

Low Grip Strength As a Predictor of Recovery From Total Hip Arthroplasty (THA)

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Research article

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Abstract

BACKGROUND:

Some patients undergoing total hip arthroplasty (THA), continue to experience pain, limitations of activities of daily living, even when no specific prosthesis-related technical problem or failure can be identified, and mechanical or biologic problems have been ruled out. This study aims to assess whether low grip strength (GS) is predictive for the bad results after THA.

METHODS:

A prospective case-control study was designed to assess 202 cases of primary THA between Jan 1, 2018, to May 1, 2018, at an urban tertiary care hospital. Patients were placed into two cohorts based on preoperative GS levels. Differences in length of stay (LOS), 90-day postoperative complications, and hospital readmissions were compared. Besides, the correlations between GS and Harris hip score (HHS) and Short Form-12 (SF-12) score were tested.

RESULTS:

Eighty-two patients (40.6%) had low GS before THA. Patients with low GS were more likely to be female, older, fracture of femoral head or neck as the primary cause, albumin < 3.5 g/dL, and have a lower body mass index (BMI), higher ASA score, increased rates of the pressure sore, blood transfusion, and LOS compared to normal GS (all $p < 0.05$). Besides, differences in 90-day postoperative complications and hospital readmissions and positive correlations between GS and HHS and SF-12 scores were detected (all $p < 0.05$).

CONCLUSION:

GS can serve as a useful indicator for assessing muscle weakness before primary THA. Clinicians should be encouraged to include GS assessment in their evaluation of patients who planned to undergo THA in order to optimize the treatment of high-risk individuals.

Introduction

Total hip arthroplasty (THA) can reconstruct hip function to significantly improve the quality of life (QoL) [1, 2]. More than 230,000 patients in the United States alone and about 500,000 patients worldwide accept THA every year [3]. These figures increase by about 10% per year [4, 5]. Unfortunately, some patients who undergo THA, continue to experience pain, limitations of activities of daily living, or limited range of motion even when no specific prosthesis-related technical problem or failure mode can be identified, and mechanical or biologic problems have been ruled out [6]. Surgeons keep exploring potential markers to predict such unsatisfactory results to help take preventive measures.

Grip strength (GS) is a noninvasive marker of overall muscle strength and function and recommended as a simple and valid assessment in the clinical setting [7]. Previous studies have revealed that low GS is associated with poor nutrition, low levels of fitness, and a range of adverse outcomes including limited functional activities, disability, prolonged length of stay (LOS) in hospitalized patients, and even mortality[8–10]. Besides, low GS has also been seen among sarcopenia, loss of skeletal muscle mass, and aging. In these regards, low GS may be relevant to the recovery from THA. Therefore, the purpose of this study is as follows: (i) to evaluate the prevalence of low GS among patients undergoing THA; (ii) to assess whether low GS is predictive for the bad results after THA and (iii) to discuss the superiority in the application of this simple indicator.

Methods

Participants

From Jan 1, 2018, to May 1, 2018, there were 231 patients who underwent primary THA included in the study. This is a prospective study. This study was approved by the human research ethics committee of the authors' affiliated institutions, and all participants provided us with written informed consent. Participants were excluded due to (1) loss of follow-up/ incomplete data (N=4), (2) inadequate ability to perform the tests due to muscular atrophy of upper extremity alone on the dominant side (N=6) and (3) vocation/recent (<6 months) exercise which could merely affect the muscle strength of upper extremity (such as pull-up hobbyist) before THA (N=2). Patients with cancer history (N=8) and those comorbidities which are considered to produce a significant influence on patients' outcome were also excluded, including *severe* diabetes, *poor* renal function, *severe* hypertension, ischemic heart disease, liver cirrhosis or other diseases (N=9).

Data collection

Participants were tested at least three times using a grip strength dynamometer (Jk-w, Jingkaida, Beijing, China) several days prior to operation(Fig.1). The standard position for testing grip strength is the supine position with the upper limb relaxed on the bed. The elbow is extended without any flexion. Low GS in the present study was defined as GS lower than 26 kg for men and 16 kg for women in the dominant hand, according to the references of the FNIH Sarcopenia Project[14].

