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Original Article

Correlation Between Quadriceps Muscles Strength and Functional Disability in Patients with Knee Osteoarthritis

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ABSTRACT

Background: Knee osteoarthritis is a common chronic musculoskeletal disorder associated with pain, stiffness, quadriceps weakness, mobility limitation, and reduced functional performance. Quadriceps muscle strength is clinically important for knee stability and activities of daily living, but local evidence regarding its association with functional disability remains limited. Objective: To determine the correlation between bilateral quadriceps muscle strength and functional disability among patients with knee osteoarthritis. Methods: A cross-sectional observational study was conducted among 60 patients with knee osteoarthritis recruited through convenience sampling. Pain intensity was assessed using the Visual Analogue Scale, functional disability was measured using the Western Ontario and McMaster Universities Osteoarthritis Index, and quadriceps muscle strength was assessed through Manual Muscle Testing. Data were analyzed using SPSS version 25. Normality was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests, and Spearman's rank-order correlation was used because key variables were not normally distributed. Results: The mean age of participants was 52.90 ± 4.77 years, and the mean body mass index was 29.76 ± 3.60 kg/m². Mean pain during walking was higher than pain at rest. Bilateral quadriceps strength showed strong negative correlations with WOMAC pain (rho = -0.950), WOMAC stiffness (rho = -0.904), WOMAC function (rho = -0.946), and total WOMAC score (rho = -0.946), all with $p < 0.001$. Conclusion: Lower quadriceps muscle strength was strongly associated with greater pain, stiffness, and functional disability in patients with knee osteoarthritis. Quadriceps strength assessment should be considered an important component of clinical evaluation and rehabilitation planning.
Keywords: Knee osteoarthritis; Quadriceps muscle strength; Functional disability; WOMAC; Manual Muscle Testing; Pain.

INTRODUCTION

Knee osteoarthritis is a prevalent chronic musculoskeletal disorder and one of the leading contributors to pain, mobility restriction, functional limitation, and reduced quality of life among middle-aged and older adults. The condition is characterized by progressive structural and functional changes within the knee joint, including articular cartilage degeneration, subchondral bone remodeling, synovial inflammation, stiffness, and impaired load-bearing capacity. Although definitive disease reversal remains limited, conservative management aims to reduce pain, preserve mobility, improve neuromuscular function, and delay functional decline, while surgical intervention may be required in advanced cases when symptoms and disability become severe (1,2).

Quadriceps muscle function is central to knee joint stability, shock absorption, lower-limb alignment, gait control, stair negotiation, sit-to-stand performance, and other activities of daily living. In patients

with knee osteoarthritis, quadriceps weakness is commonly observed and may reflect a combination of pain-related inhibition, reduced voluntary activation, disuse, altered biomechanics, and reduced physical activity. Because the quadriceps plays an essential role in controlling knee extension and absorbing joint load during functional movement, reduced strength may contribute to poorer mobility, increased perceived effort during daily activities, impaired balance, and greater functional disability (3,4).

Several mechanisms may explain the association between knee osteoarthritis, quadriceps weakness, pain, and disability. Joint pain, swelling, inflammation, and altered sensory input can contribute to arthrogenic muscle inhibition, which reduces the ability to fully activate the quadriceps even in the absence of primary muscle pathology. This inhibition may promote further weakness, reduced activity tolerance, muscle wasting, and progressive functional limitation. In turn, reduced activity and avoidance of painful movement may reinforce a cycle of pain, weakness, stiffness, and disability. Previous evidence suggests that quadriceps strengthening and exercise-based rehabilitation can improve pain and physical function in knee osteoarthritis, supporting the clinical relevance of assessing quadriceps strength as part of rehabilitation planning (5,6).

Functional disability in knee osteoarthritis is multifactorial and cannot be attributed to muscle weakness alone. Pain intensity, stiffness, body mass index, sedentary lifestyle, disease severity, physical inactivity, and comorbid health conditions may all influence functional performance. Obesity is particularly important because increased body mass can elevate mechanical loading across the tibiofemoral joint and may also contribute to inflammatory and metabolic pathways involved in osteoarthritis progression. These interacting factors may intensify symptoms and reduce the ability to perform daily activities, especially in populations with limited access to structured rehabilitation and preventive care (7,8).

