Abstract. The purpose of this study was to examine the discriminant and predictive validity of grip strength measurements obtained dynamometrically from patients in acute rehabilitation. Retrospective chart reviews were performed to retrieve information on admission grip strength. That strength was compared to published norms to establish discriminant construct validity. Predictive validity was investigated by analyzing the relationship of grip strength with rehabilitation length of stay (LOS) and discharge self-care function (Functional Independence Measure scores). Wilcoxon signed ranks tests showed that the patients’ grip strength was significantly less than normal on both their left (Z=–9.205, p<.001) and right (Z=–10.729, p<.001) sides. Grip strength was a significant but weak predictor of both LOS (Spearman rho=–0.277 to –0.352) and discharge function (Spearman rho=0.360 to 0.382) Multiple regression revealed that grip strength added nothing further to the prediction of LOS or discharge self-care function once admission self-care function was taken into account. This study provides strong support for the discriminant validity of grip strength measurements but only weak support for their predictive validity in acute rehabilitation.

Key words: Muscle strength, Dynamometry, Rehabilitation outcomes.

INTRODUCTION

The main purpose of physical rehabilitation is to assist patients in improving their functional status as this is what matters most to patients and has become the primary criterion for discharge and a proposed basis for hospital payment1). Numerous impairments, including decreased muscle strength, can contribute to limited function. Muscle strength has been the focus of considerable research. Much of that research has addressed grip strength. Grip strength measurements are employed to examine the hand2) and to characterize upper extremity strength in general3). Researchers have also used grip strength to reflect upper extremity function. Balogun et al.4) stated that “it is widely accepted that grip strength provides an objective index of the functional integrity of the upper extremity”. Nalebuff and Phillips5) found that 20 pounds of grip strength are necessary to perform most basic daily functional activities. Bohannon6) reported a strong correlation (r=.897) between paretic side grip strength and the gown donning ability of acute stroke patients. Sunderland et al.7) looked at grip strength as an indicator of function following stroke. They stated that “improvements in grip strength closely paralleled improvement in more complex motor tasks, suggesting that although a
simple function in itself, strength of grip can be used as an index of recovery of arm function more generally”. Boissy et al.8) suggested that maximal grip strength of the paretic side (normalized with the maximal grip strength on the unaffected side) appears to be a valuable outcome measure of upper extremity function in chronic stroke patients. Visser et al.9) found that loss of grip strength predicted poor recovery of mobility after a hip fracture. Keller10) used hand grip strength as a means to assess function in institutionalized older men and found it to have a correlation of .68 with Barthel Index scores.

Therapists have a limited time to examine patients in the inpatient setting. Measures capable of identifying impairments and predicting outcomes are therefore desirable. The degree to which grip strength is valuable in this regard has not been established for a heterogeneous sample ofacute rehabilitation patients. The objectives of this study of patients in an acute rehabilitation setting, therefore, were to determine if grip strength dynamometry is capable of: 1) discriminating between the forces patients actually generate and the forces they would be expected to generate if normal, and 2) predicting length of stay (LOS) and discharge self-care function.

METHODS

Following approval by the Institutional Review Committee of Hartford Hospital, a retrospective study was conducted. The study employed the medical records of patients discharged from the acute rehabilitation unit of a large community hospital over a two year period (January 1, 1998–December 31, 1999).

Subjects

For patients to be included in this study their initial physical therapy/occupational therapy note had to include documentation of gender, hand dominance, and age (which have all been shown to correlate with strength)11, 12). The note also had to include diagnosis and documented measurements of bilateral grip strength and Functional Independence Measure (FIM)13) scores for all self-care items (i.e. eating, grooming, bathing, dressing the upper body, dressing the lower body, and toileting). The discharge note had to include documentation of self-care function as measured by the FIM as well as rehabilitation LOS.

A total of 188 patients had medical records that met the inclusion criteria. Of these patients, 82 were women (43.6%) and 106 were men (56.4%). The ages of these patients ranged from 18 to 87 years with a mean age of 58 (SD=16.5) years. Of those included in the study, 17 were left-hand dominant (9.0%) and 171 (91.0%) were right-hand dominant. The primary diagnosis for the 188 patients included in the study varied widely: stroke=52, lower extremity amputation=25, debility=20, cancer=15, trauma=13, joint replacement=9, pulmonary disease=7, transplant=4, other neurological=25, other medical=13, and other surgical=5. The charts of five patients who had experienced trauma to an upper extremity were excluded.

