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Original Research Article

Efficacy of Russian Current on Pain, Strength of Quadriceps and Function in Subjects with Primary Knee Osteoarthritis: A Randomized Clinical Trial

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ABSTRACT

BACKGROUND AND PURPOSE: The purpose of this study was to find out the effect of Russian current on pain, strength of quadriceps and function in subjects with primary knee osteoarthritis.
MATERIALS AND METHODS: 31 subjects with primary knee osteoarthritis were included and randomly assigned in two groups. Group-A (n=16) received Russian current along with supervised exercises, Group-B (n=15) received supervised exercises only, for 5 session per week for 2 consecutive weeks. Pain intensity was measured using numeric pain rating scale (NPRS), Isometric strength of quadriceps muscle (SOQ) was measured using Handheld Dynamometer and function was assessed using Lysholm knee scoring scale (LYSH). These outcome parameters were measured at pre-intervention, post- intervention and at the end of 4 weeks of follow up.
RESULTS: Baseline data were homogenous (p>0.05) for age, gender, BMI, NPRS, SOQ & LYSH score. Within group analysis shown statistically significant (p<0.05) improvement in both the Groups for all parameters after 2 & 4 weeks of treatment. However between group analysis shown statistically insignificant difference.
CONCLUSION: The results of this study suggested that supervised exercises with Russian current and supervised exercises alone were effective management strategies for primary knee osteoarthritis in relieving pain, improving strength of quadriceps and function, however no added effect of Russian current was found.
Key Words: Isometric strength, NPRS, LYSH, SOQ, Hand held dynamometer, Osteoarthritis and Russian current.

INTRODUCTION

Osteoarthritis (OA) is a chronic degenerative synovial joint disease of multi factorial etiology. Pathologically it is characterized by focal loss of articular hyaline cartilage with proliferation of new bone at the margins, subchondral sclerosis and remodelling of joint contour.[1,2] The joints most commonly affected are the knees, hips and those of the hands and spine.[1] A recent survey in India reported that the prevalence of OA in older adults more than 65 years of age was 32.6% in the rural population and 60.3% in the urban population.[3] Knee OA is likely to become most important cause of disability in men and the fourth most important cause of disability in women according to the World Health Organization report on global burden of disease.[4]

Osteoarthritis is classified as primary and secondary. The risk factors for primary osteoarthritis of knee are- obesity, heredity, occupation involving prolonged standing, sports, multiple endocrine disorder and multiple metabolic-disorders and causes of secondary osteoarthritis of the knee are valgus/varus deformities of the knee, intra-articular fracture of the knee, rheumatoid-arthritis, infection, trauma, TB, hyperparathyroidism, overuse, intra-articular steroid therapy etc.[5] Knee osteoarthritis is classified as patellofemoral osteoarthritis, medial tibiofemoral osteoarthritis and lateral tibiofemoral osteoarthritis.[6]

New bone outgrowth called “spurs” or osteophytes can form on the margins of the joints. These bone changes, together with the inflammation, can be both be painful and debilitating.[1] Three physical impairments, such as knee pain, stiffness and decreased strength of quadriceps muscles are mostly associated with knee OA and are believed to leads physical disability and progression of the disease.[7,8] Pain which is the chief complaint in OA occurs due to stimulation of capsular pain fibers, mechanoreceptors), periosteal nerve fibers and by perception of subchondral micro fractures or painful enthuses and bursae.[9] Conservative treatment for knee osteoarthritis of NSAIDS, Corticosteroid therapy, exercises, electrotherapy (low/mid/high frequency currents), Kinesio taping, acupuncture, weight management and the use of orthosis.[10-13]

Russian current is a medium frequency current, which was developed for improving muscle strength in Russian Olympic athletes and was found to increase force gain up to 40%. Russian current is a modulated sinusoidal Alternating Current (AC) with 2500-Hz delivered in a series of bursts (10-millisecond burst and a 10-millisecond interval, or 50% duty cycle). It has been reported that the most commonly used electric stimulation to increase muscle strength is Russian current.[14] In a case study conducted by Ward A.R et al. on electrical stimulation with Russian current (2500Hz) applied at 10 milliseconds burst with 10 sec on followed by 50 sec off concluded that these parameters of Russian current are suboptimal for strengthening.

