



# **Efficacy of Quadriceps Muscle Strengthening Exercises and Infrared Radiation Therapy in the Management of Symptomatic Knee Osteoarthritis in a South- Eastern Nigerian Population: A Randomised Clinical Study**

**Ebere Yvonne Ihegihu<sup>1</sup>, Chima Collins Ihegihu<sup>2</sup>, Egwuonwu Afamefuna Victor<sup>3\*</sup>, Okonkwo Uchenna Prosper<sup>1</sup> and Ativie Rita Nkechi<sup>4</sup>**

<sup>1</sup>Department of Physiotherapy, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria.

<sup>2</sup>Department of Surgery, Nnamdi Azikiwe University, Nnewi, Nigeria.

<sup>3</sup>Department of Medical Rehabilitation, Nnamdi Azikiwe University, Nnewi, Nigeria.

<sup>4</sup>Department of Medical Rehabilitation, University of Nigeria, Enugu Campus, Nigeria.

## **Authors' contributions**

*This work was carried out in collaboration between all authors. Author EYI designed the study, wrote the protocol and wrote the first draft of the manuscript. Author CCI managed the literature searches and data collection, author EAV helped in statistical data analysis, meanwhile, authors OUP and ARN helped in drafting of the manuscript. All authors read and approved the final manuscript.*

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## **ABSTRACT**

**Background:** Quadriceps strengthening exercises and infrared radiation therapy had been shown to be effective in improving pain, function and quality of life in subjects with knee osteoarthritis (OA). The aim of this study was to determine the efficacy of these modalities of treatment in the management of symptomatic knee OA in a south- eastern Nigerian population using knee joint pain intensity, quadriceps muscle strength and 30.4metres walk-time as outcome measures.

\*Corresponding author: E-mail: vaegwuonwu@gmail.com;

**Materials and Methods:** Participants diagnosed of symptomatic knee OA were randomly distributed into two groups: Study group (quadriceps strengthening exercises and infrared radiation therapy) and Control group (placebo). Each participant in both groups was given one tablet of vitamin B complex twice daily. The participants in the study group in addition, performed supervised quadriceps strengthening exercises (isometric and isotonic) and were administered Infrared radiation therapy three times per week. Each participant was treated for seven consecutive weeks.

**Results:** The participants comprised 21 (32.81%) males and 43 (67.19%) females. The male to female ratio was 1:2. At the end of the seven weeks, there was a statistically significant reduction in knee joint pain intensity score ( $p < 0.05$ ), 30.4m walking time ( $p < 0.05$ ) and a significant increase in quadriceps muscle strength ( $p < 0.05$ ) in the study group. There was no statistically significant change ( $p > 0.05$ ) in any of the outcome measures in the control group.

**Conclusion:** Combination of quadriceps strengthening exercises and infrared radiation therapy significantly alleviated symptoms in subjects with osteoarthritis of the knee.

**Keywords:** *Quadriceps strengthening exercises; infrared radiation therapy; knee joint pain intensity; quadriceps muscle strength and 30.4metres walk-time.*

## 1. INTRODUCTION

Quadriceps strengthening exercises and infrared radiation therapy are non-pharmacological, physiotherapeutic modalities of treatment frequently recommended in the management of symptomatic knee osteoarthritis (OA) [1,2]. Some studies have demonstrated that quadriceps weakness and voluntary activation deficits are common in individuals with knee OA when compared with age matched healthy controls [3,4]. This weakness may reduce the physical performance of functional and recreational activities and potentially lead to disability. Quadriceps strengthening exercises have been shown to be effective in improving pain, function and quality of life in subjects with knee OA with benefits seen across the range of disease severities [5].

Infrared radiation, a physical agent of heat is often used to alleviate the symptoms of OA. Although not capable of curing arthritis, amelioration of symptoms may lead to improved function. Heat contributes to pain relief by increasing the pain threshold, increasing blood flow and washing out pain producing metabolites [6]. It decreases muscle guarding through its effects on the muscle spindle and Golgi tendon organs [7] and may also improve flexibility by reducing pain or by increasing the extensibility of connective tissue [8]. The use of heat allows collagen to deform more readily, leading to an increased range of motion [9] and improved disability in subjects with knee OA [10].

