Title:
Leveraging Grip Strength and Sociodemographic Data to Predict Pain and Function Prognoses in Lower Extremity Amputees

Background:

Lower extremity amputation presents a significant disruption to mobility, independence, and quality of life. In the aftermath of limb loss, patient outcomes such as pain interference and functional mobility vary widely and are influenced by physiological, psychological, and sociodemographic factors. Identifying reliable, low-cost, and easily administered prognostic tools could greatly enhance individualized rehabilitation planning and long-term care for amputees. Grip strength, a validated marker of global muscular strength and physical resilience, has demonstrated predictive value across diverse patient populations, including those undergoing orthopedic procedures and those with chronic illness or frailty syndromes. However, its role in predicting outcomes specific to the amputee population, particularly patient-reported pain and function, remains unexplored. Given its simplicity and potential utility in clinical assessments, grip strength may offer a unique biomarker for stratifying recovery trajectories in lower extremity amputees. This study aimed to investigate the relationship between grip strength and self-reported outcomes related to pain and functional mobility in a cross-sectional cohort of individuals with lower limb amputation, while also accounting for relevant sociodemographic and clinical variables.

Methods:

We conducted a cross-sectional analysis of 46 adults with lower limb amputation. Grip strength was analyzed both continuously (kgs) and categorically, using age- and sex-adjusted normative data to define frail (>1 SD below mean), average (±1 SD), and robust (>1 SD above mean) groups. Bivariate analyses were used to explore associations between grip strength and PROMIS pain intensity, pain interference, neuropathic pain, and Neuro-QoL lower extremity function with and without prosthesis. Depending on data distribution and grip strength coding, we employed one-way ANOVA or Kruskal-Wallis tests, and Pearson or Spearman correlations. Multivariable linear regression models were built for each outcome. Continuous grip strength models were adjusted for age, sex, race, ethnicity, amputation level and cause, presence of neuropathic pain, caregiver status, and relationship status. For categorical grip strength models, age and sex were excluded as these were incorporated in category derivation. Variance inflation factors were used to assess multicollinearity.

Results:

The 46 patients reviewed had a mean grip strength of 37.6 kgs and represented a variety of ages, races, ethnicities, amputation characteristics, and pain histories (Table 1). Although grip strength was not significantly associated with PROMIS pain or pain interference scores in either bivariate or multivariable analyses, grip strength did show a positive correlation with Neuro-QoL lower extremity function ($\rho = 0.46$, $p = 0.0017$), with a trend toward significance across grip strength categories ($p = 0.06–0.09$) (Figure 1). Individual regression analyses revealed that Black/African American and White races were associated with greater PROMIS pain interference and that requirement of a primary caretaker and frail-level grip strength were associated with worse Neuro-QoL lower extremity function. Presence of neuropathic pain consistently predicted worse outcomes across all models ($p < 0.001$), and transfemoral amputation was associated with higher pain intensity. Other demographic or clinical factors showed limited effects.

Conclusion:

While grip strength was not significantly associated with pain intensity or interference scores in this cohort, its positive correlation with Neuro-QoL lower extremity function highlights its potential relevance as a biomarker of functional prognosis and recovery in lower extremity amputees. The trend toward significance across grip strength categories suggests that physical resilience, as captured by handgrip dynamometry, may relate more directly to mobility and adaptive capacity than to pain perception itself. Importantly, the consistent impact of neuropathic pain on worse outcomes underscores the need for targeted management of neuropathic symptoms in amputees, regardless of other clinical or demographic variables. Additionally, transfemoral amputation and caregiver dependence emerged as negative predictors of function, reinforcing the complex interplay between biomechanical, psychosocial, and support factors in recovery after limb loss.

Significance/Clinical Relevance:

These findings suggest that grip strength may serve as a clinically meaningful, non-invasive marker to help identify patients at higher risk of poor functional outcomes, particularly those with frail-level grip strength, and may inform tailored rehabilitation strategies. Future research should focus on validating these associations in larger, longitudinal cohorts to determine whether changes in grip strength over time correspond with trajectories toward functional recovery, and whether interventions aimed at improving global strength can meaningfully alter these outcomes.

Table 1. Patient sociodemographic and amputation-related data.

Variables	Patients (n = 46)
Age (mean years)	58.0
Gender	
Female	10
Male	36
Race	
Black/African American	10
White	31
Asian	2
Other	3
Ethnicity	
Hispanic	11
Not Hispanic	35
Relationship Status	
Married	22
Unmarried	23
Affected Side	
Right	18
Left	16
Both	12
Amputation Level	
Transtibial	26
Transfemoral	18
Knee Disarticulation	2
Indication for Amputation	
Arterial Insufficiency	10
Diabetes	11
Trauma	25
Pain Type	
Neuropathic	4
Residual Limb	9
Both	23
Neither	10
Grip Strength (mean kgs)	37.6

Figure 1. Grip strength and patient-reported outcomes Spearman bivariate analysis.