There is limited literature on the effect of Russian current in improving strength of quadriceps muscle in osteoarthritis of knee. Also, there are contradictory results of effectiveness of exercises on osteoarthritis knee. Thus a need arises which addresses these perspective for new management strategies. The current study thus intended to investigate the additional effect of Russian current along with supervised exercises on pain, strength of quadriceps and function in subjects with primary knee osteoarthritis.

MATERIALS AND METHODS

Total 95 subjects were screened according to inclusion/exclusion criteria at National Institute for Locomotor Disabilities (Divyangjan) (NILD) in Kolkata, India, over a period of 12 months from March 2018 to March 2019. Scientific & Ethical clearance was obtained from Institutional Ethics Committee of NILD. Informed consent was obtained from 34 subjects who fulfilled the inclusion criteria and they were randomly allocated in two groups (Group-A & Group-B) by simple random sampling by chit picking method. All the subjects were blinded about the interventions and unaware about the research question.

Inclusion criteria were a) Knee osteoarthritis grade II and III as determined using the Kellgren and Lawrence plain radiograph classification, b) Knee pain duration of more than 3 months, c) Age group between 40-60 years, d) Pain intensity by Numerical Pain Rating Scale ranging from 3-8. Whereas subjects with following criteria were excluded like- a) Any surgery of the knee b) Musculoskeletal deformity of lower extremity and spine (like varus/valgus deformity, LLD, Scoliosis etc.) c) Knee joint instability d) Peripheral vascular diseases (like Deep vein thrombosis, Varicose vein etc.) e) Neurological impairment (like Stroke, Parkinson's disease etc.) f) Had received steroids or intra-articular injection within the previous three month g) Cardiac pacemaker. h) Metallic implant i) Local skin disorder j) Uncooperative subjects.

Subjects in Group-A (n=17) has received Russian current and supervised exercises for five sessions per week in two weeks (Total ten sessions) and subjects in Group B (n=17) has received supervised exercise alone for five sessions per week in two weeks (Total ten sessions). The data for pain intensity, Strength of Quadriceps and functional status were taken at pre-intervention and at the end of two weeks post intervention. Follow up data were obtained from all subjects 4 weeks after the last intervention. One subject was dropped out from Group-A within first two weeks of treatment because of other health issues and another two subjects discontinued treatment because of personal issues after two weeks from Group-B.

Outcome Measures

The measurement of pain intensity was done by using Numerical Pain Rating Scale (NPRS), with 0 to 10 numbers marked on a line in which 0 representing "no pain" and 10 representing "pain as bad as it could be." Each subject was explained about the scale and asked to indicate the level of pain at their knee joint. Subjects were instructed to select a value that is in line with the intensity of current pain being experienced and that value was recorded. The readings were taken at pre-intervention ($NPRS_0$) and at the end of 2 weeks of treatment ($NPRS_2$) and at the end of 4 weeks follow up ($NPRS_4$).

Maximal isometric force generated by knee extensor muscle (Strength of Quadriceps) was measured using a hand held dynamometer (Grip SAEHAM™ hydraulic hand-held dynamometer, Korea). The subjects were in high sitting position on a wooden chair with relaxed Quadriceps muscles. The tested knee was kept on a wooden block in 35^0 flexion from the maximum extension position. The dynamometer was placed anteriorly 2.5cm proximal to the ankle and therapist was in sitting position in front of the subject (Fig:-1).[15] Then the subjects were asked to perform a maximal voluntary contraction (MVC) against the dynamometer and the force exerted by the subject was measured in Kg. The test was administered three times with 30 sec rest interval & the mean of the three values was recorded. The readings were taken at pre-intervention (SOQ_0) and at the end of 2 weeks of treatment (SOQ_2) and at the end of 4 weeks of follow up (SOQ_4).

