Original Article

# EFFECT OF RUSSIAN CURRENT ON QUADRICEPS MUSCLE STRENGTH IN SUBJECTS WITH PRIMARY OSTEOARTHRITIS OF KNEE: A RANDOMIZED CONTROL TRIAL

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## ABSTRACT

**Relevance**: OA knee is one of the most common conditions leading functional disabilities seen worldwide. There are different methods to manage osteoarthritis, conservatively, and/or surgically. Physiotherapy treatment, as a part of conservative management, involves reduction of pain, improvement of muscle strength and improvement of functional ability by various approaches like exercise therapy, electrotherapy and manual therapy techniques. Quadriceps muscle weakness is one of the main features seen in OA knee. Russian current stimulation has been successfully used to increase muscle strength in healthy athletes but its effect on quadriceps muscle strength in OA knee has not been studied. Hence the present study was undertaken to know the effect of Russian current stimulation on quadriceps muscle strength in patients with primary OA knee.

**Participants**: 30 subjects (mean age 50.25±6.35 years) diagnosed with primary OA knee were recruited from Out-Patient Department of Physiotherapy of KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum.

**Method**: Subjects were randomly allocated into 2 groups namely Group A (n=15) who received Short Wave Diathermy (SWD) and exercises and Group B (n=15) who received SWD, exercises and Russian current stimulation for 10 days. The outcome measures were Visual Analog Scale (VAS) for pain, muscle strength by using Hand-held dynamometer, and WOMAC osteoarthritis index for functional disability.

**Analysis:** Within group and between group analysis after intervention was done to assess changes using paired t-test and unpaired t - tests.

**Result**: The VAS scores for group A reduced from 6.8±1.49 (baseline) to1.4±0.91 (post-intervention) and for group B from 6.3±1.29 (baseline) to 1±1.14 (post-intervention). The WOMAC score of group A decreased from 59.7±11.56 (baseline) to 24.1±6.01 (post-intervention) and of group B decreased from 50.4±22.30 (baseline) to 12.5±7.54 (post-intervention). The muscle strength of group A increased from 7.9±0.94 (baseline) to 8.6±0.95 (post-intervention) and of group B it increased from 8.3±0.67 (baseline) to 10.6±0.89 (post-intervention).Group B showed better improvement in muscle strength and function than group A. The intra group and between group comparison was statistically significant with p= <0.001 for both the groups.

**Conclusion**: Russian current stimulation is effective in increasing quadriceps muscle strength and secondarily improving the functional ability in subjects with primary OA knee.

**KEYWORDS:** Primary Osteoarthritis, Russian electrical stimulation, Quadriceps muscle strength, Hand-held dynamometer, Knee.

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**Access this Article online**

Quick Response code

International Journal of Physiotherapy and Research
ISSN 2321- 1822
www.ijmhr.org/ijpr.html

Received: 13-05-2014 Accepted: 22-05-2014
Peer Review: 13-05-2014 Published: 11-06-2014

## INTRODUCTION

Osteoarthritis (OA), a degenerative joint disease,[1] is one of the most common causes leading to functional disabilities seen worldwide. Etiologically,

OA is classified into Primary OA and Secondary OA. Primary OA occurs as a result of natural wear and tear of knee joint structures due to aging, overuse or obesity, whereas Secondary OA occurs due to known primary causes like trauma, infection, rheumatoid arthritis, etc.[2]

OA is gaining recognition in both developed and developing countries as major cause of pain and diability.[3]The prevalence of OA increases with age. Men are affected more commonly than women before 50 years whereas after 50 years of age the prevalence in women is 2-3 times greater than men.[4] In India, the prevalence of OA knee is relatively more as compared to western population which could be related to excessive squatting in a day- to –day activities, especially among females.[5]

