 1977). Not surprisingly, the loss of muscle mass results in decreased muscle strength (Peng et al., 2007).

Muscle strength can be estimated using various measurements such as the Medical Research Council scale and, as studied here, the SUSS test and Hand Grip Strength (HGS) (Humphreys et al., 2002). HGS has mainly been tested in elderly, post-operative and chronically physically ill patients, and has been found to correlate, in those populations, with Bone Mineral Density, which might have relevance for AN (Norman et al., 2011). In Chinese elderly inpatients, HGS was correlated with nutritional status and BMI (Zhang et al., 2017).

The Medical Research Council Scale (MRC) (Table 1). Grades muscle power on a scale of 0 to 5 in (Medical Research Council, 1975). Use of this scale in patients with AN has not been published. However, Melchiorri and Rainoldi (2008) found, in a controlled study of patients with AN and controls, that there was no significant difference between AN patients and controls in torque observed during voluntary contraction of the thigh muscles. Hence, it is likely that the majority of AN patients would score highly on the MRC test which, we conclude, is unlikely to detect weakness in AN with sufficient sensitivity.

TABLE 1 Scoring of the MRC scale of muscle power

Score	Description
0	No contraction
1	Flicker or trace of contraction
2	Active movement, with gravity eliminated
3	Active movement against gravity
4	Active movement against gravity and resistance
5	Normal power

Abbreviation: MRC, Medical Research Council.

1.6 | Purpose

In the present study, we wished to examine the characteristics of the SUSS and HGS tests. How well do they assess muscle strength? Are they correlated with BMI? What is their inter-rater reliability? A secondary intention was to compare the SUSS with the SUSS_VARIANT.

1.7 | Hypotheses

The SUSS tests (SUSS and SUSS-VARIANT) and Hand Grip Strength (HGS)

1. Will be feasible and acceptable to patients and observers.
2. Will predict BMI in a group of inpatients with Anorexia Nervosa.
3. Will show good test-retest and inter-rater reliability.

2 | METHODS

2.1 | Study design

Participants with AN were tested by two ward doctors (Researchers 1 and 2). The SUSS test is carried out each week as part of the physical risk assessment for each patient admitted to the unit. Because each patient followed a full treatment programme, the tests were done whenever convenient for the patients during the daytime, between 0900 h and 1700 h. Each participant was approached by one researcher and asked to perform the SUSS test according the original version, then tested again according to the SUSS-VARIANT test. HGS was measured with a dynamometer. The second researcher then approached the participant and performed the same tests out of sight of the first researcher. The order of testing by the two researchers was varied randomly in order to correct for possible fatigue due to repeated testing.

Prior to commencing the study, ethical approval was granted by the West London NRES committee, reference 13/LO/1679.

2.2 | Study population

The participants were recruited from the inpatients in a 20 bedded acute inpatient unit for adults with an eating disorder requiring inpatient treatment.

The researcher then provided the participant with the patient information sheet and at least 24 h later, obtained informed written consent.

The inclusion criteria were:

1. Diagnosis of anorexia nervosa according to Diagnostic and Statistical Manual of Mental Disorders, 5th edition.
2. Patients having compulsory treatment were included in the study if able to provide informed consent. Approval of their psychiatrist was obtained.

The exclusion criteria were:

1. Lack of capacity to provide informed consent
2. Too unwell to participate.

Any significant physical findings were rapidly conveyed to the treating team.

2.3 | Muscle strength measures

Two versions of the SUSS test were performed, the SUSS and the SUSS_variant. Both use the Sit Up and Squat Stand tests. The SUSS test was performed as described (Royal College of Psychiatrists, 2014). It is illustrated in Figure 1. The scoring was as follows:

0: unable, 1. Unable without using hands or arms, 2. Able with noticeable difficulty, 3. Normal.

The SUSS-VARIANT was performed as described (Treasure, 2009). The only difference between the SUSS and the SUSS_VARIANT was the scoring instructions. In the SUSS-VARIANT scoring was adapted to a 4-point scale so that the two tests could be compared.

