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Effect of Self-Reported Distress Thermometer Score on the Maximal Handgrip and Pinch Strength Measurements in Hemodialysis Patients

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Abstract

Background: Muscle weakness is a risk factor for mortality in hemodialysis (HD) patients. Muscle strength measurements are routinely used as a screening tool but depend on patient cooperation and motivation. We wished to determine whether measuring maximal voluntary muscle strength was affected by patient self-reported distress. *Methods:* We measured pinch strength (PS) and handgrip strength (HGS) in 382 adult HD patients with a corresponding self-reported distress thermometer (DT) scores. Postdialysis body composition measurements were made using multifrequency bioelectrical assessments and patients assessed for frailty. *Results:* Mean age was 66.4 ± 14.9 years, with 238 males (62%), 48% diabetic, and dialysis vintage 36 (15–75) months. The mean DT score was 4.4 ± 3.3, with a frailty score of 4.6 ± 1.5. On multivariable analysis, DT scores were associated with frailty ($\beta = 0.35$, $P = .003$), prescription of aspirin for cardiac disease ($\beta = 1.0$, $P = .004$), lean body mass ($\beta = 0.04$, $P = .004$), and negatively with age ($\beta = -0.05$, $P < .001$), hematocrit ($\beta = -8.2$, $P = .004$), and maximum PS ($\beta = -1.4$, $P = .003$). *Conclusion:* Paradoxically higher self-reported DT scores were associated with younger age and lean body mass. As such, younger healthier, rather than more comorbid, patients may have greater expectations for their health and therefore report more distress. We found no association between DT scores and HGS, and as such, although HGS is a voluntary test, it appears to be a robust test independent of patient stresses. However, PS was lower in patients with higher DT scores, and as such, greater care may be required in interpreting these measurements. (*Nutr Clin Pract*. XXXX;xx:xx-xx)

Keywords

chronic kidney disease; dialysis; hand strength; pinch strength; muscle strength; distress thermometer; chronic renal insufficiency; wasting syndrome

Patients with chronic kidney disease (CKD) requiring hemodialysis (HD) are at increased risk of muscle wasting, termed *sarcopenia*.[1] There are potentially many causes for muscle weakness and loss of muscle loss, ranging from reduced physical activity and dietary protein intake, coupled with urinary protein losses, increased catabolism driven by the inflammatory milieu of uremia, vitamin D deficiency, insulin resistance, anemia, depression, testosterone deficiency in men, and protein losses associated with dialysis treatments.[1–3]

As HD patient survival is reduced in cases of both muscle weakness and wasting, rapid screening tests are useful to detect muscle weakness and wasting at an early stage. Although dual-energy x-ray absorptiometry (DXA) and bioimpedance methods can be used to assess lean body mass (LBM),[4,5] these methods may overestimate LBM in patients who are overhydrated.[6,7] As such, many kidney dialysis centers use handgrip strength (HGS) as a functional assessment of muscle weakness,[8] which can be readily tested when patients attend for dialysis sessions or in the outpatient clinic.

However, HGS is measured as a maximum voluntary effort and as such depends on patient cooperation. Historically, studies used additional electrical stimulation to ensure that all muscle motor units were contracting to determine that there was no increase above the maximum voluntary effort. However, this requires specialized equipment and may cause discomfort to patients.[9]

For more than a decade, our institution has used a simple visual analog scale as a rapid screening tool for assessing distress in patients with cancer.[10] Since then, the distress thermometer (DT) has been used and validated in patients and their caregivers with various cancers and other chronic medical conditions, including chronic heart failure and human

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immunodeficiency virus.[11,12] In our institution, the DT has been used as a rapid screening tool for assessing adjustment disorders and major depression.[13] It was shown to have acceptable sensitivity and specificity compared with other screening tests, including the Hospital Anxiety and Depression Scale (HADS) and the 12-item General Health Questionnaire (GHQ-12).[14] It was also found to be readily acceptable by patients.[14]

As several studies have reported a discrepancy between muscle mass and muscle strength in HD patients,[5] we wished to determine whether there could be an effect of psychological distress in HD patients that would affect the maximum voluntary effort achieved when measuring HGS.

Methods

Adult patients with CKD established on dialysis attending for routine outpatient HD treatments were asked to provide a self-reported DT score[10,15] and were also assessed using the Canadian frailty score as a measure of general physical ability (Supplementary Table S1).[16] Maximum voluntary muscle strength was measured using both HGS and pinch strength (PS) with the grip-D strength dynamometer (Takei Scientific Instruments, Nigata, Japan) and a pinch gauge (Jamar digital plus; Lafayette Instrument, Lafayette, IN). Patients were instructed and shown how to use both strength gauges, and measurements were made according to the manufacturer's recommendations with patients asked to make their maximal voluntary exertion.[17] Three measurements were made in the dominant arm, unless the patient had an arteriovenous fistula or graft that prevented them from using the strength gauges, and the maximal value was recorded.