Baseline data were prospectively collected and included patient demographics (age, sex, body mass index[BMI]), the surgeon's diagnoses, medical history, length of stay, and American Society of Anaesthesiologists (ASA) score [11]. Clinical outcomes included surgery- and prosthesis-related variables. The Harris hip score (HHS) [12] and the Short Form Health Survey (SF-12) [13] were completed at the baseline visit and at 1 and 2 years postoperatively in the outpatient department to assess the hip's function and quality of life. Postoperative questionnaires were mailed to patients to complete and bring with them to their scheduled follow-up appointments. Additional mail-outs were also sent for any incomplete data or missing surveys. Complications that occurred 90 days postoperatively were recorded. Demographic variables, medical comorbidities, and 90-day major complications, hospital readmissions,

and mortality were compared among patients in low GS and normal GS cohort. A major complication was defined as myocardial infarction, postoperative mortality, sepsis, stroke, PJI, and death. Cardiac diseases were identified as arrhythmia, myocardial infarction, cardiac failure, coronary artery disease, and cardiomyopathy. Deep vein thrombosis (DVT) was confirmed by angiography and color ultrasound.

Perioperative Management Protocol

THA was performed using a standard Watson-Jones approach with a fully coated tapered stem (LCU Hip system, Waldemar Link, Munich, Germany) and acetabular cup (CombiCup, Waldemar Link, Munich, Germany). Both the acetabular cup and femoral stem were cementless. All patients were routinely given with prophylactic cefuroxime one hour preoperatively and the first 24 hours postoperatively (1.5g, iv, tid). Preventive anticoagulant therapy [10mg rivaroxaban every day or 2850 international units (IU) low-molecular-weight heparin (LMWH) (body weight <90 kg) or 5700 IU (bodyweight >90 kg)] began within 12 hours postoperatively and continued for 28 days at least. Patients were encouraged to begin weight-bearing as soon as tolerable with the help of ambulatory aids (usually within the first 24 hours). They then were allowed to discontinue the assistance of aids as they could ambulate without a limp (usually within 6-12 weeks). The physical therapist performed a functional exercise for all patients. The postoperative X-ray alignment on standard views was evaluated by two experienced orthopaedists, and all enrolled cases have a good quality of component placement without the femoral stems placed in a varus or valgus position. Patients were kept their anatomical abductor lever arm and offset after surgery.

Sample Size

Using G Power 3.1.9.2, posthoc achieved study power was calculated for the effect size of 0.3, error of the first type 0.05, and the total number of respondents with the number of 202 patients undergoing THA. The calculated study power equals 92.13%, which indicates good study power.

Statistical Analysis

Countable variables were presented as percentages and compared using the Chi-square test. Normally distributed continuous and non-normally distributed continuous data were respectively presented as mean \pm SD and the median and range. A *t*-test was used to compare clinical outcomes between groups. A multivariate logistic regression analysis was then performed to estimate the odds ratio (OR) and the associated 95% confidence interval (CI) to identify factors independently associated with 90-day major complications. To control for confounding variables, we used a multivariate logistic regression analysis to assess associated risk factors for 90-day major complications. Patient demographic factors and preoperative status were controlled for multivariate analysis. The Pearson correlation coefficient (coefficient, *r*) was used to test the correlation between preoperative GS and HHS and SF-12 improvement by controlling parameters with a correlation value of more than 0.5. *P* < 0.05 was considered statistically significant, and power analysis was ≤ 0.9 . All data were collected and analyzed using SPSS for Windows version 18.0 (SPSS Inc., Chicago, Illinois).

Results

Patient Demographics

A total of 202 participants have completed records for analysis finally. The patients were followed up for an average of 24.8 months postoperatively (24-26 months). Of this total, 82 participants (40.6%) had low GS. Patients with low GS were more likely to be female, older, fracture of femoral head or neck as the primary cause, albumin < 3.5 g/dL, and have a lower BMI, higher ASA score, increased rates of pressure sore before surgery, blood transfusion, and LOS compared to normal GS (all $p < 0.05$, Table 1).

Bivariate Analysis of Clinical Outcomes

Patients in the low GS cohort showed a statistically significant increased unplanned hospital readmissions and decreased discharge home compared to normal GS (both $p < 0.05$, Table 2). In addition, there was an increasing rate of complications between two cohorts, for cardiac complications, pressure sore after THA, respiratory complications, urinary tract infection, stroke, and DVT (all $p < 0.05$, Table 2).

Multivariate Analysis of Adverse Outcomes

Controlling for age, sex, and BMI, the patients having low GS were more likely to experience a major complication within 90 days of surgery (Table 3). Other risk factors included smoking history, pressure sore before THA, preoperative albumin < 3.5 g/dL, and ASA 4 or greater (Table 3).

