

1 **EFFICACY OF QUADRICEPS MUSCLE STRENGTHENING EXERCISES AND INFRARED**
2 **RADIATION THERAPY IN THE MANAGEMENT OF SYMPTOMATIC KNEE OSTEOARTHRITIS IN**
3 **A SOUTH- EASTERN NIGERIAN POPULATION. A RANDOMIZED CLINICAL STUDY**

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15
16 **Abstract:**

17 **Background:** Quadriceps strengthening exercises and infrared radiation therapy had been
18 shown to be effective in improving pain, function and quality of life in subjects with knee
19 osteoarthritis (OA). The aim of this study was to determine the efficacy of these modalities of
20 treatment in the management of symptomatic knee OA in a south- eastern Nigerian
21 population using knee joint pain intensity, quadriceps muscle strength and 30.4metres walk-
22 time as outcome measures. Materials and Methods: Participants diagnosed of symptomatic
23 knee OA were randomly distributed into two groups: Study group (quadriceps strengthening
24 exercises and infrared radiation therapy) and Control group (placebo). Each participant in
25 both groups was given one tablet of vitamin B complex twice daily. The participants in the
26 study group in addition, performed supervised quadriceps strengthening exercises (isometric
27 and isotonic) and were administered Infrared radiation therapy three times per week. Each
28 participant was treated for seven consecutive weeks. Results: The participants comprised 21
29 (32.81%) males and 43 (67.19%) females. The male to female ratio was 1:2. At the end of the
30 seven weeks, there was a statistically significant reduction in knee joint pain intensity score
31 ($p < 0.05$), 30.4m walking time ($p < 0.05$) and significant increase in quadriceps muscle
32 strength ($p < 0.05$) in the study group. There was no statistically significant change ($p > 0.05$)
33 in any of the outcome measures in the control group. Conclusion: Combination of quadriceps
34 strengthening exercises and infrared radiation therapy significantly alleviated symptoms in
35 subjects with osteoarthritis of the knee.

36 **Keywords:** Quadriceps strengthening exercises, infrared radiation therapy, knee joint pain
37 intensity, quadriceps muscle strength and 30.4metres walk-time.
38

39 **Introduction:**

40 Quadriceps strengthening exercises and infrared radiation therapy are non-pharmacological,
41 physiotherapeutic modalities of treatment frequently recommended in the management of
42 symptomatic knee osteoarthritis (OA) ^[1,2]. Some studies have demonstrated that quadriceps
43 weakness and voluntary activation deficits are common in individuals with knee OA when
44 compared with age matched healthy controls ^[3,4]. This weakness may reduce physical

45 performance of functional and recreational activities and potentially lead to disability.
46 Quadriceps strengthening exercises have been shown to be effective in improving pain,
47 function and quality of life in subjects with knee OA with benefits seen across the range of
48 disease severities^[5].

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

57 Vitamin B complex is a class of water-soluble vitamins that play important roles in cell
58 metabolism. Each B vitamin is either a coenzyme for key metabolic processes or is a
59 precursor needed to make one. They have not been documented in the literature to have any
60 mitigating effect on the symptoms of osteoarthritis of the knee.

61

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

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

74 Though frequently recommended in the management of subjects with symptomatic OA of the
75 knee in this South- Eastern Nigerian Hospital, the efficacy of the combination of quadriceps
76 strengthening exercises and infrared radiation therapy has not been determined in its patient
77 population. Hence, the aim of this study was to determine the efficacy of the combination of
78 these physiotherapeutic modalities of treatment in the management of symptomatic knee OA
79 in a South- Eastern Nigerian patient population using knee joint pain intensity, quadriceps
80 muscle strength and 30.4metres walk-time as outcome measures.

81 **Materials and Methods:**

82 **Study design:**

83 The study was a randomized clinical trial.

84 **Study population:**

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

89 **Study period:**

90 The study lasted for one year.

91 **Study instrument:**

92 Tablets of vitamin B complex (Manufactured by Emzor Pharmaceutical Industries Isolo-
93 Lagos, Nigeria) containing 1mg each of vitamin B1 and B2 and 15mg of Nicotinamide were
94 administered orally as the placebo drug. A Stadiometer (SECA model) was used to measure
95 the weights and heights of the participants while Infra-red Lamp (Infraphil, Philips model,
96 150watts) was used to administer infrared radiation therapy. A Stop watch (Nokia model,
97 8850) was used to measure the 30.4m walk-time whilst the quadriceps muscle strength of the
98 affected limbs was obtained using the Oxford grading scale ^[17]. Sand bags of different
99 weights were used to increase resistance during quadriceps strengthening exercises and the
100 Box Numerical Pain Scale was used to assess pain intensity. ^[18] Baseline knee joint pain
101 intensity score, quadriceps muscle strength and 30.4metres walk-time were recorded at
102 beginning of the study for each participant.

103

104 **Selection criteria:**

105 **Inclusion criteria:**

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

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

109 Subjects who were able to give verbal information

110 Subjects who were living in study location

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

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

113 **Exclusion criteria:**

114 Excluded from this study were subjects:

115 With knee injuries six months prior to the research

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

117 Who had Arthroscopy of knee joint

118 Who received corticosteroids or chondro-protective substance intra-articularly over the
119 period of four weeks prior to the research

120 Who were currently participating in another clinical trial/study

121 Unwilling to sign informed consent

122 Unlikely to reside in the clinic area during period of study

123 **Ethical permission:**

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

126 **Study procedure:**

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

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

142 **Statistical Analysis:**

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

150 **Results:**

151 Sixty four subjects participated in this study. They comprised 21 (32.81%) males and 43
152 (67.19%) females. The male to female ratio was 1:2. The participants were within the age
153 range of 45yrs and 80yrs, with a mean age of 53.78 ± 6.80 years. The mean weight, height
154 and body Mass Index (BMI) of the participants were $87.89 \pm 6.94\text{kg}$, $1.73 \pm 0.04\text{m}$, $29.29 \pm$
155 2.26kg/m^2 respectively. The mean length of time since onset of condition was 2.69 ± 1.19
156 years while the mean pain intensity score, quadriceps muscle strength and 30.4m walk time at
157 beginning of study were 7.59 ± 1.31 , $3.14 \pm .35$ and $41.33 \pm 6.43\text{seconds}$ respectively. The
158 anthropometric measurements and baseline outcome measures of the participants in the two
159 groups are shown in Table 1. The difference in the mean duration of onset of knee OA,
160 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±1.16	2.5±1.24	1.040	.302
Mean age(years)	52.95 ± 6.20	55.00 ± 7.54	-1.19	. 238
Mean weight (kg)	89.58 ± 5.75	85.42 ± 7.85	2.307	.026*
Mean height (m)	1.72±0.04	1.75±0.04	2.626	-.011*
Mean BMI (kg/m ²)	30.21± 1.87	27.93 ± 2.12	4.532	.000*

Values are presented as the mean ± 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 \pm 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 of study	t-value	p-value
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 \pm 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 ^[20] 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 ^[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.

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 this study also support the finding by Stiskal ^[27] that exercises improved functional capacities of subjects with knee OA.

Conclusion:

The findings from this study demonstrate that the combination of 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.

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