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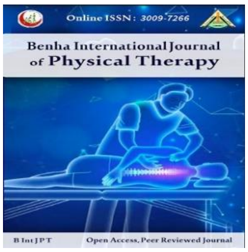

Original research

Assessment of Isokinetic Muscle performance of Hip Abductors in Knee Osteoarthritis.

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Abstract:
Background: Knee osteoarthritis (OA) is characterized by the progressive degeneration of articular cartilage. Emerging evidence suggested that hip muscle strength influences knee joint loading and may contribute to disease progression. Hip abductor strength has been associated with reduced knee adduction moments, potentially decreasing pain and improving function in individuals with knee OA. Isokinetic dynamometry provides a valid and reliable means of assessing joint torque, power, and velocity. **Purpose**: This study aimed to evaluate differences in the isokinetic performance of the hip abductor muscles between the painful and less painful sides in patients with knee osteoarthritis, and to examine the correlations of these parameters with pain intensity and functional disability. **Methods:** Thirty-five patients diagnosed with unilateral or bilateral knee OA were recruited from the outpatient clinic of the Faculty of Physical Therapy, Cairo University, Egypt. Isokinetic performance of the hip abductors—including peak power, torque, and work—was evaluated using the Biodex isokinetic dynamometer. **Results:** Significant differences were observed in hip abductor isokinetic performance between the painful and the less or non-painful sides in both unilateral and bilateral OA cases. In unilateral OA, the p-values were: power = 0.012, torque = 0.002, and work = 0.008. Similarly, in bilateral OA, significant differences were found (power < 0.001, torque < 0.001, and work < 0.001). **Conclusion:** The painful side exhibited reduced hip abductor performance compared to the less or non-painful side in patient suffered from either unilateral or bilateral knee osteoarthritis. No significant correlations were found between isokinetic parameters and either pain severity or functional disability in patient with chronic knee osteoarthritis.

Keywords: Hip abductors, Isokinetic dynamometer, Knee Osteoarthritis, Muscle power, Muscle torque.

Introduction

Knee osteoarthritis (OA) is traditionally regarded as a progressive degeneration of the articular cartilage. However, recent evidence suggests that OA is a multifactorial inflammatory condition affecting the entire synovial joint. This includes not only the mechanical deterioration of the cartilage but also structural and functional alterations in the meniscus, synovial fluid, ligaments, subchondral bone, and surrounding soft tissues [1] .

Osteoarthritis pathology encompasses physiological and biological changes in the hyaline cartilage and periarticular structures, accompanied by subchondral sclerosis, synovial proliferation, and osteophyte formation [2].

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Weakness in the hip abductor muscles has been implicated in the development of various hip and knee disorders. In individuals with knee osteoarthritis, elevated peak knee adduction moments have been observed [3].

The knee adduction moment refers to the medial load acting on the knee joint in the frontal plane, which results in medial rotation of the tibia relative to the femur during walking [4].

This mechanical load has been directly associated with the severity and progression of medial compartment osteoarthritis [5] .

A previous study indicated that the strength of hip abductor muscles is crucial in minimizing the adduction moment on the knee. These muscles are essential for stabilizing the pelvis, as they counteract the drop on the opposite side when standing on one leg during walking. This stabilization helps distribute forces more effectively, preventing excessive stress on the inner part of the knee, particularly during the stance phase of walking [6].

In individuals with knee osteoarthritis, both the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the McGill Pain Questionnaire (MPQ) have demonstrated a strong association between pain severity and functional impairment [7]. Persistent pain often leads to reduced physical activity, which may contribute to muscle atrophy and further functional decline [8].

The widespread application of isokinetic devices in orthopedic and sports medicine has led to the development of several reliable tools for assessing muscular performance [9] .

Among these, the Biodex system has been extensively utilized for isokinetic testing of muscle strength, offering objective evaluations of muscular function that are commonly employed in clinical and rehabilitation research [10].

Despite the recognized role of hip abductors in knee joint mechanics, limited research has explored their isokinetic performance in individuals with knee osteoarthritis, particularly when comparing painful and less painful limbs. Understanding whether differences exist in muscle performance, and whether these differences correlate with pain or functional disability, may offer insights into rehabilitation strategies. Therefore, this study aimed to assess the isokinetic performance of the hip abductors in patients with unilateral or bilateral knee OA and to investigate the relationship between isokinetic parameters, pain intensity, and functional limitation.

