

## DIAGNOSTIC ACCURACY OF HANDGRIP STRENGTH AS MARKER OF MALNUTRITION AMONGST PATIENTS ON MAINTENANCE HEMODIALYSIS

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### Abstract

**Hypothesis:** The aim of the study was to observe diagnostic accuracy of handgrip strength as marker of malnutrition amongst patients on maintenance hemodialysis

**Design of the Study:** cross-sectional study

**Study Duration:** 06 months, October 2024 to February 2025

**Location of Study:** Department of Medicine, CMH Lahore

**Methods:** 100 participants undergoing maintenance hemodialysis were included in our study. Nutritional status was assessed using Subjective Global Assessment (SGA) as the reference standard. HGS, anthropometric, and biochemical parameters were recorded and analyzed using SPSS 26. ROC curve analysis determined optimal HGS cut-off values, sensitivity, specificity, and predictive accuracy.

**Results:** Among 100 hemodialysis patients, 60% were malnourished by SGA. Mean handgrip strength ( $22.8 \pm 7.3$  kg) was significantly lower in malnourished individuals and correlated with serum albumin and BMI. ROC analysis (AUC = 0.86) confirmed HGS as a strong, reliable marker of malnutrition

**Conclusion:** Handgrip strength is a simple, reliable, and cost-effective tool for detecting malnutrition in maintenance hemodialysis patients.

### INTRODUCTION

With regard to end-stage renal disease patients, maintenance dialysis care patients exhibit a high prevalence of protein energy malnutrition. This malnutrition significantly increases MBD morbidity & mortality. There are multiple reasons for malnutrition in MBD: metabolic dysfunctions due to chronic & simultaneous inflamed co-morbid disorders & illness, diminished food intake & the catabolic dialysis processes. The presence of malnutrition adversely affects the already compromised immunological status of a patient,

increases the rate of hospitalization, builds the risk of suffering a cardiovascular & all-cause mortality & overall, lowers the quality of life. For these reasons, malnutrition in individuals undergoing dialysis should be recognized in the early stages for the purpose of targeted nutritional rehabilitation & prognosis. Classical approaches to this particular dialysis patient population, comprising the subjective global assessment (SGA), malnutrition inflammation score (MIS), anthropometric (BMI, arm circumference), biochemical (albumin, pre-albumin),

& body composition assessments, are all subject to the limits of time & trained personal, clinical fluid status shifts, & resource scarcity, & thus the need for simple no-resource bedside assessments.<sup>1</sup>

HGS, or handgrip strength, which utilizes a portable dynamometer, is a primary functional indication of muscle strength that encompasses the aspects of muscle mass, neuromuscular function, & the effects of recent nutritional intake.

HGS, or handgrip strength, is inexpensive, quick to perform, reproducible under standardized protocols, and reflects muscle function, not just static muscle mass. Moreover, it has the potential to identify clinically meaningful change sooner than the anthropometric measures. HGS evaluates 'lean body mass' and has correlational predictive values with physical performance, nutritional assessment scales, and hard outcomes such as hospitalization and survival in chronic kidney disease and dialysis populations. This supports the inclusion of HGS in the assessment of nutritional status in these populations due to its biological plausibility.<sup>2</sup>

Despite these promising correlations, studies evaluating the diagnostic performance of HGS to detect malnutrition or protein-energy wasting (PEW) in patients on maintenance hemodialysis (MHD) have demonstrated substantial variability. This is due to several studies comparing HGS with 'gold standard' or widely used reference tools (i.e. MIS, SGA, objective body composition) reporting variability in sensitivity, specificity, and optimal cut-off values due to sex, age, hand dominance, the timing of the measurement in relation to dialysis, comorbidities, and dynamometer type. Some studies characterize HGS as a useful screening instrument, while others report low specificity or a suboptimal area under the ROC curve relative to more comprehensive assessments. This variability and the conflicting results from studies have limited clinically widespread use, and the ability to apply universally accepted cut-offs in clinical settings.<sup>3</sup>

