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Clinical Predictors of Functional Disability in Knee Osteoarthritis: Risk Stratification Approach as Implications of Nursing Practice

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ABSTRACT

Osteoarthritis (OA) of the knee is one of the most common musculoskeletal disorders and a leading cause of disability in the elderly. The severity of osteoarthritis can be assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which is a widely used tool to measure pain, stiffness, and physical dysfunction in patients with OA. This study aimed to analyze the relationship between the demographic and clinical characteristics of patients with knee osteoarthritis and their WOMAC scores. The study used a quantitative, cross-sectional observational design. The relationship between functional disability (measured by the WOMAC score) and various factors was analyzed. The independent variables included age, sex, occupation, body mass index (BMI), OA grade, and duration of OA to the WOMAC score. Significant correlations were found between the WOMAC score and both OA grade (p=0.049) and OA duration (p=0.030). Furthermore, the multiple linear regression analysis revealed that OA duration (p=0.038) and OA grade (p=0.036) were significant predictors of the WOMAC score, collectively explaining 13.0% of its variance (R^2 value = 0.130). The findings of this study indicate that OA grade and duration of illness are significant predictors of the level of disability as measured by the WOMAC scores. OA levels and disease duration were the primary predictors of functional disability, explaining 13.0% of the WOMAC score variance. Nursing interventions should focus on risk stratification based on these clinical markers, prioritizing early intervention for newly diagnosed patients, irrespective of their age or BMI.

Keyword: Duration of Disease, Grade OA, Osteoarthritis of the knee, Stratification, WOMAC

1. Introduction

Osteoarthritis (OA) of the knee is the most common degenerative musculoskeletal disorder in the elderly population, characterized by joint pain, stiffness, and limitations in physical function, which significantly impairs with the patient's quality of life (Bekki et al., 2020). Knee OA is a leading cause of global disability, and the burden of disease continues to increase as life expectancy and obesity prevalence increase (Katz et al., 2021). Risk factors that influence the development of OA symptoms have been extensively studied, including age, disease duration, body mass index (BMI), and OA severity based on radiological classification. Old age is often associated with increased joint degeneration, osteoporosis, and decreased cartilage tissue; however, recent research suggests that OA pain is not only determined by age factors but also by other mediators such as inflammation and physical activity (Chehade et al., 2020). Osteoporosis is a disease that requires attention

as it contributes significantly to the burden of disease in the aging global population (Bit-LianYEE et al., 2022). Osteoporosis and osteoarthritis are two common conditions that often coexist, particularly in older populations. The relationship between these conditions is complex, with several risk factors contributing to the development of osteoporosis in individuals with osteoarthritis. Osteoporosis, characterized by low Bone Mineral Density (BMD), contributes to structural changes in bones that can worsen osteoarthritis symptoms (Ko et al., 2022; Rai et al., 2019; Wang et al., 2021).

A report on the Global Burden of Disease 2021 by Langworthy et al., 2024 identifies osteoarthritis as the leading cause of musculoskeletal disability. The disease is characterized by progressive damage to the articular cartilage, subchondral bone changes, osteophyte formation, and synovial inflammation, which collectively cause pain, stiffness, and decreased physical function. In Indonesia, the prevalence of knee osteoarthritis tends to increase with age, particularly among those with a high physical workload in the informal sector. Citing data from RISKESDAS 2018, Adnani et al. (2022) reported that approximately 35% of individuals over the age of 60 experience symptoms of chronic joint pain indicative of osteoarthritis (Adnani et al., 2022). The disease has not only a physical but also psychosocial and economic impact, as it decreases the quality of life of individuals and increases the burden of long-term health services.

Clinical evaluation of knee osteoarthritis requires objective and standardized instruments. One of the most widely used measuring tools internationally is the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which has three main components that assess pain, stiffness, and physical function (Jinks et al., 2002). The WOMAC score not only describes the severity of the disease but also provides a comprehensive picture of the impact of osteoarthritis on a patient's daily life. (da Silva Júnior et al., 2023).

Various studies have shown that WOMAC scores are influenced by several risk factors, both modifiable and non-modifiable. These factors include age, sex, body mass index (BMI), physical activity level, occupation (duration, intensity, and frequency), family history of osteoarthritis, use of nonsteroidal anti-inflammatory drugs (NSAIDs), and radiographic grade based on the Kellgren-Lawrence (KL) classification (Alghadir & Khan, 2022). However, the relative influence of each factor on the components of WOMAC has not been systematically studied within the local population.

