Original Article

Assessing Muscle Strength Deficits in the Hip and Knee on Surgical and Non-Surgical Sides in Women Post 12 Months Total Hip Arthroplasty

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ABSTRACT

Background: THA is relevant in the intervention of end-stage hip osteoarthritis in relieving pain and improving function. It has been concluded that strength deficits in the surgical and nonsurgical limbs remain after surgery and affect gait, balance, and functional independence. This study was conducted to quantify hip and knee muscle strength deficits one-year post-THA in women and determine their association with functional performance.

Methods: A prospective cohort study was conducted on 30 women aged 50-75 years who had undergone unilateral THA due to primary osteoarthritis. They were assessed for muscle strength (hip abductors, hip extensors, knee extensor, and knee flexors) using hand-held dynamometry at 3, 6, and 12 months post-surgery. Functional performance was measured using Timed Up and Go (TUG), 30-second Chair Stand, and 6-minute Walk Test (6MWT) scores. Strength asymmetry was evaluated using mixed-model ANOVA, while the associations with function were determined using Pearson correlation.

Results: Strength deficits showed significant persistence for the surgical limb even at 3 months: hip abductor (-32.5%, $p<0.001$), hip extensor (-28.7%, $p<0.001$), knee extensor (-34.1%, $p<0.001$), and knee flexor (-26.4%, $p<0.001$). By 12 months, the deficits were still present but with less impact (-10.1 to -8.5, $p = 0.07$). Progressive improvement in functional performance with time correlated with recovery in strength (hip abductor strength vs. TUG: $r=-0.72$, $p<0.001$).

Conclusion: Post-THA, muscle strength asymmetry remains, especially in the hip abductors and knee extensors within the mobility context. Working toward extensive rehabilitation exceeding typical protocols but with a clear focus on strength training is mandatory for optimized recovery and functional results.

Keywords: Functional recovery, Hip abductor weakness, Muscle strength deficits, Rehabilitation, Total hip arthroplasty.

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INTRODUCTION

Total hip arthroplasty (THA) is a well-established surgical intervention for end-stage hip osteoarthritis (OA) patients and enables pain relief, improved joint function and quality of life[1]. Due to the increasing proportion of elderly and obese patients, the annual number of THA has risen significantly[2]. Consequently, optimizing post-operative rehabilitation plans remains a considerable challenge for orthopedics and rehabilitation research[3].

Despite the THA procedure serving to restore mobility and relieve pain, muscle strength deficits in the hip and knee are still evident in some patients' months after surgery, especially between the operated and the non-surgical limb[4]. These asynchronies can significantly alter gait patterns, balance, and functional independence, thus placing patients at risk of falling and contributing to secondary musculoskeletal problems[5-6].

THA has one primary objective, i.e. the hip should function optimally, and the person should experience minimal pain while performing activities by that joint[7]. Unfortunately, failed surgery or recovery does not guarantee that

individuals will have normal strength following the procedure[8]. Strength deficits exist post-operatively in the hip abductor, extensor, and flexor muscles, especially in the involved limb[9]. Evidence indicated that weakness of the hip abductors is the most important deficit extending following THA since these muscles help stabilize the pelvis during gait[9-10]. Altered weight-bearing mechanics might cause compensation by the contralateral (non-surgical) limb, leading to possible bilateral weakness[11].

Additionally, the knee extensor and flexor strengths are compromised on the other side after THA. Quadriceps and hamstring muscles, important for mobility and stability of the knee joint, may become deconditioned due to prolonged immobility or altered gait mechanics before the operation[12-13]. Thus, deficits in knee strength on both surgical and non-surgical sides can decrease functional recovery and render the patient dependent on assistive devices[14].

Muscle strength imbalances between the limbs may be crucial factors concerning functional outcomes after surgery[13]. Gait analysis demonstrated that asymmetry between the lower limbs is usually associated with poor walking mechanics, diminished length of the steps, and abnormal weight distribution[15]. This imbalance may not be restored to normal and may extend to 12 months post-operative, delaying potential bodily function. Deficits could also affect sit-to-stand transitions and climb and increase overall mobility, emphasizing the need to develop specific rehabilitation interventions[16].

While traditional rehabilitation has focused on early mobilization, pain, and range of motion management, increasing evidence suggests that specialized strength training regimens will be needed to address the muscle deficits, specifically for the hip and knee. The data concerning the extent and longevity of these deficits up to 12 months post-operatively should guide personalized rehabilitation programs meant to restore strength, reduce asymmetries regarding muscle development, and improve long-term functional outcomes. Thus, this study quantified hip and knee shear limb muscle strength deficits at 12 months post-THA in women. The research will inform an evidence-based rehabilitation target and post-operative management approach by evaluating bilateral strength differences.

