



Digital Patient-Reported Outcome Measurements (PROMs) to Support Sustainable Rehabilitation Management among Individuals with Knee Osteoarthritis

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Abstract.

Objective: This study explored the relationship between knee pain and physical function among individuals with knee osteoarthritis (KOA) using Digital Patient-Reported Outcome Measurements (PROMs) highlighting their potential contribution to sustainable rehabilitation management.

Method: A cross-sectional study was conducted among 40 adults aged 40 years and above with KOA. Participants completed a digital survey comprising demographic information, the Brief Pain Inventory–Short Form (BPI-SF), and the Knee Injury and Osteoarthritis Outcome Score-12 (KOOS-12). Pearson's correlation analysis was performed to determine the relationship between knee pain and physical function.

Results: Participants reported predominantly mild-to-moderate pain during daily activities with generally mild functional limitations. A significant weak positive correlation was identified between average knee pain and standing difficulty ($r = 0.393$, $p = 0.012$), whereas no significant associations were observed for rising from sitting, getting in and out of a car, or twisting and pivoting activities. The findings suggested that digital PROMs effectively capture patient-centered functional outcomes while enabling efficient, technology-supported clinical assessment.

Practical/Theoretical Contribution: Digital administration of the BPI-SF and KOOS-12 demonstrates the feasibility of integrating data-driven outcome measurement into routine physiotherapy management. By reducing paper consumption, minimizing administrative workload, enabling secure longitudinal data management, and supporting real-time clinical decision-making. Thus, facilitate technology-enabled sustainable healthcare systems.

Keywords: Digital health; knee osteoarthritis; physiotherapy; sustainable, rehabilitation

1 Study Background

Knee osteoarthritis (KOA) is one of the leading causes of pain, disability, and reduced quality of life among older adults worldwide, placing a substantial burden on healthcare systems and rehabilitation services [1]. Routine monitoring of patient out-comes is essential for evidence-based physiotherapy; however, conventional paper-based patient-reported outcome measures (PROMs) are often time-consuming, re-source-intensive, and difficult to integrate into longitudinal clinical practice [2]. The emergence of digital PROMs offers an innovative approach to collecting patient-centred outcomes through secure, efficient, and environmentally sustainable data management, supporting the global transition toward digital healthcare and green clinical practices [3]. Thus, this study therefore explored the relationship between knee pain and physical function among individuals with KOA using digitally administered PROMs to evaluate their potential contribution to sustainable physiotherapy rehabilitation management

2 Methodology

2.1 Study design

This study employed a quantitative cross-sectional correlational design to examine the relationship between knee pain and physical function among individuals with knee osteoarthritis (KOA) using Digital Patient-Reported Outcome Measures (PROMs).

2.2 Study participants

The sample size for this study was determined using the G-Power 3.1.9.7 statistical power analysis software. The F tests (multiple linear regression- Fixed model), with the effect size set at 0.15 (medium effect size), probability error set at 0.5, and power at 0.90 with the significance level kept at α : 0.05, were used for the calculation. The total sample size suggested was 88. Considering the possibility of dropout and corrupted data, the sample size increased by 10%, with 97 respondents. The survey targets respondents ages 40 years old and above, who have been formally diagnosed with knee OA, can understand English, and has no history of lower limb injuries or surgery.

2.3 Outcome measures

The electronic questionnaire consisted of three sections.

Demographic Form—this form was used to record the respondent's age, gender, body mass index (BMI), usage of anti-inflammatory/antalgic drugs, duration, and side of knee osteoarthritis.

The Brief Pain Inventory (BPI) Short Assessment Form- The BPI is a 9-items, self administered questionnaire involving two pain-related domains: intensity and interference (impact). The BPI was used to record the nature of pain of respondents and its association with physical functioning and health-related quality of life [4].

The Knee Injury and Osteoarthritis Outcome Score (KOOS-12)-The (KOOS) is a patient-self-reported outcome measure which consisted of 12 questions that contain 4 KOOS Pain items, 4 KOOS Function (Activities of Daily Living and Sport/Recreation) items, and 4 KOOS Quality of Life (QOL) items [5].