Therefore, A statistical approach is needed to identify and predict the risk factors that contribute most significantly to the severity of knee osteoarthritis, as measured by higher WOMAC scores. This approach helps healthcare workers design more targeted prevention strategies and interventions. In addition, risk factor modeling is useful for determining prognosis, choosing conservative therapy or surgery, and evaluating the effectiveness of long-term therapies. This study aimed to analyze the factors associated with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores in patients with knee osteoarthritis (OA). The main focus was to evaluate the contribution of age, sex, occupation, body mass index (BMI), duration of OA, and OA level to symptom severity based on correlation and regression analyses. The findings are intended to provide strong scientific evidence to support clinical decision-making and health policies in the musculoskeletal field.

While previous studies have identified individual risk factors for OA disability, limited research has examined the relative contribution of these factors in Southeast Asian populations, where employment patterns and healthcare access may influence disease presentation and management. Furthermore, most research focuses on Western populations with different demographic characteristics and healthcare systems, creating a significant knowledge gap in the Indonesian context. Identifying key predictive factors within this population is crucial for strengthening nursing interventions and promoting the delivery of evidence-based care.

2. Methods

This was a quantitative observational study using a cross-sectional design. A total of 102 participants were recruited for this study using a purposive sampling technique. Functional disability was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). The Indonesian-validated version of the WOMAC instrument, which has documented reliability (Cronbach's $\alpha = 0.89$), was administered through face-to-face interviews. The questionnaire consists of 24 items measuring pain (five items), stiffness (two items), and physical function (17 items) on a 5-point Likert scale. The total score ranges from 0 to 96, with higher scores indicating greater disability. Other data collected included Body Mass Index (BMI), calculated from measured height and weight, and OA severity, assessed using the Kellgren-Lawrence classification of standard radiographs as reviewed by radiologists. Demographic, clinical, and WOMAC score data were collected simultaneously without intervention. To minimize bias, eligible patients were approached consecutively, and interviews were conducted by trained research assistants using a standardized questionnaire. This study was conducted at the Prof. Dr. P. Lubis USU Hospital and Haji General Hospital in Medan over a five-month period from January to May 2025.

The study population comprised all patients diagnosed with knee osteoarthritis (OA) by an orthopedic specialist. To be included, participants were required to meet the following criteria: (1) be aged 40 years or older; (2) have a formal diagnosis of knee OA according to the Kellgren-Lawrence classification; and (3) be able to read, understand, and provide written informed consent. The exclusion criteria were patients with mobility impairments from other conditions (e.g., stroke, fracture) or those with mental or cognitive conditions that would hinder questionnaire completion.

A purposive sampling strategy was employed, where subjects were selected based on the predetermined criteria. From this eligible pool, participants were recruited using a consecutive sampling method from the physiotherapy room during their routine follow-up visits. To minimize selection bias, all eligible patients who presented during the study period were invited to participate until the target sample size was reached. The sample size calculation was based on detecting a moderate correlation ($r = 0.3$) between OA values and WOMAC scores, with a power of 80% and $\alpha = 0.05$, requiring a minimum of 84 participants. We recruited 102 participants to account for potentially incomplete data or attrition