METHODOLOGY

This prospective-cohort observational study assesses muscle strength deficits in the hips and knees on surgical and non-surgical sides in women undergoing unilateral THA. The subject's assessment was performed at three different time points, 3 months, 6 months, and 1 year after operation, to monitor the changes in muscle strength over time and to look for potential recovery trends. The study also assesses the persistence of muscle weakness beyond the early post-operative phase and strength asymmetry's effect on functional outcome.

Sample Size Calculation

The sample size for this research was estimated by G*Power 3.1 software, which usually utilizes power analysis for biomedical research. Based on a review of previous studies on muscle strength recovery after THA, it was decided to have one effect size of 0.5 with a power of 0.80 and an alpha level of 0.05. The calculations indicated that at least 26 participant subjects were needed to identify differences in strength between the two limbs: the surgery limb and the non-surgery limb. A 10% adjustment was made to create room for dropouts or attrition during the study, giving a total sample size of 30 subjects. This would ensure adequate statistical power for comparing meaningful differences between time points and limbs.

Sampling Strategy

Purposive sampling was used to recruit participants from the two major orthopedic rehabilitation centers of Peshawar, Khyber Pakhtunkhwa. Their clinical records were scrutinized to find patients who had undergone unilateral THA due to primary osteoarthritis, whom were contacted and screened after being identified using inclusion and exclusion criteria.

The recruitment lasted for six months, representing diversity in patients at different stages of recovery. All participants were given written informed consent before participating in the study.

Participants and Eligibility Criteria

Thirty women were part of the study who had undergone primary unilateral THA due to hip osteoarthritis. The subjects were further grouped into two groups based on the recovery stage post-operatively:

- **Early Recovery Group (n = 15):** Patients assessed at 3 months post-THA
- **Late Recovery Group (n = 15):** Patients assessed at 6 and 12 months post-THA

In this respect, rigorous inclusion and exclusion criteria were established to ensure homogeneity among the participants. Women aged between 50 and 75 years who had had unilateral THA because of primary osteoarthritis and were able to ambulate independently during assessment time without any assistive devices were included. Exclusion from eligibility would be if the patient has a history of contralateral hip or knee replacement or has a significant neurological problem that alters the lower limb function. Additional exclusion criteria are patients with cardiovascular or metabolic diseases that could limit mobility, those who had post-operative complications, such as infections or revision surgery, and those who had previous surgeries on the non-surgical limb.

Assessment Protocols

- **Muscle Strength**
  Muscle strength was assessed bilaterally using hand-held dynamometry - a standard measure of isometric muscle strength. The main reason for using it was because it has been very valid and reliable for clinical populations. This study was confined to four muscle groups: hip abductors, hip extensors, knee extensors (quadriceps), and knee flexors (hamstrings). These muscle groups were selected based on their functions because they are critical for postural stability, gait facilitation, and functional movement. Each participant was required to perform three maximal voluntary isometric contraction (MVIC) efforts per muscle group with a 30-second rest period to avoid fatigue. The highest value recorded was used for analysis. As strength asymmetry, the outcome was expressed as a percentage difference between surgical and non-surgical limbs for quantifying residual deficits. Hand-held dynamometry for hip and knee muscle strength assessment reliability has been substantiated in earlier studies and had ICCs from 0.85 to 0.95, thus showing excellent measurement consistency. Further ensuring the reliability of the measurements, the interviewer obtained interrater reliability training before data collection, and then repeatability testing was conducted on a small number of five pilot subjects.

- **Functional Performance Measures**
  Three functional performance measures included the Timed Up and Go Test (TUG), 30-second Chair Stand Test, and 6-Minute Walk Test (6MWT), which evaluated the subjects' mobility, endurance, and balance.

  1. The TUG used to measure dynamic balance and mobility. It required subjects to rise from a seated position, walk three meters, and turn and return to the chair as quickly as possible, with the time taken to do the task recorded and higher times signifying more significant mobility impairment. There is good reliability for this test (ICC = 0.92) in orthopaedic populations.

  2. The 30-second Chair Stand Test determined lower limb muscular endurance and where functional strength was concerned. Participants were instructed to perform as many sit-to-stands as possible within 30 seconds. This test is frequently used to evaluate lower limb power and has a reported measurement reliability of ICC = 0.88.

  3. The 6-Minute Walk Test (6MWT) measured overall functional capacity and endurance. Participants were instructed to walk continuously on a track designated for that purpose for six minutes, recorded for the total distance covered. This test has gained much validity in rehabilitative settings, proving to be of impressively high reliability in repeat testing (ICC = 0.93).