2.4 Data Collection Procedure

Upon ethics approval [REC/11/2021(UG/MR911)], a self-reporting questionnaire Google form link was distributed to respondents attending physiotherapy service at the UiTM Physiotherapy Clinic. A flyer containing brief information on the objectives of the study, benefits, and risks was distributed to the carers and patients at the clinic. The distribution of the questionnaires was conducted from March to July 2022. Only the completed questionnaires from respondents over 40 years old who had been formally diagnosed with knee OA, with no history of previous knee surgery were included for analysis.

2.5 Statistical analysis

The data was analyzed using the Statistic Package for Social Sciences (SPSS) version 20. The mean, standard deviation (SD), frequency, and percentages were established to report the level of knee pain and functional ability profile. Pearson's analysis was conducted to identify the effects of knee pain on physical functions (4 KOOS Function (Activities of Daily Living and Sport/Recreation) items). The significant level is set at a p-value less than 0.05 (<0.05).

3 Results

3.1 Respondent's Demographic Information

A total of 61 respondents replied to the digital survey. However, only 40 feedback were fully complete and met all specified inclusion criteria. Among the excluded responses, 12 were removed due to the absence of a formal clinical diagnosis of knee osteoarthritis (OA), 9 had a documented history of previous knee surgery, and 3 were excluded due to incomplete information.

Table 1 presents a comprehensive summary of the demographic and clinical baseline characteristics of the valid participants ($n = 40$). The mean age of the sampled population was 58.35 ± 10.51 years. Gender distribution showed that the majority of respondents were female (57.5%, $n = 23$) compared to male respondents (42.5%, $n = 17$). In terms of ethnicity, a predominant majority were Malays (95.0%, $n = 38$), while Chinese and Indian participants each constituted 2.5% ($n = 1$) of the cohort. Geographically, approximately 62.5% ($n = 25$) of the respondents resided in the Petaling, Shah Alam, and Subang Jaya districts, followed by Klang (15.0%), Kuala Lumpur (12.5%), Gombak (7.5%), and Hulu Langat (2.5%).

The average body weight and height of the participants were recorded at 73.60 ± 10.74 kg and 1.60 ± 0.89 m, respectively. Broken down by gender, male participants had a mean weight of 76.76 ± 11.50 kg and height of 1.66 ± 0.08 m, while female participants averaged 71.26 ± 9.75 kg in weight and 1.56 ± 0.06 m in height. According to Body Mass Index (BMI) classifications, over half of the respondents were categorized with pre-obesity (52.5%, $n = 21$), 32.5% ($n = 13$) fell into Obesity Class I, and only 15.0% ($n = 6$) maintained a normal BMI range.

Table 1. Demographic and Clinical Characteristics of Participants (n = 40)

Characteristics	n (%)	Mean ± SD
Age (years old)	-	58.35 ± 10.51
Male	17 (42.5%)	59.53 ± 12.02
Female	23 (57.5%)	57.48 ± 9.42
Race		
Malay	38 (95.0%)	-
Chinese	1 (2.5%)	-
Indian	1 (2.5%)	-
Area of Living		
Petaling (inc. Shah Alam & Subang)	25 (62.5%)	-
Klang	6 (15.0%)	-
Kuala Lumpur	5 (12.5%)	-
Gombak	3 (7.5%)	-
Hulu Langat	1 (2.5%)	-
Anthropometric Measurements		
Weight (kg)	-	73.60 ± 10.74
Male	-	76.76 ± 11.50
Female	-	71.26 ± 9.75
Height (m)	-	1.60 ± 0.89
Male	-	1.66 ± 0.08
Female	-	1.56 ± 0.06
Body Mass Index (BMI) Status		
Normal	6 (15.0%)	-
Pre-obesity	21 (52.5%)	-
Obesity Class I	13 (32.5%)	-
Affected Knee with OA		
Right (Unilateral)	20 (50.0%)	-
Left (Unilateral)	5 (12.5%)	-
Both (Bilateral)	15 (37.5%)	-
Duration of Symptoms (months)	-	30.82 ± 30.00

3.2. Respondent's Pain and Functional Activities Profile

The Brief Pain Inventory (BPI) indices provided specific insights into pain severity and clinical symptoms. Respondents scored their worst pain at a mean VAS of 5.00 ± 2.06 and least pain at a mean of 1.78 ± 2.07 .

