

**DETERMINE THE EFFICACY OF QUADRICEPS MUSCLE STRENGTHENING EXERCISES AND  
INFRARED RADIATION THERAPY IN THE MANAGEMENT OF SYMPTOMATIC KNEE  
OSTEOARTHRITIS IN A SOUTH- EASTERN NIGERIAN POPULATION. A RANDOMIZED  
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>, Ativie Rita<sup>4</sup>

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

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

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

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

**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. 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 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.

**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) <sup>[[1,2]</sup>. 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 <sup>[3,4]</sup>. This weakness may reduce 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 <sup>[5]</sup>.

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 <sup>[6]</sup>. It decreases muscle guarding through its effects on the muscle spindle and Golgi tendon organs <sup>[7]</sup> and may also improve flexibility by reducing pain or by increasing the extensibility of connective tissue <sup>[8]</sup>. The use of heat allows collagen to deform more readily, leading to increased range of motion <sup>[9]</sup> and improved disability in subjects with knee OA <sup>[10]</sup>.

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 <sup>[11,12]</sup>. 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 <sup>[13]</sup>.

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 <sup>[14]</sup> and muscle dysfunction may actually precede and expedite the cartilage deterioration <sup>[15]</sup>. 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.

## **Materials and Methods:**

### **Study design:**

The study was a randomized clinical trial.

### **Study population:**

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

90 **Study period:**

91 The study lasted for one year.

92 **Study instrument:**

93 Tablets of vitamin B complex (Manufactured by Emzor Pharmaceutical Industries Isolo-  
94 Lagos, Nigeria) containing 1mg each of vitamin B1and B2 and 15mg of Nicotinamide were  
95 administered orally as the placebo drug. A Stadiometer (SECA model) was used to measure  
96 the weights and heights of the participants while Infra-red Lamp (Infraphil, Philips model,  
97 150watts) was used to administer infrared radiation therapy. A Stop watch (Nokia model,  
98 8850) was used to measure the 30.4m walk-time whilst the quadriceps muscle strength of  
99 the affected limbs was obtained using the Oxford grading scale <sup>[17]</sup>. Sand bags of different  
100 weights were used to increase resistance during quadriceps strengthening exercises and the  
101 Box Numerical Pain Scale was used to assess pain intensity. <sup>[18]</sup> Baseline knee joint pain  
102 intensity score, quadriceps muscle strength and 30.4metres walk-time were recorded at  
103 beginning of the study for each participant.

104

105 **Selection criteria:**

106 **Inclusion criteria:**

107 The following categories of individuals were included in the study:

108 Subjects of either sex aged 46 -65 years old Subjects with at least six months history of knee  
109 osteoarthritis.

110 Subjects who were able to give verbal information

111 Subjects who were living in study location

112 Subjects who could walk without the assistance of a walking aid.

113 Subjects with at least grade 2 tibio-femoral OA on the Kellgren /Lawrence grading system

114 **Exclusion criteria:**

115 Excluded from this study were subjects:

116 With knee injuries six months prior to the research

117 With total or partial endo-prosthesis or osteotomy of the knee joint

118 Who had Arthroscopy of knee joint  
119 Who received corticosteroids or chondro-protective substance intra-articularly over the  
120 period of four weeks prior to the research  
121 Who were currently participating in another clinical trial/study  
122 Unwilling to sign informed consent  
123 Unlikely to reside in the clinic area during period of study

124 **Ethical permission:**

125 Ethical approval was obtained from the Hospital Ethical Committee and all participants gave  
126 written informed consent for participation.

127 **Study procedure:**

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

134 Each participant in both groups had one tablet of vitamin B complex twice daily (morning  
135 and evening) taken before a meal without chewing, with a glass of water for seven  
136 consecutive weeks. The participants in the study group in addition performed supervised  
137 Quadriceps strengthening exercises (isometric and isotonic) and received Infrared radiation  
138 therapy three times a week for seven consecutive weeks<sup>[19]</sup>. During the study period, the  
139 subjects were not allowed additional therapies such as oral or topical NSAIDS, analgesics  
140 and intra-articular corticosteroid injections. The knee joint pain intensity score, quadriceps  
141 muscle strength and 30.4meters walk-time were measured and recorded again at end of  
142 seven weeks of treatment for each participant.