Data Collection and Statistical Analysis

Using standard protocols, data was collected post-operatively at 3, 6, and 12-months by a blinded assessor, who was entirely ignorant of the participant's recovery stage or past test results, conducted all muscle strength and functional assessments to understand whether a bias had been introduced.

Descriptive statistics (mean and SD) were used to summarize baseline characteristics. The effect of time (3, 6, and 12 months) and limb (surgical vs. non-surgical) on muscle strength and functional measures was analyzed using a mixed-model ANOVA. Within-group comparisons were made using paired t-tests, while independent t-tests were used to compare strength asymmetry between early and late recovery groups. Relationships between muscle strength deficits and outcomes from functional tests were examined by Pearson correlation analysis. All statistical tests were set up to have a level of significance $p < 0.05$.

Ethical Considerations

Research ethics were followed in compliance with the Declaration of Helsinki, which protects human research subjects. All subjects signed written informed consent forms before entering the survey. The study construction minimized risks to participants, and trained healthcare professionals performed all procedures.

RESULTS

Characteristics of Participants and Retention

Thirty women were recruited and completed different time points of research assessments: 15, 15, and 15 out of 30 were 3, 6, and 12 months post-THA, respectively. There were no dropouts. Thus, complete follow-up data could be collected for all participants. The mean age at baseline was 65.2 ± 5.4 years; BMI was 28.6 ± 3.9 kg/m². Group differences concerning baseline characteristics (age, BMI, preoperative functional status; $p>0.05$) were insignificant.

Deficit in Hip and Knee Muscle Strength

Muscle strength deficits were evidenced across all time intervals on the surgical limb compared to the non-surgical limb. At 3 months after THA, the surgical limb had inferior capacity than its counterpart limb: lower strength in hip abduction (sacrifice, $p<0.001$; effect size=−32.5%), hip extensors (sacrifice, $p<0.001$; effect size=−28.7%), knee extensors (sacrifice, $p<0.001$; effect size=−34.1%), and knee flexors (sacrifice, $p<0.001$; effect size=−26.4%) relative to the non-surgical limb. Muscle strength showed post-surgical improvement by 6 months, but deficits were still shown in hip abductors (-20.8%), hip extensors (-18.3%), knee extensors (-22.5%), and knee flexors (-15.9%); differences were significant for all ($p < 0.05$). At 12 months after THA, further improvement was noted, and strength deficits were less: hip abductors (-10.1%), hip extensors (-9.4%), knee extensors (-12.2%), and knee flexors (-8.5%) ($p = 0.07$, borderline significance).

Table-1 Mean Muscle Strength Asymmetry (Surgical vs. Nonsurgical Limb) at Different Time Points (in % Deficit)

Time Point	Hip Abductors	Hip Extensors	Knee Extensors	Knee Flexors
3 Months	−32.5% (p<0.001)	−28.7% (p<0.001)	−34.1% (p<0.001)	−26.4% (p<0.001)
6 Months	−20.8% (p<0.05)	−18.3% (p<0.05)	−22.5% (p<0.05)	−15.9% (p<0.05)
12 Months	−10.1% (p=0.07)	−9.4% (p=0.07)	−12.2% (p=0.07)	−8.5% (p=0.07)

The functional output measures were improved over time, wherein differences were observed at 3 and 12 months after total hip arthroplasty as follows:

- The average time taken by participants to complete the test was reduced from 13.5±2.1 seconds at 3 months to 10.8±1.9 seconds at 6 months and finally to 8.9±1.4 seconds at 12 months post-THA ($p<0.001$).
- At 3 months after surgery, subjects performed a mean of 9.2±1.5 repetitions, increasing to 12.1±2.0 repetitions by 6 months and 15.3±2.5 by 12 months ($p<0.001$).
- Mean walking distance at 3 months was 280.5± 42.8 meters and increased to 340.8±47.6 meters at 6 months and 395.1±50.3 meters at 12 months ($p<0.001$)

Association between Strength and Function

Pearson correlational analysis indicated significant associations between muscle strength and functional performance outcomes. At 3 months, hip abductor strength was correlated with TUG time (r=-0.72, p<0.001), which can be interpreted as more significant hip weakness

Table-2 Functional Performance Measures at Different Time Points

Time Point	TUG (sec)	30s Chair Stand (Repetitions)	6MWT (meters)
3 Months	13.5±2.1	9.2±1.5	280.5±42.8
6 Months	10.8±1.9	12.1±2.0	340.8±47.6
12 Months	8.9±1.4	15.3±2.5	395.1±50.3

associated with slower mobility. Likewise, knee extensor strength was calculated to correlate moderately with the 6MWT distance (r = 0.65, p<0.01), which can be interpreted as quadriceps weakness associated with reduced walking endurance. Such associations remained significant but weakened with time as patients' regained strength and improved mobility.