Vitamin B complex is a class of water-soluble vitamins that play important roles in cell metabolism. Each B vitamin is either a coenzyme

for key metabolic processes or is a precursor needed to make one. They have not been documented in the literature to have any mitigating effect on the symptoms of osteoarthritis of the knee.

OA is the most prevalent joint disease-causing pain, reduced joint range of motion, swelling, crepitation and disability especially in the elderly population [11,12]. As joint degeneration progresses, subjects may notice weakness of the quadriceps, reduced ambulation speed, locking, catching and grinding sensations in the joint. These subjects also demonstrate reduced functional capacity that can be attributed to joint pain, stiffness, and loss of muscular strength of the lower limb muscles [13].

Although OA is diagnosed and defined as a loss of hyaline cartilage within the joint, muscle impairments associated with the disease may be the primary underlying cause of functional impairments [14] and muscle dysfunction may actually precede and expedite the cartilage deterioration [15]. As such, knee OA cannot solely be considered a disease of the cartilage, and clinical management of the disease must also take into account associated muscular impairments.

Though frequently recommended in the management of subjects with symptomatic OA of the knee in this South- Eastern Nigerian Hospital, the efficacy of the combination of quadriceps strengthening exercises and infrared radiation therapy has not been determined in its patient population. Hence, the aim of this study was to determine the efficacy of the combination of these physiotherapeutic modalities of treatment

in the management of symptomatic knee OA in a South- Eastern Nigerian patient population using knee joint pain intensity, quadriceps muscle strength and 30.4metres walk-time as outcome measures.

## **2. MATERIALS AND METHODS**

### **2.1 Study Design**

The study was a randomised clinical trial.

### **2.2 Study Population**

The research population comprised of participants diagnosed of symptomatic knee OA who fulfilled the American College of Rheumatology (ACR) criteria for knee OA [16] and were consecutively recruited by the Orthopaedic and Physiotherapy teams working in a Teaching Hospital in South- Eastern Nigeria.

### **2.3 Study Period**

The study lasted for one year.

### **2.4 Study Instrument**

Tablets of vitamin B complex (Manufactured by Emzor Pharmaceutical Industries Isolo-Lagos, Nigeria) containing 1mg each of vitamin B1and B2 and 15mg of Nicotinamide were administered orally as the placebo drug. A Stadiometer (SECA model) was used to measure the weights and heights of the participants while Infra-red Lamp (Infraphil, Philips model, 150watts) was used to administer infrared radiation therapy. A Stop watch (Nokia model, 8850) was used to measure the 30.4m walk-time whilst the quadriceps muscle strength of the affected limbs was obtained using the Oxford grading scale [17]. Sand bags of different weights were used to increase resistance during quadriceps strengthening exercises and the Box Numerical Pain Scale was used to assess pain intensity [18]. Baseline knee joint pain intensity score, quadriceps muscle strength and 30.4metres walk-time were recorded at beginning of the study for each participant.

### **2.5 Selection Criteria**

#### **2.5.1 Inclusion criteria**

The subjects included in the study, were both male and female aged 46 -65 years old, with at

least six months history of knee osteoarthritis. The subjects must be able to give verbal information that resides within the study location, who could walk without the assistance of a walking aid. Selected subjects were with at least grade 2 tibio-femoral OA on the Kellgren /Lawrence grading system.

#### **2.5.2 Exclusion criteria**

The subjects with knee injuries six months prior to the research, with total or partial endo-prosthesis or osteotomy of the knee joint were excluded from the study. Subjects receiving corticosteroids or chondro-protective substance intra-articularly over the period of four weeks prior to the research. Subjects were also excluded if they had arthroscopy of knee joint and currently participating in another clinical trial/study. Additionally, subjects that objected to sign informed consent.

### **2.6 Ethical Permission**

Ethical approval was obtained from the Hospital Ethical Committee: certificate number NAUTH/CS/166/VOL.7/48 and all participants gave written informed consent for participation.

### **2.7 Study Procedure**

The participants were randomly distributed into two groups using the table of random numbers, while odd numbers were assigned into study group, even numbers were assigned into control group: study group (quadriceps strengthening exercises and infrared radiation therapy) and control group (placebo). The age, sex, history of knee pain, effusion, mechanical dysfunction and joint instability, deformities, presence and duration of knee stiffness, general medical history, tenderness, crepitus, and swelling of the knees were recorded. The presence of bony changes was confirmed by antero-posterior and lateral weight bearing radiographs.