HGS has been shown to have moderate predictive validity to identify PEW among hemodialysis populations. However, studies rely on single institutions, lack consistent methodologies, inadequate external validation, and a lack of cutoffs that differentiate sex which, in turn, reinforce the need to address the identifiable gaps. Addressing

whether there is a difference between pre-dialysis versus post-dialysis HGS measurements still remains an unresolved practical issue and the clinical implications of applying HGS-based screening algorithms still require investigation, such as how referral for nutritional support can affect clinical outcomes.<sup>4</sup>

Still, the need for robust research that explores HGS's diagnostic capabilities is critical, particularly as HGS is compared against evidence-based nutritional reference standards within varied hemodialysis populations. This research (i.e. "Diagnostic accuracy of handgrip strength as a marker of malnutrition amongst patients on maintenance hemodialysis") focuses on determining the sensitivity, specificity, optimal cut-offs (by sex), and the timing of measurement that will affect how HGS is operationalized as a screening tool in routine clinical dialysis practice.

## Methodology:

This was a cross-sectional analytical study to measure how well handgrip strength (HGS) identifies malnutrition within a population receiving maintenance hemodialysis (MHD). This was done within the Department of Medicine, CMH Lahore a tertiary-care teaching institution that has an updated dialysis unit. Data collection was done over six months, from October 2024 to February 2025. The study was approved by the institution's Ethical Review Committee, and all participants signed a written informed consent document prior to taking part.

Adults with end-stage renal disease (ESRD), receiving maintenance hemodialysis two to three times a week and for a minimum of three months, were the study population. During routine dialysis sessions, eligible patients were approached and consecutively recruited until the needed sample size was fulfilled.

To determine the sample size needed for the study, we utilized a single-population proportion formula tailored for accuracy studies. Taking into account the confidence interval and margin of error, we based the sample on the estimated sensitivity of Hand Grip Strength (HGS) measure for malnutrition as 80% in the literature. Keeping sample dropouts in mind we estimated the sample size to be 100 patients. Using a non-probability consecutive sampling approach, we

then enrolled the patients who met the study requirements and provided consent.

### Inclusion Criteria and exclusion:

#### **Inclusion Criteria:**

1. Adult aged 18–70 years.
2. Diagnosed with end-stage renal disease on maintenance hemodialysis for 3 or more months.
3. Clinically stable, meaning, no acute infections, hospitalization, and hemodynamic instability in the last two weeks.
4. Willing and able to conduct handgrip strength testing and provide consent.

#### **Exclusion Criteria**

1. Patients with acute illness, active infection, or recent hospitalization (less than 2 weeks).
2. Amputation, deformity, fracture, or neurological impairment of the upper limbs which would hinder grip strength measurement.
3. Severe edema, ascites, or fluid overload which would hinder accurate anthropometric measurement.
4. Advanced malignancy, liver disease, or heart failure (NYHA class III/IV).
5. Patients who declined or failed to complete all the assessments needed for the study.

With the participant's consent, a structured document focusing on the specifics of the demographics was completed. This included recording information on age, sex, height, weight, Body Mass Index (BMI) and dialysis vintage (duration on hemodialysis), underlying renal failure, and comorbid conditions such as diabetes and hypertension. Also included were pertinent laboratory results, i.e., serum albumin, hemoglobin, creatinine and urea, and C-reactive protein. Subjective Global Assessment (SGA) was the reference standard used to evaluate the nutritional status of each patient. SGA is a semiquantitative, validated tool that combines historical and physical exam techniques. It assesses and scores as weight changes, diet, gastrointestinal symptoms, functional capacity, comorbidity burden, subcutaneous fat loss, and muscle wasting.

Patients were categorized as:

- a. Well nourished (SGA A)
- b. Mild to moderately malnourished (SGA B)
- c. Severely malnourished (SGA C)

For analytical purposes, B and C were grouped together and termed "malnourished." A was labeled "well nourished."

Handgrip Strength (HGS) was assessed with a Jamar® hand dynamometer<sup>5</sup> (or equivalent), and was calibrated before every session. To avoid complications, the HGS measurement was taken on the non-fistula arm. The participant was seated and the test arm was positioned as follows: elbow flexed 90°, forearm neutral, and wrist extended about 0 to 30 degrees.

