Relationship of Pain, Function and Quality of Life with Disease Grading among Patients with Knee Osteoarthritis

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Abstract

Knee Osteoarthritis (KOA) is a global public health problem. The prevalence of KOA is on the rise leading to increased disease burden. Female and older adults have a higher risk of developing KOA. The diagnosis of KOA is usually based on specific clinical signs and symptoms or based on structural changes evident on radiographs. The clinical decision for management in these patients is based on X-ray grading. Recently there is a discussion on concordance between clinical and radiological findings in KOA patients. Therefore, it is necessary to identify a relationship between patient-reported findings and disease grading based on standard radiographs. This cross-sectional study recruited KOA patients from rural and urban parts of Phagwara and Jalandhar, Punjab, India. Participants were identified during medical and physiotherapy camps. Participants were included based on the American College of Rheumatology Criteria (ACR). Demographic characteristics, pain intensity, functional status, and Quality of Life (QOL) were assessed and documented. Disease grading was done based on presenting X-rays using grading proposed by Kellgren and Lawrence. The association between these variables was analyzed using R software and reported. We also predicted disease grading using QOL metrics. 120 Participants’ data were included in the final analysis. Findings suggest an association between demographic (age, height, weight and BMI) variables and disease grading. Pain, functional status, and QOL were found to be associated with disease grading. SF-Physical functioning and SF-General Health QOL metrics significantly predicted disease grading. The study’s findings suggest that disease grading based on X-rays shows an association with the participants’ clinical presentation.

Keywords: Disease Grading, Epidemiology, Osteoarthritis, Quality of Life, Radiography

1. Introduction

Osteoarthritis (OA) is the most widespread form of arthritis reported among older adults¹–². The health care costs and disease burden are on the rise in many countries and are predicted to increase further in the future³. The knee joint is the most common joint affected with OA equated with other joints¹. The prevalence of Knee Osteoarthritis (KOA) has shown a remarkable increase from 2002 to 2020⁴,⁵. The global occurrence of Knee Osteoarthritis (KOA) is reported as 22% among individuals aged 40 and over⁶. There are remarkable variations in prevalence and incidence among different parts of the world⁷, incidence and years lived with disability (YLDs). Prevalence reported among Asians (19.2%) is higher as compared with other continents⁶.

In the literature, different parameters and criteria are specified for the diagnosis of KOA. Kellgren and Lawrence (KL) described the diagnosis of KOA based on

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the presence of structural changes on X-rays\(^6\). The clinical diagnosis of OA is based on diagnostic criteria defined by the American College of Rheumatology (ACR) criteria\(^7\), European League Against Rheumatism (EULAR)\(^8\) or National Institute for Health and Care Excellence (NICE) guidelines\(^9\). Imaging in KOA is used for two purposes: 1. To aid in the differential diagnosis when the clinical picture is doubtful and 2. To decide management strategies in patients with KOA\(^10\)-\(^13\).

In KOA patients, various management strategies are recommended, like exercise, education, lifestyle modifications, medications and surgery\(^14\),\(^15\). The clinical decision-making for selecting a management strategy depends on pain intensity, proof of structural damage, conservative treatment failure and impaired quality of life\(^16\). There is a discussion on concordance between clinical and radiological findings in KOA patients\(^5\),\(^17\),\(^18\). Studies report variation in terms of the association between disease grading and clinical presentation of patients. Therefore, the present study aimed to analyze the association of disease grading with pain intensity, functional status, and Quality of Life (QOL). Additionally, we also predicted disease grading using QOL metrics.

2. Methods

2.1 Study Design and Setting

The study was cross-sectional based in Phagwara and Jalandhar, Punjab, India. We followed STROBE guidelines for conducting and reporting the findings.

2.2 Participants

We recruited participants through rural and urban camps organized for providing primary medical and physiotherapy care. We used convenient sampling technique. The selection criteria comprised of: 1. 40 years or older, 2. Complaints of knee pain on most days of the past month, 3. Diagnosis of bilateral knee OA based on radiographic findings, 4. Complains of knee pain while doing activities of daily living and 5. Presence of morning stiffness for ≥30 minutes. We only included females in our study as we did not get enough bilateral OA male participants. Participants were excluded if they had any history of previous surgery of lower limbs, hip OA or they had a history of any severe medical conditions. Participants signed informed consent before final participation, which was voluntary. The dependent variables were only collected for the more painful knee. The study was approved by the Project Approval Committee (PAC) of Lovely Professional University, Phagwara, Punjab, India. The study’s ethical principles were in concordance with the WMA Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects)\(^19\).

