ORIGINAL RESEARCH

Effect of Russian Current Stimulation on Quadriceps Strength of Patients with Burn

Amr Almaz Abdel-aziem, Emad Tawfik Ahmed

Background: Burn leads to catabolic process in the form of severe muscle weakness, loss of mass and function. So, it is important to maintain the muscle strength of patients with burn.

Objective: To evaluate the effect of Russian current stimulation on the peak torque of quadriceps muscles of healed burned patients.

Materials and Methods: Forty volunteer burned male subjects participated in this study, they were randomly allocated into two equal groups: (1) Control group: received physical therapy in the form of splinting, massage, stretching, range of motion exercise, functional training for ambulation and activities of daily living. (2) Russian group: received 20 min of Russian stimulation, in addition to physical therapy of the control group, day after day for 4 weeks. Concentric peak torque of quadriceps at angular velocity 30°/s and ambulation speed measured before and after interventions.

Results: After 4 weeks of treatment, the quadriceps peak torque of Russain group and Control group significantly increased (p= 0.000), the post value of peak torque of Russian group was significantly higher than the post value of control group (p = 0.010). Moreover, there was significant increase in ambulation speed of Russain and Control group (p= 0.000), the post value of ambulation speed of Russian group was significantly higher than the post value of Control group (p = 0.004).

Conclusion: Application of Russian current stimulation in addition to conventional physical therapy increased the quadriceps muscle peak torque and ambulation speed for patients with anterior thigh burn.

Keywords: Burns, Russian current, Muscle strength, Isokinetic.

Amr Almaz Abdel-aziem PhD is Assistant professor of Biomechanics, Department of Biomechanics, Faculty of Physical Therapy, Cairo University, Egypt.

Emad Tawfik Ahmed PhD is Assistant professor of Physical Therapy for Burn and Surgery, Department of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University, Egypt.

Corresponding Author:

Amr Almaz Abdel-aziem

E-mail: amralmaz@yahoo.com

INTRODUCTION

In the past two decades the survival rates after severe burn have significantly improved that is associated with a progressive decline in mortality that explained the importance of rehabilitation after burn to maximize the physical function recovery[1, 2]. Burn injury leads to immobilization period that may last several weeks. This is accompanied by muscle wasting and loss of strength especially the antigravity muscles. These changes become predominant after only 2 weeks of bed rest[3, 4], in addition to disturbance of motor control, decreased cognitive status, pain and anxiety[5]. So, the treatment of muscle weakness has become prominent areas for research interest in the rehabilitation of burns during chronic period.

Pulsed current (PC) and burst-modulated alternating current (BMAC) are two forms of electrical stimulation that commonly used clinically. Examples of BMAC are “Russian current” and “interferential current.” Burst-modulated alternating current stimulation is claimed to be more comfortable than PC and capable of eliciting greater muscle torque[6]. The ability of Russian current protocols to improve the skeletal muscle performance of healthy muscles is proved[7,8], that has been accepted and explained both in research studies and in rehabilitation practice[9,10].

Russian current is 2.5 kHz AC, applied in 50 Hz rectangular bursts with a burst duty cycle of 50%. The burst duration is 10 milliseconds at 50 Hz. Russian current is pretended to be helpful for increasing force-generating capacity of muscles[11]. This type of treatment modality has been claimed to relieve pain in injured areas, increase local blood flow, strengthen muscles, cause muscle hypertrophy, and facilitate muscle contraction[12].

Several investigators have examined strength response to electrical stimulation during repeated sessions and reported increased skeletal muscle strength[13-15]. In contrast, some studies using electrical stimulation in repeated session have not supported the claims of increased muscular strength[16, 17], in spite of controversy regarding the effect of electrical stimulation on strength of skeletal muscle, there is no previous studies regarding the use of Russian currents in improving muscular strength in patients with burn. So, the purpose of this study was to evaluate the effect of Russian current stimulation on the peak torque of quadriceps muscles of patients with healed burn.