The medical records of 144 patients did not meet the inclusion criteria. The initial and/or discharge notes were missing documentation items including grip strength (n=96), any self-care FIM score (n=31), grip strength and self-care FIM scores (n=11), and hand dominance (n=1). Five medical records were missing an initial physical/occupational therapy note.

Instrumentation

The Jamar hand-grip dynamometer was used to measure bilateral grip strength (in pounds). In addition to being quick and easy to administer, the Jamar dynamometer offers additional benefits. Normative values for this device have been established by Mathiowetz et al.14) and it is readily available commercially. The Jamar has achieved the highest calibration accuracy for the measurement of grip strength2) and has demonstrated construct validity for characterizing upper extremity strength impairment3). It has also been shown to have good inter-tester reliability (reliability coefficients $\geq 0.80$)2, 15) as well as high test-retest reliability (reliability coefficients $\geq 0.95$)2).

Although multiple measures exist for quantifying function, the therapists of Hartford Hospital utilize the FIM to quantify self-care independence. The FIM is a functional assessment instrument of the Uniform Data System for Medical Rehabilitation (UDS)13) that has gained wide clinical acceptance in acute care and rehabilitation settings11). Many investigators have employed the FIM as a measure of change in function16–18). The FIM measures disability in 18 basic items of daily living. Each
item is scored ordinally based on the patient’s performance with scores ranging from “1” (total assistance) to “7” (complete independence). The FIM is divided into two subscales including 13 motor items and 5 cognitive items. Although this scale is usually used in aggregate, only the six motor (self-care) items that most focused on use of the upper extremities were selected for this study. The FIM has been investigated thoroughly in terms of quality and clinical utility19–24). Researchers have demonstrated its inter-rater reliability19) and test-retest reliability (especially for the motor subscale)17). They have also demonstrated its discriminant construct validity20, 21) (especially on the basis of age and co-morbidity)22), its internal consistency21, 22), and its responsiveness22, 23). It has been reported to be more valid than the Barthel Index24).

**Procedures**

A list of the medical record numbers for patients admitted to the acute rehabilitation unit was obtained from the hospital’s administrative database. Patient records (n=337) were reviewed for age, gender, diagnosis, hand dominance, bilateral grip strength upon admission, FIM scores for self-care at admission and discharge, and length of stay. When complete information was found in the chart (n=188), this information was recorded onto data sheets for later analysis. Charts with missing information (n=144) or charts for patients who fit the exclusion criteria (n=5) were omitted.

The grip strength and FIM self-care scores obtained from the charts were recorded by occupational therapists experienced in measuring these two entities. The FIM tool serves as a key element of the rehabilitation unit’s program evaluation process at the facility. In addition, a manual (Uniform Data System for Medical Rehabilitation13)) with algorithms for determining patient scores was available to staff if questions arose in patient scoring.

Prior to analysis of the data, grip strength measures from the left and right sides were converted to Newtons. Taking each patient’s age and gender into account, the strength measurements obtained from the left and right sides were compared to the appropriate norms published by Mathiowetz et al.24). The six self-care FIM scores were added together resulting in a total FIM self-care score of 6 to 42 points for each patient at admission and discharge.

**Statistical analysis**

The SYSTAT software program (version 10.0) was employed for statistical analysis. Descriptive statistics were calculated to determine counts for gender and hand dominance. Descriptive statistics were also calculated to determine summary information for grip strength, age, LOS, and total self-care FIM scores at admission and discharge for the entire sample. Summary information for grip strength measures was also determined for two subgroups: those with neurological diagnoses (including stroke, multiple sclerosis, neuropathy, Guillan-Barre, meningitis, encephalopathy, and brain/spinal injuries and tumors) and those with diagnoses not neurological in nature. Cronbach’s alphas were calculated to check the reliability (internal consistency) of bilateral grip strength and of FIM scores on admission and discharge. To examine discriminant validity, patients’ actual grip strength measures were compared to gender and age matched norms using Wilcoxon signed ranks tests. Separate comparisons were made for the left and right sides. Predictive validity was examined using Spearman rho correlations (r_s) and multiple regression analysis. Specifically, Spearman correlations were calculated between both left and right grip strength measures and LOS and discharge self-care. For comparative purposes, Spearman correlations were also calculated between admission self-care and discharge LOS and self-care. Thereafter, regression analysis was used to determine if grip strength added to the prediction of LOS or discharge self-care provided by admission self-care.

**RESULTS**

Table 1 contains descriptive statistics for selected variables. Grip strength measures ranged from 0N to 600.5N. Length of stay ranged from 3 to 62 days with a mean of 17 days. Mean self-care scores were 25.6 at admission and 32.6 at discharge.