0 Unable, 1 Unable without using arms as leverage, 2 Unable without using arms for balance, 3. Normal.

Hand Grip Strength (HGS) was also measured weekly by each researcher separately using a handgrip

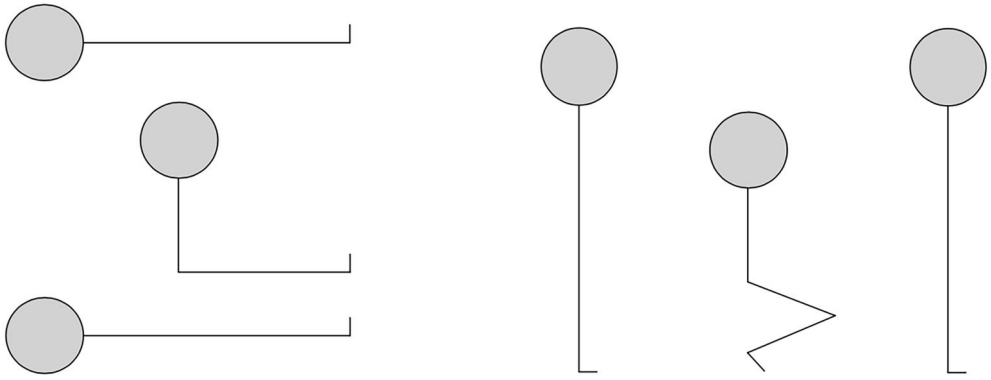

FIGURE 1 Instructions for the Sit Up Squat Stand (SUSS) test (Royal College of Psychiatrists 2014)

FIGURE 2 The Camry Hand Grip Strength dynamometer in use

dynamometer (Ahmed, 2020) (CAMRY Digital Hand Dynamometer (Figure 2)). The participant held the dynamometer in the dominant hand and squeezed as hard as possible. The researcher noted the result (in Kg) and took the best of 3 tries.

Testing took under two minutes. Patients were also routinely weighed weekly, and their most recent weight and BMI was provided by the ward staff.

2.4 | Statistical analysis

Statistical data analysis was undertaken using SPSS, version 25. Non-parametric tests were used whenever possible for the non-normal SUSS data. Descriptive statistics, Intra-Class Coefficients, and Cohen's Kappa for inter-rater reliability (Cohen, 1960; Landers, 2011), Pearson's r and Spearman's Rank Test for correlation and

TABLE 2 Age, BMI and initial scores on muscle measures. In brackets are the results for the 10 participants having the HGS test. There was one male in the study. Removing his muscle power results result in <5% change in data. The overall mean change was a 3% increase in power without the male

Variable	Mean	SD	n	Range
Age	32.1 (30.3)	13.5 (12.45)	25 (10)	18–60 (19–55)
BMI	14.2 (13.6)	1.39 (0.95)	25 (10)	11.6–17 (11.6–14.8)
Sit up	1.8 (1.8)	0.94 (1.14)	25 (10)	0–3 (0–3)
Squat stand	2.26 (2.05)	0.9 (1.09)	25 (10)	0–3 (0–3)
Sit up (variant)	1.9 (2.0)	0.97 (1.15)	25 (10)	0–3 (0–3)
Squat stand (variant)	2.28	0.89	25 (10)	0–3 (0–3)
HGS (kg)	18.9	4.85	10	10.6–26.7
Days in study	69.8 (70)	32.9 (0)	25 (10)	14–159
Number of observations	9.84 (10)	3.21 (10)	25 (10)	4–16 (10)

Abbreviation: HGS, Hand Grip Strength.

TABLE 3 Inter-rater reliability. Cohen's Kappa and Intra-Class Variance for measures of muscle power

Measure	Cohen's Kappa	Intra-Class Correlation	n
SU Res 1 versus **Res 2**	**0.52**	**NA**	**183**
SS Res 1 versus **Res 2**	**0.58**	**NA**	**183**
SUV Res 1 versus **Res 2**	**0.40**	**NA**	**183**
SSV Res 1 versus **Res 2**	**0.52**	**NA**	**183**
HGS Res 1 versus **Res 2**	**NA**	**0.940**	**87**

Note: $P < 0.001$ all comparisons.

Abbreviations: HGS, Hand Grip Strength; n, number of subjects; Res 1, Res 2: Researcher 1, Researcher 2; SU, Sit Up; SS, Squat Stand; SUV, Sit Up Variant; SSV, Squat Stand Variant.

stepwise multiple regression to assess prediction of BMI and BMI risk level (Royal College of Psychiatrists, 2014) (<13 or >13). Significance was set at $P < 0.05$.