Clinical assessment tools such as Manual Muscle Testing, the Western Ontario and McMaster Universities Osteoarthritis Index, and the Visual Analogue Scale are frequently used to evaluate muscle strength, functional disability, and pain intensity in patients with knee osteoarthritis. The Western Ontario and McMaster Universities Osteoarthritis Index provides a structured measure of pain, stiffness, and physical function, while Manual Muscle Testing offers a practical method for estimating quadriceps strength in routine clinical and low-resource settings. Previous studies have reported inverse associations between quadriceps strength and functional limitation, indicating that lower muscle strength is generally associated with higher disability scores and poorer functional performance (7,9).

Despite the established clinical importance of quadriceps strength in knee osteoarthritis, evidence from local Pakistani populations remains limited. Differences in lifestyle, health-seeking behavior, obesity patterns, physical activity, access to physiotherapy, and rehabilitation adherence may influence the relationship between muscle strength and disability. Locally generated evidence is therefore needed to support context-specific rehabilitation strategies and to guide clinicians in prioritizing modifiable factors such as quadriceps weakness, pain intensity, and body weight during conservative management. Therefore, this study aimed to determine the correlation between bilateral quadriceps muscle strength and functional disability among patients with knee osteoarthritis. The study hypothesized that lower quadriceps muscle strength would be significantly associated with higher functional disability scores in patients with knee osteoarthritis (10).

MATERIAL AND METHODS

This cross-sectional observational study was conducted to determine the association between bilateral quadriceps muscle strength and functional disability among patients with knee osteoarthritis. The study was completed over a four-month period after approval of the research synopsis. Participants were recruited through non-probability convenience sampling from clinical and community-linked sources. Initial contact and screening were performed through an online survey pathway and direct face-to-face recruitment at a tertiary care hospital. The online pathway was used for preliminary screening and collection of self-reported demographic and activity-related information, whereas objective clinical

assessment, including quadriceps Manual Muscle Testing, was completed through standardized face-to-face evaluation before inclusion of strength-related data in the final analysis.

A total of 60 participants diagnosed with knee osteoarthritis were included in the study. Eligible participants were adults aged 45 to 60 years with clinically diagnosed knee osteoarthritis and symptoms affecting routine functional activities. Participants were included if they were able to understand the study procedures, provide informed consent, complete the required questionnaires, and undergo quadriceps strength assessment. Participants with recent knee surgery, acute traumatic knee injury, inflammatory arthropathy, neurological disorder affecting lower-limb strength, severe cardiorespiratory limitation preventing assessment, or any other musculoskeletal condition substantially interfering with knee function assessment were excluded to reduce measurement bias and confounding from non-osteoarthritic causes of disability.

Data were collected using a standardized assessment form that included demographic characteristics, anthropometric measurements, pain intensity, functional disability, and quadriceps muscle strength. Age, height, weight, and body mass index were recorded for descriptive and analytical purposes. Body mass index was calculated in kg/m^2 using measured weight and height. Pain intensity was assessed using the Visual Analogue Scale at rest and during walking, with higher scores indicating greater pain intensity. Functional disability was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index, which evaluates pain, stiffness, and physical function in patients with knee osteoarthritis. Higher WOMAC scores were interpreted as greater symptom burden and functional disability. Quadriceps muscle strength was assessed using Manual Muscle Testing by standardized resisted knee-extension assessment. Strength was recorded separately for both limbs and combined as a bilateral quadriceps MMT score, with higher values indicating better quadriceps strength.

To improve consistency of measurement, the same standardized data-collection procedure was followed for all participants. Participants received a clear explanation of the study purpose, assessment sequence, and voluntary nature of participation before data collection. Written informed consent was obtained before enrollment. The questionnaire and clinical assessment were completed in a structured order to minimize information bias. The use of standardized outcome measures reduced variability in assessment, while predefined eligibility criteria were applied to limit confounding from other conditions that could independently affect pain, quadriceps strength, or functional disability. Data were reviewed for completeness before entry, and responses with incomplete key outcome data were not included in the final analysis.

The primary exposure variable was bilateral quadriceps muscle strength measured by Manual Muscle Testing, and the primary outcome variable was functional disability measured by the total WOMAC score. Secondary variables included pain at rest, pain during walking, WOMAC pain, WOMAC stiffness, WOMAC function, age, height, weight, and body mass index. The principal analysis examined the correlation between bilateral quadriceps muscle strength and total WOMAC score. Additional correlation analyses were performed to explore relationships among quadriceps strength, pain intensity, WOMAC subscales, and functional disability. Because WOMAC subscale scores contribute to the total WOMAC score, correlations involving WOMAC total were interpreted cautiously as related but not fully independent measures.