Methods:

This observational correlational study was conducted at the outpatient clinic and isokinetic laboratory of the Faculty of Physical Therapy, Cairo University.

A total of Thirty-five participants, comprising both men and women aged between 40 and 65 years, were recruited from the outpatient clinic. This study extended from June 2024 and ended to Mars 2025. All participants were diagnosed with unilateral or bilateral primary knee osteoarthritis (OA), classified as Grade II (mild) or Grade III (moderate) according to the Kellgren-Lawrence grading system **.**

Ethical approval for the study was obtained from the Ethical Committee of the Faculty of Physical Therapy, Cairo University (approval NO: P.T.REC/012/005242).

Inclusion Criteria:

Participants were eligible for inclusion in the study if they met all of the following conditions**:**

•Were aged between 40 and 65 years, irrespective of sex [11] **.**

•Had been referred by an orthopedic surgeon and diagnosed with unilateral or bilateral primary knee osteoarthritis (with one knee more painful than the other), classified as Grade II (mild) or Grade III (moderate) according to the Kellgren–Lawrence (KL) scale[12] **.**

•Presented a body mass index (BMI) between 18.5 kg/m² and 41.33 kg/m² [13] **.**

Exclusion Criteria:

Candidates were excluded from participation if they met any of the following conditions**:**

•Had a history of systemic or neurological disorders affecting lower extremity biomechanics (e.g., stroke, cerebral palsy, or spinal cord injury) [14,15] .

•Reported previous lower limb trauma or sustained injuries to knee ligaments or the meniscus [16] **.**

•Had undergone prior surgical procedures on the knee or hip [17] **.**

Assessment Methods:

Before data collection, participants received a detailed explanation of the study protocols and provided written informed consent. Anthropometric measurements were obtained using a calibrated weight and height scale, and body mass index (BMI) was calculated **.**

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Visual analogue scale:
Pain intensity was quantified using the visual analogue scale (VAS). Participants were instructed to mark the point on a 10-centimeter horizontal line that best reflected their pain level, with one end representing "no pain" and the other end corresponding to "severe pain" [18]**.**

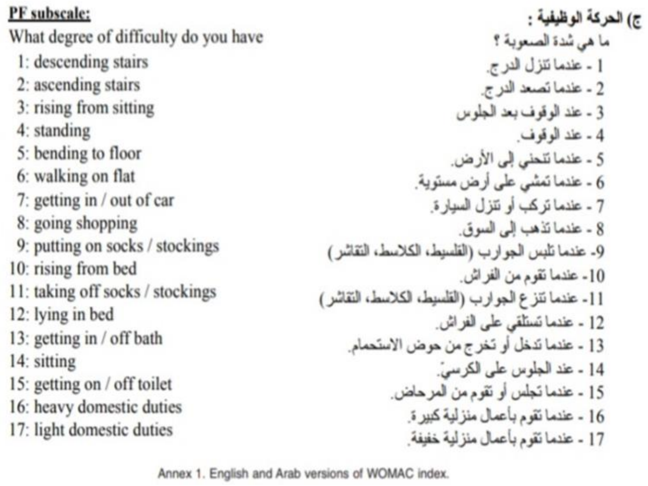
Assessment of muscular performance:
Muscular performance was evaluated using the Biodex System 4 Pro in concentric mode. This device has demonstrated excellent test–retest reliability for measuring muscle torque, power, and work [19].

During testing, the dynamometer's rotational axis was aligned with the hip center in the coronal plane. A custom hip attachment secured the test limb via a strap positioned just above the knee, ensuring proper fixation and minimal extraneous movement [20]**.**

A familiarization session was conducted in which subjects performed 5 to 10 submaximal practice repetitions to ensure proper technique, as verified by the examiner. During the isokinetic testing phase, subjects were positioned in front of the Biodex dynamometer with the device's axis properly aligned to the center of the hip. To minimize trunk movement, each subject was instructed to grasp the dynamometer head firmly for support. Testing commenced with the right limb, with each subject performing 5 maximal-effort repetitions at an angular velocity of 120°/s; trials exhibiting excessive trunk motion were excluded from analysis. Following a 60-second rest interval, the same protocol was repeated for the left limb. Peak hip abduction torque, power, and work were recorded for subsequent analysis **(Fig.1)**.[21]**.**

***Fig (1)** Patient familiarized with 5 repetitions to the machine before testing.*

Functional Assessment:
The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was employed as a self-report tool to evaluate functional disability. The WOMAC questionnaire consists of 24 items, categorized into three domains: pain (5 items), stiffness (2 items), and physical function (17 items). Participants completed this questionnaire to assess their condition over the past 48 hours. Higher total scores on the WOMAC indicate greater levels of impairment in pain, stiffness, and physical function **Appendix (1)** [22].