3 | RESULTS

3.1 | Participants characteristics (Table 2)

Twenty-five inpatients were included in the study including a male. Participants were tested a mean of 9.84 times over a mean of 69.8 days (range 36–128 days). No patient refused to participate, although two were approached and subsequently excluded because they were too unwell. The number of data points varied between participants. Some were not available every week, some had been discharged while some were too ill to participate. Hand grip strength was introduced part way through the study, and only 10 participants received that measurement. Initial measurements for each of the muscle power tests are presented in Table 2. No patient refused testing, unless he or she felt too unwell.

3.2 | Inter-rater reliability

ICC and Kappa results are given in Table 3 and HGS agreement is illustrated in Figure 3. ICC values between 0.75 and 0.9, and greater than 0.90 are indicative of good, and excellent reliability, respectively (Koo & Li, 2016; Ottenbacher & Stull, 1993; Richman et al., 1980). Hence the HGS test reliability was 'Excellent'. For the Squat Stand and Sit Up measures, Kappa levels (Cohen, 1960), demonstrate 'Moderate' agreement (0.4–0.6).

3.3 | Validity of the measures

We examined this construct by calculating the Pearson correlation coefficients or Spearman Rank tests (non-parametric) between BMI measures and each of the muscle power tests. The results are seen in Table 4. Correlations were moderate in size (0.361–0.411 for the SUSS and 0.659 for the HGS) and all correlations were significant at $p < 0.001$. We present a scatter plot of the HGS against BMI in Figure 4.

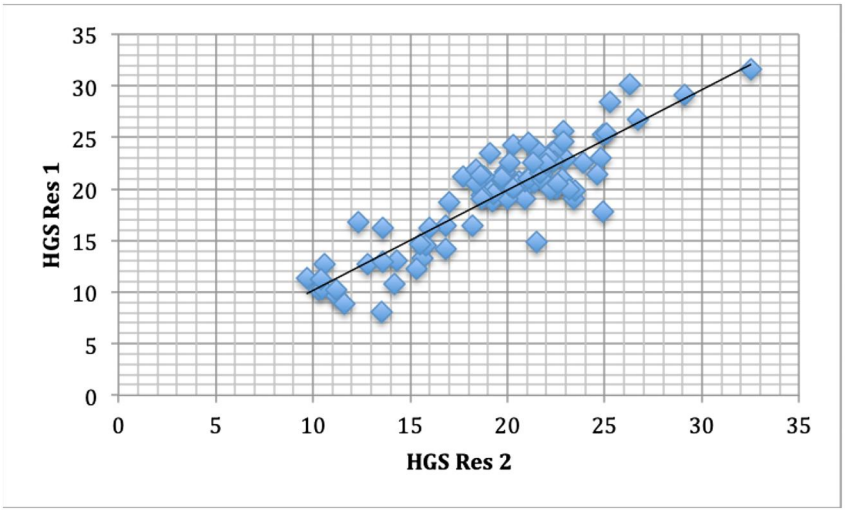

FIGURE 3 Showing Researcher 1 and Researcher 2 scores on using the Hand Grip Strength test (HGS), all 88 measurements made. ICC = 0.885

TABLE 4 Correlations between measures of muscle power and BMI

Measure	Spearman's rank	% Variance explained	N
SU versus **BMI**	**0.411**	**16.89%**	**175**
SS versus **BMI**	**0.361**	**13.03%**	**175**
SUV versus **BMI**	**0.363**	**13.18%**	**175**
SSV versus **BMI**	**0.340**	**11.56%**	**175**
	Pearson's r		
HGS versus **BMI**	**0.659**	**43.43%**	**81**

Note: $p < 0.001$ for all correlations. For non-normal data Spearman's Rank test was used, otherwise Pearson's r was used.

Abbreviations: HGS, Hand Grip Strength; n, number of subjects; SU, Sit Up; SS, Squat Stand; SUV, Sit Up Variant; SSV, Squat Stand Variant.

