ASSOCIATION BETWEEN HIP STRENGTH, PHYSICAL FUNCTION AND DYNAMIC BALANCE IN A PEOPLE WITH UNILATERAL HIP OSTEOARTHRITIS

Dr. Erum Ghaffar[1], Arooba maqsood [1], Fatima Mazhar[1], Rimsha Ameen[1], Rimsha Tariq[1],Rehna khizar [1], Aneeqa Aqdas[1], Uzma irshad [1], Ahtasham farzand [1], M.saeed [1]

Department of Physical Therapy, Hajvery University, Pakistan

Corresponding Author: Dr. Erum Ghaffar [1] Hajvery University, Pakistan

***Abstract*- Background:** Hip osteoarthritis (OA) is a prevalent degenerative joint disease that significantly impacts mobility and quality of life. Among individuals with unilateral hip OA, the condition often leads to reduced hip strength, compromised physical function, and impaired dynamic balance. In people with hip osteoarthritis, the association between multidirectional hip strength and physical function or balance is unknown.

Methods: Fifty- five participants (20 men and 35 women, age 40-80 years) with unilateral hip osteoarthritis were included. Hip strength was assessed with Muscle strength grading scale (oxford scale), physical function was assessed with 30-s chair-stand test (30sCST) and stair-climb test (SCT); and dynamic balance was assessed in 3 directions using the Star Excursion Balance Test. Multivariable linear regression analysis was used to determine the strength of relationships between measures. Data analysis was done by using the IBM SPSS Statistics 29.

Results: Hip strength, except for internal rotation, was positively associated with better physical function (SCT: $R^2 = 0.5$ to 0.54; 30sCST: $R^2 = 0.39$ to 0.42) and dynamic balance (anterior: $R^2 = 0.33$ to 0.45; posteromedial: $R^2 = 0.32$ to 0.45; posterolateral: $R^2 = 0.27$ to 0.35). Adjusting for knee extension strength, hip strength explained an additional 8%-12% ($p < 0.05$) in anterior reach and 5%-12% ($p < 0.05$) in posteromedial reach on the Star Excursion Balance Test.

Conclusions: Hip strength in various directions is linked to physical function and dynamic balance in individuals with unilateral hip osteoarthritis. Clinicians should incorporate multi-directional hip strength into exercise programs to address patients' functional and balance goals.

***Index Terms*-** Hip osteoarthritis, Hip Strength, Function, Balance.

Introduction:

Wear and tear and the progressive loss of articular cartilage are usually the causes of hip osteoarthritis (OA), sometimes referred to as degenerative joint disease. Seniors are most likely to experience it. There are two categories of hip osteoarthritis: primary and secondary. Articular degeneration in primary osteoarthritis has no discernible underlying cause. Either aberrant articular cartilage, as in rheumatoid arthritis (RA), or an aberrant concentration of force across the joint, as in post-traumatic reasons, can result in secondary osteoarthritis (1).

Most research has focused on OA at specific sites, some studies have provided data on OA prevalence and incidence more generally. An estimated 240 million individuals worldwide have symptomatic OA, including 10% of men and 18% of women age 60 and older (2).

Usually, osteoarthritis progresses over time and can eventually cause disability. Each person may experience the clinical signs at a different intensity. But over time, they usually get worse, happen more often, and become more incapacitating (3). Also, each person's rate of advancement differs. Clinical symptoms that are frequently experienced include gradual-onset, activity-exacerbated knee pain, hip stiffness and edema, discomfort after extended periods of sitting or rest, and pain that gets worse with time. Hip osteoarthritis is treated conservatively at first, and if conservative measures are ineffective, surgical options become available. There are presently no proven disease-modifying drugs for the treatment of osteoarthritis in the knee, despite the fact that pharmaceuticals can help delay the progression of RA and other inflammatory disorders (4).

The most prevalent type of arthritis identified is hip osteoarthritis, and as life expectancy and obesity increases, so too will the prevalence of this condition. Roughly 10% of men and 13% of women 60 years of age and older have symptomatic osteoarthritis in their hip, according to various sources. The frequency increases to 40% among people over the age of 70. Males are also less likely than females to get hip osteoarthritis. It's interesting to note that not all people with hip osteoarthritis who have radiographic results will have symptoms. According to one study, only 15% of patients with hip OA identified on radiographs also had symptoms. When age is not taken into account, the annual incidence of symptomatic hip osteoarthritis is about 240 instances per 100,000 persons (5).