PF subscale:	ج) الحركة الوظيفية :
What degree of difficulty do you have	ما هي شدة الصعوبة ؟
1: descending stairs	1 - عندما تنزل الدرج.
2: ascending stairs	2 - عندما تصعد الدرج.
3: rising from sitting	3 - عند الوقوف بعد الجلوس
4: standing	4 - عند الوقوف.
5: bending to floor	5 - عندما تنحني إلى الأرض.
6: walking on flat	6 - عندما تمشي على أرض مستوية.
7: getting in / out of car	7 - عندما تركب أو تنزل السيارة.
8: going shopping	8 - عندما تذهب إلى السوق.
9: putting on socks / stockings	9- عندما تلبس الجوارب (القلسيط، الكلاسط، التقاشر)
10: rising from bed	10- عندما تقوم من الفراش.
11: taking off socks / stockings	11- عندما تنزع الجوارب (القلسيط، الكلاسط، التقاشر)
12: lying in bed	12 - عندما تستلقي على الفراش.
13: getting in / off bath	13 - عندما تدخل أو تخرج من حوض الاستحمام.
14: sitting	14 - عند الجلوس على الكرسي.
15: getting on / off toilet	15 - عندما تجلس أو تقوم من المرحاض.
16: heavy domestic duties	16 - عندما تقوم بأعمال منزلية كبيرة.
17: light domestic duties	17 - عندما تقوم بأعمال منزلية خفيفة.

Annex 1. English and Arab versions of WOMAC index.

Appendix (1) Arabic version of WOMAC for Functional Assessment.

Statistical analysis

Descriptive statistics were calculated for demographic and clinical variables. Group comparisons were performed using unpaired t-test, while data normality was evaluated using both the Shapiro–Wilk and Kolmogorov–Smirnov tests. Pearson's correlation coefficient was computed to assess the relationships. Furthermore, paired t-tests were conducted to compare isokinetic parameters between the painful and non-painful or less painful sides; when significant differences were observed, the Least Significant Difference (LSD) test was subsequently applied. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25 (IBM SPSS, Chicago, IL, USA), with a significance level set at $p < 0.05$.

Results

Participant Characteristics:
A total of 35 participants (23 women, 12 men) with knee osteoarthritis (OA) completed the study. The demographic data of the participants are presented in **Table 1**. Nine patients (30%) had unilateral knee OA (right: n = 4; left: n = 5), while 26 patients (70%) had bilateral involvement.

In bilateral cases (n=26), the mean pain intensity on VAS for the more painful side was 4.73 ± 1.12, and for the less painful side was 2.13 ± 0.74. However, in unilateral cases (n=9), the mean pain intensity on VAS for the painful side was 4.22 ± 1.09.

The overall mean WOMAC score was 29.71 ± 7.33 (n = 35).

Table 1: Demographic characteristics of patients with osteoarthritis (OA) of the knee

	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	35	40	63	56.29	5.322
Weight (kg)	35	52.0	122.0	91.349	13.8974
Height (cm)	35	165	186	176.34	5.11
BMI (kg/m²)	35	19.1	35.8	29.180	3.8334
Duration of disease	35	4	180	80.69	42.357

Isokinetic Assessment:

The isokinetic performance of the hip abductors was systematically compared between the painful and less or non-painful sides in both unilateral and bilateral knee osteoarthritis (OA) groups. As summarized in Table 2, patients with unilateral OA (n = 9) demonstrated significantly lower mean values for power, torque, and work on the painful side compared to the non-painful side (power: 28.04 ± 15.15 W vs. 48.77 ± 11.98 W, $p = 0.012$; torque: 50.72 ± 10.33 Nm vs. 66.86 ± 7.80 Nm, $p = 0.002$; work: 94.16 ± 51.93 J vs. 152.03 ± 19.72 J, $p = 0.008$). Similarly, in the bilateral OA group (n = 26), the more painful side exhibited significantly reduced isokinetic parameters relative to the less painful side (power: 20.98 ± 10.92 W vs. 45.72 ± 28.21 W, $p < 0.001$; torque: 48.68 ± 14.90 Nm vs. 73.37 ± 27.48 Nm, $p < 0.001$; work: 72.05 ± 33.19 J vs. 115.48 ± 51.83 J, $p < 0.001$).