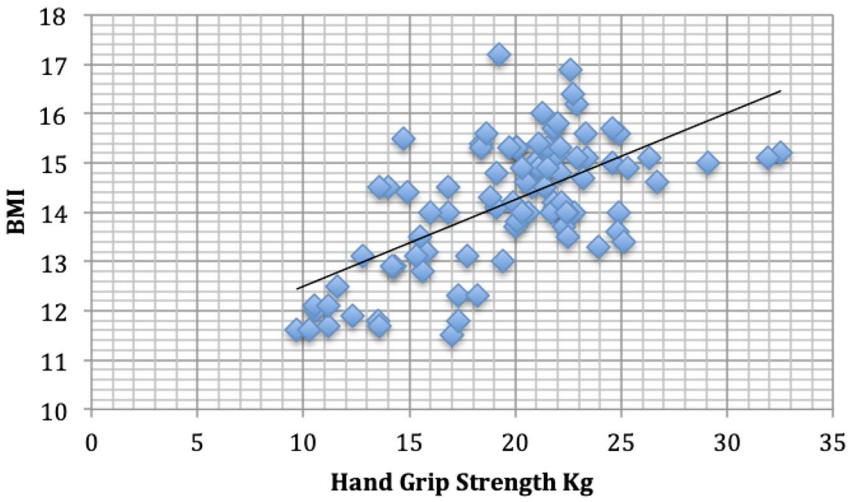

FIGURE 4 BMI and Hand Grip Strength (HGS) for all 88 measurements. Pearson's $r = 0.659$, $p < 0.001$

3.4 | Predicting BMI

We performed stepwise linear regression including average (between Researchers) ratings of each measure of muscle power as the independent variables and BMI as the dependent variable. Each SUSS model was tested separately (Table 5). Both the SUSS/HGS and the SUSS-VARIANT/HGS explained about two-third of the variance in BMI with little difference between them. Only the Squat Stand and HGS had significant coefficients in this analysis.

TABLE 5 Comparing the two models. Results of Stepwise Multiple Regression. Only the 10 participants having the HGS are included

Model	R^2	ANOVA	Coefficients		
DV = BMI		F (3,77) =	Sit up	Squat stand	HGS
IVs = SUSS + HGS	0.644 (64.4% variance)	46.4, $p < 0.001$	NS	$t = 2.94$ $p = 0.004$	$t = 2.66$ $p = 0.009$
IVs = SUSS-VARIANT + HGS	0.663 (66.3% variance)	50.5, $p < 0.001$	NS	$t = 2.50$ $p = 0.014$	$t = 3.98$ $p = <0.001$

Note: R^2: percent variance in BMI explained. R^2 change: change in percent variance explained by adding additional variable.

Abbreviations: ANOVA, Analysis of Variance for each regression model; DV, Dependent variable; HGS, Hand Grip Strength; NS, Not significant; SS, Squat Stand; SU, Sit Up; SUSS-VARIANT, Sit Up Squat Stand Variant.

TABLE 6 Influence of each element in the tests of muscle power. Only the 10 participants having the HGS are included. Results of Stepwise Linear Regression

Regression model (DV = BMI)	R^2% variance	R^2 change % variance	Significance of change	ANOVA significance
SS	59.9%	59.9%	$P < 0.001$	$P < 0.001$
SS + SU	61.1%	1.2%	NS	$P < 0.001$
SS, SU, HGS	63%	3.3%	$P = 0.009$	$P < 0.001$
SS + HGS	63.7%	−0.7%	NS	$P < 0.001$

Note: R^2: percent variance in BMI explained. R^2 change: change in percent variance explained by adding additional variable.

Abbreviations: ANOVA, Analysis of Variance for each regression model; DV, Dependent variable; HGS, Hand Grip Strength; NS, Not significant; SS, Squat Stand; SU, Sit Up.

In order to study the different measures, we performed a stepwise linear regression for the SUSS test. The results are summarised in Table 6. The regression produced four models: 1. Squat Stand (SS), 2. SS + Sit Up (SU), 3, SS + SU + HGS, 4. SS + HGS. The ANOVAS for all 4 regression models were highly significant. However, only models 1 and 3 added significantly to the change in R^2. We can also see from the correlations (Table 4) that, using r^2 or Spearman's ρ^2 to estimate proportion of variance explained, the four SUSS tests each explained around 19% of the variance in BMI and the HGS performed better, explaining 43.4%. In a further stepwise linear regression with BMI <13 or >13 (Table 7), the three tests all gave significant coefficients and all the ANOVAs were significant. For both regressions the three tests together accounted for an average of 65.4% of the variance.

