Use of handgrip strength in the assessment of the muscle function of chronic kidney disease patients on dialysis: a systematic review

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Abstract

Background. Even though handgrip strength (HGS) is considered a simple and reliable method to evaluate muscle function and, indirectly, the nutritional status in clinical settings, there is still no consensus concerning its use in patients with chronic kidney disease (CKD) undergoing dialysis. This study presents a systematic review of the literature on the use of HGS as a parameter for nutritional assessment and a prognostic marker in patients on dialysis.

Methods. The MEDLINE database (1966 to October 2009) was consulted for this systematic review by using the search terms hand strength or muscle strength dynamometer and dialysis. Eighteen articles were identified and included in the analysis.

Results. Similar to the general population, HGS values were associated with age and gender. The analysed studies showed correlation between muscle function estimated by HGS and variables used in the assessment of muscle mass and nutritional status, as well as the prediction of clinical complications.

Conclusions. The analysis indicates that HGS is a useful tool for continuous and systematic assessment of muscle mass related to nutritional status in patients on dialysis.
However, it is still necessary to standardize the techniques used for HGS, especially with respect to the position of measurement, the evaluation period, the choice of arm side and the diagnostic criterion.

**Keywords:** dialysis; hand strength; muscle strength dynamometer

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**Introduction**

Protein–energy wasting (PEW) is the term proposed to describe the reduction in the stores of energy and protein in patients with chronic kidney disease (CKD) [1]. Muscle wasting is one of the best markers of PEW in these patients [2,3]. Several methods of assessing muscle reserves have been used in this population, ranging from anthropometry to more sophisticated methods, such as magnetic resonance imaging. In particular, handgrip strength (HGS) has been shown to be a reliable method to easily assess skeletal muscle function in the general population [4] and in patients with CKD [2,5]. The internal consistency of force measurements exerted by different muscle groups and their correlation with the extent of HGS underlies its use in characterizing the functional status of general muscles [6].

Functional tests are usually the most sensitive and relevant indicators of short-term changes in nutritional status and also correlate to clinical complications [6]. HGS has proven to be useful in monitoring surgical patients [7] and in the assessment of the elderly [8] mainly because it is a fast, inexpensive and non-invasive procedure. However, the main obstacle to the general adoption of HGS as a tool for nutritional evaluation lies in the fact that there are still few studies proposing reference values based on representative samples of the population [4] and because the cutoff point to classify muscle wasting has not yet been defined [6].

CKD complications (carnitine deficiency, accumulation of β2-microglobulin, water and electrolyte imbalance and secondary hyperparathyroidism [9–11]) and specific factors related to the dialysis procedure may be related to lower values of HGS, which are observed when chronic renal patients are compared with healthy individuals of the same gender and age. Because symptoms of muscle weakness may occur in the presence of severe uraemia, inadequate dialysis is capable of reducing the HGS values [2,5,12].

In patients undergoing haemodialysis (HD), high values of ultrafiltration may lead to hypotension and a poor general condition, negatively affecting muscle function whenever HGS is performed after the dialysis session [13]. Furthermore, given the presence of a permanent vascular access e.g. an arteriovenous fistula (AVF), the side of the body to be evaluated should also be considered in HD patients [14].

Even though it is considered a simple and reliable method to assess muscle function, HGS is not considered by the International Society of Renal Nutrition and Metabolism as a diagnostic criterion for PEW in patients with CKD [1]. For this reason, the goals of this study, based on a systematic review of the biomedical literature, were to describe the use of HGS as a parameter for nutritional assessment and a prognostic marker in patients on dialysis and to evaluate factors that are possibly associated with the reduction in muscle function in this population.

**Materials and methods**

The MEDLINE database was consulted for research articles by using the search terms hand strength or muscle strength dynamometer and dialysis. Criteria for inclusion were the following: text fully written in English, French or Spanish and adult population sample (≥18 years). No filter was applied for the year of publication.