The measurement of functional status of the knee was done by using Lysholm knee scoring scale. It is a questionnaire designed to give information about knee pain, swelling, instability, limp, support, locking, stair climbing and squatting etc. with maximum score 100 It has demonstrated high reliability and validity (ICC=0.91 and IC=0.65). The readings were taken at pre-intervention ($LYSH_0$) and at the end of 2 weeks of treatment ($LYSH_2$) and at the end of 4 weeks of follow up ($LYSH_4$).[16]

Fig:1 Position of the hand held dynamometer measurement

Fig:2 Application for Russian current

Interventions

All subjects in Group-A were treated with Russian current & Supervised Exercises.

For Russian current application, the subjects were made to sit comfortably on a wooden chair with quadriceps relaxed on a wooden block at an angle of 35^0 knee flexion from full extension position. The anterior area of the thigh of the affected limb was cleaned with alcohol and two electrodes were placed on the limb: One electrode is placed at the vastus medialis obliqus (VMO) and the second electrode at the proximal antero-lateral thigh. The current intensity was increased gradually & the subjects were instructed to inform the maximum level of tolerance and contract the quadriceps muscles synchronizing with the current.[17]

Russian Current (PRO-MED-IFT-PLUS Device) of 2500 Hz with pulse frequency of 50 Hz, symmetric pulses of sinusoidal form, with a pulse duration of 200-300 µs, 2-3 seconds ramp up, 2 seconds ramp down for comfort and a duty cycle of 50% was applied for 10 minutes duration.[14] This current was applied five sessions per week for two consecutive weeks (Fig:-2).

Supervised exercises include patellar mobilization (superior, inferior, medial and lateral glides) with Grade I or II oscillations at 2-3 per sec was applied for 1 to 2 minutes. Strengthening exercises (isometric quadriceps, hamstring setting exercises, vastus medialis oblique strengthening and straight leg raise exercise) with each contraction was held for 6 seconds. 4 sets of 10 repetitions were performed with proper rest period between the sets.[18] Stretching exercises (posterior knee capsule, hamstring, Tendo-Achilles and rectus femoris stretching exercises). This was held for 12-30 seconds and repeated 3 times. Between each repetition there was a rest period of 5 seconds.[19] All the subjects in Group B has received supervised exercises program only.