MATERIALS AND METHODS

Subjects

Forty volunteer male subjects participated in this study. The subjects were included if they had a second-degree burn on the anterior thigh (deep partial thickness of thermal injury), as a burn to the posterior thigh will lead to knee flexion contracture, which affected the function of the quadriceps muscle. They were refereed from the outpatient burn clinic at Om El-Masryeen Hospital to outpatient clinic of faculty of physical therapy. Total body surface area (TBSA) for the burns ranged from 30% to 40% (more than this percentage would affect other areas more than the lower limb, e.g. the abdominal or chest wall). Patients enrolled in this study after more than 3 months since burn injury. Patients were excluded if they had one or more of the following: neurological disorders, musculoskeletal disorders, diabetes mellitus, psychiatric, severe behavior or cognitive disorders, along with those participated in any rehabilitation program prior to the study[18,19], except regular rehabilitation in the form range of motion exercise, splinting, stretching, functional training for activities of daily living and ambulation that done during hospitalization stage. A standardized 3-point grading scale used to determine the sensory affection of the patients[20], all patients underwent bilateral pinprick sensory testing for anterior thigh. No sensory impairment has been reported. The demographic data for the participants is shown in Table 1.

They were randomly allocated into two groups: (1) Control group: 20 subjects with burn and didn’t receive any method for strengthening. They had to continue their rehabilitation program in the form splinting, massage, stretching, range of motion exercise, functional training for ambulation and activities of daily living. (2) A Russian current group: 20 subjects with chronic burn which receive 20 minutes of Russian stimulation, in addition to physical therapy of the control group, day after day for 4 weeks.

Table 1 Demographic data			
Characteristics	**Russian group Mean (SD)**	**Control group Mean (SD)**	**P- value#**
Age (years)	20.08 (4.51)	21.13 (4.52)	0.478
Weight (kgs)	70.55 (5.77)	69.48 (5.53)	0.561
Height (cms)	172.20 (5.18)	174.38 (4.74)	0.186

- Unpaired t test

A randomized sequence was generated by Excel to ensure that the subjects were randomly allocated. Electronic password-protected document was used to conceal the sequence from consent design[2].The ethical committee Faculty of Physical Therapy, Cairo University, Egypt, approved the study and informed consent was assigned at the first visit to the physical therapy clinic by all patients.

1. Peak torque measurement

The evaluation was applied before and after the training program, while training applied only on the dominant side quadriceps. The participants did warm-up on a stationary bicycle at a speed of 20km/h and load of 20W for a five-minute, after that they stretched the quadriceps femoris and hamstring muscles of both limbs. Each muscle group was stretched three times for 30 sec alternately.

Following the warm-up, the participants were positioned in an isokinetic dynamometer (Biodex Multi-joint System 3, Biodex, Shirley, NY), in accordance with the equipment instructions the hip joint angle set at 100º. The trunk, pelvis and thigh were stabilized using straps. The rotation axis of the dynamometer was aligned with the axis of the knee joint, at the level of the lateral epicondyle of the femur, while it was attached to the distal part of the leg, about 5cm above the medial malleolus. A gravity effect correction and isokinetic device was calibrated before each evaluation and training session, as recommended by the manufacturer.

For familiarization, the subjects performed a series of three submaximal contractions. The subjects then performed three series of ten consecutive maximal concentric isokinetic contractions; the knee joint was moved through the ROM from 90 to 15º of knee flexion at an angular velocity 30º/s[21]. There was three minutes of resting before each series, and there were no pauses between the ten contractions (Figure.1). Verbal encouragement, as well as visual feedback from the equipment, was given to all participants in an attempt to achieve maximal voluntary effort level during all the contractions. The peak torque (Nm) of the quadriceps femoris muscle was measured before training and after 4 weeks of training of both groups.

Drouin et al.[22] proved that the Biodex System 3 isokinetic dynamometer provided mechanically reliable measures of torque, position and velocity on repeated trials performed on the same day as well as on different days. The validity of isometric torque and position measurements was acceptable for both clinical and research purposes. Concentric velocity measures were valid up to approximately 300°/s, with a systematic decrease in maximum velocity occurring at higher test velocities.

2. Measurement of ambulation activity

The patient's walking speed used to evaluate the ambulation activity. The time it took to complete a predetermined distance of 50 m on a treadmill as comfortable walking without running or pain and quickly was recorded. When subject completed 50 m, the treadmill alarm sound will be released[23]. The same physiotherapist used stopwatch to determine the walking time.