**Results**

A total of 22 articles were identified, of which 13 corresponded to the researched topic. Because the search by descriptors resulted in a very limited number of articles, we decided to perform a search using words. However, many items that did not correspond exactly to the requested topic were listed, such as those where patients undergoing conservative treatment were assessed and those evaluating muscle function in the quadriceps.

From the references of the 13 articles analysed, 7 additional articles were identified. Table 1 presents a summary of the articles that assessed HGS-related aspects in patients on dialysis. Of the 20 articles examined, 11 concerned patients on HD and 5 concerned patients on peritoneal dialysis (PD). Four articles evaluated incidents in dialysis (HD or PD) from the same cohort and, because of this, only the most recent and with the biggest sample (Carrero et al. [3]) were included in the table. This publication also evaluated HD patients previously studied by Carrero et al. [15]. Therefore, only the reference Carrero et al. [3] was included in the table. The studies were conducted mainly in Europe (11), followed by Asia (6), North America (2) and Oceania (1). No studies conducted in South America were found.

The mechanical dynamometers (Harpenden and Smedley) were the most used (nine studies) followed by the Jamar dynamometer (five studies). Some other instrumentation (strain gauge and hydraulic dynamometer) was also used.

In studies that presented the results of HGS on the basis of gender, mean values ranged from 12 to 38 kg in men and from 11 to 26 kg in women. Some studies presented the values for HGS as percentage of results obtained in a group of healthy individuals, whilst others stratified the results according to a prior classification of nutritional status (Table 1). The studies by Carrero et al. [3] and Konings et al. [16] were the only ones that did not report HGS results.

The position for measurement of HGS is described only in the studies conducted by Limaye et al. [9], Tander et al. [12], Duruoz et al. [17] and Jamal et al. [18]. In these four studies, the patients remained seated with the shoulder abducted, elbow flexed at 90° and forearm in a neutral position. The interval between measurements was specified as 5 s by Jamal et al. [18], 30 s by Headley et al. [11] and...
1 min by Constatin-Teodosiu et al. [10]. Headley et al. [11] described adjustment of the dynamometer according to each individual’s grip and Limaye et al. [9] determined the use of the second position in the Jamar dynamometer.

In the studies that assessed patients on HD, no trend was observed with respect to the arm to be evaluated. Carrero et al. [3] assessed muscle function in the dominant and non-dominant arms but they used only the values of the former because the AVF is usually located in the non-dominant arm. Problems with homeostasis, such as bleeding, can occur if the arm with the AVF is overexerted after an HD session. For this reason, it is prudent to recommend the use of HGS, as well as anthropometric evaluation, on the side opposite to the vascular access [14].

The time of HGS measurement (before or after the HD session or in the day without HD) was not specified in six studies, which impairs the establishment of a relationship between the extent of HGS, uraemia, dialysis efficiency and ultrafiltration values. Carrero et al. [3] and Duruoz et al. [17] performed the HGS evaluation after the HD session. In the studies conducted by Jamal et al. [18] and van Hoek et al. [19], the HGS measurement occurred before the HD session. Only Qureshi et al. [20] evaluated the patients on a day without HD.

Discussion

HGS and patients characteristics

Gender, age, stature, body mass and dominant hand can influence the results of muscle function assessment [6]. Similar to the general population, HGS values for chronic renal patients undergoing dialysis were associated with age and gender [5,21,22]. Qureshi et al. [20] observed a negative correlation between age and HGS (r = −0.54) and % HGS values from controls were significantly higher in patients under 65 years of age (70.2 ± 24.5%) when compared with those over 65 (45.2 ± 23%). As observed in the general population, HGS is significantly higher in men than in women [5,10,21].

HGS and CKD complications

Residual renal function. With regards to the factors related to the dialysis procedure that may influence muscle function, Wang et al. [5] did not find an association between HGS and dialysis efficiency, estimated by Kt/V. The authors found an association between reduced muscle function and lower haemoglobin, presence of diabetes mellitus and decreased residual renal function (RRF).