Multifrequency bioelectrical assessment (MFBIA) was performed using an 8-electrode segmental bioimpedance device (InBody 720; InBody, Seoul, South Korea)[18] after the midweek outpatient HD session in 3 freestanding kidney dialysis centers. Patients were asked to wait after the dialysis session had been completed to allow for reequilibration, and then MFBIA was measured in a standardized manner, after they had emptied the bladder.[19] Patients who were pregnant and those with ascites were excluded.[20] MFBIA measured total body water (TBW), intracellular water (ICW), extracellular water (ECW), and body cell mass (BCM). Body composition determined by MFBIA divided the body into fat mass (FM) and fat-free mass (FFM). Patient comorbidity was assessed using the Davies-Stoke comorbidity scoring system.[21] Pre-midweek blood samples were taken for measurement of urea, creatinine, hemoglobin, and C-reactive protein (CRP). Dialysis adequacy was calculated from corresponding postdialysis samples, and urea generation in the interdialytic interval was calculated from the difference in predialysis and postdialysis serum urea concentrations and bioimpedance-measured TBW.

This retrospective audit complied with the U.K. National Health Service (NHS) guidelines for clinical audit, and service development was approved. Individual patient consent was waived by the local research and development office as the audit was compiled with NHS guidelines (U.K. NHS guidelines for clinical audit and service development, available at http://www.hra.nhs.uk/documents/2013/09/defining-research.pdf and http://www.gov.uk/government/publications/health-research-ethics-committees-governancearrangements).

Statistical Analysis

Data are presented as mean ± standard deviation, median (interquartile range), or as percentage. Standard statistical tests were used (*t* test, Mann-Whitney *U* test, and χ^2 test) with appropriate corrections made for multiple testing, where appropriate. Correlation was by Pearson or Spearman analysis, depending on whether variables were normally distributed. Nonparametric data were log transformed for multivariable backward linear analysis, using all variables with a $P < .1$ correlation, and then variables were excluded if not statistically significant, unless they improved the model fit. Models were checked for variable inflation factor and collinearity between variables. Statistical analysis used Prism 6.0 (GraphPad Software, San Diego, CA) and SPSS (SPSS version 21; SPSS, Inc, an IBM Company, Chicago, IL). Statistical significance was taken as $P < .05$.

Results

In total, 382 of 412 established HD patients attending for routine outpatient dialysis provided self-reported DT scores. In all cases but 1, failure to complete self-reporting DT was due to the inability to understand how to self-report distress, predominantly due to language barriers. We studied 238 males (62%), 48% diabetic, with a mean age of 66.4 ± 14.9 years, a median dialysis vintage of 36 (15–75) months, and a median Davies comorbidity grade 1 (1–2) (Table 1). Most patients were white (47%), followed by African-Afro-Caribbean (26%). Dialysis adequacy was assessed by a sessional urea reduction ratio of 74.0% ± 8.9% and single-pool K_t/V_{urea} of 1.3 ± 0.41. The mean DT score was 4.4 ± 3.3, with a frailty score of 4.6 ± 1.5. The right arm was dominant in 91% of patients, and measurements were made in the right arm in 87% of cases. The maximum HGS and PS was 16.6 (12.3–23.1) kg and 5.5 (3.9–7.8) kg, respectively.

As expected, male patients were stronger and had more FFM and less FM than female patients (Table 1). Normative data for sex- and age-matched healthy participants have been reported for HGS and PS to be around 41 kg for men and 26 kg for women and 8.7 kg and 6.4 kg, respectively.[22,23]

There were no differences between the sexes in terms of patient age, dialysis vintage, or predialysis hemoglobin, serum albumin, urea, or CRP. More female patients were assessed as having a greater frailty score, but more male patients had undergone coronary artery stenting or coronary

Table 1. Patient Demographics Divided by Sex.[a]