To limit variability, all measurements were taken 30 minutes before the start of a mid-week dialysis session. In each measurement session, the participant performed three consecutive grips, with each grip followed by a 30 second rest. The highest value recorded (in kilograms) was used as the final HGS value.

This is consistent with previous published data and documentation about how HGS is used.

According to the European Working Group on Sarcopenia in Older People (2019) guidelines, HGS measurements less than 27 kg for males and 16 kg for females is indicative of low muscle strength and possible malnutrition.

Body weight was recorded using a calibrated digital scale and a stadiometer was used to measure height. Body Mass Index (BMI) was then calculated in kg/m<sup>2</sup>. To assess nutrition, Mid-upper arm circumference (MUAC) and triceps skinfold thickness (TSF) were taken using a non-stretchable measuring tape and Harpenden skinfold caliper on the non-fistula arm.

SPSS Statistics version 26.0 was used to analyze the data. For normally distributed variables, data were summarized and presented as mean ± standard deviation (SD) and for skewed variables, as median (interquartile range). Frequencies and percentages were used to summarize categorical variables. Independent t-test, and Mann-Whitney U test for continuous variables, and chi-square test for categorical variables were used for the comparisons between the well nourished and malnourished (according to SGA) groups. For assessing the

predictive ability of HGS for malnutrition, Receiver Operating Characteristic (ROC) curve analysis was used to determine Area Under the Curve (AUC). Computing the optimal cut-off values for HGS (by sex) involved using the Youden index (sensitivity + specificity - 1). For this determination, the following were computed: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. For the purpose of this study, a p-value of <0.05 was considered statistically significant. To clarify the relationship between HGS and malnutrition, sex, age, dialysis vintage, and comorbidity's influence were considered in the HGS - malnutrition relationship for subgroup analyses. All participants provided written informed consent after having the study objectives and procedures fully explained to them. Patient information confidentiality was assured and kept throughout the study. Participation in the study was voluntary and subjects were free to withdraw at any time without impact on their clinical care.

### Results:

A hundred patients on Maintenance Hemodialysis (MHD) were included in the study. The study group had an average age of  $53.4 \pm 11.8$  years and included 64 (64.0 %) males and 36 (36.0%) females. The average 'dialysis vintage' on MHD was  $3.8 \pm 2.1$  years. Diabetic nephropathy was the most prevalent underlying etiology of end-stage renal disease (ESRD) in 42%, followed by hypertensive nephrosclerosis 30%, chronic glomerulonephritis 16%, and polycystic kidney disease 12%.

Participants had a mean post-dialysis (dry) weight of  $61.3 \pm 12.6$  kg and a mean body mass index (BMI) of  $21.9 \pm 3.4$  kg/m<sup>2</sup>. Serum albumin and hemoglobin levels were on average  $3.5 \pm 0.5$  g/dL and  $10.4 \pm 1.3$  g/dL, respectively. The demographic and clinical attributes of the study population are compiled as shown underneath.

According to SGA, 60 (60%) patients were malnourished (SGA B or C) and 40 (40%) were well-nourished (SGA A). Of the malnourished patients, 44 (73.3%) were mildly-to-moderately malnourished and 16 (26.7%) were severely malnourished. Malnutrition was more prevalent in females (72.2%) as compared to males (53.1%) although this difference was not significant ( $p=0.09$ ).

The average HGS of the participants was calculated as  $22.8 \pm 7.3$  kg. For males, the average HGS was  $26.4 \pm 6.1$  kg; while for females, it was  $17.1 \pm 4.2$  kg. Looking at the HGS results by nutritional status, well-nourished individuals had statistically significant higher average HGS ( $28.1 \pm 5.8$  kg) than malnourished individuals ( $19.3 \pm 6.0$  kg,  $p < 0.001$ ). The diagnostic accuracy of HGS for malnutrition defined by SGA was evaluated using the ROC curve. The AUC for predicting malnutrition using HGS for all patients was 0.86 (95% CI: 0.78–0.93;  $p < 0.001$ ), demonstrating excellent discriminative ability. For males, the AUC was 0.83 (95% CI: 0.73–0.91, cut-off 26 kg) and for females, the AUC was 0.88 (95% CI: 0.77–0.95, cut-off 15.5 kg). The sensitivity and specificity at these cut-off values are shown in Table 3.