Pain is the earliest symptom of OA knee, which is initially intermittent, dull aching, experienced after a period of rest which later becomes continuous and cramp like occurring after activity. Patients also complain of crepitus, stiffness, swelling of the joint, feeling of instability and 'locking' of the joint. On examination, tenderness along the joint line, occasional effusion, terminal limitation of movement, weakness and atrophy of the quadriceps femoris muscle may be noted. The radiographic features of OA knee include narrowing of joint space, osteophyte formation, loose bodies and subchondral sclerosis.[1]

Various measures are available for the treatment of OA knee such as conservative management including Pharmacotherapy and Physiotherapy, or surgical management in the form of resurfacing of joint or replacement surgeries.[1] Physiotherapy treatment aims at reduction of pain and stiffness, improve joint mobility, increase muscle strength and to help the individuals affected with OA achieve greater functional independence in performing activities of daily living using various approaches such as exercise therapy, electrotherapy, manual therapy techniques, taping and by providing ergonomic advice to the patient. Short wave diathermy (SWD) has been reported to have measurable effects in patients with OA knee. It involves the application of deep heat, resulting in vascular dilatation, increased circulation leading to decrease in pain and swelling.[6]

According to the World Journal of Orthopedics 2011, isometric exercises are helpful in improving muscle function. Exercises such as static Quadriceps ,static hamstrings, strengthening of vastus medialis, mini squats, use of Quadriceps table,10 to 15 repetitions, done 5 days a week for 2 weeks have proved to be effective in improving muscle strength.[7,8]

Quadriceps femoris muscle plays an important role in mechanics of knee joint[9].It is the only muscle crossing anterior to the axis of the knee and is the prime mover for knee extension. During quiet standing and stance phase of gait, knee is an intermediate joint in a closed chain. The quadriceps muscle controls the amount of flexion at the knee during initial contact and also causes knee extension through reverse muscle pull on the femur during mid-stance .It also controls the amount of flexion during pre-swing (heel off to toe off ) and excessive heel rise during initial swing. With loss of quadriceps function, the patient lurches the trunk anteriorly during initial contact to move the centre of gravity anterior to the knee so that it is stable or rotates the extremity outward to lock the knee; with fast walking there may be excessive heel rise during initial swing.[10]

In OA knee, there is stiffness and deformity of knee joint which leads to weakness and atrophy of the quadriceps muscle. Certain studies have proved that quadriceps femoris muscle weakness plays an important role in the disability associated with OA knee.[11, 12] Quadriceps weakness and OA knee form a vicious circle.[7]

Russian current (medium frequency alternating current) is a type of electrical stimulation which has been advocated for use in increasing muscle force. It was originally developed for improving muscle strength in Russian Olympic athletes and was found to increase force gain up to 40% in elite athleltes.[13]

Russian current stimulation has been successfully used to increase muscle strength in healthy athletes. There is paucity of studies on the effect of electrical stimulation in improving strength of quadriceps muscle in osteoarthritis of knee in Indian population. The present study was therefore undertaken with an objective to determine the effectiveness of Russian current stimulation on quadriceps muscle strength in

patients with primary osteoarthritis of knee.

## MATERIALS AND METHODS

**Participants**-30 subjects diagnosed with primary OA knee were recruited in the study as per the following inclusion criteria: a) Knee pain for a duration of more than 3 months, b) Unilateral and/or bilateral OA knee c) Age group of 40 years and above (Both male & female). Subjects were excluded if they had a history of a) previous and recent traumatic injury to knee, b) any recent surgical interventions, c) intra-articular steroid injections to knee within last 3 months, d) peripheral vascular diseases, e) systemic illness and/or neurological illness, f) acute stage classification of OA.

The study was carried out in KLES Dr Prabhakar Kore Hospital and Medical Research Center, Belgaum after approval of Institutional Ethical Committee, KLEU Institute of Physiotherapy, Belgaum.