Data were analyzed using Statistical Package for the Social Sciences version 25. Continuous variables were summarized using mean, standard deviation, minimum, and maximum values. Normality of key continuous variables was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Because the Shapiro-Wilk test indicated non-normal distribution of the main study variables and because Manual Muscle Testing generates ordinal strength scores, Spearman's rank-order correlation coefficient was used to assess associations between quadriceps muscle strength, pain, stiffness, and functional disability. Statistical significance was set at $p < 0.05$. Where regression-based interpretation is retained in the manuscript, functional disability should be modeled as the dependent variable and body mass index,

quadriceps strength, and relevant clinical covariates should be entered as independent variables, with assumptions, collinearity, coefficients, confidence intervals, and p-values reported in a separate regression table.

Ethical approval was obtained from the relevant institutional review committee before data collection. All participants were informed about the study objectives, procedures, confidentiality protections, and their right to withdraw at any stage without penalty. Participant anonymity and confidentiality were maintained throughout the study, and data were used only for research purposes. Informed consent was obtained from all participants before participation, and consent for anonymous use of data for publication was also obtained.

RESULTS

A total of 60 patients with knee osteoarthritis were included in the final analysis. Continuous demographic, anthropometric, pain, disability, and quadriceps strength variables are summarized in Table 1.

Table 1. Descriptive Characteristics of Continuous Study Variables (n = 60)

Variable	Minimum	Maximum	Mean	SD
Age, years	45	60	52.90	4.77
Height, cm	152	178	164.27	7.23
Weight, kg	64	96	80.03	8.61
Body mass index, kg/m²	24	36	29.76	3.60
Pain at rest, VAS	1	8	4.50	2.27
Pain during walking, VAS	2	10	5.88	2.45
Total WOMAC score	8	84	48.35	23.98
Bilateral quadriceps MMT score	4	10	6.62	1.81

Abbreviations: MMT, Manual Muscle Testing; SD, standard deviation; VAS, Visual Analogue Scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

The mean age of participants was 52.90 ± 4.77 years, with an age range of 45 to 60 years. The mean body mass index was 29.76 ± 3.60 kg/m², indicating that the study population was, on average, within the overweight range. Pain intensity was higher during walking than at rest, with mean VAS scores of 5.88 ± 2.45 and 4.50 ± 2.27, respectively. The mean total WOMAC score was 48.35 ± 23.98, reflecting variable levels of pain, stiffness, and functional disability among participants. Bilateral quadriceps MMT scores ranged from 4 to 10, with a mean score of 6.62 ± 1.81. Normality of the main study variables was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. The results are presented in Table 2.

Table 2. Normality Testing for Main Study Variables (n = 60)

Variable	Kolmogorov-Smirnov Statistic	Kolmogorov-Smirnov p-value	Shapiro-Wilk Statistic	Shapiro-Wilk p-value
Total WOMAC score	0.092	0.200	0.940	0.006
Bilateral quadriceps MMT score	0.147	0.003	0.930	0.002

Abbreviations: MMT, Manual Muscle Testing; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

The Shapiro-Wilk test showed statistically significant departures from normality for both total WOMAC score and bilateral quadriceps MMT score, with p-values of 0.006 and 0.002, respectively. The Kolmogorov-Smirnov test also indicated non-normal distribution for bilateral quadriceps MMT score. Based on these findings, and considering the ordinal nature of Manual Muscle Testing, Spearman's rank-order correlation was used to assess the relationship between quadriceps muscle strength, pain intensity, WOMAC subscales, and functional disability. The correlations between bilateral quadriceps MMT score and clinical outcome variables are presented in Table 3.

Bilateral quadriceps MMT score showed strong negative correlations with pain and disability-related outcomes. The strongest inverse correlation was observed between bilateral quadriceps strength and WOMAC pain score (rho = -0.950, $p < 0.001$), followed by WOMAC function and total WOMAC score,

both of which showed correlations of rho = -0.946 with bilateral MMT score. Pain at rest and pain during walking were also strongly and negatively correlated with quadriceps strength, with rho values of -0.938 and -0.936, respectively. These findings indicate that lower quadriceps strength was associated with higher pain intensity, greater stiffness, and higher functional disability among patients with knee osteoarthritis. The intercorrelations among pain intensity and WOMAC-based disability measures are shown in Table 4.