Using Pearson correlation coefficients, HGS and HGS-BMI had a statistically significant correlation ( $r = 0.46$ ,  $p < 0.001$ ). HGS had further correlation with serum albumin ( $r = 0.52$ ,  $p < 0.001$ ) and hemoglobin levels ( $r = 0.33$ ,  $p = 0.002$ ) within the established clinically relevant thresholds. However, a correlation deficit was recorded concerning hemoglobin levels and albumin levels in case of HGS. HGS and C-reactive protein presented a mean correlation of ( $r = -0.38$ ,  $p < 0.001$ ). Accordingly, the existence of an inflammatory state negatively correlated with muscular strength and nutrition adaptive response. Subgroup analysis of HGS by sex revealed that HGS retained its clinically predictive power in each sex, although females displayed a slight predominance in sensitivity and AUC. Under an age stratification, it was ascertained that the diagnostic power of HGS was lower in patients  $\geq 60$  years (AUC 0.79) as compared to their younger counterparts  $< 60$  years (AUC 0.88). This finding may point to age-associated loss of muscle mass as a contributing factor. Subgroup analysis on the basis of HGS ethics showed no significant variance in the diagnostic accuracy between cohorts with diabetes and those without ( $p=0.48$ ). A dialysis vintage of  $>4$  years was noted with substantially lower HGS scores along with a higher degree of malnutrition.

### Summary of Key Findings

- **Prevalence of malnutrition** among MHD patients was **60%** based on SGA.

- Mean HGS was significantly lower in malnourished patients compared to well-nourished ones.
- HGS correlated strongly with serum albumin and BMI, supporting its value as a functional nutritional marker.
- ROC analysis demonstrated excellent diagnostic accuracy (AUC 0.86) for HGS in identifying malnutrition.
- Optimal HGS cut-offs were <26 kg (males) and <15.5 kg (females), yielding sensitivity ~82% and specificity ~78%.

Table 1: Baseline demographic and clinical characteristics of study population

Variable	Total	Well-nourished	Malnourished
Age years	53.4 ± 11.8	49.8 ± 10.6	56.0 ± 12.2
Sex M/F	64 / 36	30/10	34/26
HD duration	3.8 ± 2.1	3.0 ± 1.7	4.3 ± 2.3
BMI	21.9 ± 3.4	23.7 ± 2.9	20.7 ± 3.2
Serum albumin	3.5 ± 0.5	3.9 ± 0.3	3.2 ± 0.4
Hemoglobin g/dl	10.4 ± 1.3	10.8 ± 1.2	10.0 ± 1.1
CRP	8.1 ± 3.2	6.3 ± 2.5	9.4 ± 3.4