**Outcome measures**: The outcome measures were Visual Analog Scale (VAS) for pain, muscle strength in kg using Baseline Push-Pull® Hand-held dynamometer and WOMAC Osteoarthritis Index for functional disability. Pain was measured using VAS by asking the patient to mark a point indicating the severity of his/her pain on a 0 to 10 cm horizontal scale, where 0 signified no pain and 10 signified the worst pain. For the measurement of muscle strength, subjects were instructed to sit erect on a high stool or table and keep their knees at 65 degrees of flexion and hips at a constant angle. Hand held dynamometer was placed near the ankle joint, perpendicular to the limb surface, as specified in the manual provided with the instrument. Patients were then instructed to exert as much force as possible against the dynamometer and hold the contraction for 4 sec. The test was repeated thrice with a rest period of 30 to 60 sec between each trial and the mean of the 3 trials was taken. Functional disability was measured by using Western Onatario and McMaster University Osteoarthritis Disability index (WOMAC), a well validated, self-support, self-completed questionnaire designed for hip and knee osteoarthritis which contains 24 items measuring severity of pain (5 items), stiffness (2 items) and physical functioning (17items). Each item is scored as: 0-none, 1-mild, 2-moderate, 3-severe and 4-extreme with the total score ranging from 0 to 96, where higher scores indicate higher level of disability.

**Intervention:** The subjects were randomly allocated into 2 groups.

**Group A** received shortwave diathermy (SWD) and exercises. SWD was given for duration of 20min/session, 1 session per day for 10 days. (Figure 1}

**Fig. 1:** Application of SWD.

**Group B** received Russian current stimulation in addition to SWD and exercises. The stimulation was given for duration of 10 minutes (10/50/10 regimen-10 sec "on" followed by 50 sec "off" and again 10 sec "on".) (Figure 2)

**Fig. 2:** Application of Russian Current.

The exercises given included 1) static quadriceps contractions 2) static hamstrings contractions, 3) vastus medialis strengthening and 4) mini squats with 10-15 repetitions each.

## RESULTS AND TABLES

The results were analyzed in terms of reduction in pain, improvement in muscle strength and functional improvement. Statistical analysis was done using SPSS version 12. Statistical measures such as mean, standard deviation and test of

significance (paired and unpaired "t" tests) were used to analyze the data. Level of significance was set as pd" 0.05.

**Demographic profile**: Each group had 15 participants. The mean age of participants in group A was 52.9 years ± 7.5 and group B was 47.6 years ± 5.2. (Table 1). Due to the randomization process and patient compliance, only female participants were noted in both the groups.

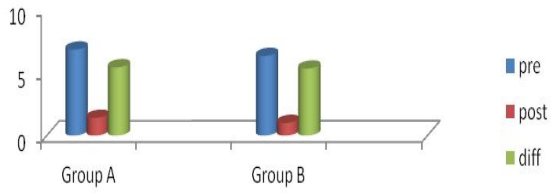
**Table 1:** Age Distribution:

| | Mean(SD) |
|---|---|
| Group A | 52.9(±7.5) |
| Group B | 47.6(±5.2) |

**Outcome parameters**: Within each group a statistically significant decrease in pain, increase in functional ability and muscle strength was noted. In group A, the mean VAS score pre-treatment of 6.8 ±1.49 reduced to 1.4 ± 0.91 post-treatment with mean difference of 5.4 ± 1.22. In group B, the mean VAS score pre-treatment of 6.3 ± 1.29 reduced to 1 ± 1.14 with mean difference of 5.3 ± 0.99. Between group comparison of pain score revealed no statistical significance (p= 0.796) (Table 2, Graph 1)

**Table 2:** Between group comparison of VAS:

| | Pre | Post | Diff | t | p |
|---|---|---|---|---|---|
| Group A | 6.8 ±1.49 | 1.4 ±0.91 | 5.4 ±1.22 | 41.83 | <0.001 |
| Group B | 6.3 ±1.29 | 1 ±1.14 | 5.3 ±0.99 | 29.6 | <0.001 |
| t | 0.741 | 0.895 | 0.261 | | |
| p | 0.465 | 0.329 | 0.796 | | |