Correlation Analysis between GS level and Patient-Reported Outcomes for THA

A partial correlation test by controlling medical comorbidities and demographic factors was used to determine the correlation between GS and HHS. There was a significant correlation between them ($r = -0.673$; $p = 0.002$).

A partial correlation test by controlling medical comorbidities and demographic factors showed a significant correlation between GS and SF-12 ($r = 0.645$; $p = 0.001$).

Discussion

Low GS (≈ 26 kg for men and ≈ 16 kg for women in the dominant hand) is associated with poor nutritional status, low levels of fitness, and a range of adverse outcomes including limited functional activities, disability, prolonged LOS, as well as even mortality[8-10]. The extent of these effects on patient-reported outcome measure (PROM), postoperative complications, and unplanned readmissions following primary THA is unclear. In this study, through conducting a prospective case-control design, we concluded that low GS before THA is a significant risk factor for increased LOS, unplanned hospital readmissions, worse PROM, and postoperative complications.

A number of previous studies have examined the predictive role of low GS for the clinical outcomes following orthopedic surgery [15-19]. For instance, Shen et al. reported patients with high preoperative GS to display a better surgical outcome in terms of disability and health status six months after spine surgery [15]. Selakovic et al. showed multivariate regression analysis adjusted for age and gender revealed that grip weakness was an independent predictor of worse functional outcome at 3 and 6 months after hip fracture for both genders and in all age populations[16]. Similarly, Hershkovitz et al. suggested that grip strength is independently associated with rehabilitation outcome in post-acute frail hip fracture patients [17]. A few studies have also investigated the predictive role of low GS in arthroplasty patients. Hashimoto et al. have investigated the effects of preoperative GS on stair ascent and descent ability in patients undergoing total knee arthroplasty[19]. In another study, Shyam et al. examined this simple GS test may be highly beneficial preoperatively in identifying those patients likely to require longer inpatient stays and therefore those who would benefit from early nutritional intervention and focussed physiotherapy on a cohort of total hip and total knee arthroplasty patients[20]. Similar to our study, they chose to measure the GS in patients who planned to undergo THA in the pre-admission clinic and reported similar findings to our study about the LOS, with an average delay in-hospital stay of 5 days in low GS cohort compared to the normal GS (12.2 ± 3.1 vs. 7.2 ± 3.8). However, unlike in our study, Hashimoto et al. and Shyam et al. did not investigate whether there existed a statistically significant difference in PROM and postoperative complications between the two cohorts.

Our study further corroborated previous findings [16,18-20] about the patient characteristics associated with low GS in this population undergoing primary THA. As expected, there were significant differences in preoperative characteristics between the low GS and normal GS cohorts. Patients with low GS, were more likely to be female, older, have a lower BMI and higher ASA score. Also, these patients were more likely to have increased rates of pressure sore before THA, preoperative albumin < 3.5 g/dL, and perioperative blood transfusion rate. This meant patients with low GS experienced worse nutritional status and limitations in mobility. Multivariate analysis was utilized to demonstrate that even when accounting for these differences in preoperative characteristics, low GS patients remained at risk for 90-day postoperative major complications after THA. The statistically significant variables in the univariate analysis in Table 1 were treated as potential confounders and analyzed in the multivariate analysis.

Low GS was present in 31.9% in men and 48.1% in women of the total primary THA patients in this study. This percentage is higher than 5% in men and 18% in women aged 65 years and above in multiple populations (Europe/North America, South America, Middle East, Africa, South East Asia, South Asia, and China) [14], and 18.0% and 38.4% in Australian men and women, respectively [21]. The reason for the difference in reported prevalence about low GS could be related to the race and the selection of the studied population. Our population, who is based on the patients undergoing THA in Asia, may have worse overall muscle strength and function compared to the general elderly population. When considering such a considerable percentage, these equate to significant effects on the over 600,000 primary THAs performed annually [22]. Low GS patients were more likely to have a worse functional outcome and quality of life reflected by HHS and SF-12 scores. Besides, they were nearly seven times (OR, 7.11) as likely to had a higher risk of experiencing a major complication within 90 days of surgery, which

in this study included myocardial infarction, postoperative mortality, sepsis, stroke, PJI, and death, after controlling for confounding variables. Limitations in mobility, reflected by the GS, may explain the high risk for these complications and other adverse outcomes, including pressure sore after THA, respiratory complications, urinary tract infection, and DVT. Of note, despite no statistically significant difference in dislocation after THA between two cohorts, the percentage in the low GS cohort is nearly 3.6 times than that in normal GS cohort (6.1 vs. 1.7, $p=0.082$). This could mean GS has a close association with the function of the abductor muscle group.

