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Stage-stratified Analysis of Handgrip Strength and Body Composition of Chronic Kidney Disease Patients

Anjani Bakshi*, Kalyani Singh, Anupa Siddhu

Abstract

Background: Handgrip strength (HGS) is strongly associated with lean muscle mass and can accurately determine nutritional compromised state of chronic kidney disease (CKD) patients at all stages of illness. **Methodology:** In this cross-sectional study, 114 CKD patients from different stages were enrolled. HGS of the patients was measured by Jamar Hydraulic Hand Dynamometer. Body composition for 47 patients was measured by body composition monitor. Stage stratified analysis was done using various statistical tests. **Results:** CKD patients had low HGS at all stages. Patients at Stage 4 had significantly ($P < 0.001$) lower HGS (19.45 ± 7.09 kg) than patients of stage 2 (25.7 ± 8.53 kg). With one unit increase in age, the value of HGS significantly ($P < 0.001$) decreased by 6.35 units. Female patients had significantly lower HGS by 21.36 unit, ($P < 0.001$) at all age groups as compared to males. The value of lean tissue mass (LTM) was significantly ($P = 0.03$) low at Stage 4 as compared to Stage 2. HGS was positively correlated with LTM (r = 0.65). Muscle strength and muscle mass were strongly related with disease progression. **Conclusion:** Timely assessment of HGS and muscle mass of CKD patients determine nutritional status at early stage of illness.

Keywords: Body composition, Chronic kidney disease, Handgrip strength, Lean tissue mass, Nutritional status

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Introduction

Handgrip strength (HGS) is an objective measure of upper body strength. Under normal bio kinetic, HGS is determined when maximum force or power applied by the muscle results into forceful flexion of all finger joints.[1,2] It is a simple and inexpensive bedside test to measure muscle strength.[3-7] It is directly associated with lean body mass and useful to determine nutritional status of patient population.[1] Factors such as gender, hand dominance, weight, height, and hand length can influence the grip strength.[8]

In chronic kidney disease (CKD) patients, uremic symptoms like disturbances in protein and energy metabolism, hormonal derangement, presence of inflammatory cytokines, and poor dietary intake, affect patients' nutritional status, which eventually results in loss of their muscle mass.[9] Hand grip strength is an important determinant of bone mineral content and hence can be associated with lean tissue mass (LTM) of kidney patients.[8] HGS has an immense importance as a functional index in CKD.

Materials and Methods

The study was cross-sectional. Patients were selected from a well-established renal outpatient department after ethical committee approval (Ref. No.: TS/MSSH/SKT-2/NEPHRO/IEC/14-35). About 114 CKD patients of different Stages 2, 3a, 3b, four were selected purposively. Informed consent form and certificate of patient participation were obtained from each patient. Patients with age ≥18 years and in CKD Stage 2, 3a, 3b, four were included in the study. Patients with kidney disease after transplant and patients on dialysis were excluded from the study. HGS of the patients was measured by Jamar Hydraulic Hand Dynamometer (U.S.A), model: 5030J1, S/N: 30809187. The instrument was calibrated prior collecting the data. Body composition was measured by body composition monitor (BCM). Only 47 patients (32 males and 15 females) consented for body composition analysis. LTM and adipose tissue mass (ATM) were assessed to understand their relation with HGS. Stage stratified analysis was done using various statistical tests such as Student's t-test, analysis of variance, Pearson's correlation, and multiple linear regression.

Department of Food and Nutrition, Lady Irwin College, University of Delhi, New Delhi, India.

Corresponding Author: Dr. Anjani Bakshi, Department of Food and Nutrition, Lady Irwin College, New Delhi, India. E-mail: anjanibakshi04@gmail.com

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Results

Majority of CKD patients were in the age range of 55–65 years. After *post hoc* analysis Bonferroni, significant difference ($P = 0.003$) in mean age was observed between Stage 2 and Stage 4. Patients in Stage 4 were older as compared to patients in Stage 2. Most of the patients (57.42%) in the present study were diagnosed with CKD in ≤1 year. Diabetes (56.67%) and hypertension (79.17%) were common comorbidities among CKD patients. Almost 45% of patients had both diabetes as well as hypertension. Among all causative factors, diabetic nephropathy ($n = 52$) was most common and more prevalent in males than females.