2.3 Procedure

Eligible participants were screened for basic demographic characteristics such as age, weight and height. The corresponding author had experience in assessing and managing KOA patients graded the X-rays using the KL grading system. The other authors confirmed the grading and any differences were discussed and amended. The other dependent variables, pain, health status and QOL, were assessed using the NPRS, WOMAC index and SF-36 questionnaire. Association between disease grading and the studied variables were analyzed.

2.4 Outcome Measures

2.4.1 Pain

Pain intensity was measured using a Numeric Pain Rating Scale (NPRS). NPRS is an 11-point scale with scores from 0 to 10. 0 indicates “no pain,” and 10 means “worst pain imaginable.” Participants rated their pain on NPRS during three different activities: Walking, maneuvering stairs and resting pain. NPRS have been extensively tested in diverse populations and have excellent psychometric properties\(^20\).

2.4.2 Western Ontario McMaster Scale (WOMAC)

We used WOMAC to assess the health status of the individuals. WOMAC is a self-administered health status measure commonly used in patients with hip and KOA. WOMAC assesses three different domains affecting health (pain, stiffness and function)\(^21\),\(^22\). Higher scores on the scale suggest the low health status of the patients. WOMAC is available in two different formats, visual analog and Likert-boxes versions. We used a Likert version of the scale. WOMAC scores can be described in terms of percentages and total scores. We used total scores in the final analysis, did not categorize scores into different sections. The psychometric properties of the WOMAC scale are well studied and reported in the literature\(^23\).
2.4.3 Short Form-36
SF-36 was used to assess the Quality of Life (QOL) in our study. SF-36 is the most used health-related quality of life measure utilized in research\textsuperscript{24}. SF-36 is divided into eight different concepts of health (Table 1). The public version of SF-36 and its scoring instructions can be accessed from the RAND Corporation website. We calculated the scores for eight scales using the same instructions\textsuperscript{25}. Higher scores on the scales indicate better QOL.

2.5 Data Analysis
The association of disease grading with the demographic characteristics, pain, health status and QOL were assessed using Kendall’s tau. Since many different tests were conducted (one for each variable), we adjusted the p-values using the procedure of Benjamin-j-Hochberg to arrive at the false discovery rates (FDR)\textsuperscript{26}. Logistic regression was calculated to assess whether any of the QOL metrics could predict disease grading. The data was analyzed using R software.

3. Results
A total of 120 participants were included in the study. The mean age of the sample was mean (SD) 59.79 (9.861). Demographic characteristics are mentioned in table 2. The data propose an association between demographic variables, pain, functional status, and quality of life metrics with disease grading (Table 3).

The association between the WOMAC Score and disease grading was positive and statistically significant (\(\tau_b \, 0.5777, \text{FDR} \, 2.683e^{-15}\)). Participants with the more advanced disease tend to have a higher WOMAC rating score. For SF-36 scales, all the subscales were negatively correlated with disease grading (Table 3). Participants with advanced disease had a low quality of life among the sample. For pain (NPRS), we assessed the pain intensity during three activities: Rest, maneuvering stairs and walking. Pain during walking was positively associated with disease grading (\(\tau_b \, 0.6111, \text{FDR} \, 2.683e^{-15}\)). Pain during rest (\(\tau_b \, 0.4981, \text{FDR} \, 1.146e^{-10}\)) and stair climbing (\(\tau_b \, 0.5612, \text{FDR} \, 4.717e^{-13}\)) was also positively associated; the calculated associations were statistically significant for pain intensities.

We used a linear regression model to predict the disease grading from the quality-of-life metrics (SF1-SF8); the fitted coefficients are highlighted in Table 3. While all the metrics were significantly correlated with the disease grading in Table 4, only SF1 and SF8 are statistically significant predictors of disease grading for our data among the eight metrics. We also constructed a model using only SF1 and SF8 (Table 5). SF8 shows some statistically significant predictive power among these two variables predictor model when taken with SF1 only. Figures 1 to 5 highlight the association of disease grading with age, WOMAC and QOL.