3. Training procedure

Russian current group performed training three times a week for four weeks. NMES (phyaction 787, Neitherlands) was used. The carrier wave frequency was 2,500Hz, modulated at 50 bursts/s, with a pulse duration of 200µs (10/50/10 protocol meaning that 10

Figure 1 Subject position during measurement of quadriceps peak torque

sec. on, 50 sec. off and 10 stimulation cycles with burst modulation current at 50 Hz). This configuration is known as Russian current[8]. Two self-adhesive electrodes (5 x 13cm) were placed on the participant's thigh: one approximately 10cm below the anterosuperior iliac spine in the proximal region of the quadriceps; and the other over the distal portion of the quadriceps femoris, about 5cm above the suprapatellar line, over the belly of the vastus medialis obliquus muscle. At each training session, the amplitude of current used was the maximum each participant could tolerate. The stimuli were applied only during knee extensor contraction, therefore there was no Russian application during passive knee flexion. All patients conducted their treatment program without any complications.

Statistical Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS version 16). Paired t-test to compare between pre and post values of both groups and unpaired t-test used to compare between the two groups. The level of significant was set at 0.05 for all statistical tests.

RESULTS

There were no significant differences in the age, weight and height (p = 0.478, 0.561, 0.186; respectively) between both groups. There was no significant difference between the pretest values of quadriceps concentric peak torque of Russian and control group (p = 0.792). There was significant increase in the peak torque value of posttest value of Russian and group and control group (p = 0.000). However, the posttest peak torque value of Russian group was significantly higher than that of control group (p = 0.010) as shown in Table 2. The Russian group had (14.93% vs. 5.46%) increased peak torque compared with the control group (Figure. 2).

There was no significant difference between pretest values of average ambulation speed of the Russian group and control group (p = 0.527). There was significant increase in the ambulation speed value of posttest value of Russian and control group (p = 0.000). However, the posttest ambulation speed value of Russian group was significantly higher than that of control group (p = 0.004) as shown in Table 3. The Russian group had (24.36% vs. 12.59%) increased ambulation speed compared with the control group (Figure. 3).

DISCUSSION

The current study was conducted to examine the effect of Russian current stimulation on the peak torque of quadriceps

Table 2 Knee extensor peak torque (Nm) of Russian and Control groups			
	Russian group Mean (SD)[Y]	**Control group Mean (SD)** [Y]	**P- value**[#]
Pretest	86.05 (10.91)	85.20 (9.28)	0.792
Posttest	98.90 (12.41)	89.85 (8.36)	0.010*
% of change	14.93%	5.46%	

[Y]- Knee extensor peak torque (Nm), [#] - Paired t test, *- Significant p< 0.05

Table 3 Average ambulation speed (m/min) of Russian and Control groups			
	Russian group Mean (SD)[Y]	**Control group Mean (SD)** [Y]	**P- value**[#]
Pretest	71.85 (6.44)	73.05 (5.39)	0.527
Posttest	89.35 (8.54)	82.25 (5.70)	0.004*
% of change	24.36%	12.59%	

[Y]- Average ambulation speed (m/min), [#] - Paired t test, *- Significant p< 0.05

muscles of healed burned patients. The burn injury leads to catabolic process that produces loss muscle mass and decrease of function. Therefore, the patients were unable to generate the same muscular force during many repetitions, and a single repetition of muscular contraction, as indicated by the decreased total muscle work[24,25]. The combination of protein catabolism due to burn [24] and bed rest[26, 27] may have contributed to the differences in muscle strength between patients with burn and healthy subjects. These effects were more predominant in muscles of the lower extremity, that occupied by high percent fast-twitch fibers[28].

The findings of this study were that Russian current was effective in increasing the strength of quadriceps and, moreover, the Russian current produced significant increase in the ambulation speed. There was no previous studies examined the effect of Russian current stimulation on the quadriceps strength of patients with burned injury. Our results were coincident with the findings of Maffiuletti et al.[29] who found that short-term electrostimulation increased maximal voluntary strength by 12%, which was accompanied by neural adaptations (cross-educational effect and increased muscle activation) and muscle adaptations in healthy individuals. Similarly, Yaz et al.[30] have found that both Russian current and low frequency current were capable to increase the maximum extensor peak torque of quadriceps muscles, even that the low frequency current was more effective than Russian current.

Moreover, the recruitment order of NMES is reversed relative to volitional exercise. During volitional activity, the slow oxidative (SO) muscle fiber types are recruited first, whereas fast glycolitic (FG) are the most difficult to recruit. During electrical stimulation of the muscle the order of muscle fiber recruitment is reversed, with the largest-diameter muscle fibers FG being recruited first and the smaller-diameter SO muscle fibers being recruited later[31].