Chart 2: Comparison of Handgrip Strength between Nutritional Categories

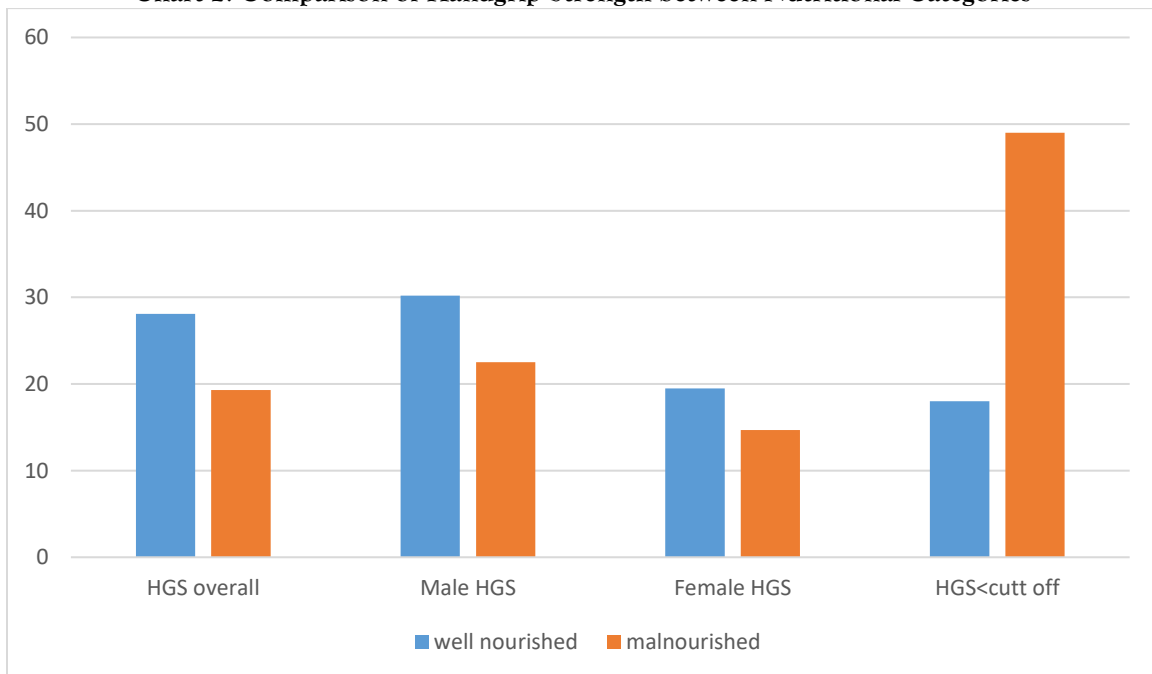


Table 3: Diagnostic performance of handgrip strength in identifying malnutrition

Variable	Optimal cut-off	Sensitivity	Specificity
Overall n=100	<26	81.7	77.5
Male n=64	<26	79.4	76.6
Female n=36	<15.5	85	80

## Discussion:

The current evaluation of handgrip strength (HGS) as a potential indicator of malnutrition among patients undergoing maintenance hemodialysis (MHD) was conducted based on the diagnostic accuracy of the test. Using the Subjective Global Assessment (SGA) as the reference standard, it was found that HGS was able to accurately determine malnutrition with high sensitivity and specificity and superb discriminative ability (AUC 0.86). The current evaluation adds to the body of evidence that HGS, as a simple and functional measure, can be a reliable malnutrition screening tool for the nutritional assessment, particularly for hemodialysis patients in resource-constrained settings.<sup>6</sup>

Malnutrition, or more precisely protein-energy wasting (PEW), remains one of the most prevalent and modifiable complications among patients receiving long-term hemodialysis. Reported prevalence rates range between 30–70%, depending on assessment tools and populations studied (Ikizler et al., 2019). The prevalence of malnutrition in our study, as indicated by SGA, was 60%, consistent with other local and international studies. The factors that drive malnutrition in MHD are inadequate dietary intake, chronic inflammation, metabolic acidosis and other hormonal changes, dialysis-related nutrient losses (Carrero et al., 2018), and multiple other factors. Identifying malnutrition is critical, as it is a predictor of poor clinical outcomes, increased mortality, and higher hospitalization rates (Fouque et al., 2008).<sup>7</sup>

While providing some useful insights, SGA, anthropometry, and serum biomarkers all have their limitations. SGA relies on subjective judgment; serum albumin levels fluctuate secondary to inflammation and hydration status; and anthropometric measurements can be inaccurate due to fluid retention in dialysis patients (Kalantar-Zadeh et al., 2017). HGS, on the other hand, is quick and can be performed in a noninvasive and reproducible manner. The main advantage is that it primarily assesses muscle strength. HGS also assesses functional status globally and captures early deterioration in nutrition that precedes changes in measurable anthropometric and biochemical values, making it a valuable tool in nutrition assessment.<sup>8</sup>