143 **Statistical Analysis:**

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

151 **Results:**

152 Sixty four subjects participated in this study. They comprised 21 (32.81%) males and 43  
153 (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  $87.89 \pm 6.94\text{kg}$ ,  $1.73 \pm 0.04\text{m}$ ,  $29.29 \pm 2.26\text{kg/m}^2$  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  $41.33 \pm 6.43\text{seconds}$  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 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 ( $\text{kg/m}^2$ )	$30.21 \pm 1.87$	$27.93 \pm 2.12$	4.532	.000*

Values are presented as the mean  $\pm$  standard deviation

\*Means  $p < 0.05$  is significant

Table 2 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 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±1.47	4.84±2.64	6.74	0.000
Control group	7.38±1.02	7.00±1.47	1.41	0.170

PIS =pain intensity score

Values are presented as the Mean ± Standard Deviation

\*means p<0.05 is significant.

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 3: mean quadriceps strength of participants and baseline and end of study.**

	QMS baseline	QMS end of study	t-value	p-value
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 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 ( $p > 0.05$ ).

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

	MWT baseline	MWT end	t-value	p-value
--	--------------	---------	---------	---------

		of study		
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.

## Discussion:

The study revealed that quadriceps strengthening exercises and infrared radiation therapy significantly reduced knee joint pain intensity. This is consistent with the finding in a previous study conducted by Lankhorst et al<sup>[20]</sup> which demonstrated that quadriceps muscle weakness was common in subjects with knee OA and correlated positively with pain. Furthermore, their study showed that strengthening the quadriceps muscles was beneficial in the management of pain in these subjects. The ability of infrared radiation therapy to reduce pain has also been reported by Nadler et al<sup>[21]</sup> 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<sup>[22]</sup>. The stability and the functional capacity of the knee joint are largely dependent on the quadriceps muscle strength<sup>[23]</sup>. 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.,<sup>[24]</sup> 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.

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<sup>[25]</sup> and Maly et al<sup>[26]</sup>. The results of this study also support the finding by Stiskal<sup>[27]</sup> that exercises improved functional capacities of subjects with knee OA.

233

234 **Conclusion:**

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

243

244 **References:**

245 1 Roddy E., Zhang W., Doherty M., Arden N.K., Barlow J., Birrell F., et al. (2005) Evidence-  
246 based recommendations for the role of exercise in the management of osteoarthritis of the  
247 hip or knee—the MOVE consensus. *Rheumatology* 44: 67–73 [PubMed].

248 2 Hochberg MC, Altman RD, April KT, Benkhalti M, Guyatt G, McGowan J, Towheed T, Welch  
249 V, Wells G, Tugwell P; American College of Rheumatology. American College of  
250 Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic  
251 therapies in osteoarthritis of the hand, hip, and knee. *Arthritis Care Res (Hoboken)*. 2012  
252 Apr;64(4):465-74.

253 3Cheing GLY, Hui-Chan CWY. The motor dysfunction of subjects with knee osteoarthritis in a  
254 Chinese population. *Arthritis Care Res*. 2001;45(1):62-68 [PubMed].

255 4 Diracoglu D, Baskent A, Yagci I, Ozcakar L, Aydin R. Isokinetic strength measurements in  
256 early knee osteoarthritis. *Acta Reumatol Port*. 2009;34(1):72-77 [PubMed].

257 5 Imoto AM, Peccin MS, Trevisani VF. Quadriceps strengthening exercises are effective in  
258 improving pain, function and quality of life in subjects with osteoarthritis of the knee. *Acta*  
259 *Ortop Bras*. 2012;20(3):174-9. doi: 10.1590/S1413-78522012000300008

260

261 6 Berliner MN, Maurer AI. Effect of different methods of thermotherapy on skin  
262 microcirculation. *Am J Phys Med Rehabil* 2004; 83:292–7.

263

264 7 Lehmann JF, DeLateur BJ. Therapeutic heat. In: Lehmann JF, ed. *Therapeutic heat and cold*.  
265 3rd ed. Baltimore: Williams and Wilkins; 1982. p. 404–562

266 8 Wright V, Johns RJ. Quantitative and qualitative analysis of joint stiffness in normal  
267 subjects and in subjects with connective tissue diseases. *Ann Rheum Dis* 1961; 20:36–46

268 9 Lentell G, Heatherington T, Eagan J, Morgan M. The use of thermal agents to influence the  
269 effectiveness of a low-load prolonged stretch. *J Orthop Sports Phys Ther* 1992; 16:200– 7