Stage stratified analysis of body composition [Table 1] shows significant difference ($P = 0.04$) in LTM between all stages. The value of lean mass was significantly ($P = 0.03$) low at Stage 4 as compared to Stage 2.

Mean HGS of CKD patients was 23.55 ± 8.47 kg. Patients at Stage 4 had mean HGS 19.45 ± 7.09 kg which was significantly ($P < 0.001$) lower than patients of Stage 2 with HGS 25.7 ± 8.53 kg [Table 2].

Table 1: Stage stratified analysis of body composition (*n*=47)

Variables	*Stages*				*P*-value
	2	*3a*	*3b*	*4*	
	Mean±SD	*Mean±SD*	*Mean±SD*	*Mean±SD*	
LTM[a]	33.31±4.25	37.02±6.03	35.1±11.16	28.1±6.57	0.04*
ATM[b]	47.97±18.92	33.99±10.75	39.8±17.68	43.59±17.45	0.30

*P-value significant<0.05 (Statistical test: ANOVA), [a]LTM: Lean tissue mass, [b]ATM: Adipose tissue mass, SD: Standard deviation

Male patients had significantly ($P = 0.002$) higher HGS (26.5 ± 7.97 kg) as compared to female patients (17.38 ± 5.76 kg) [Table 3]. Regression analysis of HGS and gender showed that the female CKD patients had significantly lower HGS by 21.36 unit, ($P < 0.001$) as compared to males.

It is well known that muscular strength decreases with age due to imbalance in the nutrient availability, utilization, and restoration.[2] It was found that the patients of age above 70 years had significantly lower HGS as compared to patients of age <40 years [Table 4]. With one unit increase in age, value of HGS decreased by 6.35 ($P < 0.001$) [Table 5].

HGS was positively associated with LTM (r = 0.65, $P < 0.001$) whereas negatively with ATM. Stage stratified analysis showed, significant association ($P < 0.001$) between LTM and HGS for the patients at Stage 3b and 4 [Table 6]. LTM and HGS were found to be less for higher stage of illness.

Table 2: Stage stratified analysis of handgrip strength (*n*=114)

CKD Stages	*Handgrip strength in kg*	*P*-value
	Mean±SD	
Total (*n*=114)	23.55±8.47	
Stage 2 (*n*=21)	25.7±8.53	<0.001**
Stage 3a (*n*=26)	27.27±7.27	
Stage 3b (*n*=32)	23.57±9.11	
Stage 4 (*n*=35)	19.45±7.09	

**P-value significant<0.01 (Statistical test: ANOVA), SD: Standard deviation

Table 3: Gender and stage stratified analysis of handgrip strength (*n*=114)

CKD Stages	*Handgrip strength in kg*		*P*-value
	Male (n=77)	*Female (n=37)*	
	Mean±SE	*Mean±SE*	
Total (n=114)	26.5±7.97	17.38±5.76	0.002**
Stage 2 (*n*=21)	27.18±9.52	22.10±3.89	0.23
Stage 3a (*n*=26)	28.70±7.21	22.51±5.62	0.07
Stage 3b (*n*=32)	26.74±8.53	16.59±6.12	0.002**
Stage 4 (*n*=35)	23.56±6.37	13.96±3.28	<0.001**

**P-value significant<0.01 (Statistical test: ANOVA), SE: Standard error

Table 4: Gender and age stratified analysis of handgrip strength (*n*=114)

Age	*Handgrip strength in kg (n=114)*		*P*-value
	Male (n=77)	*Female (n=37)*	
	Mean±SE	*Mean±SE*	
<40 years	31.86±2.91	23.96±1.66	0.04*
40–49 years	36.20±2.36	16.97±2.26	<0.001**
50–59 years	24.86±1.48	16.21±1.20	0.003**
60–69 years	25.12±1.60	13.78±1.50	<0.001**
70 years and above	21.07±1.89	12.76±1.34	0.04*