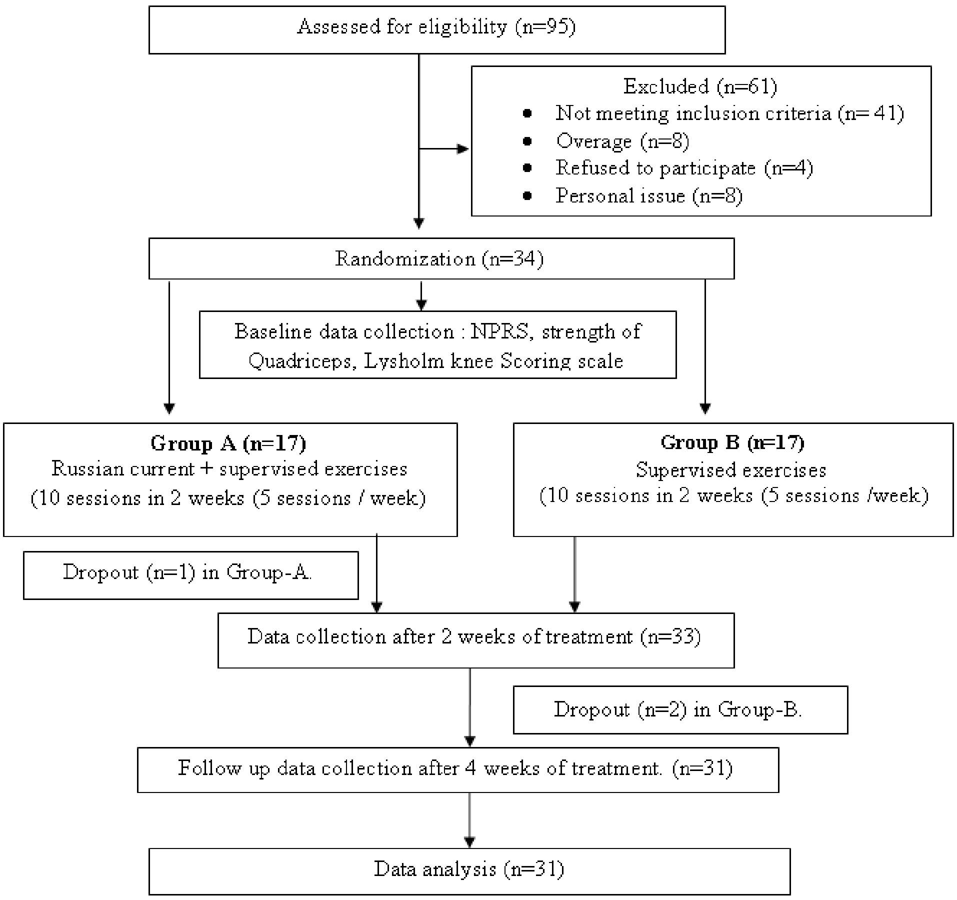

Fig-3: Consort flow diagram

Statistical Analysis

Statistical package for social sciences (SPSS) version 23 software was used for analysis of the collected data. Numerical pain rating scale (NPRS), Strength of Quadriceps (SOQ) and Lysholm knee scoring scale (LYSH) is continuous data. Baseline characteristics and post treatment data were analysed between two groups by using "Independent sample t test". Repeated measures ANOVA were used to compare the mean of variables (NPRS, SOQ and LYSH) at three different time of interval. Bonferroni Post hoc analyses were done to compare the mean of variables. The tests were applied at 95% confidence interval on α value set at 0.05. The result were taken to be significant if P value <0.05.

RESULTS

Both the groups were homogeneous in terms of baseline values for outcome variables (pain, strength of quadriceps and functional status) and demographic details with p-value greater than 0.05 (Table:1). Intragroup analysis revealed significant improvement in NPRS, Strength of quadriceps and Lysholm score (p-value <0.0001) at the end of 2 weeks and after 4 weeks of follow up in both Group-A and Group-B [Table:2]. Intergroup analysis revealed insignificant changes in NPRS, Strength of quadriceps and Lysholm score at the end of 2weeks and after 4th weeks of follow up (p>0.0001) as shown in [Table:3].

TABLE:1 Baseline characteristics of Participants'

Parameters	GROUP A (n=16)	GROUP B (n=15)	P value
AGE	51.62±3.93	48.33±6.00	0.08
BMI	22.81±1.94	23.54±2.14	0.32
$NPRS_0$	6.69±1.14	6.47±1.46	0.64
SOQ_0	14.19±2.48	15.40±2.75	0.20
$LYSH_0$	62.50±9.20	63.07±10.26	0.87
MALE/ FEMALE	4/12	4/11	1.00

TABLE:2- Intra group analysis of outcome parameters.

Groups	Outcome	Mean ± (SD)	F-Value	p value
Group A (n=16)	$NPRS_0$ - $NPRS_2$	6.69±1.14 - 2.06±1.18	348.32	0.00*
	$NPRS_2$ - $NPRS_4$	2.06±1.18 - 1.25±0.93		
	$NPRS_0$ - $NPRS_4$	6.69±1.14 - 1.25±0.93		
	SOQ_0 - SOQ_2	14.19±2.48 - 15.50±2.34	102.18	0.00*
	SOQ_2 - SOQ_4	15.50±2.34 - 17.00±2.06		
	SOQ_0 - SOQ_4	14.19±2.48 - 17.00±2.06		
	$LYSH_0$ - $LYSH_2$	62.50±9.20 - 83.37±6.29	158.74	0.00*
	$LYSH_2$ - $LYSH_4$	83.37±6.2 9- 90.00±4.08		0.00*
	$LYSH_0$ - $LYSH_4$	62.50±9.20 - 90.00±4.08		0.00*
Group B (n=15)	$NPRS_0$ - $NPRS_2$	6.47±1.46 - 2.67±1.45	199.40	0.00*
	$NPRS_2$ - $NPRS_4$	2.67±1.45 -1.73±1.10		0.00*
	$NPRS_0$ - $NPRS_4$	6.47±1.46 - 1.73±1.10		0.00*
	SOQ_0 - SOQ_2	15.40±2.75 - 16.53±2.89	79.49	0.00*
	SOQ_2 - SOQ_4	16.53±2.89 -17.73±2.55		0.00*
	SOQ_0 - SOQ_4	15.40±2.75 - 17.73±2.55		0.00*
	$LYSH_0$ - $LYSH_2$	63.07±10.26 -85.20±6.80	110.86	0.00*
	$LYSH_2$ - $LYSH_4$	85.20±6.80 - 89.60±4.91		0.00*
	$LYSH_0$ - $LYSH_4$	63.07±10.26 - 89.60±4.91		0.00*