Hip OA has been linked to a number of risk factors, including age, obesity, joint trauma or injury, and genetics (6). The most important risk factor for hip OA is age, as the disorder is more prevalent as people age. Another significant risk factor for hip OA is obesity, since an excess of body weight puts more mechanical strain on the joints. Another significant risk factor for hip OA is joint trauma or injury; a history of joint injury can boost the likelihood of getting hip OA by four times. Hip OA pathogenesis is also influenced by genetic factors; several genes are linked to the development and susceptibility of OA (7).

Although there isn't a single cause for hip osteoarthritis, there are a few things that can increase your risk of getting the condition, such as: growing older with a family history of osteoarthritis, prior hip joint damage, being overweight, developmental dysplasia of the hip refers to abnormal hip joint formation from birth (8).

Articular cartilage is primarily composed of proteoglycans, chondrocytes, water, and type II collagen, maintaining a balance between synthesis and degradation to stay healthy. In osteoarthritis, overexpression of matrix metalloproteases (MMPs) disrupts this balance, leading to collagen and proteoglycan loss. Although chondrocytes attempt to counteract this by increasing proteoglycan synthesis and secreting tissue inhibitors of MMPs (TIMPs), these efforts are insufficient. Despite increased synthesis and water content, the disorganized collagen and decreased proteoglycans result in a loss of equilibrium (9).

While hip osteoarthritis and aging are closely associated, it's crucial to remember that hip osteoarthritis is a disease in and of itself rather than just the result of age. The alterations in cartilage observed with osteoarthritis and aging provide evidence for this. In addition, the breakdown-causing enzymes are expressed at normal levels in normal aging cartilage, but at elevated levels in hip osteoarthritis (10).

Before a physical examination of the hip, conduct a visual evaluation for quadriceps muscle atrophy, varus or valgus deformities, and periarticular erythema and swelling. Observe for abnormal hip motion or pain during gait, indicating possible ligamentous instability. Inspect the surrounding skin for soft tissue lesions, trauma signs, or surgical scars. Assess and record both active and passive range of motion (ROM) for flexion and extension. The hip exam should also include palpation of bone and soft tissue structures, categorized into medial, midline, and lateral areas (11).

Individuals with unilateral hip osteoarthritis exhibit reduced hip strength, especially in the sagittal and frontal planes, and poorer dynamic balance compared to healthy controls. Greater baseline hip abduction strength helps maintain trunk position during gait and protects against medial hip osteoarthritis progression. In knee osteoarthritis, hip abduction strength predicts performance on get-up-and-go and stair-climb tests. While individually designed exercise programs are recommended, the most beneficial types and contents of these programs for various outcomes in hip osteoarthritis remain unclear. However, there is strong evidence supporting the need for tailored fitness regimens for these individuals (12).

Material and Methods:

This cross-sectional study was conducted at Services Hospital and Physio Care and Rehab Clinic, spanning a six-month data collection period following approval of the study synopsis. The sampling method employed was non-probability convenient sampling, with a target population consisting of individuals aged 40 to 80 years diagnosed with unilateral hip osteoarthritis. The sample size of 55 participants was determined using Epitools (13), based on an estimated proportion of 0.3, desired precision of 0.05, and a confidence interval of 0.95, considering a population size of 3000.

Inclusion criteria for participants encompassed age eligibility, a confirmed diagnosis of unilateral hip osteoarthritis (14), a minimum of three months of activity-related hip pain, severe pain in the groin or buttocks region (15), and pain experienced on most days of the previous month, with a minimum pain severity score of 3 out of 10 on a Numeric Pain Rating Scale during aggravating activities. Exclusion criteria included recent back or hip injuries within the past year, post-traumatic hip pain, history of lower limb realignment procedures (such as hip osteotomy), systemic conditions like rheumatoid arthritis, recent use of oral corticosteroids (16), assistance required for walking on level ground or stairs, inability to provide informed consent, active joint infections or other systemic conditions affecting joint function, and specific musculoskeletal conditions like hip bursitis or sciatica (17).

Data collection was performed using standardized assessments and tools. The Muscle Strength Grading Scale (Oxford Scale) was used to evaluate hip strength in multiple directions (flexor, abductor, adductor, internal and external rotators). Functional outcomes were assessed using the 30-second Chair-Stand Test (30sCST) and stair-climb test. Dynamic balance was evaluated through the Star Excursion Balance Test (SEBT), focusing on anterior, posteromedial, and posterolateral reach directions. Data analysis was conducted using SPSS version 29, with descriptive statistics including means and standard deviations used to summarize demographic characteristics and study outcomes. Categorical bar charts were utilized to visually represent data. Statistical significance was set at $P < 0.05$.