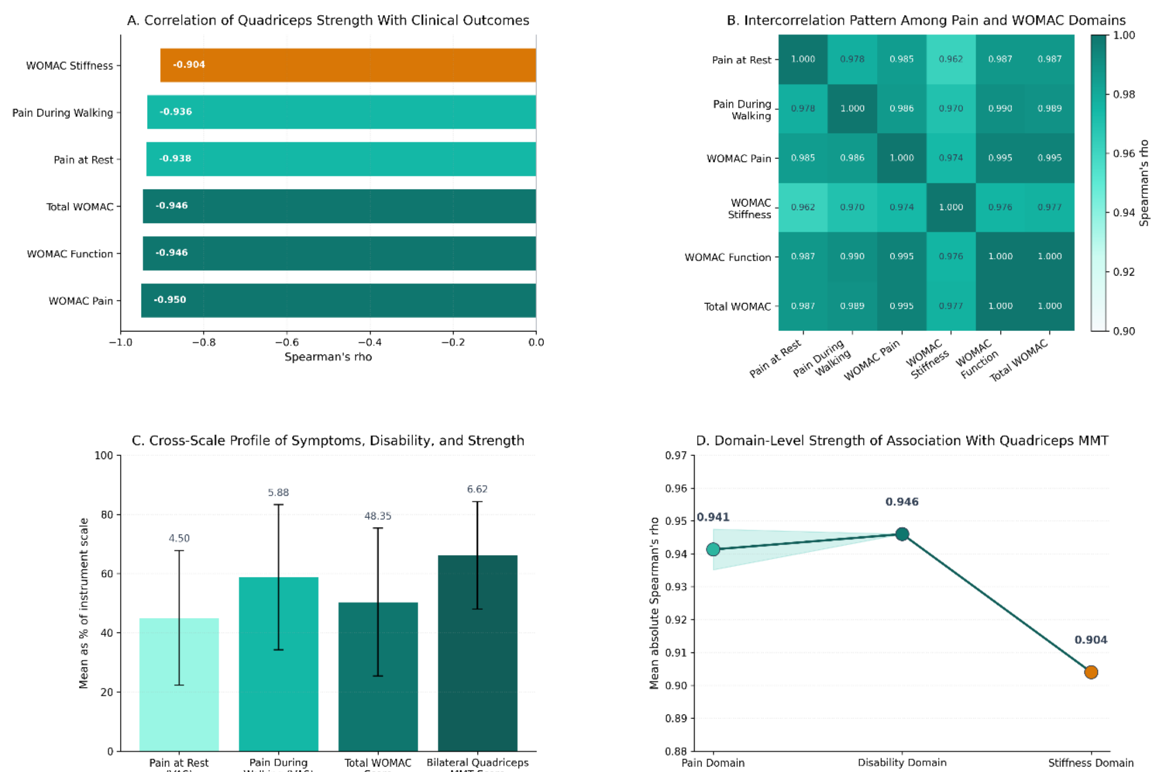

Figure 1. Quadriceps Strength, Pain, and Functional Disability in Knee Osteoarthritis. The panelled figure demonstrates the inverse relationship between bilateral quadriceps Manual Muscle Testing scores and clinical burden among patients with knee osteoarthritis. Quadriceps strength showed strong negative correlations with WOMAC pain (rho = -0.950), WOMAC function (rho = -0.946), total WOMAC score (rho = -0.946), pain at rest (rho = -0.938), pain during walking (rho = -0.936), and WOMAC stiffness (rho = -0.904), indicating that lower quadriceps strength was consistently associated with higher pain, stiffness, and functional disability. The intercorrelation matrix further shows strong positive relationships among pain and WOMAC domains, with rho values ranging from 0.962 to 1.000. Mean pain intensity was higher during walking than at rest, while the total WOMAC score indicated a moderate disability burden. At the domain level, the strongest average association with quadriceps strength was observed for disability-related outcomes, followed closely by pain-related outcomes and stiffness.

Pain and WOMAC-related variables demonstrated strong positive intercorrelations. Pain at rest was strongly correlated with pain during walking, WOMAC pain, WOMAC stiffness, WOMAC function, and total WOMAC score, with rho values ranging from 0.962 to 0.987. Pain during walking showed similarly strong correlations with WOMAC pain, WOMAC stiffness, WOMAC function, and total WOMAC score, with rho values ranging from 0.970 to 0.990.