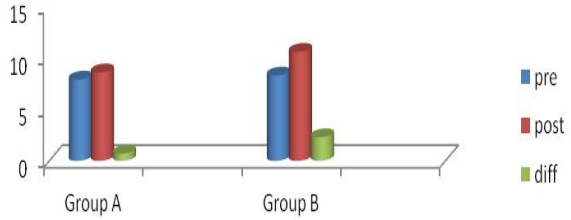



Graph 1 - VAS SCORE

In group A, the mean muscle strength pre-treatment was 7.9 ± 0.94 which increased to 8.6 ± 0.95 at the end of the treatment with 0.7 ± 0.95 mean difference. In group B, the mean muscle strength pre-treatment was 8.3 ± 0.67 which increased to 10.6 ± 0.89 with mean difference 2.3 ± 0.32 at the end of the treatment. Between group comparison of strength was significant ($p < 0.001$) (Table 3, Graph 2)

**Table 3:** Between group comparison of Muscle strength.

| | Pre | Post | Diff | t | p |
|---|---|---|---|---|---|
| Group A | 7.9 ±0.94 | 8.6 ±0.95 | 0.7 ±0.95 | 17.164 | <0.001 |
| Group B | 8.3 ±0.67 | 10.6 ±0.89 | 2.3 ±0.32 | 20.72 | <0.001 |
| t | 1.243 | 5.926 | 19.23 | | |
| p | | <0.001 | <0.001 | | |

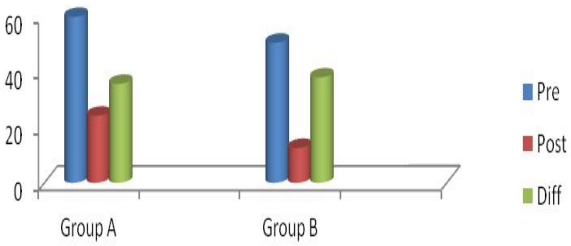



Graph 2 - MUSCLE STRENGTH

The mean WOMAC score in group A pre-treatment was 59.7 ± 11.56 that reduced to 24.1 ± 6.01at the end of the intervention, having a mean difference of 35.6 ± 7.86. In group B, the mean WOMAC score of 50.4 ± 22.30 pre-treatment reduced to 12.5 ±7.54 post- treatment with mean difference of 37.9 ± 22.35. Between group comparison was statistically significant ($p < 0.001$) (Table 4, Graph 3)

**Table 4:** Between group comparison of WOMAC Score.

| | Pre | Post | Diff | t | p |
|---|---|---|---|---|---|
| Group A | 59.7±11.56 | 24.1 ±6.01 | 35.6 ±7.86 | 17.536 | <0.001 |
| Group B | 50.4±22.30 | 12.5 ±7.54 | 37.9±22.35 | 16.561 | <0.001 |
| t | 1.428 | 4.634 | 0.37 | | |
| p | 0.168 | <0.001 | 0.716 | | |




Graph 3 - WOMAC SCORE

## DISCUSSION

The present study was undertaken to determine the effect of Russian current stimulation on quadriceps muscle strength in subjects with primary OA knee, as measured using a hand-held dynamometer. The other outcomes parameters were pain measured by the VAS scale and

functional limitation measured using the WOMAC scale.

Group A received conventional treatment (SWD + exercise) while group B received Russian current stimulation in addition to conventional treatment.

Both groups showed improvement in pain as evident by a decrease in the VAS score.

Participants in both groups received SWD prior to the exercises, which is a non-pharmacological deep heating treatment. It helps to increase tissue temperature, causes vascular dilatation and improves circulation and thereby reduces pain[6]. Mark R et al in 1999 did a survey of literature on SWD as applied to OA knee and found SWD to be effective in reducing pain in patients with OA knee[14]. Chung - Liwang et al studied the effect of repetitive shortwave diathermy on synovitis in patients with OA and concluded that the application of short wave diathermy in patients with OA knee can significantly reduce both synovial thickness and knee pain.[15]