Results

A cross-sectional survey was conducted to find out association between hip strength, physical function and dynamic balance in a people with unilateral hip osteoarthritis. Fifty-five participants in which (21 male and 34 females) were taken in this study. Data was collected from Services Hospital and Physio care and rehab Clinic. Performa was made to collect data about hip strength, physical function and dynamic balance. Patient-reported outcomes, hip and knee strength, physical function and dynamic balance outcomes are presented. One participant scored zero on the 30sCST. Four female and one male participant failed the posterolateral direction of the SEBT (four bilaterally, one on the symptomatic limb only). One of these five participants failed all 6 directions of the SEBT. The average age of those who failed at least one test direction of the SEBT was 76.2 (±2.4 years), in contrast to 65.0 (±7.81 years) for those with successful tests the relationship between hip strength, physical function and dynamic balance was investigated which showed a multivariable linear relationship. It also showed increased strength. These multi variables are positive correlate. The coefficient correlation R showed the strength of relationship r value between multivariable come out to be .12 and 0.004. Probability value (P=0.03) also showed that there is a significant correlation between the variables.

Table no. 1 Descriptive Statistics of Physical Function

	Minimum	Maximum	Mean	Std. Deviation
30s chair-stand test (CST) (reps)	12	4	10.7	3.6
Stair climbs test (SCT) (sec)	5.9	8	7.9	3.3

Table no. 2 Descriptive Statistics of Dynamic Balance (mm/mm)

	Minimum	Maximum	Mean	Std. Deviation
Anterior	2	4	0.94	0.15
Posteromedial	10	15	1.7	0.22
Posterolateral	8	12	0.90	0.24

Figure no. 1 Chair Stand Test across different age groups

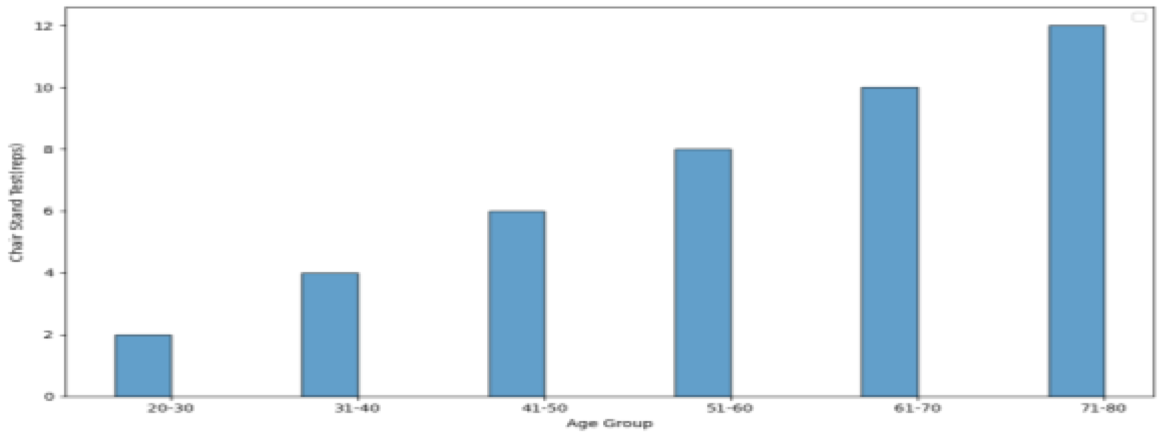


Figure no. 2 Statistics of Dynamic Balance (mm/mm)