Table 3. Spearman Correlations of Bilateral Quadriceps Strength With Pain and Functional Disability (n = 60)

Outcome variable	Spearman's rho	p-value
Pain at rest, VAS	-0.938	<0.001
Pain during walking, VAS	-0.936	<0.001
WOMAC pain	-0.950	<0.001
WOMAC stiffness	-0.904	<0.001
WOMAC function	-0.946	<0.001
Total WOMAC score	-0.946	<0.001

Abbreviations: VAS, Visual Analogue Scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index. Statistical test: Spearman's rank-order correlation.

WOMAC function was perfectly correlated with total WOMAC score in the reported matrix, which likely reflects the dominant contribution of the function subscale to the total WOMAC score and should not be interpreted as an independent association. Overall, the correlation pattern indicates that greater pain intensity was closely associated with higher stiffness and functional disability scores in patients with knee osteoarthritis.

Table 4. Spearman Correlation Matrix of Pain and WOMAC Variables (n = 60)

Variable	Pain at Rest	Pain During Walking	WOMAC Pain	WOMAC Stiffness	WOMAC Function	Total WOMAC
Pain at rest	1.000	0.978	0.985	0.962	0.987	0.987
Pain during walking	0.978	1.000	0.986	0.970	0.990	0.989
WOMAC pain	0.985	0.986	1.000	0.974	0.995	0.995
WOMAC stiffness	0.962	0.970	0.974	1.000	0.976	0.977
WOMAC function	0.987	0.990	0.995	0.976	1.000	1.000
Total WOMAC score	0.987	0.989	0.995	0.977	1.000	1.000

Abbreviation: WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index. Statistical test: Spearman's rank-order correlation. All reported correlations were significant at $p < 0.001$. Correlations between WOMAC subscales and total WOMAC score should be interpreted cautiously because the subscales contribute to the total score.

DISCUSSION

The present study examined the association between bilateral quadriceps muscle strength and functional disability among patients with knee osteoarthritis. The main finding was a very strong inverse correlation between bilateral quadriceps Manual Muscle Testing score and total WOMAC score, indicating that participants with lower quadriceps strength had higher levels of pain, stiffness, and functional disability. Quadriceps strength was also strongly and negatively correlated with WOMAC pain, WOMAC function, pain at rest, pain during walking, and WOMAC stiffness. These findings support the clinical relevance of quadriceps assessment in patients with knee osteoarthritis and suggest that reduced quadriceps strength is closely associated with greater symptom burden and poorer functional performance in this population.

The observed association between quadriceps weakness and functional disability is consistent with previous evidence showing that quadriceps impairment is an important contributor to pain and disability in knee osteoarthritis. O'Reilly et al. reported that quadriceps weakness was associated with pain and physical disability in individuals with symptomatic knee osteoarthritis, highlighting the importance of muscle performance in functional outcomes (11). Similarly, Serrão et al. demonstrated that knee extensor torque was associated with pain, stiffness, and functional performance among men with early knee osteoarthritis, supporting the relationship between knee extensor strength and clinical disability (12). The present findings extend this evidence within a local clinical context and reinforce the need to include quadriceps strength assessment as part of routine physiotherapy evaluation in knee osteoarthritis.

The strong negative correlations between quadriceps strength and pain-related variables may be explained by the interaction between pain, joint loading, and neuromuscular inhibition. Knee pain and joint pathology can reduce voluntary quadriceps activation through arthrogenic muscle inhibition, a process in which altered afferent input from the affected joint limits the ability to generate normal muscle contraction. This mechanism may contribute to reduced strength, impaired lower-limb control, altered gait, and progressive functional limitation. Previous work on arthrogenic muscle inhibition has emphasized its role in knee dysfunction and the need for targeted neuromuscular rehabilitation to restore muscle activation and functional capacity (13,14). In the present study, the high inverse correlations between MMT score and pain at rest, pain during walking, and WOMAC pain suggest that pain and quadriceps weakness may be closely linked components of disability in knee osteoarthritis.

Pain during walking was higher than pain at rest, which is clinically expected in knee osteoarthritis because weight-bearing activities increase mechanical load across the knee joint. Walking pain also showed strong positive correlations with WOMAC pain, stiffness, function, and total WOMAC score. This

pattern indicates that activity-related pain may be especially important in functional limitation because patients with greater walking pain are more likely to restrict mobility, avoid physical activity, and experience difficulty in daily tasks such as stair climbing, prolonged standing, and ambulation. However, because the study was cross-sectional, it cannot determine whether pain led to reduced strength, whether reduced strength increased pain, or whether both occurred together as part of progressive osteoarthritic dysfunction.