According to Dong et al. [23], in patients on PD without RRF (glomerular filtration rate < 2 mL/min), serum phosphorus levels appear to be an indirect indicator of nutritional status because HGS values were higher in the presence of hyperphosphataemia (phosphorus > 5.6 mg/dL). In patients with RRF, there were no differences in HGS relative to serum phosphorus levels. Since there was a tendency for reduction of RRF according to the time on dialysis, it is plausible that patients that still have RRF are less exposed to the complications of CKD, such as anorexia. Thus, these patients have a trend towards better nutritional status. Therefore, hyperphosphataemia could reflect better protein intake (protein-rich foods are also rich in phosphorus) with subsequent maintenance of the body’s protein stores. When measuring patients on HD, Carrero et al. [15] also found lower scores of HGS in men with anorexia.

Fluid control. For patients undergoing PD, HGS values were also associated with control of fluid status. After 9 months of follow-up, Cheng et al. [24] reported worsening of muscle function in patients with extracellular fluid overload, assessed by bioelectric impedance. In patients with more adequate fluid status, higher (but not statistically significant) values for HGS were observed. The authors suggested that the gastrointestinal oedema caused by fluid overload may facilitate translocation of bacteria and endotoxins that may ultimately promote an increase of proinflammatory cytokines such as TNF-α, which are responsible for protein catabolism.

Inflammation. HGS was correlated with C-reactive protein (CRP) in incident patients from the same cohort [2,21,25]. In contrast, Wang et al. [4] did not find association between muscle function and levels of CRP, which exemplifies the importance of HGS as a prognostic marker independent of systemic inflammation. Since patients with CKD are in a chronic inflammatory state [26], an inflammatory-independent method of nutritional status assessment may be very useful. In this sense, Qureshi et al. [20] found that values of HGS had better correlation (r = 0.56) with insulin-like growth factor 1 than with albumin (r = 0.42), a nutritional marker known to be influenced by inflammation. Some studies showed correlation between HGS and albumin [5,21], whilst others did not [2,16,22].

Carnitine deficiency. Carnitine is an amino acid that is related to muscle function due to its involvement in the transport of long chain fatty acids for mitochondrial oxidation. In patients with CKD, its availability or metabolism may be altered. In the study conducted by Constatin-Teodosiu et al. [10], the concentration of plasma carnitine in HD patients was lower in women and positively correlated with HGS values. Thus, the authors suggested that carnitine deficiency may be responsible for the lower HGS values in women and their lower tolerance to exercise.