These findings indicate a marked reduction in hip abductor muscle performance on the affected side, regardless of whether OA involvement was unilateral or bilateral. The statistical significance of these differences, as well as the mean differences and confidence intervals, are detailed in Table 2.

Table 2. Isokinetic Performance of Hip Abductors: Painful vs. Less/Non-painful Side

Group	Parameter	Painful Side Mean ± SD	Less/Non-painful Side Mean ± SD	Mean Difference (95% CI)	t-value	p-value
Unilateral (n=9)	Power (W)	28.04 ± 15.15	48.77 ± 11.98	–20.72 (–35.46, –5.97)	–3.24	0.012
	Torque (Nm)	50.72 ± 10.33	66.86 ± 7.80	–16.13 (–24.26, –8.00)	–4.58	0.002
	Work (J)	94.16 ± 51.93	152.03 ± 19.72	–57.87 (–99.31, –19.44)	–3.47	0.008
Bilateral (n=26)	Power (W)	20.98 ± 10.92	45.72 ± 28.21	–24.74 (–33.98, –15.50)	–5.512	<0.001
	Torque (Nm)	48.68 ± 14.90	73.37 ± 27.48	–24.69 (–33.47, –15.91)	–5.79	<0.001
	Work (J)	72.05 ± 33.19	115.48 ± 51.83	–43.43 (–59.40, –27.46)	–5.60	<0.001

Values are expressed as mean ± SD (standard deviation); mean differences (95% CI) and t-values derived from paired t-tests; p < 0.05 considered statistically significant.

Correlations:
Pearson's correlation analyses were used to examine the associations between isokinetic measures (peak power, peak torque, and total work), pain intensity (VAS), and functional disability (WOMAC) in patients with unilateral and bilateral knee osteoarthritis. As shown in Table 3, none of the isokinetic performance variables correlated significantly with either VAS or WOMAC scores—neither on the most painful side (whole sample, n = 35) nor on the less painful side in those with bilateral involvement (n = 26) (all p > 0.05). These findings suggest that hip abductor muscle performance, as assessed by isokinetic testing, is not directly associated with self-reported pain intensity or functional limitation in this study.

Table (3). Pearson Correlations between Isokinetic Parameters, Pain (VAS), and WOMAC Scores in Unilateral and Bilateral Knee OA Groups.

Group	Isokinetic Parameter	VAS		WOMAC	
		r	p	r	P
Most painful for all sample **(n = 35)**	Power (W)	0.08	0.82	–0.19	0.62
	Torque (Nm)	–0.12	0.74	–0.23	0.55
	Work (J)	0.15	0.70	–0.11	0.76
Less painful in the bilateral sample **(n = 26)**	Power (W)	–0.09	0.66	–0.17	0.41
	Torque (Nm)	–0.14	0.52	–0.21	0.31
	Work (J)	–0.10	0.63	–0.18	0.39

r = Pearson correlation coefficient; p = p-value. No significant correlations were found (all p > 0.05).

**. Correlation is significant at the 0.01 level (2-tailed).

Discussion
This study demonstrated that individuals with knee osteoarthritis (OA) exhibit significantly reduced peak torque, power, and work of the hip abductors on the more painful limb compared to the less painful or non-painful side. Notably, no significant correlations were observed between isokinetic performance measures and either pain intensity (assessed by VAS) or functional disability (evaluated via WOMAC). These findings suggest that, although hip abductor muscle weakness is evident in the painful limb, it may not directly relate to the subjective experience of pain or the degree of self-reported functional limitation in this study.

Isokinetic Assessment:
The use of isokinetic dynamometry provided an objective and reliable method to quantify muscle strength deficits, with prior research demonstrating excellent intraclass correlation coefficients (ICC ranging from 0.74 to 0.99) for torque measurements [23]. Isokinetic testing is widely regarded as the gold standard for muscle performance evaluation due to its capacity to control contraction velocity and isolate specific muscle groups, thereby minimizing measurement variability [9]. Furthermore, hip abduction assessment at 120°/second in a standing position has been shown to offer excellent reliability and better mimic functional movement patterns compared to non-weight-bearing protocols [24].

