

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

5
6 Ebere Yvonne Ihegihu¹, Chima Collins Ihegihu², Egwuonwu Afamefuna Victor^{3,*},
7 Okonkwo Uchenna Prosper¹, Ativie Rita⁴

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11 ¹Department of Physiotherapy, Nnamdi Azikiwe University Teaching Hospital, Nnewi

12 ²Department of Surgery, Nnamdi Azikiwe University, Nnewi

13 ³Department of Medical Rehabilitation, Nnamdi Azikiwe University, Nnewi

14 ⁴Department of Medical Rehabilitation, University of Nigeria, Enugu Campus

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16
17 **Abstract:**

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

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

39
40 **Introduction:**

41 Quadriceps strengthening exercises and infrared radiation therapy are non-
42 pharmacological, physiotherapeutic modalities of treatment frequently recommended in

43 the management of symptomatic knee osteoarthritis (OA) ^{[[1,2]}. Some studies have
44 demonstrated that quadriceps weakness and voluntary activation deficits are common in
45 individuals with knee OA when compared with age matched healthy controls ^[3,4]. This
46 weakness may reduce physical performance of functional and recreational activities and
47 potentially lead to disability. Quadriceps strengthening exercises have been shown to be
48 effective in improving pain, function and quality of life in subjects with knee OA with
49 benefits seen across the range of disease severities ^[5].

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

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

62

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

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

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

82 **Materials and Methods:**

83 **Study design:**

84 The study was a randomized clinical trial.

85 **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 ^[16] 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 ^[17]. 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. ^[18] 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^[19]. 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

154 range of 45yrs and 80yrs, with a mean age of 53.78 ± 6.80 years. The mean weight, height
 155 and body Mass Index (BMI) of the participants were $87.89 \pm 6.94\text{kg}$, $1.73 \pm 0.04\text{m}$, $29.29 \pm$
 156 2.26kg/m^2 respectively. The mean length of time since onset of condition was 2.69 ± 1.19
 157 years while the mean pain intensity score, quadriceps muscle strength and 30.4m walk time
 158 at beginning of study were 7.59 ± 1.31 , $3.14 \pm .35$ and $41.33 \pm 6.43\text{seconds}$ respectively. The
 159 anthropometric measurements and baseline outcome measures of the participants in the
 160 two groups are shown in Table 1. The difference in the mean duration of onset of knee OA,
 161 male/female ratio, mean age, baseline knee joint pain intensity score, quadriceps muscle
 162 strength and 30.4m walk time were not statistically significant ($p>0.05$). However, the
 163 difference in mean BMI in the two groups was statistically significant ($p<0.05$).

164 **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*

165 Values are presented as the mean \pm standard deviation

166 *Means $p < 0.05$ is significant

167

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

172 **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

173 PIS =pain intensity score

174 Values are presented as the Mean ± Standard Deviation

175 *means p<0.05 is significant.

176

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

183 **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

184 QMS = quadriceps strength score

185 Values are presented as the Mean ± Standard Deviation

186 *means p<0.05 is significant.

187 Table 4 reveals that there was a reduction in walk-time of the participants in the study
 188 group from 41.92±6.22 seconds to 37.00±5.64 seconds which was statistically significant (p
 189 < 0.05) while there was a negligible increase in the control group from 40.45±6.76 to
 190 40.47±7.30 which was not statistically significant ($p > 0.05$).

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

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	MWT baseline	MWT end	t-value	p-value
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		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

196 MWT =mean work time

197 Values are presented as the Mean ± Standard Deviation

198 *means p<0.05 is significant.

199

200 **Discussion:**

201 The study revealed that quadriceps strengthening exercises and infrared radiation therapy
 202 significantly reduced knee joint pain intensity. This is consistent with the finding in a
 203 previous study conducted by Lankhorst et al ^[20] which demonstrated that quadriceps muscle
 204 weakness was common in subjects with knee OA and correlated positively with pain.
 205 Furthermore, their study showed that strengthening the quadriceps muscles was beneficial
 206 in the management of pain in these subjects. The ability of infrared radiation therapy to
 207 reduce pain has also been reported by Nadler et al ^[21] and is consistent with the results of
 208 this present study. The heat from infrared radiation therapy activates thermo receptors
 209 which are temperature sensitive nerve endings in the skin which initiate nerve signals that
 210 block pain signal processing within the spinal cord, thereby reducing pain in symptomatic
 211 knee OA subjects. Quadriceps strengthening exercises and infrared radiation therapy also
 212 have other beneficial effects such as increased tissue metabolism, increased blood flow,
 213 muscle relaxation and improved stability in the knee joint and these probably may have
 214 contributed significant reduction in knee joint pain intensity in the participants in the study
 215 group.

216 Assessment of quadriceps muscle function which is largely dependent on quadriceps muscle
 217 strength remains the gold standard of assessment of knee joint function in research of
 218 subjects with knee OA ^[22]. The stability and the functional capacity of the knee joint are
 219 largely dependent on the quadriceps muscle strength ^[23]. Thus, putting the quadriceps
 220 muscles in the affected knees of the participants in the study group through a strengthening
 221 regimen increased the strength in the affected quadriceps muscles when compared with the
 222 participants in the control group who did not perform strengthening exercises. This is
 223 consistent with the findings of Bennell et al., ^[24] who reported that judicious quadriceps
 224 strengthening exercises to an osteoarthritic knee improved the quadriceps muscle strength
 225 which translated into alleviation of symptoms in OA subjects.

226 At the end of seven weeks of quadriceps muscle strengthening exercises and infrared
 227 radiation therapy, there was reduction in the 30.4m walk-time in the study group. This was
 228 probably due to the combined effect of reduction in pain and increased quadriceps muscle
 229 strength. Quadriceps muscle strength has been shown to be related to functional tasks, such
 230 as standing up from a chair, going up and down stairs, and level surface walking as reported
 231 by Liikavainio et al ^[25] and Maly et al ^[26]. The results of this study also support the finding by
 232 Stiskal ^[27] 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.

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