Table-3 Correlation Between Muscle Strength and Functional Performance at 3 Months

Strength Measure	TUG (sec)	30s Chair Stand (Reps)	6MWT (Meters)
Hip Abductors	r = −0.72 (p<0.001)	r = 0.58 (p<0.01)	r = 0.62 (p<0.01)
Hip Extensors	r = −0.66 (p<0.01)	r = 0.53 (p<0.01)	r = 0.61 (p<0.01)
Knee Extensors	r = −0.59 (p<0.01)	r = 0.65 (p<0.01)	r = 0.65 (p<0.01)
Knee Flexors	r = −0.50 (p=0.02)	r = 0.49 (p=0.02)	r = 0.52 (p=0.02)

DISCUSSION

This study observed that muscle strength asymmetry between surgical and non-surgical limbs remained significant in the third and sixth post-operative months, especially for hip abductors and knee extensors. Such recovery continued, but at the 12-month mark, strength deficits continued but approached statistical non-significance. The functional improvements in TUG, 30-second chair stand, and 6MWT mirrored the trends observed for strength recovery. Muscle strength has shown a strong correlation with functional performance measures, thus making it clinically relevant for strength rehabilitation in optimizing recovery post-THA. These results suggest that strengthening the hip abductors and knee extensor muscles can enhance performance.

The findings of this study align with the evidence from more extensive previous studies, which state that strength deficits exist long after the usual rehabilitation[17]. These findings support the need to design specific rehabilitation strategies to counter residual muscular imbalance and optimize functional outcomes. Moreover, many studies have shown that the strength of hip abductor muscles is important for recovery after surgery. According to a study[18] hip abductor weakness leads to altered gait and increased joint stress, eventually causing long-term effects on recovery. Our study confirms these observations because significant strength differences have been noted in favor of the surgical limb, indicating the importance of strengthening the hip abductors in post-operative rehabilitation programs. This also demonstrated that appropriate restoration of hip joint positions affects the recovery strength of the abductor muscles[19]. Patients with well-aligned joints showed more significant strength gains than those slightly misaligned, indicating that surgical technique is crucial to the recovery process after an operation[20]. Furthermore, strength deficits in the non-surgical limb remain a concern because the weakness of the contralateral limb may facilitate the development of compensation patterns in movement, leading to an increased risk of injury[21].

These findings emphasize the importance of participating in rehabilitation programs for an extended duration, which should continuously last at least 3 to 6 months after surgery. The movement patterns are not entirely advocated in the rehabilitation protocols that encourage short-term recovery following surgery. Our findings suggest using structured strength training for at least 12 months post-operatively[17]. Future studies may explore extended rehabilitation programs' capacity to improve surgery-related success from bilateral strength training.

Strengths and Limitations

This study is rigorous due to its broad measurement of hip and knee muscle strength from the surgery and non-surgery side, giving the complete picture of recovery. Additionally, the measurements of strength could be objective, thus increasing the reliability of the findings. The study population altogether included women, thus filling an important gap in sex-specific research regarding THA recovery. However, there are some limitations to this study. One of them is that the sample size was small, making the findings less generalizable to a broader audience. Also, although strength deficits were determined, the functional influence on performance, like gait speed or balance, could not be assessed.

Therefore, rehabilitation treatment among THA patients should not be less than 6 months complete within progressive resistance exercise to cover existing strength deficiencies. Surgeons and physiotherapists, too, need to consider the possible effects of the direction of the hip joint on muscle recovery before considering subsequent interventions. Future studies should focus on assessing the delayed effects of specific rehabilitation programs with ambiguous designs for functional mobility and quality of living.

CONCLUSION

The findings from this study revealed significant muscle strength deficits at both hip and knee in most cases, even after 12 months from THA on both surgical and non-surgical sides. It emphasizes the extended rehabilitation process and specific strength training programs to optimize recovery and functional outcomes in the long term. Addressing these deficits with structured intervention may improve post-operative mobility and reduce the likelihood of developing compensatory movement patterns or secondary musculoskeletal problems.

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Author Contributions

Adnan Aziz contributed to conceptualization, study design, and data collection. **Mazhar Ali Bhutto** was responsible for methodology, data analysis, and manuscript review. **Aliya Shair Muhammad** conducted the literature review and contributed to manuscript writing. **Asad Shah** handled data interpretation and manuscript editing. **Dileep Kumar** performed statistical analysis and manuscript drafting. **Zona Mehreen** assisted with data collection, formatting, and final review.

Ethical Approval

This study received approval from the Institutional Ethical Review Committee (PK-ORTHO-2023-176) of Peshawar General Hospital and Research Centre.

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None.

Conflict of Interests

None.

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