Our findings have certain implications. First, there is an ongoing urgent need to identify THA patients at increased risk for worse outcomes. Identifying this population of patients allows for the initiation of prevention and specific intervention to avoid the debilitating consequences of THA. Especially for patients undergoing THA due to hip fracture, other methods measuring muscle strength such as gait speed and muscle mass cannot be assessed before surgery. Instead, GS measurement is simple enough to be applied in the clinical setting. Therefore, confirmation of the prognostic value of HGS assessed in the THA setting is very significant. To the best of our knowledge, this is the first study to evaluate the role of HGS in predicting the clinical outcomes following THA for both gender and all ages. Second, muscle weakness, reflected by GS, is a modifiable risk factor that can be improved. It has been well known that strengthening exercises, especially for patients undergoing a selective operation, had positive effects on various outcomes after THA [26]. Therefore, GS measurement before THA could be considered in the design for individualized treatment plans to improve functional recovery.

Our study has several limitations. First, the sample size was relatively small. Patients were collected only from one single center. Second, analyzed complications in this study are limited to medical complications 90 days postoperatively. Therefore, we do not have data on delayed complications or orthopedic-specific perioperative complications. Third, despite being discussed, there are significant differences in preoperative characteristics between the cohorts. The multivariate analysis attempts to account for these differences; however, there remains a risk that the analysis missed important confounding factors not included in the model. Therefore, the potential confounding effects of these factors on grip strength could not be determined. Lastly, we are also completely aware of the fact that our GS measurement method is different from the standardized approach advocated by the American Society of Hand Therapists (ASHT), where the subjects are tested in a seated position [23]. GS was measured before THA in the supine position, since we noticed that it is unrealistic for a portion of patients, such as those with hip fracture, to complete the GS test in a seated position. Measuring GS after THA in a seated position would definitely be a more standardized way to assess muscle strength. However, we have standardized the way to measure GS in all the included patients, and this approach was also used by other authors [16, 24, 25]. Consequently, it is reasonable to assume that measuring GS in the supine position is an appropriate way to assess function.

Conclusion

GS can serve as a useful indicator for assessing muscle weakness before primary THA. In this prospective case-control study, we identified low GS as a modifiable significant risk factor for increased LOS, 90-day postoperative complications, worse functional results, and hospital readmissions. This study further supports the need for screening and preoperative intervention for patients at this risk group. Clinicians should be encouraged to include GS assessment in their evaluation of patients who planned to undergo THA in order to optimize the treatment of high-risk individuals.

Abbreviations

THA

total hip arthroplasty;

GS

grip strength;

LOS

length of stay;

HHS

harris hip score;

SF-12

short Form-12;

BMI

body mass index;

QoL

quality of life;

ASA

American Society of Anaesthesiologists;

IU

international units;

LMWH

low-molecular-weight heparin;

OR

odds ratio;

CI

confidence interval;

PROM

patient-reported outcome measure;

ASHT

American Society of Hand Therapists;

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Medical Ethics Committee of China-Japan Friendship Hospital.

Consent for publication

The patient had made consent to publish identifiable information and data.

Availability of data and materials

Data can be made available upon request to the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

TM and GL participated in concept development, data generation, quality control of the data, data analysis and interpretation, and writing of the manuscript. YP and GL were responsible for the data analysis and participated in the interpretation and presentation of the data. GL and TM provided input into the data interpretation. YP and GL were involved in the concept development, quality control of the data, and data analysis and interpretation of the manuscript. All authors have read and approved the final version of the submitted manuscript.

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Tables

Table 1. Comparisons of Demographic and THA-related operative data for patients with low GS and normal GS.