***: p<0.05 significant**
$NPRS_0$-Numerical pain rating scale at baseline,
$NPRS_2$- Numerical pain rating scale after 2 weeks of treatment,
$NPRS_4$- Numerical pain rating scale after 4 weeks of treatment,
SOQ_0- Strength of Quadriceps at baseline,
SOQ_2- Strength of Quadriceps after 2 weeks of treatment,
SOQ_4- Strength of Quadriceps after 4 weeks of treatment,
$LYSH_0$- Lysholm knee score at baseline,
$LYSH_2$- Lysholm knee score after 2 weeks of treatment,
$LYSH_4$- Lysholm knee score after 4 weeks of treatment.

TABLE:-3 - Inter Group analysis of outcome parameters

Parameters		Group A (n=16) Mean ± (SD)	Group B (n=15) Mean ± (SD)	t value	p value
NPRS	$NPRS_0$	6.69±1.14	6.47±1.46	0.47	0.64†
	$NPRS_2$	2.06±1.18	2.67±1.45	-1.28	0.21†
	$NPRS_4$	1.25±0.93	1.73±1.10	-1.32	0.19†
SOQ	SOQ_0	14.19±2.48	15.40±2.75	-1.291	0.207†
	SOQ_2	15.50±2.34	16.53±2.89	-1.096	0.282†
	SOQ_4	17.00±2.06	17.73±2.55	-0.883	0.385†
LYSH	$LYSH_0$	62.50±9.20	63.06±10.26	-0.162	0.872†
	$LYSH_2$	83.37±6.29	85.20±6 .80	-0.776	0.444†
	$LYSH_4$	90.00±4.08	89.60±4.91	0.479	0.635†

†: p>0.05 insignificant

DISCUSSION

This study attempted to focus our attention towards the efficacy of Russian current along with supervised exercise on pain, strength of quadriceps and function in subjects with primary knee osteoarthritis. In this study subject's pain intensity, quadriceps muscle strength and physical function improved with both kinds of treatment. Significant difference was found within the groups in NPRS score (pain intensity), Strength of Quadriceps and Lysholm knee scoring scale (functional status), however, between group analysis revealed insignificant difference among the two groups. Moreover, analysis of follow-up data showed that the results were sustained even after four weeks of completion of treatment.

The improvement in Group-A could be attributed to the effect of Russian current stimulation as it is believed to relieve pain, re-educates muscle function, prevents muscle atrophy and restores function.[14] According to the gate control theory of pain, noxious stimuli are transmitted from the periphery along myelinated A-delta nerve fibres and non-myelinated C fibres. Activation of non-nociceptive A-beta fibres can inhibit transmission of these noxious stimuli from the spinal cord to the brain by activating inhibitory inter neurons in the spinal cord. Russian current when applied with appropriate parameters, can selectively activate A-beta nerve fibers. Because pain perception is determined by the relative activity of A-delta and C nerve fibres in comparison to A-beta nerve fibres, when A-beta activity is increased by any kind of electrical stimulation, pain perception is decreased.[17]

Russian current can cause depolarization of sensory and motor nerve fibres. It activates fast type II motor unit and evoke muscle contraction which leads strengthening of muscle.[14]