Data analysis involved using Spearman's rank correlation to assess the relationship between variables and multiple linear regression to model the predictors of the WOMAC score. The research was conducted after receiving ethical approval from the Health Ethics Committee of the University of North Sumatra (Permit Number: 27/KEPK/USU/2025). A flow diagram of the study process is presented in Figure 1.
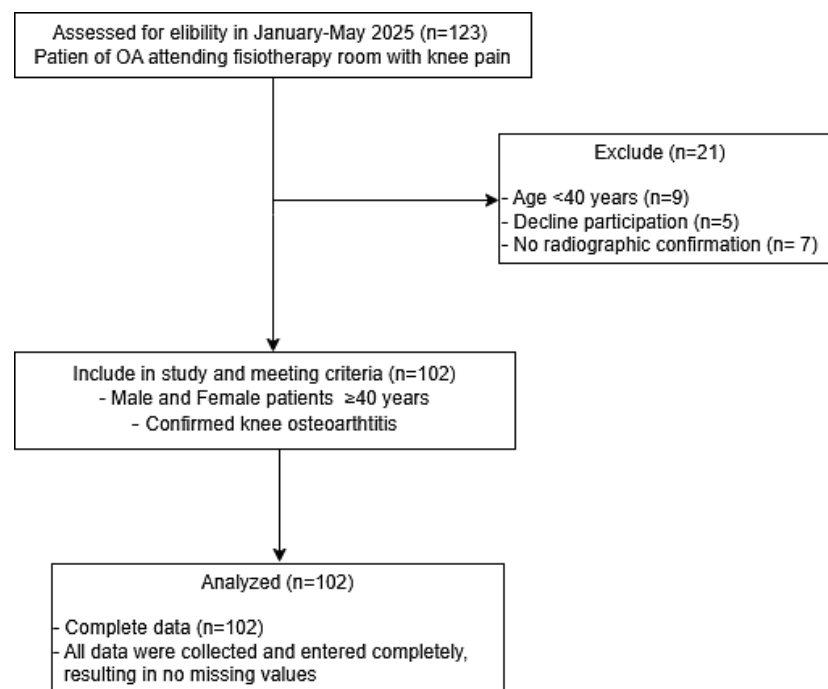

Figure 1 Study Flow Diagram

3. Results

This section presents the data analysis results from the 102 respondents who met the study's inclusion criteria. All statistical analyses were performed using JASP (Version 0.19.3). The results are systematically organized to address the primary research question outlined in the introduction: whether a relationship exists between demographic and clinical characteristics (age, sex, occupation, BMI, duration of OA, and OA grade) and the WOMAC scores in patients with knee osteoarthritis.

3.1. Frequency Distribution and Presentation Based on Subject Characteristics

Table 1 displays the demographic characteristics of the respondents. The majority of participants belonged to the 55-65 year age group (n = 52, 50.9%), followed by the ≥66 years group (n = 30, 29.4%) and the 40-54 years group (n = 20, 19.6%). In terms of gender, the sample was predominantly female, with women accounting for 87.3% of respondents (n = 89), while men comprised the remaining 12.7% (n = 13). The distribution by occupation shows that the largest group consisted of housewives (52.9%), followed by retired individuals (30.4%) and civil servants/private sector workers (16.7%).

Table 1 Frequency distribution and presentation based on subject characteristics (n=102)

Characteristic	f	%
Age		
40– 54 Years	20	19.6
55– 65 Years	52	50.9
≥ 66 Years	30	29.4
Gender		
Male	13	12.7
Female	89	87.3
Job Description		
Post-Employment	31	30.4
Housewife	54	52.9
Civil Servant/Private Sector	17	16.7

3.2. Frequency Distribution of Clinical Characteristic Subject

Analysis of the participants' clinical characteristics revealed the following descriptive statistics. The mean Body Mass Index (BMI) was 28.3 kg/m² (SD = 4.43), with a range of 19.7 to 39.1 kg/m². The 95% confidence interval (CI) for the mean was [27.4, 29.2], indicating that the sample was, on average, in the overweight to obese category. The mean osteoarthritis (OA) grade was 2.74 (SD = 0.59) on a scale of 1.0 to 4.0 (95% CI [2.63, 2.86]), suggesting that most subjects had moderate to severe OA. The mean duration of illness was 23.7 months (SD = 35.9). The wide range (1–240 months) and the large standard deviation relative to the mean indicate considerable variation in illness duration among respondents. Finally, the mean total WOMAC score was 42.8 (SD = 16.6), with individual scores ranging from 10 to 81 (95% CI [39.5, 46.0]). This average score indicates moderate to severe functional impairment, as a score above 40 is typically associated with significant activity limitations requiring intervention.

Table 2 Frequency distribution of clinical characteristic subject (n=102)

Characteristic	Mean	SD±	Min	Max	95% CI Lower	Upper
IMT (kg/m²)	28.3	4.43	19.7	39.1	27.4	29.2
Grade OA	2.74	0.59	1.00	4.00	2.63	2.86
Duration OA (month)	23.7	35.9	1.00	240	16.6	30.7
WOMAC	42.8	16.6	10.0	81.0	39.5	46.0

3.3. Spearman Correlation Test Results between Characteristic and WOMAC Score

The Spearman correlation test showed that the duration of osteoarthritis (OA) was significantly and positively correlated with the WOMAC score (r = 0.215, p = 0.030). Although this correlation was statistically significant, the effect size was small, indicating that OA duration explained approximately 4.6% of the variance in the WOMAC scores. Similarly, OA levels were also positively correlated with WOMAC scores (r = 0.196, p = 0.049). In contrast, age, sex, occupation, and BMI were not significantly associated with WOMAC scores (p > 0.05).