Characteristic	Female	Male
Number	144	238
Age, y	65.2 ± 15.0	67.2 ± 14.8
Dialysis vintage, mo	34.1 (14.4–77.9)	38.0 (16.5–75.0)
Diabetic, %	49.3	48
Myocardial infarction, %	18.8	27.0
CABG/coronary stent, %	11.1	27.0[b]
Peripheral vascular disease, %	10.4	17.8
Cerebrovascular accident, %	15.3	14.0
Malignancy, %	10.4	6.41
Davies comorbidity grade	1 (1–1)	1 (1–2)
Frailty grade	4.9 ± 1.5	4.4 ± 1.6[c]
Distress thermometer score	4.2 ± 3.4	4.5 ± 3.2
Postdialysis weight, kg	67.1 ± 19.9	73.4 ± 14.8[b]
Body cell mass, kg	26.1 ± 5.7	33.6 ± 7.4[b]
Fat-free mass, kg	41.1 ± 8.8	52.7 ± 11.5[b]
Body fat mass, kg	26.0 ± 15.0	20.8 ± 10.8[c]
Body fat, %	36.3 ± 10.6	27.67 ± 10.6[b]
Dominant right arm, %	90.3	91.2
Maximum HGS, kg	12.8 (9.1–16.8)	19.6 (14.8–25.7)[b]
Maximum PS, kg	4.4 (3.1–6.7)	5.9 (4.5–8.7)[b]
Maximum right arm HGS, kg	12.8 (9.1–17.4)	19.8 (15.1–26.0)[b]
Maximum left arm HGS, kg	12.7 (7.5–16.2)	18.2 (13.7–24.0)[b]
Maximum right hand PS, kg	4.4 (3.1–7.1)	5.9 (4.6–8.7)[b]
Maximum left hand PS, kg	4.3 (2.9–5.4)	5.0 (3.2–9.3)[b]
Hemoglobin, g/L	108.0 ± 14.2	110.0 ± 17.9
Serum albumin, g/L	38.89 ± 4.4	39.2 ± 5.5
Serum C-reactive protein, mg/L	5 (2–13)	5 (2–12)
Serum urea, mmol/L	17.0 ± 5.9	18.1 ± 5.0
Urea reduction rate, %	76.4 ± 9.2	72.3 ± 9.2[b]
Urea generation, mmol/d	232 ± 192	269 ± 103[b]

CABG, coronary artery bypass surgery; HGS, handgrip strength; PS, pinch strength.
[a]Normal laboratory reference ranges: hemoglobin, 135–170 g/L; serum albumin, 35–50 g/L; C-reactive protein, 0– 5.0 mg/L; and urea, 2.1–7.1 mmol/L. Values expressed as raw number, mean ± SD, or median (interquartile range).
[b]$P < .001$ vs female.
[c]$P < .01$ vs female.

artery bypass grafting. Other comorbidities and the overall comorbidity grade did not differ, and the self-reported DT scores also did not differ (Table 1). Simple univariate correlation showed that DT scores positively correlated with frailty scores and body size, and a negative correlation was seen with DT scores and age, serum albumin, hemoglobin, and percentage body fat (Table 2). Maximum voluntary PS was affected by psychological distress scores (Table 2) but not HGS. When we compared individual medications, antihypertensives, lipid-lowering drugs, and anticoagulants, only aspirin prescription had a positive association with DT scores. There were no differences between the self-reported DT scores and ethnicity: white, 5 (1–7); African-Afro-Caribbean, 5 (1–7); South Asian, 5 (1–7); East Asian, 2 (0–5); and other ethnicity, 2 (0–7). Similarly, there were no statistically different self-reported DT scores for the individual comorbidities or overall comorbidity grading.

Table 2. Univariate Associations Between Variables Associated With Self-Reported Distress Thermometer Scores.

Variable	r	*P* Value
Serum albumin, g/L	−0.15	.004
Aspirin prescription	0.15	.004
Maximum pinch strength, kg	−0.14	.005
Frailty score	0.11	.005
Peripheral vascular disease	0.13	.009
Age, y	−0.13	.010
Hemoglobin, g/L	−0.13	.011
Extracellular water, L	0.13	.011
Total body water, L	0.12	.024
Fat-free mass, kg	0.12	.029
Cancer	0.11	.030
Intracellular water, L	0.11	.037
Serum glucose, mmol/L	0.14	.044
Body fat, %	−0.11	.047
Body cell mass, kg	0.11	.063

Taking variables with a univariate association of <0.1 for the self-reported DT scores and other variables thought to be of clinical relevance, a series of step backward multiple regression models were constructed. On multivariable analysis, DT scores were positively associated with frailty, soft lean mass, and prescription of aspirin and negatively with age, maximum voluntary PS, and hematocrit (Table 3).

Discussion

Studies in HD patients have repeatedly reported that muscle weakness is strongly associated with an increased risk in mortality.[24,25] However, studies have differed markedly in terms of reporting on muscle wasting. Some studies reported a strong association between loss of muscle strength as measured by HGS and loss of muscle mass when measuring body composition.[5] Others reported no association or a weak association with <10% of the loss in muscle strength being explained by loss in skeletal muscle mass.[26] As expected, our patients were weaker than reports of HGS and PS from healthy controls.[22,23] It is well recognized that kidney dialysis patients have increased levels of self-reported depression.[27] As such, we wondered whether these differences could potentially be explained by differences in patient cooperation, as patients with low mood[28] may be less likely to fully cooperate when asked to produce and sustain a maximal muscle contraction. In addition, patients with psychological depression may be less physically active[29] and therefore may be more prone to loss of muscle mass.

