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Clinical and Radiographic Indices as Correlates and Predictors of Self-Reported Physical Functions in Patients with Chronic Knee Osteoarthritis

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Abstract: It is unknown if there would be relationship between symptoms, radiographic changes and self-reported physical functions among patients with knee osteoarthritis (OA). The primary aims were to determine if there would be correlation between symptomatic and radiographic indices of knee OA, and physical function; and also determine if the indices are significant predictors of functional ability. 53 patients who had grade III knee OA participated in the study. The major test instruments were plain X-ray films and Western Ontario and Mcmaster University – WOMAC Osteoarthritis index Questionnaire. The Joint Space Width (JSW), inter-condylar thickening (ICT), tibia width (TW) and other measurements were measured using standard procedures. Descriptive statistics, Pearson's product moment correlation, ANOVA and step-wise multiple regression analysis were used to summarize the data. Alpha level was set at $p = 0.05$. The mean WOMAC score was 33.78 ± 9.71. The duration of onset was 10.39 ± 7.14 months. Active knee flexion range of motion (AKFROM) was 102.71 (15.21) degrees while the medial and lateral JSW; ICT and TW were 0.51 ± 0.12cm, 0.74 ± 0.15cm, 1.09 ± 0.35cm and 7.01 ± 1.11cm respectively. There were significant correlations between WOMAC score; and AKFROM, PIA and passive KF ($r = -0.37$, $p = 0.06$; $r = -0.32$, $p = 0.02$; $r = -0.57$, $p = 0.001$ respectively). There were also significant correlations between WOMAC score and lateral JSW ($r = -0.31$, $p = 0.02$), and TW ($r = 0.37$, $p = 0.007$) on plain radiograph. The result of the multiple regression analysis showed that the most significant predictor of functional capability was active knee flexion range of motion ($F = 23.92$, $p = 0.001$), contributing 31.9% to the prediction. It was concluded that pain intensities, active knee flexion range of motion, pain intensity, inter-condylar thickening, joint space and tibia widths were correlates of physical functions. Active Knee Flexion Range of Motion was the most significant predictor of self-reported functional capability of patients with knee OA.

Keywords: Knee Osteoarthritis, Physical Functions, Pain Intensity, Range of Motion, Radiographic Parameters

1. Introduction

Musculoskeletal conditions caused 40% of all chronic conditions, 54% of all long term disability, and 24% of all restricted activity days [1]. Osteoarthritis is a chronic localized joint disease and a leading cause of musculoskeletal pain and disability. Pain, joint stiffness, decreased knee flexibility, joint effusion, crepitus, deformities, instability, swelling and reduced physical functions are common associated features [2] [3]. The pathogenesis is both destructive and productive; and there are secondary inflammatory changes that lead to structural and functional failure of the joints [4].

The specific causes of OA are unknown, but it is mostly attributed to both mechanical and molecular episodes at the affected joint while the onset is gradual and usually begins after the age of 40 years [5]. Knee OA substantially reduces life expectancy by 12% when occurring as co-morbidity with obesity[6]. The quadriceps, hamstring and calf muscle becomes tightened, resulting in poor coordination and slower reaction time that leads to poor functional capability [7]. Pain is the most prominent symptom in most people with arthritis, and it is the most important determinant of loss of functions in patients with osteoarthritis [2]. Current guidance from the European League Against Rheumatism (EULAR) recommends that a diagnosis of OA of the knee can be made in people who are aged over 40 years with persistent pain, morning stiffness, reduced function, one or more of crepitus (noise on movement) and restricted movement [8].