The result of the present study proved that Russian current stimulation of quadriceps was effective in improving the ambulation activities of participants after 4 weeks of training program, Russian group achieved improvement of 24.80%, while the control group had 11.82%. Improvement in functional locomotion of burned subject is a vital goal of rehabilitation program. There is a significant correlation between maximum walking speed and quadriceps muscle strength[32, 33]. Moreover, isokinetic training

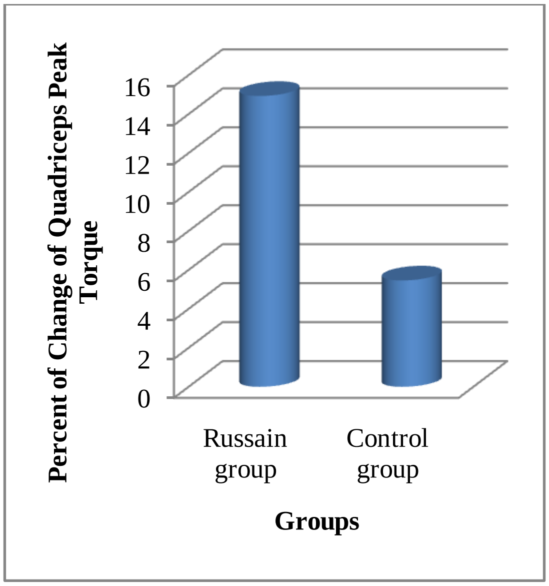

Figure 2 Mean changes in quadriceps peak torque of (Nm) of Russian and Control groups

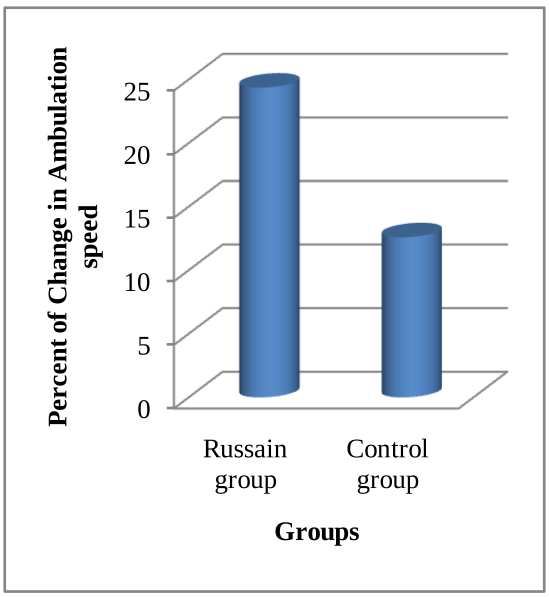

Figure 3 Mean changes in average ambulation speed (m/min) of Russian and Control groups

increased the quadriceps strength[23, 34] and produced improvement of ambulation speed in burned patients[23].

These results were consistent with the findings of Snyder-Mackler et al.[35] who compared Russian current stimulation with interferential therapy (IFT) and an NMES protocol. The IFT resulted in significantly less muscle force generation in response to the stimulation. The highest average force results were obtained with Russian current stimulation, but there were no significant difference between results obtained from the NMES stimulation and Russian current stimulation. Moreover, Snyder-Mackler et al.[36] compared an electrical stimulation protocol with a voluntary exercise protocol post anterior cruciate ligament reconstruction on muscles strength. Quadriceps and hamstring co-contractions were undertaken (exercise and stimulation groups) with a 15 sec hold/stim followed by 50 seconds rest. The results in the form of gain in muscle strength obtained with the Russian current stimulation group were significantly better than those undertaking exercise.

There are some limitations of this study. First, the total study time was limited to 4 weeks, which could be extended to achieve a greater benefit of Russian current training on muscle weakness after burn injury. Secondly, the gender in this study was limited to males only. Thus, the appropriateness of generalizing the results is confined to this specific population. Finally, the only isokinetic parameter examined in this study was concentric peak torque, other isokinetic parameters, such as eccentric peak torque, power, work, and fatigue, were not considered.

Conclusion

Application of Russian current stimulation in addition to conventional physical therapy for subjects suffering from burn injury at anterior thigh increased the quadriceps muscle concentric peak torque and ambulation speed.

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Conflicts of Interest

None declared

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