HGS versus others nutritional variables

Qureshi et al. [20] and Stenvinkel et al. [21] found significantly lower values for HGS in patients with some degree of malnutrition, according to the Subjective Global Assessment (SGA), when compared with a control group of well-nourished patients. When evaluating prevalent HD patients from the same cohort of incidents studied by Stenvinkel et al. [21] but using only the SGA clinical evaluation of muscle wasting, Carrero et al. [3] observed that HD patients with any level of muscular atrophy had significantly lower HGS values when compared with those without muscular atrophy. For patients on PD, Wang et al. [5] observed a correlation between muscle function
<table>
<thead>
<tr>
<th>Reference/country of the study</th>
<th>Sample population</th>
<th>Mean age ± SD or median (range)</th>
<th>Type of dynamometer/value used</th>
<th>Arm assessed</th>
<th>Time of measurement</th>
<th>HGS values (kg), mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jones et al.</strong> [22]/UK</td>
<td>76 on PD, classified as well nourished and malnourished according to SGA</td>
<td>Well nourished M = 45.0 ± 14.1 F = 49.0 ± 14.0 Malnourished M = 54 ± 17.1 F = 56 ± 15.5</td>
<td>Smedley/NS</td>
<td>NS</td>
<td>NA</td>
<td>Well nourished M = 33.6 ± 8.8 F = 26.3 ± 6.9 Malnourished M = 27.1 ± 7.9 F = 16.9 ± 3.7</td>
</tr>
<tr>
<td><strong>Qureshi et al.</strong> [20]/Sweden</td>
<td>128 on HD subdivided into three groups based on SGA: (I) well nourished; (II) mild malnutrition; (III) moderate or severe malnutrition</td>
<td>Group I = 57.0 (26–79) Group II = 68.0 (32–85) Group III = 64.0 (33–83)</td>
<td>Harpenden/ &gt; of three measurements</td>
<td>D/ND</td>
<td>Day without HD</td>
<td>Group I M = 34.0 ± 12.0 F = 22.0 ± 9.0 Group II M = 24.0 ± 9.0 F = 13.0 ± 7.0 Group III M = 12.0 ± 11.0 F = 11.0 ± 6.0 Group II M = 24.0 ± 9.0 F = 13.0 ± 7.0</td>
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<tr>
<td><strong>Johannsson et al.</strong> [33]/Sweden</td>
<td>20 elderly on HD evaluated after 6 months of GH treatment (GH group and placebo group)</td>
<td>GH group = 73.5 ± 9.0 Placebo group = 72.7 ± 9.0</td>
<td>Strain gauge/NS</td>
<td>Non-fistula arm</td>
<td>NS</td>
<td>GH group: increase of 3.6 ± 1.2 Placebo group: reduction of 1.0 ± 1.6 D = 25.0 ± 11.4 ND = 22.8 ± 12.1 M = 26.4 ± 1.5 F = 14.1 ± 1.1</td>
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<tr>
<td><strong>Limaye et al.</strong> [9]/Australia</td>
<td>35 on HD</td>
<td>53.0 ± 15.2</td>
<td>Jamar/mean of three measurements</td>
<td>D/ND</td>
<td>NS</td>
<td>D = 25.0 ± 11.4 ND = 22.8 ± 12.1 M = 26.4 ± 1.5 F = 14.1 ± 1.1 Before Right = 41.6 ± 4.9 Left = 39.3 ± 4.5 After Right = 40.7 ± 4.7 Left = 39.9 ± 4.3 D = 22.9 ± 9.5 ND = 19.2 ± 8.3 Results not reported</td>
</tr>
<tr>
<td><strong>Constantin-Teodosiu et al.</strong> [10]/UK</td>
<td>114 on HD</td>
<td>M = 58.0 ± 2.0 F = 60.0 ± 2.0 42.8 ± 4.4</td>
<td>Strain gauge/ &gt; of five measurements</td>
<td>D</td>
<td>NS</td>
<td>M = 26.4 ± 1.5 F = 14.1 ± 1.1 Before Right = 41.6 ± 4.9 Left = 39.3 ± 4.5 After Right = 40.7 ± 4.7 Left = 39.9 ± 4.3 D = 22.9 ± 9.5 ND = 19.2 ± 8.3 Results not reported</td>
</tr>
<tr>
<td><strong>Headley et al.</strong> [11]/United of States</td>