Osteoarthritis of the knee is a major cause of impaired mobility, particularly among women and the course varies while the radiographic changes progress inexorably [2]. Physical activity improves function in adults with arthritis, but it is doubted if there is relationship between radiographic changes and functional benefits [9]. Valerie [10] reported that there should be further quest to understand how it affects performance of functional tasks and also monitor changes that occur in patients with knee OA. Also, the severity of pain and the extent of changes on X-ray of patients with OA are not well correlated [2]. Most literature on relationship between symptoms, radiographic changes and physical functions are obsolete. Considering the preponderance and increasing ageing of our population with increase in other OA risk factors such as obesity, there would be need to update the literature [11]. Aside this, most previous studies utilized generic instruments, there is likelihood that indices which include functions that are unaffected by OA might have diluted the influence of knee OA on lower limb functions; neglecting self - reported disability of the patients [12]. It is important that we have a clear understanding about the relationship between function and radiographic features [13]. Also, functional status prior to OA is not known in most cases and there is dearth of empirical data on the use of radiographic parameters as predictors of physical functions among patients with knee osteoarthritis. The primary aims of this study were to determine if there would be correlation between symptomatic clinical indices (pain intensity and range of motion) and radiographic parameters (Joint space width, inter-condylar thickening and tibial width) of knee OA, and physical function. It also aimed at determining if the indices could significantly predict functional ability of patients with knee OA.

2. Material and Method

2.1. Subjects

The participants were 53 out-patients with knee osteoarthritis receiving treatment at the physiotherapy departments of three tertiary hospitals located at Osogbo, Osun State, South West Nigeria.

2.2. Research Design

This study was a quasi experimental design as there was no control and randomization of the sample.

2.3. Inclusion and Exclusion Criteria

The major inclusion criteria were participants with knee osteoarthritis whose ages ranged between 30 and 70 years old, history of knee OA not less than three months, radiological evidence of knee osteoarthritis and grade III using Kellegren classification. Those excluded from the study were patients with history of knee surgery or knee replacement, those with neuromuscular and musculoskeletal diseases like rheumatoid arthritis, poliomyelitis, muscular dystrophy, septic arthritis, cardiac disorder who were using cardiac pacemaker and those on intra-articular steroid therapy within two (2) months before the commencement of this study.

2.4. Sample and Sampling Techniques

Purposive sampling technique was used to recruit patients who met the inclusive criteria.

2.5. Instruments and Test Items

A bathroom weighing scale was used to measure the weight of each participant in kilogram [Kg) while modified height meter[m), 10 point visual analogues scale, goniometer and Western Ontario and Mcmaster University – WOMAC Osteoarthritis index Questionnaire were used to measure the height, pain intensity, knee range of motion and physical function. WOMAC Osteoarthritis index questionnaire has one of the various outcome measures that has been designed and validated for monitoring a number of clinical conditions including osteoarthritis [14).

2.6. Procedure for Data Collection

Ethical Approval was obtained from the Health Research and Ethics Committee, Institute of Public Health, Obafemi Awolowo University, Ile Ife and informed consent was obtained from the subjects. The age was recorded while weight and height of each subject were also measured and recorded. The Body Mass Index was computed using weight/height^2(kg/m^2). The pain rating scale was explained to each patient. Previous studies had established the reliability of the scale [15]. The active knee flexion was measured in prone lying position. A plastic semi-circle goniometer was placed on the lateral aspect of the knee joint with the fixed proximal reference pointing towards the head of the greater tronchanter, fulcrum was at the distal lateral condyle of the femur while the moveable arm was at the line pointing towards the lateral malleolus. The patients were asked to bend the knee fully to measure active flexion range of motion. Physical function was assessed using the Western Ontario Mcmaster Osteoarthritis Questionnaire (WOMAC). The Joint Space Width and Inter-Condylar Thickening were measured using standard procedures adopted by Deep et al [16] and Lequesne [17]. Using the antero-posteripor view of the x-ray film of each patient, the horizontal distance between the superior tip of the lateral and medial condyles of the tibial was divided into two while the lateral joint space width was measured at the mid-point of the first-half and the medial JSW was measured at the mid- point of the second half. The dividing pointer was used to prick the two inter-bone distances on the radiograph with the aid of a magnifying lens and then pricked a sheet of paper. The caliper was used to measure the inter-bone distances, on which the distance between the pricks was measured [17]. The inter-condylar thickening on the x-ray film was measured manually as the distance between the tip of the anterior and posterior margins of the intercondylar eminence using the method described by Lequesne [17]. The points of the caliper were used to measure inter-margin distance on the radiograph with the aid of a magnifying lens. This was transferred on the pinpricks sheet of paper. The tibia width was measured from the superior tip of the lateral to the tip of the medial condyle of the tibial horizontally using the pointing divider and vernier caliper with the aid of magnifying lens [18].