The relationship between functional disability and knee osteoarthritis is multifactorial. In the present sample, the mean body mass index was within the overweight range, which is clinically relevant because excess body weight increases mechanical stress across the knee joint and may contribute to symptom severity and functional decline. Obesity-related knee osteoarthritis is also influenced by metabolic and inflammatory mechanisms, which may amplify pain and impair mobility beyond the effect of mechanical loading alone (8). Evidence from previous studies suggests that body mass index, malalignment, metabolic syndrome, and adiposity-related factors can contribute to knee pain, structural progression, and functional disability (15,17). Although the present results support the importance of considering body weight in clinical management, regression-based claims regarding body mass index as an independent predictor should only be retained if a fully reported regression model is included in the Results section.

The correlations among WOMAC pain, stiffness, function, and total WOMAC score were very strong. This indicates that pain, stiffness, and functional difficulty were closely interconnected in the study population. However, these relationships must be interpreted cautiously because WOMAC subscales are components of the total WOMAC score, and therefore correlations between subscales and total scores may be inflated by part-whole overlap. The perfect or near-perfect correlation between WOMAC function and total WOMAC score likely reflects the strong contribution of the function domain to the total score rather than an independent statistical relationship. Future studies should consider using additional independent functional performance measures, such as timed up-and-go, stair-climb test, gait speed, or sit-to-stand performance, to provide a broader and more objective assessment of physical function.

The findings also support the practical role of physiotherapy in knee osteoarthritis management. Exercise-based interventions, particularly strengthening programs targeting the quadriceps, have been shown to improve clinical outcomes in patients with knee osteoarthritis (9). Integrated physiotherapy protocols may also support pain reduction, mobility improvement, and better functional performance when they combine strengthening, flexibility, pain modulation, functional training, education, and weight-management guidance (10). The present study does not test an intervention; therefore, it cannot conclude that strengthening caused improvement. Nevertheless, the strong association between quadriceps strength and disability provides a clinically reasonable basis for prioritizing quadriceps assessment and individualized strengthening within comprehensive rehabilitation planning.

The study has several limitations. First, the cross-sectional design prevents causal inference, and the direction of the relationship between quadriceps weakness, pain, and functional disability cannot be established. Second, convenience sampling and the relatively small sample size limit generalizability. Third, Manual Muscle Testing is a practical clinical tool but is less precise than handheld dynamometry or isokinetic testing and may be influenced by examiner technique, patient effort, and pain inhibition. Fourth, radiographic grading of knee osteoarthritis severity was not reported, which limits interpretation of whether the observed associations differed by structural disease severity. Fifth, recruitment from both online screening and face-to-face clinical sources may introduce selection and information bias unless all final strength assessments were performed using the same standardized clinical protocol. Finally, regression results should not be interpreted unless the complete statistical model, covariates, coefficients, confidence intervals, assumptions, and p-values are reported.

Overall, the study demonstrates a strong association between reduced bilateral quadriceps strength and greater pain, stiffness, and functional disability among patients with knee osteoarthritis. These findings

emphasize that quadriceps weakness is an important clinical feature in knee osteoarthritis and should be considered alongside pain intensity, body mass index, and functional limitation during assessment and rehabilitation planning. Future research should use larger samples, standardized diagnostic criteria, objective muscle-strength testing, radiographic severity grading, and longitudinal or interventional designs to clarify whether improvement in quadriceps strength leads to meaningful reduction in disability.

CONCLUSION

The study concluded that bilateral quadriceps muscle strength was strongly and inversely associated with pain, stiffness, and functional disability among patients with knee osteoarthritis. Participants with lower quadriceps Manual Muscle Testing scores had higher WOMAC pain, stiffness, function, and total disability scores, indicating that quadriceps weakness is closely linked with greater clinical burden in this population. Pain during walking was higher than pain at rest and was strongly associated with WOMAC-based disability measures, suggesting that activity-related pain is an important contributor to functional limitation. Although the cross-sectional design does not permit causal interpretation, the findings support the clinical importance of assessing quadriceps strength as part of routine knee osteoarthritis evaluation. Rehabilitation strategies for these patients should consider quadriceps strengthening, pain management, functional activity promotion, and weight-management guidance as integrated components of conservative care.

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