Each participant in both groups had one tablet of vitamin B complex twice daily (morning and evening) taken before a meal without chewing, with a glass of water for seven consecutive weeks. The participants in the study group, in addition, performed supervised Quadriceps strengthening exercises (isometric and isotonic) and received Infrared radiation therapy three times a week for seven consecutive weeks [19]. During the study period, the subjects were not allowed additional therapies such as oral or

topical NSAIDS, analgesics and intra-articular corticosteroid injections. The knee joint pain intensity score, quadriceps muscle strength and 30.4meters walk-time were measured and recorded again at end of seven weeks of treatment for each participant. All the participants were counselled on the importance of health lifestyle post intervention.

## 2.8 Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 20 statistical software was used for the data entry and analysis. Descriptive statistics of mean and standard deviation were calculated for measurements taken. Independent samples T test was used to compare the means of the baseline characteristics and outcome measures of the two groups. Paired-Samples T-test was used to compare pre and post test score changes for each parameter (knee joint pain intensity, quadriceps muscle strength and 30.4 meters walk-time) in each of the two groups. Alpha level for all statistics employed was set at 0.05.

## 3. RESULTS

Sixty four subjects participated in this study. They comprised 21 (32.81%) males and 43 (67.19%) females. The male to female ratio was 1:2. The participants were within the age range of 45yrs and 80yrs, with a mean age of  $53.78 \pm 6.80$  years. The mean weight, height and body Mass Index (BMI) of the participants were  $87.89 \pm 6.94$ kg,  $1.73 \pm 0.04$ m,  $29.29 \pm 2.26$ kg/m<sup>2</sup>

respectively. The mean length of time since onset of condition was  $2.69 \pm 1.19$  years while the mean pain intensity score, quadriceps muscle strength and 30.4m walk time at beginning of study were  $7.59 \pm 1.31$ ,  $3.14 \pm .35$  and  $41.33 \pm 6.43$ seconds respectively. The anthropometric measurements and baseline outcome measures of the participants in the two groups are shown in Table 1. The difference in the mean duration of onset of knee OA, male/female ratio, mean age, baseline knee joint pain intensity score, quadriceps muscle strength and 30.4m walk time were not statistically significant ( $p > 0.05$ ). However, the difference in mean BMI in the two groups was statistically significant ( $p < 0.05$ ).

Table 2 reveals that at the end of seven weeks of study, there was a significant reduction in knee pain intensity score in the study group ( $p < 0.05$ ). The table also reveals that the control group did not demonstrate any significant reduction in knee pain intensity score at end of study ( $p > 0.05$ ).

Table 3 shows that there was a statistically significant increase in the quadriceps muscle strength in the study group ( $p < 0.05$ ) when the mean quadriceps strength at the beginning of the study was compared with the mean quadriceps strength at end of study. There was no statistically significant change in the quadriceps muscle strength in the control group when the mean quadriceps muscle strength at the beginning of the study was compared with the mean muscle strength at end of study ( $p > 0.05$ ).

**Table 1. Anthropometric measurements of the participants in the two groups**

	Study group	Control group	t-value	p-value
Number of participants	38	26		
Number of Male/Female	12/26	9/17		
Mean duration of condition (in years)	$2.82 \pm 1.16$	$2.5 \pm 1.24$	1.040	.302
Mean age(years)	$52.95 \pm 6.20$	$55.00 \pm 7.54$	-1.19	.238
Mean weight (kg)	$89.58 \pm 5.75$	$85.42 \pm 7.85$	2.307	.026*
Mean height (m)	$1.72 \pm 0.04$	$1.75 \pm 0.04$	2.626	-.011*
Mean BMI (kg/m <sup>2</sup> )	$30.21 \pm 1.87$	$27.93 \pm 2.12$	4.532	.000*

*Values are presented as the mean  $\pm$  standard deviation, \*Means  $p < 0.05$  is significant*

**Table 2. Mean knee joint pain intensity of the 2 groups at baseline and end of study**

	PIS at baseline	PIS at end of study	t-value	p-value
Study group	$7.74 \pm 1.47$	$4.84 \pm 2.64$	6.74	0.000
Control group	$7.38 \pm 1.02$	$7.00 \pm 1.47$	1.41	0.170