The DT has been reported to be equally reliable in different countries and populations,[10–12] and we found no differences in the scores from male and female patients or in the scores from the 4 major ethnic populations dialyzing in our centers. More recently, it has been validated in CKD and HD patients.[14]

Table 3. Multivariable Backward Regression Models for Self-Reported Distress Thermometer Scores.[a]

Variables	β	SE of β Coefficient	Standardized β Coefficient	*t*	95% CL	*P* Value
Age per year	−0.05	0.01	−.20	−3.6	−0.7 to −0.02	<.001
Frailty per point	0.35	0.12	0.17	3.0	0.12–0.58	.003
Maximum voluntary PS per kilogram	−0.14	0.05	−0.17	−3.0	−2.3 to −0.05	.003
Aspirin	1.31	0.35	0.16	2.9	0.34–1.7	.004
HCT per 0.1%	−8.3	3.9	−3.1	−2.1	−1.7 to −0.34	.004
SLM per kilogram	0.04	0.32	0.12	−2.1	0.24–0.03	.026

β, nonstandardized β coefficient; CL, confidence limit; HCT, hematocrit; PS, pinch strength; SE, standard error; SLM, soft lean mass (nonfat mass minus bone and cartilage).
[a]Model fit: $r = 0.35$, $r^2 = 0.13$, adjusted $r^2 = 0.11$.

We therefore chose to assess whether patients with higher levels of self-reported distress were physically weaker on testing muscle strength with the HGS and PS devices and had less muscle mass when measured with MFBIA. First, we found no association between higher DT scores and loss of muscle mass. Indeed, we found the opposite in that on univariate analysis, there was a positive association between measures of body mass (ICW, ECW, body cell mass, lean body mass) and higher scores, and on multivariable testing, the association with lean body mass was retained. In contrast, lower DT scores were associated with a greater percentage of body fat. This may appear somewhat paradoxical, but it may reflect that more frail patients have lower expectations of health and physical abilities, whereas patients with greater physique have greater expectations of what they should be able to accomplish and are more aware of their limitations, in keeping with reports in other chronic medical conditions.[30] Similarly, this would support our finding that older patients reported lower DT scores than younger patients.

On univariate analysis, we found an association between higher self-reported DT scores and lower hemoglobin and serum albumin, and both resistance to erythropoietin therapy and lower serum albumin are associated with chronic inflammatory states and increased mortality risk.[25] We also noted an association between peripheral vascular disease, including amputation and patients being actively treated for cancer, which is not unexpected. The association between higher DT scores and the maintenance of aspirin therapy probably is accounted for by aspirin prescription crossing the boundaries of patients with symptoms of ongoing ischemic heart disease, recent coronary artery stenting, and myocardial infarction. Although there was a significant association between self-reported DT scores and frailty,[31] as assessed by the medical team, the association remained weak, with an r value of 0.144. As such, the r^2 value of 0.02 would suggest that only 2% of the variance in self-reported DT scores could be attributed to physical frailty.

We expected to find that patients with higher self-reported DT scores would have reduced voluntary muscle strength, but we found no effect with HGS. This is an important negative finding, as it is reassuring that patients can provide maximal voluntary HGS effort despite psychological and other distresses. However, we did find that patients with higher self-reported DT scores had lower PS results. This may be due to the different muscle groups involved in performing the different tasks. Fewer muscle groups are involved with PS, so changes may become more apparent at an earlier stage, or arthritis or local damage to joints around the wrist may have a greater impact on PS. We found that the self-reported DT scores tended to be scored higher by younger fitter patients and lower by older patients. Our suspicion that this may reflect differences in how patients come to terms with the impact of thrice-weekly kidney dialysis treatments on lifestyle requires further investigation. We did not find any association between higher scores and loss of muscle mass. We measured muscle mass by bioimpedance,[32] and previous studies have reported differences using bioimpedance devices in HD patients,[7,33] and even though we allowed for reequilibration following the dialysis session,[34] further studies using DXA[35] or isotopic methods may be required to confirm our results.

In conclusion, our results suggest that measurement of maximal voluntary HGS is a robust measurement of muscle strength independent of psychological and other stresses. However, as PS was reduced in patients with higher DT scores, such measurements may require more careful interpretation.

Statement of Authorship

A. Davenport contributed to the conception/design of the research S. Camilleri, S. Chong, K. Tangvoraphonkchai, and S. Yoowannakul contributed to the acquisition of the data, analysis, or interpretation of the data; critically revised the manuscript; and read and approved the final version of the submitted manuscript. K. Tangvoraphonkchai and A. Davenport performed the statistical analysis. A. Davenport drafted the first version of the manuscript and agrees to be fully accountable for ensuring the integrity and accuracy of the work. All authors read and approved the final manuscript.

Supplementary Material

Supplementary Table S1 is available with the article online at http://journals.sagepub.com/home/ncp.

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