Voluntary exercise regimens can promoted increased force production in slow-twitch, fatigue resistant muscle fibres because they are the one which recruits first in a voluntary contraction and there is limited recruitment of fast-twitch fibres in all but the fastest and most forceful voluntary contractions. An electrical stimulation regimen, by contrast, preferentially recruits the fast-twitch muscle fibres, which are innervated by larger diameter moto-neurons. On this basis, they contended, an optimal force gain program should include both exercise and electrical stimulation to increase force production of both fibre types. Electrical stimulation via Russian current causes an increase in the muscle strength with changes in the muscle fibres and the capillary system.[20]

The reduction of pain in Group -A as well as in Group-B are also in accordance with the studies of Miyaguchi et al (2003) who reported that strengthening exercise is clinically effective for the reduction of pain in knee osteoarthritis. According to them a significant increase in muscle strength affects the hyaluronan metabolism in arthritic knee joint. Normal joint fluid contains high levels of hyaluronic acid (HA) synthesized by synovial lining cells and HA influences joint lubrication and cartilage metabolism. It has been reported that hyaluronic acid (HA) concentration in joint fluid and its molecular weight are decreased in knee osteoarthritis. Hyaluronic acid (HA) plays various roles in normal and pathologic joints, e.g., as a lubricating substance, in cartilage proteoglycan metabolism, in suppression of phagocytosis and chemotaxis by polymorphonuclear leukocytes and in analgesia. In addition to significantly increasing in quadriceps muscle strength, the exercise had effects on hyaluronic acid (HA) metabolism in arthritic knee joints after 3 months. Such biochemical changes might be directly responsible for pain relief in osteoarthritis patients.[21]

A 'reflex inhibition' mechanism has been recently advocated as an important cause of quadriceps weakness in knee osteoarthritis patients in addition to disuse atrophy. Various proprioceptive receptors are present in ligaments, tendons, joint capsule, joint synovium and skin and these receptors are stimulated by pain, ligament stretching, capsule pinching and effusion leading to neurogenic inhibition of the quadriceps muscle. Findings of this study indicated that relief of reflex inhibition played an important role for increase in muscle strength. It has been widely believed that stabilization of the knee by muscle strengthening is the cause of pain relief in knees with osteoarthritis.[22]

Along with these, Patellar mobilisation might have caused the breaking of adhesion in the medial capsule and contributed to decrease the pain intensity.[23] Nor Azlin MN et.al (2011) reported that joint mobilisation produces rapid hypoalgesia with concurrent sympathetic nervous system and motor system excitation, a pattern similar to that generated by direct stimulation of the periaqueductal gray matter.[24]

In the present study, there was set of exercises including strengthening, stretching and mobilization intervention were given, it was seen that exercise intervention proved to be effective in the management of OA knee. Reduced pain and stiffness after Russian current application might have allowed the patients to participate more successfully in the exercise program and activities of daily living.

The improvement in function in this study could be attributed to analgesic effect of Russian current and exercises which lead to decrease pain and increase strength of quadriceps. Strength gain was also associated with improvement in confidence during mobility. The level of functional improvement with clinical treatment program of manual therapy and supervised exercise is greater than other reported conservative treatment.[25]

Corroborating the findings of all the outcome parameters it was observed that the addition of

Russian current that along with supervised exercise had shown significant changes in pain, strength of quadriceps and function in Group-A whereas, supervised exercise alone was helpful in reduction of pain, increasing strength of quadriceps and functional status in subjects with primary knee osteoarthritis in Group-B. Thus supervised exercise with or without Russian current can be used for pain relief, muscle strength and physical function.

Limitations

Sample size was small, no blinding was done, no true control group was taken, duration of study was short and duration of follow up period was also short.

Suggestions

Future double blind study with large sample size may be considered. Further studies with longer duration and long term periodic follow-up are recommended to assess long term benefits of the above treatment techniques.

CONCLUSION

The results of this study suggest that Russian current with supervised exercises and supervised exercises alone are effective in reducing pain, improving strength of quadriceps and function in subjects with knee osteoarthritis. Despite these results, further studies on the effects of Russian current should be taken to determine the optimal physical parameters to obtain the most effective clinical response

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