- 270 10 Stelian J, Gil I, Habot B, Rosenthal M, Abramovici I, Kutok N, Khahil A. Improvement of  
271 pain and disability in elderly subjects with degenerative osteoarthritis of the knee treated  
272 with narrow-band light therapy. *J Am Geriatr Soc.* 1992 Jan;40(1):23-6.  
273
- 274 11 Nguyen US, Zhang Y, Zhu Y, Niu J, Zhang B, Felson DT. Increasing prevalence of knee pain  
275 and symptomatic knee osteoarthritis: survey and cohort data. *Ann Intern Med.* 2011; 155:  
276 725-732.  
277
- 278 12 Losina E, Weinstein AM, Reichmann WM, Burbine SA, Solomon DH, Daigle ME, et al.  
279 Lifetime risk and age at diagnosis of symptomatic knee osteoarthritis in the US. *Arthritis*  
280 *Care Res (Hoboken).* 2013; 65: 703-711.  
281
- 282 13 Liikavainio T, Lyytinen T, Tyrväinen E, Sipilä S, Arokoski JP. Physical function and  
283 properties of quadriceps femoris muscle in men with knee osteoarthritis. *Arch Phys Med*  
284 *Rehabil.* 2008;89(11):2185-2194 [PubMed].  
285
- 286 14 O'Reilly SC, Jones A, Muir KR, Doherty M. Quadriceps weakness in knee osteoarthritis:  
287 The effect on pain and disability. *Ann Rheum Dis.* 1998;57(10):588-594 [PMC free article]  
288 [PubMed] .  
289
- 290 15 Bennell KL, Hunt MA, Wrigley TV, Lim BW, Hinman RS. Role of muscle in the genesis and  
291 management of knee osteoarthritis. *Rheum Dis Clin North Am.* 2008;34(3):731-754  
292 [PubMed].  
293
- 294 16 Altman R, Asch E, Bloch D, Bole G, Borenstein D, Brandt K, et al. (1986) Development of  
295 criteria for the classification and reporting of osteoarthritis: classification of osteoarthritis of  
296 the knee. *Arthritis Rheum* 29:1039–1049.
- 297 17 Porter, S. Musculoskeletal Assessment, in Porter's (ed) Tidy's Physiotherapy, 13<sup>th</sup> edition,  
298 Oxford, Elsevier publishers; 2004. Pages 60-69.
- 299 18 McDowell, I. & Newell, C. Pain measurements. in *Measuring Health: A Guide to Rating*  
300 *Scales and Questionnaires* 2<sup>nd</sup> edition, New York, Oxford University Press, 1996. Pages 335 –  
301 337
- 302 19 Schreiber JW (1981). Infrared and Luminous Radiation. In *manual of Electrotherapy* (4th  
303 edition), Henry Kimpton Publishers; London, 23-37.  
304
- 305 20 Lankhorst GJ, Van de Stadt RJ, Van der Korst JK. The relationships of functional capacity,  
306 pain, and isometric and isokinetic torque in osteoarthrosis of the knee. *Scand J Rehabil Med.*  
307 1985;17(4):167-72.
- 308 21 Nadler SF, Weingand K, Kruse RJ. The physiologic basis and clinical applications of  
309 cryotherapy and thermotherapy for the pain practitioner. *Pain Physician.* 2004 Jul; 7(3):395-  
310 9.

311 22 Alnahdi AH, Zeni JA, Snyder-Mackler L. Muscle impairments in subjects with knee  
312 osteoarthritis. Sports Health. 2012 Jul;4(4):284-92.

313 23 Slemenda C, Brandt KD, Heilman DK, Mazzuca S, Braunstein EM, Katz BP, Wolinsky FD.  
314 Quadriceps weakness and osteoarthritis of the knee. Ann Intern Med. 1997 Jul 15;127(2):97-  
315 104.

316 24 Bennell KL, Hinman RS, Metcalf BR, Buchbinder R, McConnell J, McColl G, Green S,  
317 Crossley KM. Efficacy of physiotherapy management of knee joint osteoarthritis: a  
318 randomised, double blind, placebo controlled trial. Ann Rheum Dis. 2005 Jun;64(6):906-12.

319 25 Liikavainio T, Lyytinen T, Tyrväinen E, Sipilä S, Arokoski JP. Physical function and  
320 properties of quadriceps femoris muscle in men with knee osteoarthritis. Arch Phys Med  
321 Rehabil. 2008;89(11):2185-2194 [PubMed]

322 26 Maly MR, Costigan PA, Olney SJ. Determinants of self-report outcome measures in  
323 people with knee osteoarthritis. Arch Phys Med Rehabil. 2006;87(1):96-104 [PubMed].

324 27 Stiskal, D. The role of the Arthritis Foundation in the treatment of osteoarthritis (patient  
325 education, self-management, and exercise programs). Phys Med Rehabil State Art Rev.  
326 2001; 15:15–32.

327

328