<td>10 on HD, evaluated before and after resistance training</td>
<td>GH group = 73.5 ± 9.0 Placebo group = 72.7 ± 9.0</td>
<td>Strain gauge/NS</td>
<td>Non-fistula arm</td>
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<td><strong>Duruoz et al.</strong> [16]/Turkey</td>
<td>60 on HD</td>
<td>50.0 ± 13.4</td>
<td>Jamar/mean of three measurements</td>
<td>D/ND</td>
<td>Post-HD</td>
<td>Group A = 19.8 ± 8.7 Group B = 21.7 ± 7.7</td>
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<tr>
<td><strong>Konings et al.</strong> [15]/Netherlands</td>
<td>40 on PD</td>
<td>54.2 ± 12.1</td>
<td>Harpenden/ &gt; of three measurements</td>
<td>D</td>
<td>NA</td>
<td>Group A = 19.8 ± 8.7 Group B = 21.7 ± 7.7</td>
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<tr>
<td><strong>Cheng et al.</strong> [24]/China</td>
<td>28 on PD followed up for 9 months with improved fluid status (Group A) and with fluid overload (Group B)</td>
<td>Group A = 58.5 ± 13.5 Group B = 63.6 ± 9.0</td>
<td>NI/mean of measurements on both arms</td>
<td>Right/left</td>
<td>NA</td>
<td>Group A = 19.8 ± 8.7 Group B = 21.7 ± 7.7</td>
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<tr>
<td>Wang et al. [5]/China</td>
<td>233 on PD</td>
<td>M = 57.0 ± 12.0 F = 53.0 ± 12.0</td>
<td>Smedley/&gt; of three measurements</td>
<td>ND</td>
<td>NA</td>
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<td></td>
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<td>66.0 ± 9.0</td>
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<td>21.5 ± 9.3</td>
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<tr>
<td>Jamal et al. [17]/Canada</td>
<td>52 on HD</td>
<td></td>
<td>Jamar/mean of three measurements</td>
<td>Without AVF</td>
<td>Before the HD session</td>
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<tr>
<td>van Hoek et al. [19]/Netherlands</td>
<td>120 on HD</td>
<td>Presented according to dialysis accesses</td>
<td>Hydraulic/&gt; of three measurements</td>
<td>Both arms</td>
<td>Before the HD session</td>
<td></td>
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<tr>
<td>Dong et al. [23]/China</td>
<td>205 on PD according to presence (Group A) or absence (Group B) of renal residual function</td>
<td>Group A = 59.5 ± 14.6 Group B = 61.7 ± 12.5</td>
<td>NS/NS</td>
<td>Right/left</td>
<td>NA</td>
<td></td>
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<tr>
<td>Tander et al. [12]/Turkey</td>
<td>120 on HD according to results of Sollerman test(a) (dominant hand)</td>
<td>51.0 ± 1.4</td>
<td>Jamar/&gt; of three measurements</td>
<td>D (value used)/ND</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Yurtkuran et al. [34]/Turkey</td>
<td>19 on HD evaluated before and after yoga-based exercise programme</td>
<td>38.0 ± 14.2</td>
<td>NI/NS</td>
<td>NS</td>
<td>NS</td>
<td>Before = 150.3 ± 40.3(c) After = 172.6 ± 50.8</td>
</tr>
<tr>
<td>Carrero et al. [3]/Sweden(d)</td>
<td>265 incidents in dialysis (A) and 221 prevalents in HD (B)</td>
<td>A = 55 (44-64) B = 66 (51-74)</td>
<td>Harpenden/NS</td>
<td>A: dominant B: without AVF</td>
<td>A: NA B: post-HD</td>
<td>Results not available (expressed graphically as adequacy to controls)</td>
</tr>
</tbody>
</table>