According to the World Journal of Orthopedics, 2011 isometric exercises are helpful in improving muscle function. Static Quadriceps contractions ,static hamstrings contractions, strengthening of vastus medialis ,mini squats & use of Quadriceps table performed 5 days a week for 2 weeks with 10 to 15 repetitions have shown to improve muscle strength.[7,8] A study conducted by Robert Topp on the effect of dynamic versus isometric exercises in OA knee on 102 subjects for 16 weeks in outpatient setting concluded that both dynamic and isometric training improves functional ability and reduces knee joint pain in patients with knee OA.[16]

In present study, both groups received static exercises while Group B received Russian current stimulation in addition to the exercises. Intra group comparison showed significant difference with respect to strength pre & post treatment ($p < 0.001$) in both groups which could be attributed to the exercise program. But the group receiving Russian current stimulation showed greater increase than the only exercise group indicating that Russian current is also effective in increasing muscle strength.

A study conducted by Michael G Parker et al on torque responses in human quadriceps to burst modulated alternating current at 3 carrier frequencies namely, 2500 Hz, 3750 and 5000 HZ in 23 healthy subjects, concluded that burst modulated alternating current given at 2500 Hz produces greater electrically induced torque than those generated at 3750 Hz and 5000 Hz.[29] in present study 2500 Hz current frequency was used.[17]

In a case study conducted by Alex Ward on electrical stimulation using kilohertz frequency alternating current (Russian current) with 2.5KHz AC applied at 10 milliseconds burst with frequency of 50 Hz and 10 sec on followed by 50 sec off concluded that the parameters of Russian protocol are suboptimal for strengthening.[13]

The author recommends a frequency of 1-2.5 KHz with burst duration of 2 milliseconds for maximum torque production.

A study conducted by R. Keith Laughman et al on strength changes in the normal quadriceps femoris muscle as a result of electrical stimulation and isometric strengthening in 58 normal healthy subjects concluded that both isometric exercise and electrical stimulation group had a 2% increase in strength compare to the control group after a 5 weeks long programme.[18]

David M. Selkowit in his study on improvement in isometric strength of the quadriceps femoris muscle after training with electrical stimulation in 24 volunteers concluded that there is relative increase in isometric strength using electrical stimulation.[19]

In the present study the Russian current parameters used were as per the study of Alex Ward. [13]

WOMAC osteoarthritis index is a functional scale used for assessing severity of functional disability. Significant reduction in WOMAC scores and improvement in functional ability of the patients after intervention was noted in both the groups of the present study but the Russian current group showed greater improvement. Pain & muscle weakness are the contributing factors for the disability seen in patients with OA knee. Reduction in pain & improvement in strength will lead to an improvement in the function of these patients, which was also seen

in the present study.[6, 7, 8]

As the participants in the Russian current group showed greater increase in strength, greater improvement of the functional scores as well was seen in this group.

**LIMITATIONS:**

Long term follow up to study the retention of strength gains was needed which was not done due to time constraint. Also, therapist blinding to the intervention groups was not done.

## CONCLUSION

Russian current stimulation is effective in increasing quadriceps muscle strength and thereby improving the functional ability in subjects with primary osteoarthritis of knee. It can be added as an adjunct to the existing protocol for management of osteoarthritis.

**ACKNOWLEDGEMENT:**

We are grateful to all the participants for providing time for the study. A heartfelt gratitude to the Management of KLEU Institute of Physiotherapy Belgaum and KLES Dr Prabhakar Kore Hospital and Medical Research Centre, Belgaum for providing the infrastructure facilities to carry out the study

**Conflicts of interest:** None

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**How to cite this article**:

Anand B Heggannavar, Snehal R Dharmayat, Sonal S Nerurkar, Sonali A Kamble.EFFECT OF RUSSIAN CURRENT ON QUADRICEPS MUSCLE STRENGTH IN SUBJECTS WITH PRIMARY OSTEOARTHRITIS OF KNEE: A RANDOMIZED CONTROL TRIAL. Int J Physiother Res 2014;2(3):555-60.