3.5 | Impact of researcher and SUSS model

A repeated measures ANOVA including Researcher (1 and 2), SUSS-Model (SUSS and SUSS variant) and time point up to Timepoint 6, showed no effect of Researcher, SUSS-Model or Timepoint. After Timepoint 6 missing values increased substantially as participants were discharged. Thus, the two Researchers not only had good inter-rater reliability, but their results were indistinguishable in the rmANOVA. Moreover, the two SUSS models were not significantly different from each other.

4 | DISCUSSION

4.1 | Summary of main findings

In this study, 25 inpatients with a primary diagnosis of AN performed the SUSS and SUSS-VARIANT tests of muscle power carried out by two independent researchers over a 17-month period. The purpose of this study was to investigate the inter-rater reliability and validity of the SUSS and SUSS-VARIANT test of muscle power, in clinically assessing muscle weakness, in patients suffering from AN and its association with BMI and in 10 participants, Hand Grip Strength.

We found that all of the test-retest reliabilities were moderate or excellent in the SUSS and SUSS-VARIANT tests of muscle power as well as HGS. Secondly we found that both the SUSS models were fairly and equally good at predicting BMI indicating fairly good face validity. However, Hand Grip Strength was substantially better at predicting BMI than either of the SUSS models and that SUSS plus HGS explained two thirds of the variance in BMI and in BMI risk level.

Hand Grip Strength has been well studied in malnourished individuals. In a systematic review by Bohannon (2017) it was reported that 14 out of 17 studies obtained good to excellent ICC (>0.80) in HGS measured by dynamometry. In our study, HGS was found to have excellent inter-rater reliability and moderate ability to predict BMI.

TABLE 7 Stepwise Linear Regression for all tests with prediction of a BMI<13 as the dependent variable. Only the 10 participants having the HGS are included. All models were significant and all individual tests contributed significantly to change in variance

Regression model (DV = BMI<13)	R^2% variance	R^2 change % variance	Significance of change	ANOVA significance
SS	55.6%	55.6%	$P < 0.001$	$P < 0.001$
SS + SU	58.2%	2.6%	$P = 0.025$	$P < 0.001$
SS, SU, HGS	63.3%	5.1%	$P = 0.001$	$P < 0.001$

Note: R^2: percent variance in BMI explained. R^2 change: change in percent variance explained by adding additional variable.

Abbreviations: ANOVA, Analysis of Variance for each regression model; DV, Dependent variable; HGS, Hand Grip Strength, NS, Not significant; SS, Squat Stand; SU, Sit Up.

4.2 | The role of muscle testing in risk assessment of Anorexia Nervosa

Patients with AN are well known to try and falsify their weight in order to avoid hospital admission. This is understandable in a condition in which weight and shape contribute so greatly to self-esteem and self-worth, and patients have been known to conceal falling weight because they seem more afraid of weight gain than of death. The following describes a case of water loading detected using the SUSS test (Robinson, 2006):

Case description: An 18-year-old patient with AN was being followed up as an outpatient. Her BMI was 11.6, and she was being monitored regularly with a view to admission which she rejected. For five weeks her weight steadily increased, by a total of 5 kg and her SUSS test remained satisfactory. After that time, although her weight increased, her sit up scores fell to zero, and, in spite of further weight gain, she was admitted against her will to an eating disorders unit. On the day of admission she lost 3.2 kg and admitted to having water-loaded over the previous two weeks. She thanked the doctor saying 'I don't think I could have drunk any more'.

In order to become aware of the patient's true risk, BMI, vital signs, muscle power, blood tests and ECG are recommended (Royal College of Psychiatrists, 2014) and the present study shows that muscle testing has good predictive value for BMI. In an inpatient setting, falsification of BMI is less likely than in outpatients because patients are under supervision and have limited access to water. Moreover, weighing was done first thing in just one layer of clothing. However, water loading still does occur in inpatients and the BMI of some patients could have been falsified. In pursuit of standardising the SUSS test we have produced a video showing the performance and scoring of the SUSS (Video 2020).

Falling scores on the SUSS test of muscle power can indicate that the patient may be developing severe under-nutrition although other factors such as Potassium deficiency can lead to muscle weakness (Meltem et al., 2009).