4. Discussion
The study found that patients with a higher disease grading based on KL grade had worse clinical scores, health status and quality of life. Demographic characteristics such as age, weight, height and BMI with disease grading also showed association with disease grading.

The study explores the relationship of disease grading with demographic characteristics and the clinical
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**Figure 1.** Graphical representation of association of age with disease grading.

**Figure 2.** Graphical representation of association of WOMAC scores with disease grading.

**Figure 3.** Graphical representation of association of pain intensity with disease grading [NPRS1- pain during walking, NPRS2-pain during stair ascend and descend and NPRS3-pain at rest].

**Figure 4.** Graphical representation of association of SF subscales with disease grading.

**Figure 5.** Graphical representation of association of SF subscales with disease grading.

**Table 3.** Association of disease grading (as measured using Kendall's tau) and its associated p-value for all variables

| Variables | Kendall’s | p-value (FDR) |
|-----------|-----------|---------------|
| Age       | 0.2852    | 6.335e-05     | 0.001448     |
| Weight    | 0.1176    | 0.09724       | 0.1111       |
| Height    | 0.09505   | 0.1845        | 0.1968       |
| BMI       | 0.08695   | 0.215         | 0.215        |
| NPRS1     | **0.6111**| **2.062e-14** | **2.683e-15**|
| NPRS2     | 0.5612    | 8.844e-14     | 4.717e-13    |
| NPRS3     | 0.4981    | 2.865e-11     | 1.146e-10    |
| WOMAC     | 0.5777    | 3.353e-11     | 2.683e-15    |
| SF1       | -0.4082   | 2.013e-08     | 6.441e-08    |
| SF2       | -0.2364   | 0.002363      | 0.003781     |
| SF3       | -0.2264   | 0.004053      | 0.005895     |
| SF4       | -0.2031   | 0.006119      | 0.008159     |
| SF5       | -0.1634   | 0.0257        | 0.03163      |
status of KOA patients. Disease grading was based on anteroposterior weight-bearing X-rays. We used Kendall’s tau for finding an association between the desired variables and disease grading. Kendall’s tau is a non-parametric measure of strength and direction of the association between two variables. A tau value of +1 means a perfect positive correlation, while -1 means a perfect negative correlation, and 0 denotes no association. In the present study, age, height, weight, BMI, and WOMAC scores showed a positive association with disease grading, while the SF-36 subscales were negatively correlated.

We measured pain intensity using NPRS. Patients were asked to rate their pain during three activities, walking, manipulating stairs and rest. Pain intensity during all three activities was positively correlated with disease grading. Patients with advanced disease reported more pain in our study. Bedson et al. reported a variable relationship of pain with disease grading. In his research, they explained three reasons for this concordance in the literature for this variation. Firstly, X-ray views may affect this relationship. Secondly, the definition of pain used in the study and thirdly, the patient population included being studied. Our findings can be explained in these terms. We assessed pain intensity during three different tasks to gain a comprehensive reporting of pain by the individuals; this may influence our findings. Moreover, the other factors linking X-ray findings with pain are age and ethnicity. The positive association of pain with disease grading may be explained in terms of age and race. It’s been reported that young patients do not have significant x-ray changes, and variations in symptoms according to age are reported in the literature. In our study, the mean age of the study population was 59.69 years. The older age study population might have resulted in a positive association of reported pain intensity and disease grading. Ethnicity could also be a factor to explain our results. Indian females are found to report more pain than other Asian populations. The current study population comprises old Indian females; this may contribute to the association between disease grading and self-reported pain intensity in the study.

The present study evaluated health status using WOMAC scores. The WOMAC showed a significant positive association with disease grading. Similar findings are reported by Herman et al. In their research, and they demonstrated a probability-order relationship between the clinical and radiographic aspects of knee OA. Cremer et al. reported that there is no relationship between WOMAC score and disease grading in their study. The difference between their research and our study findings may be attributable to the different statistical assumptions used. Patients in our study were with the more advanced disease tending to have a higher WOMAC rating.