2.7. Data Analysis

Descriptive statistics were used to summarize data obtained. The Pearson's product moment correlation was used to determine relationship between anthropometric, symptomatic and radiographic indices; and physical function. Also, step-wise multiple regression analysis was used to derive predictive equation for physical functions. Alpha level was set at p = 0.05.

3. Results

The mean age of the participants was 57.35 ±12.5 9 years. The mean weight, height and BMI are presented in table 1. The duration of onset of the knee OA was 10.39 ± 7.14 months. The range of motion and intensity of pain experienced by the patients on active and passive knee flexion were 102.71 ± 15.21^0, 5.52 ± 1.86 and 6.52 ± 1.70 on a 10-point pain rating scale respectively. The values obtained for arthro-radiographic parameters (tibial width, inter-condylar thickening, medial and lateral joint space width) are presented in table 2. The mean functional activity level of all the patients on the WOMAC scale was 33.78 ± 9.71.

Table 1. *Age and selected anthropometric parameters of participants.*

	Mean	SD
Age	57.35	12.59
Weight	77.21	9.13
Height	1.56	0.01
BMI	31.05	5.32

Table 2. *Clinical, arthro-radiographic indices and functional activity level of participants.*

	Mean	SD
Clinical Indices		
Duration of onset [months)	10.39	7.14
Pain on active knee flexion	5.52	1.86
Pain on passive knee flexion	6.52	1.70
Range of motion[ROM)	102.71	15.21
Radiographic Indices		
Medial joint space width[MJSW)	0.51	0.12
Lateral joint space width[LJSW)	0.74	0.15
Inter-condylar thickening	1.09	0.35
Tibial width	7.01	1.11
Functional activity score	33.78	9.71

The result of the Pearson's product moment correlation showed that there was significant correlation between age and duration of onset of knee osteoarthritis (r = 0.46, p = 0.001), and inter-condylar thickening (r = 0.27, p = 0.05). There was also significant correlation between active knee joint flexion, pain intensities on active knee flexion (PIAKF); and WOMAC score(r = -5.65, p = 0.001; r = -0.323, p = 0.02respectively). There were only significant correlations between functional activity score, lateral joint space width (r = -0.309, p = 0.024), and tibial width (r = 0.369, p = 0.007) on the plain radiograph. Other correlation co-efficiencies are presented in table 3.

The result of ANOVA showed that age, weight, height, BMI, selected clinical and radiographic parameters are significant predictors of functional activity level of patients with knee osteoarthritis (F = 3.53, p = 0.001), (Table 4).The result of the multiple regression analysis showed that all the independent variable contributed 54.7% to the overall predictability ofthe dependent variable (functional activity), (p = 0.001). The most significant predictor of functional capability was active knee flexion range of motion (F = 23.92, p = 0.001). The active knee range of motion contributed the highest (31.9%) to the predictability of functional level followed by width (diameter) of the tibial bone and pain intensity experienced on active knee flexion which contributed 13.6% and 10.4% respectively.The predictive equation obtained from the analysis was:

Functional activity score = 91.64 + (-0.15 x age) + (0.49 x weight) + (-0.32 x height) + (-0.54 x BMI) + (0.15 x duration) + (0.40 x active pain intensity)+ (-0.35 x passive pain intensity) + (-0.41 x ROM) + (0.08 x MJSW) + (-0.09 x LJSW) + (0.006 x ICT) + (0.29 x Tibial width).