M, males; F, females; SGA, Subjective Global Assessment; GH, growth hormone; HD, haemodialysis; PD, peritoneal dialysis; NA, not applicable; NS, not specified; NI, not identified; D, dominant arm; ND, non-dominant arm; AVF, arteriovenous fistula.

\(a\)Values are expressed as mean ± SEM.

\(b\)Sollerman test evaluates handgrip function in daily activities.

\(c\)Results expressed in millimetres of mercury.

\(d\)Study previously partly published by Heimburguer et al. [2], Carrero et al. [15], Stenvinkel et al. [21] and Nascimento et al. [25].
and lean body mass (LBM), which was estimated according to the creatinine kinetics ($r = 0.33$) in addition to serum albumin ($r = 0.24$) and SGA ($r = -0.20$).

Among the methods used to assess (LBM), dual-energy X-ray absorptiometry (DXA) is considered the most reliable, especially when serial assessments are carried out \cite{27,28}. For incidents patients from the same cohort, Heimburguer et al. \cite{2} and Stenvinkel et al. \cite{21} found a positive correlation between HGS and LBM assessed by DXA ($r = 0.70$) \cite{2,21}, creatinine kinetics ($r = 0.70$) \cite{2} and anthropometry ($r = 0.66$) \cite{2}.

In patients on PD, Jones et al. \cite{22} found a significant correlation between HGS and LBM, which was estimated by creatinine kinetics, anthropometry and bioimpedance. However, no correlation was found between HGS and LBMs estimated by anthropometry in women. Konings et al. \cite{16} also found a significant correlation between HGS and an estimate of LBM obtained by DXA, bioimpedance and anthropometry ($r = 0.58$, $r = 0.57$ and $r = 0.53$, respectively).

### HGS and survival

With respect to its importance as a prognostic factor, Stenvinkel et al. \cite{21} observed that incident patients on dialysis (HD or PD) with values of HGS above the median had higher survival rates than those with values below the median. However, when patients were stratified according to gender, HGS proved to be a prognostic index only in men. Even though LBM assessed by DXA was also correlated with survival only in men, the authors justified this difference by the fact that men are more competitive than women and that the type of dynamometer used was less comfortable for women.

In patients on PD, Wang et al. \cite{5} related both overall morbidity and mortality in both men and women to cardiovascular disease with reduced muscle function. In this study, others variables used in nutritional assessment, such as albumin, SGA and LBM, showed significant differences only in men, suggesting that HGS may be the best marker of prognosis for patients on PD regardless of gender.

### HGS: limitations and advantages

Although there is still the need for standardization of the techniques used for HGS in patients on dialysis, particularly relative to the position for measurement, the evaluation period, the choice of arm side and the reference to use, the present revision of the literature identified a correlation between muscle function estimated by HGS and variables used in muscle mass and nutritional status assessment [3,5,16,20–22]. HGS is advantageous in comparison to serum albumin, a marker of nutritional status that is more routinely used in the evaluation of these patients, mainly because it is a simple and non-invasive procedure that is not influenced by the inflammatory status [4,25]. Moreover, the prediction of clinical complications through the results of muscle function assessment [5,21] reinforces the systematic use of HGS in the evaluation of protein nutritional status in patients on dialysis. However, the definition of a diagnostic criterion for muscle depletion estimated by HGS is still missing for both dialysis patients and the general population [6].

Schlüsself et al. \cite{6} described the percentile distribution (P10, P30, P50, P70 and P90) of HGS values for healthy Brazilian adults (age $\geq 20$ years). Although there is no consensus on the parameter for classification of muscle wasting, it is reasonable to assume that the values in the lower percentiles, relative to a healthy population, are indicative of some degree of functional reduction of skeletal muscle [6].

It is also relevant to take into account the type and model of dynamometer to use because it has been shown that various types of dynamometers may yield different results in some studies [29–31] but not all [32].

### Conclusion

In summary, HGS is a useful tool for the continuous and systematic assessment of muscle mass related to nutritional status in patients on dialysis. However, it is still necessary to standardize the protocol to use, particularly in relation to the position, choice of arm side, evaluation period and diagnostic criterion.

### References

A retrospective study on outcome of microscopic polyangiitis in chronic renal replacement therapy

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Abstract

Background. Pauci-immune vasculitis is a heterogeneous disorder with an unfavourable prognosis. Renal involvement is frequently observed in antineutrophil cytoplasm autoantibody (ANCA)-associated small-vessel vasculitis and is an important cause of end-stage renal disease (ESRD). Renal replacement therapy (RRT) is frequently required. Although better prognosis under dialysis is well known, the long-term follow-up of pauci-immune renal vasculitis with RRT is rarely reported.

Methods. We described 24 patients with pauci-immune vasculitis and requirement of dialysis who were admitted in our institutions from January 1989 to December 2008. Mean age was 65 ± 12 years at the beginning of dialysis.