Correlation between hip abductors and knee osteoarthritis:
The observed reductions in hip abductor power—42.5% lower in unilateral OA patients on the affected side—likely contribute to impaired pelvic stabilization during gait and consequently increase medial knee joint loading, a key factor in OA progression [6].
This asymmetry in muscle performance may reflect compensatory mechanisms aimed at offloading the affected knee, consistent with studies linking hip abductor weakness to elevated knee adduction moments and disease progression. This association supports the biomechanical rationale that strengthening the hip abductors may

mitigate medial compartment loading and benefit patients with knee OA [25].

Several studies corroborate the present findings of hip abductor deficits in knee OA populations. Rutherford et al. (2014) observed significantly lower isometric hip abductor strength in medial knee OA patients compared to healthy controls [26]. Alnahdi et al. (2012) reported a 24% reduction in hip abductor strength among this demographic [27]. Hislop et al. (2022) compared people with unilateral knee OA to healthy controls and found that hip abduction strength (measured bilaterally by dynamometry) was ~9% lower on the symptomatic limb and ~16% lower (range 16–34%) bilaterally in the OA group versus controls [28]. Systematic reviews confirm a frequent presence of weakness in hip abductors and external rotators in medial knee OA, which may contribute to altered joint mechanics and increased medial compartment loading [29,30]. Additionally, Hinman et al. (2010), Ferber et al. (2011), and Hui et al. (2019) identified associations between hip muscle weakness, altered gait biomechanics, and knee OA pathomechanics [31,32,33].

Despite the evident weakness in hip abductor muscles, the absence of significant correlations between isokinetic parameters and pain or function diverges from some prior studies. For example, Costa et al. (2010) reported a strong negative correlation between hip abductor peak torque and both pain intensity and functional impairment in a cohort of 50 knee OA patients. In that study, weaker hip abductors were consistently associated with greater pain and disability, directly contradicting the present null findings for VAS and WOMAC associations [34].

Hislop et al. (2023) further found that in individuals with unilateral knee OA, hip muscle strength measured in multiple directions was positively related to performance on functional tests (such as the 40-meter walk, sit-to-stand, and stair climb) and balance tasks. Particularly, hip abduction torque was a strong predictor of better mobility and balance, as demonstrated by large coefficients of determination (R^2=0.48–0.65) [35]. These results suggest a clear functional link between hip abductor strength and real-world mobility; however, such a relationship was not replicated in the present study, which relied on WOMAC for functional assessment. This divergence raises the possibility that objective performance-based tests may be more sensitive than subjective self-reported outcomes, or that sample differences affected these findings.

Discrepancies in the literature may reflect methodological variation. For instance, Tevald et al. (2016) utilized handheld dynamometry in non-weight-bearing positions, as opposed to the standing, weight-bearing isokinetic testing used in the present study. Differences in participant characteristics, assessment tools, and study design likely contributed to the varying results [36].

In addition, the present findings suggest that hip abductor weakness, while measurable objectively, may not alone explain the variance in patient-reported pain or functional limitation, highlighting the multifactorial nature of symptom manifestation in knee OA.

The literature supports the role of hip abductor strengthening as a component of therapeutic interventions. Exercise programs targeting these muscles, either in isolation or combined with broader lower extremity exercises, have been shown to increase muscle strength, reduce knee pain, and improve function [37,38].

The intensity of such programs typically ranged from 50 to 80% of maximum voluntary contraction, performed three to five times per week over six weeks to three months, and demonstrated clinically meaningful benefits [39]. These findings endorse the inclusion of hip abductor strengthening within rehabilitation protocols for knee OA patients.

Nevertheless, it remains uncertain whether hip abductor weakness is primarily a consequence of knee OA or a modifiable risk factor influencing disease progression [40]. Future longitudinal studies are warranted to clarify the directionality of this relationship (whether hip abductor weakness was the cause or the consequence of knee OA). Additionally, the implications of strengthening exercises on knee joint loading warrant further investigation to optimize exercise prescriptions aimed at altering disease trajectory.

Conclusions:

The findings of this study indicate that patients with osteoarthritis (OA) of the knee show lower isokinetic torque, power, and work in the hip abductor muscles on the painful side compared to the non-painful side in cases of unilateral knee OA. Similarly, patients with bilateral knee OA exhibit lower isokinetic torque, power, and work in the hip abductor muscles on the most painful side compared to the less painful side. Additionally, there is no correlation found between measures of hip abductor isokinetic performance and pain or functional disability for either the most painful side or the less painful side in patients with knee OA.

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