The Cronbach’s alpha value for grip strength was 0.822. For the admission and discharge FIM scores the Cronbach’s alphas were 0.824 and 0.893, respectively.

Of the 188 subjects, 143 (76.1%) had grip strength measurements, on both the right and left sides, that were less than the normative values
An additional 32 (17.0%) were found to be “weak” on only one side. Only 13 subjects (6.9%) were found to have bilateral grip strength measures equal to or greater than the normative strength values\textsuperscript{14}). Of the 77 subjects with neurological diagnoses (41.0% of the total number of subjects), 72 (93.5%) were found to be weak relative to established norms on one or both sides. Of the 111 subjects with “non-neurological” diagnoses, 103 (92.8%) were found to be weak relative to established norms on one or both sides. On the basis of the normal values published by Mathiowetz et al.\textsuperscript{14}), the patients’ grip strength was decreased a mean 37.4% on the left and 43.2% on the right. The Wilcoxon signed ranks tests showed both of these differences to be highly significant (left: $Z=–9.205$, $p<.001$; right: $Z=–10.729$, $p<.001$).

Table 2 documents the Spearman rho correlations of grip strength and admission self-care function measures with discharge self-care performance and length of stay (LOS).

\begin{table}
\centering
\begin{tabular}{llll}
\hline
Predictor variables & Discharge self-care & & Los \\
& $r_s$ & $r_s^2$ & $r_s$ & $r_s^2$ \\
\hline
Grip strength & & & & \\
Left side & 0.382 & 0.146 & –0.277 & 0.076 \\
Right side & 0.360 & 0.130 & –0.352 & 0.124 \\
Admission self-care & 0.667 & 0.445 & –0.559 & 0.312 \\
\hline
\end{tabular}
\end{table}

*All correlations are significant at $p<.001$.\textsuperscript{14}
predictor of LOS (R = −0.582). That is, grip strength added nothing to the prediction of LOS provided by admission self-care function. Regression analysis also revealed that once the effect of admission self-care function was taken into account, grip strength added nothing further to the prediction of self-care function at discharge.

**DISCUSSION**

This study supports the discriminant construct validity of dynamometer measures of grip strength among patients with a variety of diagnoses in acute rehabilitation. Specifically, dynamometry discriminated between patients’ actual and predicted grip strength. Dynamometry therefore showed that the patients’ grip strength was impaired (as might be expected). Their grip strength, however, acted only as a weak predictor of LOS. It appears that admission self-care function served as a stronger predictor of LOS. Similar results existed for discharge self care, as grip strength measures offered only a weak prediction of this outcome. These results are consistent with the literature in which investigators report admission FIM scores to be predictive of FIM scores at discharge. In this case, admission self-care function by itself served as the best predictor of discharge self care. Although grip strength at admission is known to explain upper extremity performance at the time of measurement, its ability to predict subsequent LOS and functional performance at discharge is more limited.

A possible explanation for these results includes the existence of impairments, aside from weakness (i.e. fine motor coordination), in the distal upper extremity that could contribute to limited upper extremity function at discharge. In a previously mentioned study, Sunderland et al. found that strength of grip did not correlate well with manual dexterity. Cognitive deficits could also be a factor.

A large percentage of the patients in this study (41%) had a neurological diagnosis, with over two-thirds of these subjects having experienced a recent stroke. Patients with neurological diagnoses, however, were not the only subjects with impairments in grip strength. They were found to have grip strength impairments that were similar to those of patients with non-neurological diagnoses. Furthermore, the group with non-neurological diagnoses actually contained a larger percentage of subjects with bilateral grip strength that was less than predicted by normative values (79.3% versus 71.4% in the group with neurological diagnoses). This may have implications for these patients beyond independence in basic self-care tasks measured using the FIM. For example, a patient with a lower extremity amputation and decreased bilateral grip strength will have functional limitations beyond simply dressing the lower body. Such a patient could have difficulty donning and doffing a prosthesis, particularly if it had a tight neoprene sleeve. Although the neurological and non-neurological subgroups of this study were found to have similar grip strength impairments, the predictive value of grip strength for specific diagnostic groups may warrant further investigation.

A possible limitation of this study is the inability to account for the requirement of a FIM task to be performed unilaterally or bilaterally. If a person is impaired only on one side, a unilateral task may be possible, whereas a bilateral task may be difficult or impossible. However, only 17.0% of the population was found to be weak on only one side, which tends to downplay the significance of this limitation.

In summary, this study reveals that grip strength serves as a legitimate measure of strength impairment in patients in the acute rehabilitation setting, but that it is inferior to alternatives for predicting length of stay and self-care function at discharge.

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