We aimed to compare the two models of the SUSS and found them to be very similar. Hence clinicians are free to decide which test to use. It would be preferable, however if one of the tests could be the agreed method. Correlations showed a slightly better performance for the original SUSS test. We also wished to compare each of the SUSS tests with Hand Grip Strength (HGS). HGS predicted BMI better than the other measures in correlation calculations and the three tests together explained about two-third of the variance in BMI, and BMI <13. We conclude that all three tests contribute to risk assessment and that use of just one or two of them gives sub-optimal information.

4.3 | Strengths and limitations

This study examined only hospitalised patients from one institution and therefore may be at a worse physical state. Gender difference were not explored. The number of participants was rather small which indicates the need for replication and a multi-centre study to increase recruitment numbers. One participant was male and this could have affected the level of muscle power although the correlations and repeated measures would not be affected. Removing the male participant had no significant impact on the results (Table 2). In fact, the ratings of muscle power were, on average, slightly higher without the male patient. A strength of this study is that it is the first study to investigate several tests of muscle power sequentially in AN during weight restoration.

5 | CONCLUSION

In this study we found that the SUSS test and HGS have moderate to excellent inter-rater reliability, and that the tests perform well together in predicting BMI. We are aware that some clinicians only use one of the tests (generally the Squat Stand test) in monitoring muscle power. We recommend the use of all three tests because,

together, their predictive value is better than any of the tests separately. We found little difference in performance between the two versions of the SUSS test, and both have face-validity. We recommend that muscle power be included in risk assessment for Anorexia Nervosa. In the light of Covid restrictions, the SUSS test is one of the few ways that physical state can be monitored on a video link in a way that is hard to falsify.

ACKNOWLEDGEMENTS

We are grateful to the patients and staff at St Ann's Hospital, Haringey, London where the work was carried out.

DATA SHARING

At this stage we are not planning to share data.

CONFLICT OF INTEREST

No author declares any conflict of interest.

VIDEO DEMONSTRATION OF SUSS TEST

https://youtu.be/4WUF6GLu3J4 (Also available as an mp4 file from corresponding author).

ORCID

Janet Treasure https://orcid.org/0000-0003-0871-4596
Paul Robinson https://orcid.org/0000-0001-8158-4383

REFERENCES

Ahmed, I. (2020). Sarcopenia: Hand grip dynamometers, the latest addition to the doctor's bag. *British Journal of General Practice*, *70*(695), 2-280. https://doi.org/10.3399/bjgp20X709997

Arcelus, J., Mitchell, A. J., Wales, J., & Nielsen, S. (2011). Mortality rates in patients with anorexia nervosa and other eating disorders. *Archives of General Psychiatry*, *68*(7), 724–731.

Bohannon, R. (2017). Test-retest reliability of measurements of hand-grip strength obtained by dynamometry obtained from older adults: A systematic review of research in the Pubmed database. *The Journal of Frailty and Aging (JFA)*, *6*(2), 83–87.

Bratland-Sanda, S., et al. (2010). Physical activity and exercise dependence during inpatient treatment of longstanding eating disorders: An exploratory study of excessive and non-excessive exercisers. *International Journal of Eating Disorders*, *43*(3), 266–273.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*, 37–46.

Daniel, P. M., Pratt, O. E., & Spargo, E. (1977). The metabolic homeostatic role of muscle and its function as a store of protein. *The Lancet*, *310*(8035), 446–448.

Fichter, M. M., & Quadflieg, N. (2016). Mortality in eating disorders - results of a large prospective clinical longitudinal study. *International Journal of Eating Disorders*, *49*(4), 391–401.

García-Hermoso, A., Cavero-Redondo, I., Ramírez-Vélez, R., Ruiz, J. R., Ortega, F. B., Lee, D.-C., & Martínez-Vizcaíno, V. (2018). Muscular strength as a predictor of all-cause mortality in an apparently healthy population: A systematic review and meta-analysis of data from approximately 2 million men and women. *Archives of Physical Medicine and Rehabilitation*, *99*(10), 2100–2113

Humphreys, J., de la Maza, P., Hirsch, S., Barrera, G., Gattas, V., & Bunout, D. (2002). Muscle strength as a predictor of loss of functional status in hospitalized patients. *Nutrition*, *18*(7–8), 616–620.

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155–163.

Landers, N. (2011). *Computing Intraclass Correlations (ICC) as estimates of interrater reliability in SPSS*. http://neoacademic.com/2011/11/16/computing-intraclass-correlations-icc-as-estimates-of-interrater-reliability-in-spss/

McLoughlin, D. M., Spargo, E., Wassif, W. S., Newham, D. J., Peters, T. J., Lantos, P. L., & Russell, G. F. M. (1998). Structural and functional changes in skeletal muscle in anorexia nervosa. *Acta Neuropathologica*, *95*(6), 632–540.