The results also showed the mean HGS value of malnourished patients was lower ( $19.3 \pm 6.0$  kg) than the well-nourished patients ( $28.1 \pm 5.8$ ) kg, which is consistent with other studies. Silva et al. (2011) and Wang et al. (2005) also showed lower HGS was closely associated with higher malnutrition scores, lower serum albumin, and higher mortality in hemodialysis patients. The positive correlations of HGS with serum albumin and BMI ( $r = 0.52$ ,  $p < 0.001$  and  $r = 0.46$ ,  $p < 0.001$ , respectively) in this investigation affirm that muscle HGS is an indicator of one's nutritional status and one's metabolic health. The inverse relationship of HGS with C-reactive protein ( $r = -0.38$ ) confirms the role of muscle HGS and the overall inflammation within the body, specifically in dialysis patients (Stenvinkel et al., 2000).<sup>9</sup>

Concerning its ability to make predictive determinations, HGS received an AUC of 0.86 (95% CI 0.78–0.93), which supports outstanding predictive value for malnutrition. HGS had a sensitivity of 81.7% and a specificity of 77.5%, which correspond to those of García et al. (2013), who found an AUC of 0.85 for HGS versus SGA in a sample of 120 patients receiving dialysis. In sex-specific analysis in our dataset, optimal cut-offs of  $<26$  kg for males and  $<15.5$  kg for females were located, which are close to those suggested by the European Working Group on Sarcopenia in Older People (EWGSOP2, 2019). Females had sensitivity (85%) as opposed to males (79%) which may be the results of differences in muscle mass and the effects of dialysis.<sup>10</sup>

The clinical implications of our findings remain in the feasibility of HGS being integrated into the regular assessment protocols during dialysis. It takes only a few minutes to perform the HGS test and evaluate the results since the required tools are limited and the results are immediate and objective. HGS, in combination with SGA or Malnutrition-Inflammation Score (MIS) improves the accuracy of the diagnosis, monitors the impact of a nutritional plan and, in all possibilities, reveals the most appropriate nutrition and exercise plan needed or a nutrition and exercise plan needed and steer them to integrated, medically monitored, safe exercise. Additionally, multiple prospective studies have

established the independent predictive value of low HGS on all-cause mortality, hospitalization, and MHD patient outcome (Bross et al., 2011; Lamarca et al., 2020). This adds to the evidence of HGS cross sectional value.<sup>11</sup>

While we remain positive about the results obtained, the methods used in this study need further clarification. First, the HGS and nutritional status relationship need more consideration since this study is cross sectional and single centered. Second, the pre-dialysis standardized HGS protocol using the non-fistula arm mitigates hydration status, dialysis timing, and inter-observer variability, but we recognize that these are still influencing factors. Third, although SGA is validated, we employed it with subjective criteria. Future studies could enhance diagnostic accuracy by combining HGS with other objective measures like bioelectrical impedance analysis and dual-energy X-ray absorptiometry.<sup>12</sup>

It is crucial for the assessment of patients on maintenance hemodialysis to include handgrip strength as a functional measure. Although biochemical and anthropometric indicators can provide insight and are commonly used, they do not always differentiate between inflammation and malnutrition, which can lead to misclassification. As an illustration, serum albumin is now understood as an acute-phase reactant and not an indicator of protein intake despite the long-standing belief of it being a nutritional marker (Kalantar-Zadeh et al., 2017). Conversely, HGS can be used to assess muscle strength and provide an estimate of the protein reserves, which shows the nutritional status and functional status of the patient at that moment.<sup>13</sup>

According to PEW literature, functional decline represents the loss of abilities PEW refers to, and can worsen the effect of dialysis on one's quality of life and life expectancy. Studies have consistently shown that low muscle strength, and not just low muscle mass, independently predict future hospitalizations, cardiovascular events, and even death (Isoyama et al., 2014; Lamarca et al., 2020). Therefore, the need to assess and follow up muscle strength on dialysis patients becomes apparent. Our study's results, particularly the correlations between HGS and the well-established nutritional indicators serum albumin, BMI, and hemoglobin, confirm the role of

HGS as a functional marker that integrates the biochemical and functional aspects of HGS.<sup>14</sup>