*P-value significant <0.05, **P value significant <0.01 (Statistical test: ANOVA), SE: Standard error

Table 5: Regression model of handgrip strength, age and gender

Dependent variable	*Independent variables*	*Coefficient*	*SE*	*P-value*
Handgrip strength	Age[a]	−6.35	1.165	<0.001*
	Gender (Female vs. Male)[b]	−21.36	2.821	<0.001*

*P-value significant <0.01, [a]With one unit increase in age, value of handgrip strength decreased by 6.35 (P<0.001), [b]Hand grip strength was significantly less among female than male patients by 21.36 unit, P<0.001, SE: Standard error

Discussion

HGS is a reliable marker of nutritional status of CKD patients. In a population-based, cross-sectional study on patients aged ≥19 years from the Korea National Health and Nutrition Examination Survey in 2014–2017, the prevalence of low HGS was 25.2% in patients with CKD.[10] The present study observes low HGS in all patients with CKD irrespective of stage of illness, though the most affected patients were in progressive stages. This study clearly indicates significantly poor muscular function of CKD patients at higher stage of illness. Similar findings were reported on non-dialyzed kidney patients where patients with lower HGS also had significantly poor renal outcome.[11] Another study also indicated low physical function in pre-dialysis CKD patients as the disease progressed according to stage.[12]

Female patients had significantly less HGS than their male counter parts. Similar to this, comparable relation between HGS and gender was reported where the mean HGS among males was 28.0 ± 9.4 kg, which was significantly higher than female HGS 16.5 ± 6.8 kg.[11] Aged CKD patients in the present study had lowest HGS. Similar findings were reported in a cross-sectional study conducted in China where HGS peaked at approximately 20–35 years old CKD patients and gradually decreased after the age of 50 years.[13]

Approximately 60% of total body protein is located in skeletal muscle, that is, the body's primary source of amino acids in response to poor nutritional status.[14] In CKD, there is imbalance between catabolic and anabolic signals, due to which, loss of muscle mass is evident. LTM is an indirect measure of muscle protein. Any change in LTM indicates change in body muscle and somatic protein mass and hence determine nutritional compromised state.[15] In a longitudinal study, incident dialysis patients were prospectively followed up to 5 years. These patients were malnourished with low muscle strength and higher mortality rates.[16] Another study on chronic renal failure patients reported HGS and its strong correlation to LBM in both men and women.[9] Association of HGS with LTM explains the analogy between improvement in physical function and correction of renal function.

There are few limitations noted in the study. First, sample size was comparatively small. Second, there is paucity in Indian data

Table 6: Correlation of handgrip strength with lean tissue mass and adipose tissue mass

Variables	*Stage 2*		*Stage 3a*		*Stage 3b*		*Stage 4*	
	r	*P-value*	*R*	*P-value*	*r*	*P-value*	*r*	*P-value*
LTM[a]	–0.20	0.61	0.18	0.63	0.73	0.003**	0.80	<0.001**
ATM[b]	–0.38	0.31	0.24	0.50	-0.16	0.59	0.01	0.97

***P*-value significant <0.01, Statistical test: Pearson's correlation (r), [a]LTM: Lean tissue mass, [b]ATM: Adipose tissue mass

on CKD patients to compare the findings. Third, HGS is dependent on many factors other than age, gender, and reduced muscle mass. These are hand dominance, fatigue, time of day, restricted motion, pain, motivation, body position, and elbow position.[1,5,7] The present study strongly recommends to examine these factors while measuring HGS in patient population for a homogenous sample.

Conclusion

Right and timely management is crucial in restoration of muscle mass and thus HGS of CKD patients. At least strategies and goal of maintenance of HGS would ensure slow progression of disease. In conclusion, HGS is an important indicator to assess nutritional compromised state of CKD patients. Maintaining muscle mass seems to be both a goal and indicator of determining nutritional status of CKD patients.

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