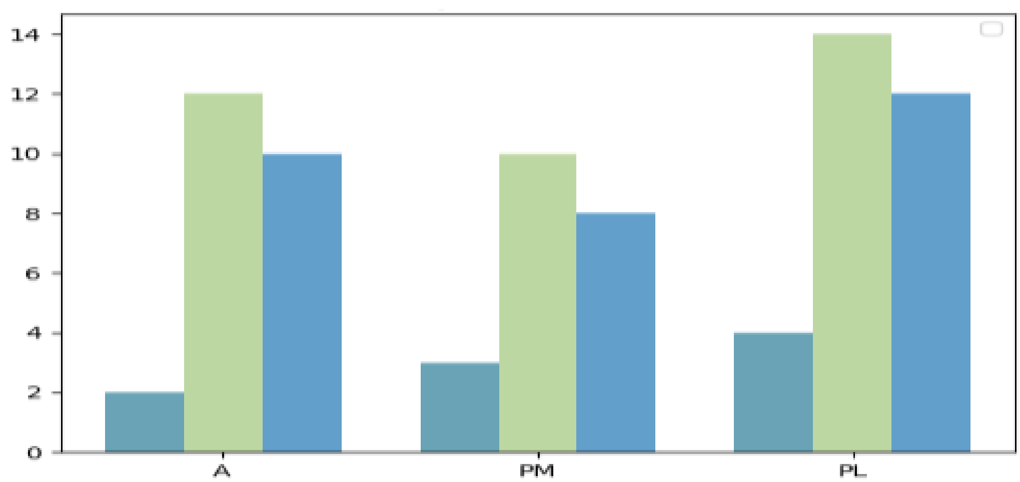
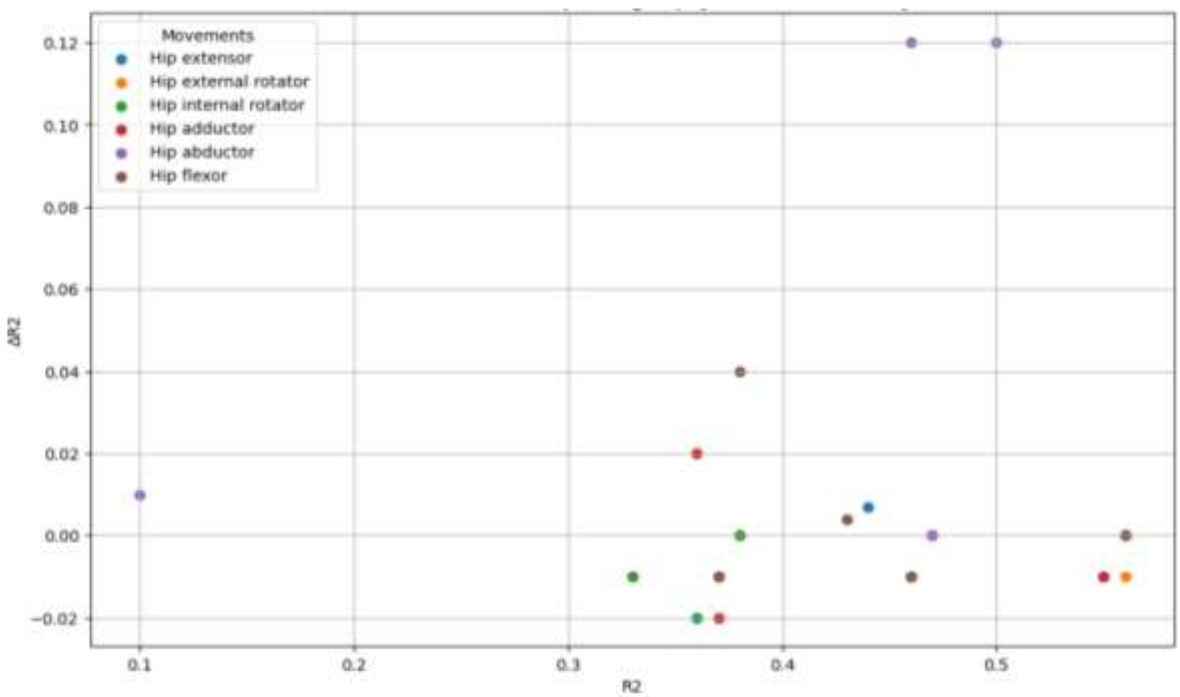


Table no. 3 Multivariable Correlation between Hip Strength, Physical Function and Dynamic Balance

Measures of a Physical Function					Dynamic Balance					
	SCT		30sCST		Anterior		Posteromedial		Posterolateral	
	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2
Hip Flexor	.55	-0.01	.46	-.01	.44	.007**	.36	-.02	.38	.00
Hip Abductor	.56	-0.01	.46	-.01	.33	-.01	.37	-.01	.38	.00

Hip Adductor	.56	-0.00	.46	-.01	.33	-.01	.36	-.02	.38	.00
Hip Internal Rotator	.55	-0.01	.47	.00	.36	.02	.37	-.02	.37	-0.01
Hip External Rotator	.56	.00	.47	.00	.46	.12**	.50	.12**	.10	.01
Hip Extensor	.56	.00	.46	-.01	.38	.04	.43	.004**	.37	-0.01
(SCT) *Stair Climb Test;* ***(30sCST)*** *30 s Chair-Stand Test; *p < 0.05, **p < 0.001.*										