4. Discussion

There are early symptoms and evidences on plain radiographs but the major consequence in the lower extremity is functional impairment in ADL with resultant disability [19]. Measurement of changes in joint space width is currently the gold standard in evaluation of structured modifying drugs in osteoarthritis [20]. The JSW is a reproducible tool for assessing progressive knee cartilage degeneration and evaluating disease modifying effects of patients with OA. Several literatures observed that prevalence increases with age and about 11% of women over the age of 60 years have symptoms due to knee OA with radiological evidence of OA [12] [21]. Symptomatic or mixed clinical and radiological criteria are currently being preferred to detect OA in epidemiological studies [22]. Radiographic OA of the knee joints is believed to be the most common manifestation of pathology in this joint [23].

There was significant positive correlation between age and duration of onset of knee osteoarthritis. This implied that as the patient ages, there is increase in chronicity of degenerative changes the arthritis. Prevalence of OA increases with age and aging is associated with decreasing physiological functions, and it is likely to cause disability in the future [13]. Age of the patients and duration of onset [chronicity] had no significant correlations with most of the radiographic parameters excluding inter-condylar thickening for the former [age].Contrarily, Creamer et al [12] found that joint space narrowing and disability was much stronger in subjects with disease duration less than 5 years compared to those with 5 or more years of symptoms. We adduced our own current findings to the same reason given by Creamer et al [12] that other factors might contribute to determining degree of functional impairments. It is also important to note that the plain radiographs show only bones but there are soft tissues that if damaged may also affect physiological function.

Current finding showed that there was significant inverse correlation between pain intensity and WOMAC scores on active knee flexion implying that the lower the former the higher the level of functional activities of the patients. The inverse relationship between pain and physical function observed in our study corroborated that of Odole [24] and Aghdam et al. [25]. Odole et al [24] reported that physical limitation, pain, and depression were closely related to each other. Function in symptomatic knee OA is determined more by pain and obesity than by structural change, at least as seen on plain X - ray [12]. We also observed that there were significant inverse correlations between active knee flexion and WOMAC scores. It is noteworthy that lower WOMAC score implies better function. The availability of joint range of motion is a prerequisite for good functional activities. Our findings further showed that pains experienced by the patients at both active and passive knee had no correlation with inter-condylar thickening, joint space and tibial widths. Pain is a dominant symptom but radiographic changes, particularly osteophytes, are common in the aged population. The symptoms of joint pain may be independent of radiographic severity in many older adults [11]. Jordan et al [26] reported a positive association of radiological grading of OA with pain, although, they observed that most patients with radiographic evidence of OA do not have symptoms. However, clinical practice strongly suggests that only symptomatic forms of OA cause suffering and disability [27]. Most times, symptoms due to OA are intermittent during the course of the disease [27].

Table 3.*Correlation matrix of relationship between age, selected anthropometric, clinical and radiographic parameters; and self reported functions.*