Variable	Low GS (n=82)	Normal GS (n=120)	p value
Mean age (years) (SD)	65.2 ± 6.2	61.2 ± 5.3	<0.001*
Female (%)	52 (63.4)	56 (46.7)	0.028*
Mean BMI (kg/m ²) (SD)	23.4 ± 3.2	25.2 ± 4.2	0.001*
Smoking history (%)	21 (25.6)	33(27.5)	0.892
Heavy drinking (%)	10 (12.2)	14 (11.7)	0.915
Pressure sore before THA (%)	7 (8.5)	3 (2.5)	0.034*
Hypertension requiring medication (%)	26 (31.7)	35 (29.1)	0.818
Cardiac diseases (%)	16 (19.5)	18 (15.0)	0.516
COPD (%)	6 (7.3)	8 (6.7)	0.918
Dialysis (%)	2 (2.4)	2 (1.7)	0.899
Diabetes mellitus (%)	25 (30.5)	34 (28.3)	0.863
Preoperative albumin < 3.5 g/dL (%)	15 (18.3)	8 (6.7)	0.020*
General anesthesia (%)	14 (17.1)	18 (15.0)	0.841
Diagnose			
AVNFH	27 (32.9)	64 (53.3)	0.008*
Fracture of femoral head or neck	34 (41.5)	22 (18.3)	
DDH	12 (14.6)	14 (11.7)	
RA	3 (3.7)	6 (5.0)	
Posttraumatic arthritis	3 (3.7)	5 (4.2)	
Others	3 (3.7)	9 (7.5)	
ASA Class			
I-II	30 (36.6)	63 (52.5)	0.047*
III-IV	51 (62.2)	57 (47.5)	
V-VI	1 (1.2)	0 (0)	
Mean operative time (minutes) (SD)	61.5 ± 8.2	62.7 ± 7.8	0.294
Perioperative blood transfusion rate (%)	20 (24.4)	15 (12.5)	0.045*
Length of stay (days)	12.2 ± 3.1	7.2± 3.8	<0.001*

*indicates statistical significance. GS=grip strength, SD=standard deviation, BMI=Body Mass Index, THA=total hip arthroplasty, COPD= chronic obstructive pulmonary disease, AVNFH=avascular necrosis of femoral head, DDH=developmental dysplasia of the hip, RA= rheumatoid arthritis, ASA= American Society of Anaesthesiologists.

Table 2. Comparisons of adverse outcomes for patients with low GS and normal GS.

Variable	Low GS (n=82)	Normal GS (n=120)	p value
Unplanned hospital readmissions (%)	13 (15.9)	5 (4.2)	0.002*
Pressure sore after THA (%)	6 (7.3)	2 (1.7)	0.031*
Dislocation after THA (%)	5 (6.1)	1 (0.8)	0.082
Wound dehiscence (%)	3 (3.7)	3 (2.5)	0.957
Wound infection (%)	2 (2.4)	3 (2.5)	0.665
PJI (%)	1 (1.2)	1 (0.8)	0.652
DVT (%)	9 (11.0)	3 (2.5)	0.028*
Cardiac complications (%)	9 (11.0)	3 (2.5)	0.028*
Stroke (%)	8 (9.8)	2 (1.7)	0.023*
Respiratory complications (%)	6 (7.3)	2 (1.7)	0.098*
Renal complications (%)	1 (1.2)	1 (0.8)	0.652
Urinary tract infection (%)	8 (9.8)	2 (1.7)	0.023*
Sepsis (%)	1 (1.2)	0 (0.0)	0.848
Death (%)	2 (2.4)	0 (0.0)	0.319
Discharge disposition (%)			
Home	68 (83.0)	115 (95.8)	0.006*
Skilled nursing or rehabilitation	12 (14.6)	5 (4.2)	
Death	2 (2.4)	0 (0.0)	

*indicates statistical significance. GS=grip strength, THA=total hip arthroplasty, PJI= periprosthetic joint infections, DVT=deep vein thrombosis.

Table 3. Adjusted risks of 90-day postoperative major complications after THA.

Risk factor	OR	95% CI #	p-value
Low GS	7.11	7.01-7.19	<0.001*
Smoking history	2.12	2.00-2.23	0.012*
Heavy drinking	1.64	1.56-1.72	0.453
Pressure sore before THA	3.42	3.25-3.60	0.023*
Hypertension requiring medication	1.85	1.76-1.94	0.253
Cardiac diseases	2.45	2.33-2.57	0.321
COPD	2.31	2.19-2.43	0.762
Dialysis	1.78	1.69-1.87	0.213
Diabetes mellitus	2.21	2.10-2.32	0.543
Preoperative albumin < 3.5 g/dL	3.52	3.34-3.70	0.021*
General anesthesia	2.11	2.00-2.22	0.212
ASA 4 or greater	4.02	3.82-4.22	<0.001*
Perioperative blood transfusion rate	2.52	2.39-2.65	0.762

*indicates statistical significance. # fully adjusted by confounding variables. Odds ratios, as well as 95% CIs, were shown. OR=Odds Ratio, CI=confidence interval, GS=grip strength, BMI=Body Mass Index, THA=total hip arthroplasty, COPD= chronic obstructive pulmonary disease, ASA= American Society of Anaesthesiologists.

Figures



Figure 1

Data collection