Figure no. 3 Multivariable Correlation between Hip Strength, Physical Function and Dynamic Balance



Discussion:

Our study demonstrated that hip strength is associated with measures of physical function and dynamic balance in people with unilateral hip osteoarthritis. Greater magnitude of hip extensor and hip strength (flexor, abductor, adductors, external rotator and extensor) were related to better performance of stair climb and posteromedial dynamic balance when modelled with age and sex covariates. Hip strength in all directions (except for internal rotation) consistently had a small positive association with dynamic balance in people with unilateral hip osteoarthritis. Hip external rotation strength had the greatest effect on dynamic balance in the anterior and posteromedial directions (1 IQR Nm/kg = 0.10 and 0.14 mm/mm, respectively) and hip adduction strength had the greatest effect on reach in the posterolateral direction (1 IQR Nm/kg = 0.26 mm/mm, only in females).

In one study by Tucker K *et al.* (2022) authors deduced that individuals with hip osteoarthritis had worse dynamic balance than controls on a Biodex stability system, which is associated with an increased risk of falls.12 Hip abduction, external rotation, and extension strength are related to dynamic balance in asymptomatic individuals, as determined by the Star Excursion Balance Test (SEBT).Thirteen People with chronic low back pain, chronic ankle instability, and anterior cruciate ligament deficit have all had their dynamic balance impairments evaluated using the SEBT(18).

Our findings are in contrast to two studies of healthy younger females, which demonstrated significant associations between hip external rotation strength and dynamic balance in only one direction each, anterior Ambegaonkar *et al*. (2021) and posteromedial Gordon *et al*. (2021). This suggests that hip external rotation strength may have an increasing impact on dynamic balance with aging and in the presence of hip osteoarthritis. The significant effect of hip adduction strength on posterolateral dynamic balance only seen in females (in this study), may be explained by gender differences in kinematics, including greater hip adduction and pelvic rotation during complex tasks Graci *et al*.(2020),Ferber *et al.* (2018), and subsequent gender differences in neuromuscular demands(19, 20).

In one of study Kasza J *et al*. (2017) there is evidence of lower-limb muscle weakness in people with hip OA. Although muscle weakness has been associated with objective measures of physical impairments little is known about the relationship between muscle strength and self-reported physical function in people with hip OA. Moreover, previous research has demonstrated that a minimal clinically important improvement (MCII) in physical function is dependent on the severity of difficulty with physical function in people with hip OA Thus, providing context for change in strength associated with a clinically relevant change in physical function according to severity of physical function can facilitate future longitudinal research (21).

Further clinical trials should evaluate the effect of hip strengthening programs tailored to individual hip strength impairments (measured with oxford scale) and patient-centered functional goals. Studies should also investigate the impact of hip strength impairments and effects of hip strengthening programs on falls risk in people with hip osteoarthritis.

Conclusion:

Measures of physical function and dynamic balance are associated to hip strength in individuals suffering from unilateral hip osteoarthritis. Strength of hip external rotator is most correlated without regard to the strength of the hip extensor, with dynamic balance. Exercise plans for hip osteoarthritis should consider functional goals and hip strength, with further study needed on multidirectional strengthening to improve function, balance, and reduce risk of fall.

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AUTHORS

First Author – Dr. Erum Ghaffar,DPT,MS-OMPT, Lecturer at Hajvery University Pakistan,

Second Author- Arooba maqsood, DPT, Hajvery University Pakistan,

Third Author – Fatima Mazhar, DPT, MS-OMPT, Lecturer at Hajvery University Pakistan

Forth author- Rimsha Ameen, DPT, Hajvery University Pakistan,

Fifth Author -, Rimsha Tariq, DPT, MS-NMPT, Lecturer at Hajvery University Pakistan

Sixth Author – Rehna khizar, DPT, Hajvery University Pakistan

Seventh Author- Aneeqa Aqdas, DPT, MS-WHPT, Lecturer at Hajvery University Pakistan

Eighth Author – Uzma irshad, DPT, Hajvery University Pakistan

Ninth Author – Ahtasham farzand, Hajvery University Pakistan.

Tenth Author – M.saeed, DPT, Hajvery University Pakistan,

Correspondence Author – Dr. Erum Ghaffar, DPT, MS-OMPT, Lecturer at Hajvery University Pakistan,