Table 3 Spearman correlation test results between characteristic and womac score

Characteristic	Spearman's rho (ρ)	p-value
Age	-0.005	0.963
Sex	0.143	0.152
Job	-0.104	0.298
Body Mass Index (BMI)	0.055	0.581
Duration OA	**0.215**	**0.030**
Grade OA	**0.196**	**0.049**

Note: *The bolded value shows statistical significance at α = 0.05*

3.4. Results of Multiple Linear Regression Analysis on WOMAC Score

Multiple linear regression analysis was performed to determine the contribution of several predictor variables to the WOMAC score. The overall regression model was statistically significant (F = 2.359, p = 0.036), with an R² value of 0.130. This indicates that 13.0% of the variance in WOMAC scores can be explained by the combination of age, sex, occupation, BMI, OA duration, and OA grade. Individually, both OA grade (β = 0.213, p = 0.036) and OA duration (β = 0.207, p = 0.038) were found to be significant predictors of a higher WOMAC score. In contrast, the variables of age, sex, occupation, and BMI did not have a significant effect on the WOMAC score. Therefore, this analysis supports the hypotheses that OA duration and OA grade are related to the WOMAC score. Conversely, the hypotheses regarding the influence of age, sex, occupation, and BMI were not supported by the data in this study.

Table 4 Results of Multiple Linear Regression Analysis on WOMAC Score

Predictor	B	SE	β	t	p-value	95 % CI	
						Lower	Upper
Constant	22.065	18.028	—	1.224	0.224	-13.762	57.855
Age	-3.077	2.633	-0.129	-1.169	0.245	-8.303	2.150
Sex	6.631	5.013	0.134	1.323	0.189	-3.321	16.583
Job	-2.292	2.596	-0.093	-0.883	0.379	-7.445	2.861
BMI	0.013	0.377	0.003	0.034	0.973	-0.737	0.762
Duration OA (month)	0.096	0.046	0.207	2.104	0.038	0.005	0.187
Grade OA	5.974	2.802	0.213	2.132	0.036	0.412	11.536

4. Discussion

This study aimed to analyze the factors related to Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores in patients with knee osteoarthritis (OA). The main focus was to evaluate the contribution of age, sex, occupation, body mass index (BMI), duration of OA, and OA grade to symptom severity based on correlation and regression analyses.

Based on the results of the Spearman correlation test, both the duration of OA (r = 0.215, p = 0.030) and OA grade (r = 0.196, p = 0.049) had a significant positive relationship with WOMAC scores. This means that the longer a patient suffers from OA and the higher the radiological severity of the condition, the higher their WOMAC score, which indicates increased pain, stiffness, and limited physical function. These findings are in line with the theory of OA progressivity, which states that the accumulation of time and radiological damage to joint structures contribute to the deterioration of a patient's clinical condition (Coaccioli et al., 2022). This finding is also reinforced by the study of Ota et al. (2021), who found that an increase in OA grade is highly correlated with functional disabilities (Ota et al., 2021).

The results of this study demonstrate that OA grade and duration are significantly related to an increase in WOMAC scores. This finding supports the research of Allen et al. (2022), who reported that greater joint damage and a longer duration of OA lead to increased disability and pain (Allen et al., 2022)**.** In contrast, age, sex, occupation, and BMI were not significantly correlated with WOMAC scores. The absence of a significant influence from these factors suggests that disability in OA is more influenced by disease progression than by sociodemographic factors alone. This is consistent with a meta-analysis by Long et al. (2022), which emphasized that OA management approaches should be tailored to the patient's clinical condition rather than just their demographic background (Long et al., 2022). This indicates that these sociodemographic factors may not be direct determinants of pain perception and activity limitations, or that their effects could be mediated by other variables, such as physical activity levels, inflammation, or psychosocial conditions.

The multiple linear regression model showed that the six independent variables combined (age, sex, occupation, BMI, duration of OA, and OA grade) had a significant influence on WOMAC scores (R² = 0.130, F = 2.359, p = 0.036). The R-squared value indicates that the model explains only 13.0% of the variance in disability, suggesting that unmeasurable factors—including pain coping strategies, social support, and comorbidities—likely play a significant role in functional outcomes. This highlights the need for individualized assessments that go beyond radiological severity.