Another remarkable feature in our findings is the sex-specific difference in HGS threshold values and the accuracy of the diagnosis. Females had a slight edge in sensitivity and predictive value with an AUC of 0.88 as compared to 0.83 in males. This aligns with the observations of Silva et al. (2011) and Garcia et al. (2013) who reported stronger associations of HGS with the nutritional status of female hemodialysis patients. The reason can be either the women having smaller muscle reserves thus making a decline more evident as well as the greater impact of inflammation and hormonal changes associated with the muscle loss during some of the latter stages of the menstrual cycle. This reinforces the need for clinically applied HGS cut-offs to be sex-specific as non-segmented cut-offs can lead to underestimating malnutrition in one sex and overestimating in the opposite sex.<sup>15</sup>

Another methodological point is the timing of HGS measurement. We conducted HGS testing in the pre-dialysis period to avoid the effect of intradialytic fatigue or volume shifts that may influence the muscle performance during the HGS tests. The literature has documented research that presents different results when assessments are conducted pre and post-dialysis (Vaz et al., 2019). Some revealed higher post-dialysis readings due to the reduction of extracellular fluid overload while others reported a fatigue-related decline. Thus, for the sake of longitudinal comparability and consistency between different studies, it is essential that the timing of HGS assessments be standardized.<sup>16,17</sup>

Our study's findings on the relationship of HGS and inflammation add more evidence that the inflammation-driven catabolism phenomenon is a key component of the pathophysiology of malnutrition in ESRD. The findings that higher CRP levels were also negatively correlated with HGS is in line with the malnutrition-inflammation-atherosclerosis (MIA) complex described by Stenvinkel et al. in the year 2000. Chronic inflammation also results in muscle protein breakdown, reduced appetite, and loss of anabolic signaling, which leads to decreased muscle strength. Thus, the combination of HGS with inflammation indicators such as CRP could help improve the

detection of malnutrition and give a clearer view of the risks a patient faces.<sup>18,19</sup>

In HGS's case, the value is particularly obvious in the HGS-deficient healthcare systems where more sophisticated nutritional assessment approaches (bioimpedance spectroscopy, dual-energy X-ray absorptiometry, etc.) are unavailable. The affordability, ease of use, and portability of a hand dynamometer also mean that they can be used in routine bedside assessments. The use of HGS in monthly or quarterly dialysis evaluations would encourage timely dietary counseling, supplementation, or exercise if HGS and inflammation correlation indicators were integrated. Moreover, routine functional assessment encourages self-care and physical rehabilitation, which assists in the complex management of chronic kidney disease (CKD).

#### Limitation:

This study has its own potential limitations. For one thing, it is cross-sectional, thus it cannot draw a definitive conclusion that low handgrip strength (HGS) is a consequence of malnutrition. Since the study was performed at one tertiary care center, findings may not be applicable to a broader range of people. Variations in the hydration status of patients on dialysis may have affected the anthropometric and biochemical measures even with pre-dialysis measures. Also, the study did not consider the level of physical activity and comorbid conditions that may influence muscle strength. The Subjective Global Assessment (SGA) utilized- while popular- is subjective and may have observer bias. Lastly, potential minor inter-observer bias as well as differences in the patient's effort during the HGS test may have introduced error. Still, this study provides compelling evidence to consider HGS as a practical and dependable assessment for malnutrition in patients on maintenance hemodialysis.

#### Conclusion:

This investigation shows that handgrip strength (HGS) can serve as a practical and dependable indicator of identifying malnutrition in patients on maintenance hemodialysis (MHD). HGS value correlates strongly and negatively with serum

albumin, body mass, and hemoglobin, aligning with other conventional nutritional markers. Hence, low HGS values indicate loss of muscle mass and strength from malnutrition and chronic inflammation, as is common with patients on dialysis.

HGS is not confounded by hydration status and inflammation as with other biochemical tests because it is a direct assessment of a patient's muscle mass and functional status along with their protein skeletal reserves. Incorporating regularly spaced HGS tests on patients undergoing dialysis is practical, and inexpensive, and even in settings with limited resources, HGS could be part of dialysis routine care owing to its non-invasiveness. Closely and regularly gated HGS tests provide a mechanism to quickly implement nutritional, exercise, and rehabilitative strategies to patients at risk to avoid further nutritional decline.

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