		Age	Weight	Height	BMI	Duration of onset	WOMAC Score	PIA	PIP	AKF	Medial JSW	Lateral JSW	ICT	Tibia width
Age	R													
	P													
Weight	R	-.093												
	P	.509												
Height	R	-.092	.079											
	P	.519	.576											
BMI	R	.010	.651**	-.662**										
	P	.943	.000	.000										
Duration of onset	R	.464**	.136	.035	.106									
	P	.001	.333	.805	.449									
WOMAC score	R	.009	.112	.202	-.089	.182								
	P	.948	.423	.151	.526	.191								
Pain intensity on active flexion (PIA)	R	.224	-.208	.165	-.246	.308*	.323*							
	P	.106	.135	.241	.076	.025	.02							
Pain intensity on passive KF(PIP)	R	.244	.142	.173	-.034	.363**	.099	.661**						
	P	.079	.311	.220	.809	.008	.480	.001						
Active KF (AKF)	R	-.183	-.241	-.119	-.089	-.220	-.565**	-.371**	-.316*					
	P	.189	.083	.402	.528	.114	.001	.006	.021					
Medial joint space width(JSW)	R	.116	.225	-.083	.214	-.036	.106	.040	.143	-.086				
	P	.408	.105	.559	.125	.800	.450	.774	.307	.541				
Lateral (JSW)	R	.109	.171	-.268	.342*	.094	-.309*	-.259	-.012	.320*	.536**			
	P	.438	.222	.055	.012	.503	.024	.062	.930	.020	.000			
Inter-condylarthickening	R	.271*	.290*	-.121	.307*	.119	.101	-.126	-.142	-.070	.179	.263		
	P	.050	.035	.394	.025	.395	.470	.368	.312	.620	.201	.057		
Tibia width	R	-.029	.070	.112	-.057	.077	.369**	-.129	-.084	-.111	.197	.019	.268	
	P	.834	.616	.430	.687	.583	.007	.358	.549	.429	.158	.891	.052	

r = correlation co-efficiency, p = level of significance, **Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level

Table 4. *Result of Analysis of variance on the prediction of functional activity.*

	Sum of Squares	Mean Square	F	P
Regression	2632.78	202.52		
Residual	2177.80	57.31		
Total	4810.58		3.53	.001

There were significant negative correlations between lateral joint space and tibial widths on the plain radiograph and WOMAC scores but while that of the former was a positive development; it was otherwise for the latter. We were unable to adduce any other reason for why increase in tibial width will provide improvement in physical function aside that the increment would likely provide more stability and wider weight bearing surface for the femoral condyle over the tibia. The relationship we found lent credence to some previous studies [28] [26] but contradicted the report of Creamer et al [12] who were unable to show a significant correlation between either osteophyte or narrowing and disability.

It was found that age, weight, height, BMI, selected clinical and radiographic parameters were significant predictors of functional activity level of patients with knee osteoarthritis. Result showed that all the independent variable contributed 54.7% to the overall predictability of the dependent variable (functional activity] showing that other factors not considered in this study are accounting for the remaining 45.3%. The most significant predictor of functional capability in this study was Active Knee Flexion Range of Motion (AKFRoM]. It contributed 31.9% to the predictability of functional level followed by width (diameter] of the tibial bone and pain intensity experienced on active knee flexion which contributed 13.6% and 10.4% respectively. We found that AKFRoM, a symptomatic indices, was a better predictor of functional activity than radiographic changes, however, some previous studies reported knee pain to bea better predictor [28] [29] [30]]. Odole [24] and Aghdam et al. [25] also revealed that pain intensity was a significant predictor of physical function in individuals with knee osteoarthritis and vice versa. This study did not consider the muscle strength of the supporting musculature at the knee joint whereas a previous study by Topp et al [31] revealed that knee extensor strength [quadriceps], joint pain during the activity, perceptions of functional ability and body weight combined can predict between 39% and 56% of the variance in the time to perform four functional tasks in adults with OA of the knee. There are multi-factorial risk factors such as ender, obesity [particularly in knee OA], previous joint injury, genetics, co-existing obesity-related disorders [heart disease, hypertension and diabetes] which determines functional capabilities of patient with knee OA [32]. The clinical implication of this study is that since pain intensity and active knee flexion correlates with physical function, focus of treatments should be shifted to effective means of managing the clinical symptoms rather than improving radiological appearance. Also, the predictive equation derived can be used to determine functional activity scores of patients with knee OAusing WOMAC scale.

5. Conclusion

It was concluded that there was significant positive correlation between age and inter-condylar thickening on the plain radiograph. Also, pain intensities and active knee flexion range of motion were correlates to physical functions but there were no correlations between pain intensities and inter-condylar thickening, joint space and tibial widths. Active Knee Flexion Range of Motion, pain intensities and the diameter of the proximal tibia [tibial width] were the most significant predictors of functional capability among patients with knee OA.

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