*PIS =pain intensity score, Values are presented as the Mean  $\pm$  Standard Deviation  
\*means  $p < 0.05$  is significant.*

**Table 3. Mean quadriceps strength of participants and baseline and end of study**

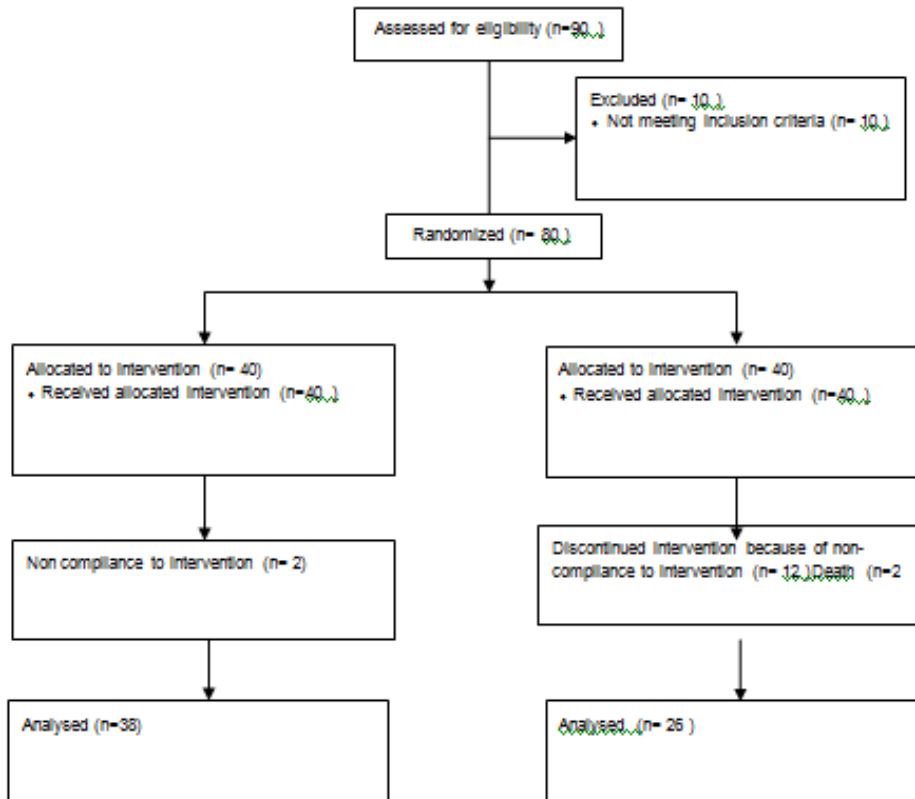
	<b>QMS baseline</b>	<b>QMS end of study</b>	<b>t-value</b>	<b>p-value</b>
Study group	3.13±0.34	3.95±0.23	12.80	0.000*
Control group	3.15±0.37	3.19±0.40	1.000	0.33

*QMS = quadriceps strength score  
 Values are presented as the Mean ± Standard Deviation  
 \*means p<0.05 is significant.*

**Table 4. Mean 30.4m walk time values of participants at baseline and end of study**

	<b>MWT baseline</b>	<b>MWT end of study</b>	<b>t-value</b>	<b>p-value</b>
Study group	41.92±6.22	37.00±5.64	5.47	0.000*
Control group	40.45±6.76	40.47±7.30	0.014	0.989

*MWT =mean work time  
 Values are presented as the Mean ± Standard Deviation  
 \*means p<0.05 is significant.*



**RCT Flow Diagram**

Table 4 reveals that there was a reduction in walk-time of the participants in the study group from 41.92±6.22 seconds to 37.00±5.64 seconds which was statistically significant (p < 0.05) while there was a negligible increase in the control group from 40.45±6.76 to 40.47±7.30 which was not statistically significant (p >0.05).