McLoughlin, D. M., Wassif, W. S., Morton, J., Spargo, E., Peters, T. J., & Russell, G. F. M. (2000). Metabolic abnormalities associated with skeletal myopathy in severe anorexia nervosa. *Nutrition*, *16*(3), 192–196.

Medical Research Council. (1975). *Aids to the examination of the peripheral nervous system*. Her Majesty's Stationary Office. [online] https://mrc.ukri.org/documents/pdf/aids-to-the-examination-of-the-peripheral-nervous-system-mrc-memorandum-no-45-superseding-war-memorandum-no-7/ Accessed 28 Jan 2021.

Melchiorri, G., & Rainoldi, A. (2008). Mechanical and myoelectric manifestations of fatigue in subjects with anorexia nervosa. *Journal of Electromyography and Kinesiology*, *18*(2), 291–297.

Meltem, A. C., Figen, C., Nalan, M. A., Mahir, K., Sebnem, B., Mehlika, I., Kasim, K. A., & Miyase, B. (2009). A hypokalemic muscular weakness after licorice ingestion: A case report. *Cases Journal*. *2*, 8053.

Norman, K., Stobäus, N., Gonzalez, M. C., Schulzke, J.-D., & Pirlich, M. (2011). Hand grip strength: Outcome predictor and marker of nutritional status. *Clinical Nutrition*, *30*(2), 135–142.

Ottenbacher, K., & Stull, G. A. (1993). The analysis and interpretation of medical comparison studies in rehabilitation research. *American Journal of Physical Medicine and Rehabilitation*, *72*(5), 266–271.

Peng, S., Plank, L. D., McCall, J. L., Gillanders, L. K., McIlroy, K., & Gane, E. J. (2007). Body composition, muscle function, and energy expenditure in patients with liver cirrhosis: A comprehensive study. *American Journal of Clinical Nutrition*, *85*(5), 1257–1266.

Polito, A., Cuzzolaro, M., Raguzzini, A., Censi, L., & Ferro-Luzzi, A. (1998). Body composition changes in anorexia nervosa. *European Journal of Clinical Nutrition*, *52*(9), 655–662.

Quadflieg, N., Strobel, C., Naab, S., Voderholzer, U., & Fichter, M. M. (2019). Mortality in males treated for an eating disorder-A large prospective study. *International Journal of Eating Disorders*, *52*(12), 1365–1369.

Richman, J., Makrides, L., & Prince, B. (1980). Research methodology and applied statistics. Part 3: Measurement procedures in research. *Physiotherapie Canada*, *32*, 253–257.

Robinson, P. (2006). *Community treatment of eating disorders*. Wiley.

Robinson, P., & Rhys Jones, W. (2018). Marsipan: Management of really sick patients with anorexia nervosa. *BJPsych Advances*, *24*(1), 20–32.

Royal College of Psychiatrists. (2014). *MARSIPAN: Management of really sick patients with anorexia nervosa* (2nd ed.). Royal College of Psychiatrists.

Steinhausen, H.-C. (2002). The outcome of anorexia nervosa in the 20th century. *American Journal of Psychiatry*. *159*(8), 1284–1293.

Treasure, J. (2009). *A guide to the medical risk assessment for eating disorders*. http://www.network-ed.org.uk/wp-content/uploads/Guide-to-Medical-Risk-Assessment-IOP.pdf Accessed 28 Jan 2021.

Zhang, X. S., Lui, Y. H., Zhang, Y., Xu, Q., Yu, X. M., Yang, X. Y., Liu, Z., Li, H. Z., Li, F., & Xue, C. Y. (2017). Handgrip strength as a predictor of nutritional status in Chinese elderly inpatients at hospital admission. *Biomedical and Environmental Sciences*, *30*(11), 802–810.

How to cite this article: Etemadi S, Sun GX, Leung SP, et al. The Sit Up Squat Stand test and Hand Grip Strength: What is the role of tests of muscle power in risk assessment in Anorexia Nervosa? *Eur Eat Disorders Rev*. 2021;1–10. https://doi.org/10.1002/erv.2839