Within the model, the two variables with a significant effect were OA Duration (β = 0.208, p = 0.038) and OA Grade (β = 0.213, p = 0.036). Both indicated a positive relationship, meaning that a longer duration of OA and a greater degree of joint damage correspond to higher symptom severity. Meanwhile, age (p = 0.245), sex (p = 0.189), occupation (p = 0.379), and BMI (p = 0.974) had no significant effects. This confirms that while demographic factors are often associated with OA risk, they do not always directly contribute to the severity

of symptoms perceived by patients. This finding is consistent with previous research; for example, Coppola et al. (2024) also showed that mechanical load from factors like BMI or sex differences does not automatically increase WOMAC scores unless accompanied by progressive factors such as disease duration and structural severity (Coppola et al., 2024).

This study aimed to explore the relationship between demographic (age, sex, occupation) and clinical (BMI, OA grade, OA duration) characteristics and the severity of disability, as measured by the WOMAC score, in patients with knee osteoarthritis. The main findings revealed that OA grade and the duration of the condition were significant predictors of the WOMAC score. These results underscore the importance of early screening for OA, particularly by monitoring radiological progression (grade) and disease duration. Such monitoring allows for more timely and effective management aimed at preventing an increase in disability levels. A more detailed explanation of these findings is provided in the following sections.

4.1 Duration of Osteoarthritis and WOMAC Score

The duration of OA was positively and significantly associated with WOMAC scores ($r = 0.215$, $p = 0.030$; $\beta = 0.207$, $p = 0.038$), suggesting that the longer a patient has had OA, the higher the level of disability they experience. This finding is consistent with the physiological mechanism of OA as a progressive chronic degenerative disease, in which cartilage damage and changes in joint structure continue to worsen over time without effective treatment (Long et al., 2022). Furthermore, Allen et al. (2022) confirmed that delayed management of OA often results in a significant decline in function, especially in patients with a disease duration of more than two years (Allen et al., 2022). Therefore, early intervention is essential to slow disease progression and prevent long-term impacts on quality of life.

4.2 Grade Osteoarthritis and WOMAC Score

OA grade, based on radiological classifications such as Kellgren-Lawrence, showed a significant positive correlation with WOMAC scores ($r = 0.196$, $p = 0.049$; $\beta = 0.213$, $p = 0.036$). This indicates that a higher degree of radiologically-assessed joint damage corresponds to greater patient-reported pain, stiffness, and functional limitation. This finding is consistent with a study by Walrabenstein et al. (2023), which reported that patients with grade III–IV OA had WOMAC scores twice as high as those with mild OA (Walrabenstein et al., 2023). This underscores the importance of radiological assessment as a key indicator for guiding therapeutic and rehabilitative strategies for patients with OA (Zhu et al., 2024).

4.3 The Role of Body Mass Index (BMI)

Although this study found no significant association between BMI and WOMAC scores ($r = 0.055$, $p = 0.581$; $\beta = 0.003$, $p = 0.974$), this outcome is contrary to extensive literature that identifies obesity as a major risk factor for the occurrence of OA, especially in major weight-bearing joints such as the knee. Binvignat et al. (2024) stated that being overweight increases the mechanical load on the joints and systemic inflammation triggered by the release of pro-inflammatory cytokines from adipose tissue. The lack of association in our findings may therefore reflect a complex relationship between weight and functional outcomes within the Indonesian population, where factors such as traditional activities of daily living or different patterns of pain expression could modify this relationship.

4.4 Age and Gender Factors

The results of this study indicated that age and sex were not significantly related to WOMAC scores. This finding is noteworthy, as the broader literature suggests that osteoarthritis (OA) is more prevalent in women, particularly post-menopause, due to hormonal changes that affect cartilage metabolism and pain sensitivity (Allen et al., 2022). Similarly, the non-significant finding for age may be explained by longitudinal research from Sun et al. (2021), which demonstrates that the decline in joint function is not necessarily linear with age but is more strongly influenced by factors such as physical activity, nutritional status, and the severity of the OA itself(Sun et al., 2021)

4.5 Job Description and OA Risk

Employment status was not significantly related to WOMAC scores in this study ($p = 0.397$). However, several studies have reported that manual labor increases the risk of OA due to repetitive mechanical stress on the knee joint. A study from China (2023) showed that workers and farmers have a higher prevalence of knee OA than office workers (Hao et al., 2024). In this context, the type of work can affect the onset and progression of OA, but its effect on WOMAC scores is likely mediated by the grade and duration of OA.