**4. DISCUSSION**

The study revealed that quadriceps strengthening exercises and infrared radiation therapy significantly reduced knee joint pain intensity. This is contrary to the finding of a previous study conducted by Lankhorst et al. [20]

which demonstrated that more than half of participants with patellofemoral pain reported an unfavourable recovery with little or no radiographic changes indicating the presence of knee OA. This may be explained by the fact that subject in the present study may have lower duration of Knee OA compare to those of Lankhorst et al. [20]. Since it is an established fact that prognosis of a disease condition is a function of its chronicity or duration of the symptoms. The lesser the duration of the clinical symptom the better the recovery rate following intervention. There is also another possibility, that in the present study, quadriceps muscle weakness was more common in subjects recruited compared to the ones in the previous study by Lankhorst et al. [20] that may not have benefitted from a targeted intervention program such as quadriceps strengthening exercise and infrared radiation therapy, which begets a better recovery outcome with knee OA. Furthermore, the present study showed that strengthening the quadriceps muscles was beneficial in the management of pain in these subjects, since patients with knee OA are known to have patellofemoral knee pain and associated weakness of quadriceps due to inactivity of the affected muscles at the long-term. The ability of infrared radiation therapy to reduce pain has also been reported by Nadler et al. [21] and is consistent with the results of this present study. The heat from infrared radiation therapy activates thermo receptors which are temperature sensitive nerve endings in the skin which initiate nerve signals that block pain signal processing within the spinal cord, thereby reducing pain in symptomatic knee OA subjects. Quadriceps strengthening exercises and infrared radiation therapy also have other beneficial effects such as increased tissue metabolism, increased blood flow, muscle relaxation and improved stability in the knee joint and these probably may have contributed significant reduction in knee joint pain intensity in the participants in the study group.

Assessment of quadriceps muscle function which is largely dependent on quadriceps muscle strength remains the gold standard of assessment of knee joint function in research of subjects with knee OA [22]. The stability and the functional capacity of the knee joint are largely dependent on the quadriceps muscle strength [23]. Thus, putting the quadriceps muscles in the affected knees of the participants in the study group through a strengthening regimen increased the strength in the affected quadriceps muscles when compared with the participants in

the control group who did not perform strengthening exercises. This is consistent with the findings of Bennell et al. [24] who reported that judicious quadriceps strengthening exercises to an osteoarthritic knee improved the quadriceps muscle strength which translated into alleviation of symptoms in OA subjects. In the study by Lankhorst et al. [20] the subjects were followed up for a long duration of 5-8 years, which is contrary to recommendations of individualised or tailored exercise intervention. It is also possible that accommodation may have set in and that the participants may no longer be responding to the targeted exercise regime. The most important clinical significance of individualised or tailored exercise intervention is recovery and sustainability, which was done by counselling all participants on healthy lifestyle for sustainability of the gains. However, follow-up on sustainability was not done since it is beyond the scope of the present study.

At the end of seven weeks of quadriceps muscle strengthening exercises and infrared radiation therapy, there was reduction in the 30.4m walk-time in the study group. This was probably due to the combined effect of reduction in pain and increased quadriceps muscle strength. Quadriceps muscle strength has been shown to be related to functional tasks, such as standing up from a chair, going up and down stairs, and level surface walking as reported by Liikavainio et al [25] and Maly et al [26]. The results of the study is in line with the findings of Stiskal [27] and Ihegihu et al. [28] that physical exercises as well as reduction in pain improved functional capacities of subjects with knee OA, since subjects are expected to engage in more physical activities due to reduced antalgic effect.

## **5. CONCLUSION**

The findings from the present study demonstrate that combination of individualised or tailored exercise intervention such as quadriceps strengthening exercises and infrared radiation therapy significantly alleviated symptoms in subjects with osteoarthritis of the knee. This may be of immense benefit to subjects with symptomatic osteoarthritis of the knee in which NSAIDS and intra articular steroids are contraindicated or in subjects who may be at risk of the side effects of NSAIDS therapy. For this group of subjects, quadriceps strengthening exercises and infrared radiation therapy can be recommended as an alternative treatment option in the management of knee osteoarthritis.

## 6. RECOMMENDATION

It is recommended that individualised or tailored exercise intervention will be sustainable, and this could be done by incorporating a longitudinal follow-up of patients that benefited from the interventions mostly on lifestyle and habits which may hamper the continued sustenance of the recovery goals. There is a need to recommend the use of quadriceps strengthening exercise and infrared therapy as the mainstay of intervention for patients that may not be disposed to use of NSAIDs.

## CONSENT AND ETHICAL APPROVAL

Ethical approval was obtained from the Hospital Ethical Committee: certificate number NAUTH/CS/166/VOL.7/48 and all participants gave written informed consent for participation.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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