### Table 4. Linear model predicting the disease grading from Quality of Life metrics

| Variables | Estimate  | Std. Error  | t value  | Pr(>|t|)  |
|-----------|-----------|-------------|----------|----------|
| SF1       | -0.01895  | 0.004572    | -4.145   | 6.678e-05|
| SF2       | -0.001059 | 0.002316    | -0.457   | 0.6484   |
| SF3       | -0.001136 | 0.001941    | -0.5852  | 0.5596   |
| SF4       | 0.004759  | 0.007759    | 0.6133   | 0.5409   |
| SF5       | 0.002137  | 0.007695    | 0.2777   | 0.7818   |
| SF6       | -0.005188 | 0.005881    | -0.8822  | 0.3796   |
| SF7       | -0.001811 | 0.007092    | -0.2554  | 0.7989   |
| SF8       | -0.01257  | 0.006573    | -1.912   | 0.0584   |
| Intercept | 3.916     | 0.4275      | 9.161    | 3.051e-15|

**Abbreviations:** SF1: Physical Functioning, SF2: Role limitations due to physical health, SF3: Role limitations due to emotional problems, SF4: Energy/Fatigue, SF5: Emotional well-being, SF6: Social Functioning, SF7: Pain, SF8: General Health

### Table 5. Linear model predicting the disease grading from only two Quality of Life metrics (SF1 and SF2)

| Variables | Estimate  | Std. Error  | t value  | Pr(>|t|)  |
|-----------|-----------|-------------|----------|----------|
| SF1       | -0.02127  | 0.003516    | -6.048   | 1.804e-08|
| SF2       | -0.01415  | 0.005369    | -2.635   | 0.009542 |
| Intercept | 4.003     | 0.2645      | 15.13    | 2.569e-29|

**Abbreviations:** SF1: Physical Functioning and SF8: General Health
QOL measured on SF-36 showed a negative association with disease grading. Higher scores on SF-36 indicate better QOL and the lower the score it means lower QOL. The negative association suggests with increasing disease severity, the QOL decreases. SF-36 has several subscales; we calculated associations between all subscales and disease grading. Nikolic et al. demonstrated similar findings using a different questionnaire. They used the EQ-5D questionnaire and concluded that radiographic changes correlate with decreased quality of life disease severity based on radiography images, functional activity level, and quality of life in patients with knee osteoarthritis in a rural population living in Serbian enclaves in Kosovo, as well as to determine the correlation between the WOMAC and the EQ-5D questionnaire in this population. Method. The cross-sectional study was conducted at the Internal Medicine Clinic, Clinical Hospital Center Pristina-Gracanica, located in Laplje Selo from February to December 2013. One hundred patients with confirmed (American College of Rheumatology criteria. Herman also suggested an association between SF-36 and radiographic grading. However, these studies did not use all the subscales of SF-36. Our study used the RAND scoring system for SF-36 and included all the subscales in the analysis, which is not reported in the literature elsewhere. The ROAD study highlighted that symptomatic KOA is related to lower physical QOL. They said that symptomatic patients report a poor QOL. The study population in the present study was symptomatic, which could elucidate the findings of our research. We fit a linear regression model to predict disease severity grading from the quality-of-life metrics. The model suggested that SF-Physical Functioning and SF-General health subscales have statistically significant predicting power for predicting disease grading. These findings suggest that patients’ physical function and general health may be a predictor of their disease severity. The surprising discovery was that SF-pain could not predict disease grading.

There were various limitations to our study. The sample size used in the study was small; a larger sample size may provide greater statistical power to detect additional predictive factors. We did not control for any confounders. The study did not have male participants, which would have introduced gender bias in the study. Despite limitations, our study had few strengths. This is the first study to our knowledge that used linear regression for predicting disease grading; this may have implications for disease predictions in future studies. Secondly, patients were recruited from rural populations through camps which may reflect the disease burden's level at grass root levels hence may be more generalizable in the Indian population.

5. Conclusion

We conclude that disease grading was associated with pain intensity, health status, and QOL among KOA patients. The study's findings are co relational and future studies may analyze a causal relationship in the studied variable. Our study's other significant finding is that the SF-physical functioning scale and SF-general health scales could predict disease grading using a linear regression model.

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7. Conflict of Interest

The authors declared that they have no competing interests.

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