5. Implications in Nursing Practice

These findings suggest that nursing assessment protocols should prioritize disease duration and radiological severity over demographic characteristics when identifying patients at risk of severe disabilities. Early intervention programs should target patients within the first year of diagnosis, regardless of their age or BMI. The results of this multivariate analysis support nursing practice in the following ways:

5.1 Patient Risk Stratification

Nurses can use **OA severity grade** and disease duration as primary screening tools to identify patients who require more intensive rehabilitation support. The clinical decision framework includes priorities in determining nursing interventions obtained from the results of this study:

5.1.1. High Priority
- OA grade III-IV + Duration OA >24 month
- OA grade II + Duration OA >36 month

5.1.2. Mild Priority
- OA grade II-III +Duration 12-24 month

5.1.3. Low Priority
- OA Grade I-II + Duration <12 month

Intensive nursing interventions should be prioritized for patients with Grade III-IV OA and a disease duration exceeding 24 months, as these factors are the strongest predictors of functional decline. Roy's Adaptation Theory is particularly relevant in managing chronic cases such as knee osteoarthritis. This theory posits that individuals respond to physiological and psychosocial stressors through adaptive mechanisms. Disability from OA acts as a chronic stressor that demands continuous adaptation. In this framework, nurses serve as facilitators, implementing interventions that support patients' coping mechanisms, including building physical resilience, providing emotional support, and facilitating peer group coaching. These adaptation-based strategies can help patients with OA maintain social function and quality of life despite their reduced mobility.

The implications of this study's results reinforce that nursing theory is not merely a conceptual framework but a practical foundation for formulating targeted interventions for chronic conditions like knee OA. Therefore, nursing education and practice must ensure the integration of relevant theories, such as Roy's Adaptation Theory, into standard patient management approaches for osteoarthritis.

Nurses can also apply King's theory in nursing practice to improve the clinical condition of OA patients. Specifically, the nurse-patient transaction model as a guide to nursing practice in the context of the nurse-patient relationship to identify patients' perceptions of the duration and grade of OA disease for their experiences. This model is used to explore experiences, analyze the actions and reactions between nurses, patients, health teams, and nurse-patient transactions in strengthening patient care strategies (Karota Evi et al., 2020).

5.2 Patient Education Priorities

Nurses, acting in their role as educators, can implement vital interventions by emphasizing early mobility and joint protection strategies. These interventions are particularly crucial for patients within the first year of diagnosis, a period when the condition is more modifiable and before severe disease progression occurs. The finding that disease duration and radiological severity (OA grade) significantly contribute to disability scores (WOMAC) aligns with the principles of Orem's self-care deficit theory. This theory posits that when an individual experiences limitations in self-care due to a chronic condition or disability, nursing intervention is needed to address those needs (Yip, 2021). In the context of knee OA, increased pain, stiffness, and limited physical function directly lead to self-care deficits in areas such as mobility, personal hygiene, and activities of daily living.

Nurses play a critical role in assessing the level of a patient's self-care needs and designing educational and supportive interventions to enhance their capacity for function and independence. Using risk stratification based on the aforementioned factors, nurses can implement targeted strategies such as joint movement training, pain management education, and daily activity modification. These actions serve as compensation for the self-care deficits experienced by patients with OA.

6. Conclusion

This study showed that the severity of knee osteoarthritis (OA Grade) and the duration of the disease were significant predictors of functional disability, as measured by the WOMAC score. These findings are based on a multiple linear regression analysis, which revealed a significant contribution from both variables ($p < 0.05$), collectively explaining 13.0% of the variance in WOMAC scores ($R^2 = 0.130$). In contrast, demographic

factors such as age, sex, occupation, and body mass index (BMI) were not found to be significantly associated with the level of disability.

The implications for nursing practice emphasize the importance of risk stratification based on clinical parameters—particularly OA grade and disease duration—when planning interventions. Nursing and rehabilitative interventions should therefore focus on newly diagnosed patients to manage disease progression early, regardless of their age or BMI.

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