The calculated average overall pain intensity was 3.18 ± 1.71 , and the active baseline pain when completing the digital questionnaire was 2.30 ± 2.39 (Table 2). Evaluated across standard functional profiles, the amount of knee pain experienced during going up and down stairs was reported as the highest localized strain (1.85 ± 0.78), followed by walking on a flat surface (1.03 ± 0.80), and sitting or lying down (0.42 ± 0.64).

Table 2. Participant Pain Severity and Functional Strain Profile

Component / Specific Items	Mean $\pm$ SD	Minimum	Maximum
Pain Severity (BPI Indices)			
Worst Pain	5.00 ± 2.06	0.00	9.00
Least Pain	1.78 ± 2.07	0.00	8.00
Average Pain	3.18 ± 1.71	0.00	8.00
Pain Right	2.30 ± 2.39	0.00	8.00
Now			
Pain Specific Items			
Frequency of knee pain	2.45 ± 0.88	1.00	4.00
Knee pain during walking on a flat surface	1.03 ± 0.80	0.00	3.00
Knee pain during going up/down stairs	1.85 ± 0.78	1.00	3.00
Knee pain during sitting or lying down	0.42 ± 0.64	0.00	2.00

Overall, respondents noted mild generalized difficulty carrying out everyday physical functions. As outlined in Table 3, perceived difficulty on a 5-point Likert scale (0–4) indicated that rising from a sitting position presented the highest functional difficulty (1.53 ± 0.99), followed closely by moving in and out of a vehicle (1.35 ± 0.86), and twisting or pivoting on the affected knee (1.28 ± 0.93). General standing presented the lowest degree of physical challenge (1.10 ± 0.93).

Table 3. Level of Difficulty in Performing Daily Physical Functions

Activities	Mean ± SD	Minimum	Maximum
Difficulty during rising from sitting	1.53 ± 0.99	0	3
Difficulty during standing	1.10 ± 0.93	0	3
Difficulty during getting in/out of a car	1.35 ± 0.86	0	3
Difficulty during twisting/pivoting on injured knee	1.28 ± 0.93	0	3

3.3. The Effects of Knee Pain Level on Functional Abilities

To evaluate the structural influence of self-reported knee pain on physical capabilities, a parametric Pearson correlation analysis (*r*) was executed. The analysis revealed no statistically significant correlation ($p > 0.05$) between baseline pain intensity and difficulties related to rising from a sitting position ($r = 0.233$, $p = 0.148$), getting into or out of a car ($r = 0.235$, $p = 0.144$), or twisting/pivoting on the affected articulation ($r = 0.160$, $p = 0.230$). However, a statistically significant, albeit weak, positive linear relationship was identified between pain level and standing difficulty ($r = 0.393$, $p = 0.012$), meeting the 2-tailed alpha significance threshold of 0.05 (Table 4).

Table 4. Pearson Correlation of Pain Intensity vs. Functional Difficulty

Functional Activities	Pearson Coefficient (<i>r</i>)	p-value	Correlation Descriptor
Rise from sitting	0.233	0.148	Weak Correlation
Standing	0.393	0.012*	Weak Correlation
In/Out of Car	0.235	0.144	Weak Correlation
Twisting/pivoting on injured knee	0.160	0.230	Weak Correlation

Note: * Correlation is significant at the 0.05 level (2-tailed). Interpreted via Schober et al. (2018) criteria.

4 Discussion

This study explicitly aimed to explore the relationship between knee pain intensity and physical function among individuals with knee osteoarthritis (KOA) utilizing digitally administered Patient-Reported Outcome Measurements (PROMs). By capturing real-time clinical indices remotely, this methodology evaluates the potential contribution of digital tools to sustainable physiotherapy rehabilitation management. Broadly, the surveyed cohort demonstrated a relatively low pain profile alongside mild localized functional difficulty (Table 3). Given that the average symptom history spanned over two years (30.82 ± 30.00 months), it is highly probable that these individuals have established robust, continuous home-based management strategies. These interventions typically encompass pharmacological adherence, localized thermal modalities, self-massage, or strategic lifestyle changes [6]. Furthermore, while the mean active score during physical exercise reached 4.68 ± 2.00 , the parallel mild physical difficulty metrics indicate successful self-pacing or behavioral movement modifications to prevent structural knee overloading [7].

A central objective of this study was determining how subjective pain profiles interface with specific functional capabilities when gathered via digital pathways. As noted by Petal et al. [8] individuals coping with long-term osteoarthritis often acquire substantial self-efficacy over time, shifting how they modulate and tolerate functional impairments. Elevated self-efficacy links directly to reduced pain perception and the maintenance of higher physical output levels. The mild functional difficulty profile noted in this trial suggests a notable level of physical and behavioral resilience [9]. This allows participants to overcome daily hurdles through stable emotional and behavioral adjustments [10]. Critically, digitally administered PROMs allow remote tracking of these shifts without requiring frequent, carbon-heavy travel to outpatient clinics. However, if severe baseline pain levels were present, these findings would likely look vastly different. Severe arthritis pain causes substantial mobility limitations, complete dependence on ambulatory devices, interference with basic activities of daily living, and significant occupational absenteeism [11].

The primary statistical objective yielded a notable result: the general absence of a significant linear impact of pain on major physical functions ($p > 0.05$), except for standard stationary standing ($r = 0.393$, $p = 0.012$). This weak yet distinct connection can be partially explained by the cohort elevated body mass distribution, with over 85% falling into pre-obese or Class I obesity brackets ($BMI \geq 25 \text{ kg/m}^2$). Extensively documented mechanical analyses confirm that elevated body weight acts as a continuous multiplier of joint loading, exacerbating cartilage wear and altering stationary stance tolerance [12,13]. While these participants do not report severe current physical breakdown, a minor BMI change of 5 kg/m^2 increases knee OA structural risk and symptomatic progression by approximately 35% [14].

From the perspective of sustainable physiotherapy rehabilitation management, these outcomes offer vital operational directions. The findings that reflect the cohort pain and physical function, supports the potential shift of clinical evaluation and monitoring toward hybrid digital models. Digitally administered PROMs allow physiotherapists to

continuously monitor data points remotely, separating stable patients from those experiencing active mechanical declines. This minimizes unnecessary clinical clinic visits, maximizes resource utilization, and reduces the patient burden. Consequently, integrating digital baseline assessments directly supports long-term, eco-efficient, and accessible rehabilitation paths for chronic joint conditions.

5 Limitation

Several methodological constraints limit the immediate scope of this research. First, the small sample size ($n = 40$) limits the ability to generalize these outcomes broadly across the wider knee osteoarthritis population within Selangor or the Klang Valley area. This smaller sample profile introduces statistical limitations, which reduces the overall power to detect more subtle interactions among clinical sub-variables.

Second, the cross-sectional, survey-based nature of the electronic data collection prevents the long-term monitoring of pain patterns over extended clinical timelines. Given the cultural, social, and physical diversity within varying demographic populations, longitudinal tracking is essential. Future research should prioritize continuous cross-sectional and longitudinal frameworks to fully map long-term functional changes and support sustainable digital clinical decisions.

6 Conclusion

This study demonstrates that the targeted population maintains a low overall pain profile accompanied by mild functional limitations during everyday tasks.

The structural application of digital Patient-Reported Outcome Measurements (PROMs) confirms that subjective pain does not universally dictate functional impairment levels, provided adaptive behaviors or self-efficacy mechanisms are established. The insights gained from this baseline evaluation offer a clear foundation for developing extended longitudinal digital health platforms. Such systems will allow clinical teams to better investigate secondary factors, including physical resilience, localized movement adaptations, and digital weight management metrics to optimize long-term, sustainable rehabilitation paths for individuals living with knee osteoarthritis.

Conflict of interest

The authors would like to declare that we have no conflict of interest.

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