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Alteration of Muscle Function and Mobility after Russian Current Stimulation in Children with Knee Hemarthrosis

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ABSTRACT

The main purpose of this work was to study the alteration of muscle function and mobility after Russian current stimulation in children with knee hemarthrosis, after 8 weeks rehabilitation period. Forty volunteer hemophilic male children participated in this study. They were randomly allocated into two equal groups: control group (A): Received a designed physical therapy program (strengthening, stretching and gait training) and study group (B): Received 20 min of Russian stimulation, in addition to the program given to the control group, day after day for 8 weeks. Concentric peak torque and power of quadriceps and hamstrings at angular velocity 60° sec^{-1} and 120° sec^{-1} and functional walking were measured for each patient of the two groups before and after eight successive weeks of intervention. Mixed design MANOVA showed significant increases in isokinetic variables after the two months period compared with "before" in both groups. Moreover, mixed ANOVA was conducted to compare mean values of 6 MWT showed no significant difference between both groups. These results show the benefits of Russian current in improving muscle strength and mobility in knee hemarthrosis.

Key words: Russian current, hemophilia, Biodex Isokinetic Dynamometer, six-minute walking test

INTRODUCTION

One of the most severe blood coagulation disorders is hemophilia. It is an inherited X-linked recessive bleeding disorder with clotting factor deficiencies (Acharya, 2012; Valentino *et al*., 2012; Alba *et al*., 2010). Classic hemophilia or hemophilia A is the commonest type and is caused by an inherited deficiency in factor VIII (1 in 5000 live male births). Christmas disease or hemophilia B (1 in 30,000 live male births) is caused by a deficiency in factor IX. Acquired hemophilia is a rare form of the disease and it is caused by antibody-mediated autoimmune response against factor VIII, typically by the elderly (Yu *et al*., 2009; Den *et al*., 2009).

The plasma level of clotting factor determines the severity of the disorder (1 international unit = 1%). Hemophilia is classified in to severe (<1%), moderate (1-5%) or mild (>5-<40%) (Minno *et al*., 2010). Coagulation factors VIII and IX deficiency alter the intrinsic pathway of the coagulation cascade, resulting in bleeding tendency. Bleeding episodes may be either life threatening (cerebral) or musculoskeletal (Querol *et al*., 2011; Duncan *et al*., 2010).

Hemarthrosis is the hallmark sign of hemophilia most commonly affecting the knee, ankle, elbow and shoulder joints. Target joint is the joint that has three or more bleeding episodes over a period of 3-6 months and is much more susceptible to subsequent bleeding and arthritic changes (Jansen *et al*., 2008). The knee joint is the largest weight-bearing joint that is subjected to tremendous stresses and strains during activity of daily living and the most frequent site of serious bleeds (45%) (Zaky and Hassan, 2013; Toca-Herrera *et al*., 2008). Despite the reabsorptive properties of the synovium, hemarthrosis tend to persist leading to a vicious circle of bleeding, synovitis and more bleeding. Flexion of the joint becomes a preferable position to avoid pain but later becoming fixed deformity (Rodriguez-Merchan, 2012).

Hemophiliac children have decreased aerobic capacity, decreased ability to involve in higher intensity activities, decreased motor fitness and passive leisure activities compared to their healthy peers as well as significant reduction in muscle strength, anaerobic power, especially in the lower limbs as well as proprioception loss (Meskaite *et al*., 2012; Gruppo *et al*., 2004).

Prophylaxis either on-demand or prophylactic is a method to replace the coagulation factors and so increase the opportunities for participation in physical activities with fewer bleeds. It is important to prevent the patient's deficient factor from falling below 1% of normal. Because children have immature skeleton and it is very sensitive to the complications of hemophilia; severe structural deficiencies may develop quickly. There for the replacement therapy should start as early as possible (Rodriguez-Merchan, 2012; Aledort, 2004).

Russian Current (RC) is Burst-Modulated Alternating Current (BMAC) producing high intensity current, there for it is believed to be more comfortable and effective than pulsed current and evoke muscle contraction as it allows to penetrate the tissues with less discomfort (Maffiuletti *et al*., 2008; Vaz *et al*., 2012; Petrofsky *et al*., 2008). It is considered to be effective in improving the performance of healthy muscles and these results have been accepted in both research studies and in rehabilitation practice (Avramidis *et al*., 2011; Bade *et al*., 2010). RC also has been claimed to relieve pain, increase local blood flow, strengthen muscles, cause muscle hypertrophy and facilitate muscle contraction (Petterson *et al*., 2009).

There are no previous studies regarding the effect of using RC in hemophilic children. So, the purpose of this work was to study the alteration of muscle function and mobility after Russian current stimulation in children with knee hemarthrosis.

MATERIALS AND METHODS

Study design: This study was a randomized controlled trial, performed over the period from July 2014 to September 2014 at the outpatient clinic of Faculty of Physical Therapy, Cairo University, Egypt.

Forty volunteer hemophilic male children participated in this study. They were selected from the outpatient clinic, faculty of Physical Therapy, Cairo University Cairo University. The Mean±SD age, weight and height were 13.83±1.11 vs 13.77±1.1 years, 59.78±6.85 vs. 62.5±8.33 kg and 162.78±5.76 vs. 159±5.72 cm for control vs study group. All participants' parents signed an agreement of the Ethical Committee of the faculty of Physical Therapy before starting the study. The children were selected according to the following criteria:

Inclusion criteria:

- Their ages ranged from 12-16 years
- They were diagnosed as moderate hemophilia
- Children with unilateral knee hemarthrosis

- The joint problems (pain and bleeding) ranged from mild to moderate according to the classification of hemophilia recommended by the Orthopedic Advisory Committee of the World Federation of hemophilia (Holdredge and Cotta, 1989)
- All the participants accepted to receive prophylactic treatment

Exclusion criteria:

- Children with advanced radiographic changes including (bone destruction, bony ankylosis, knee joint subluxation or epiphyseal fracture)
- Congenital or acquired skeletal deformities in both lower limbs were excluded
- Patients who had acute joint and muscle bleeds during treatment time were excluded
- Participants who had surgical procedures performed 6 weeks prior to or during the exercise program
- Participation in any other form of rehabilitation exercises during

Design: The children were divided randomly in to two groups in equal numbers, 20 children each.

- **Control group:** Received a selected physical therapy program including (stretching and strengthening exercises, gait training)
- **Study group:** Received Russian current stimulation for 20 min in addition to the selected physical therapy program given to the control group
- **Two groups:** Received the intervention for 3 days week^{-1}, for 8 successive weeks

Instrumentations for evaluation:

- **Clinical data:** Including age, weight and height were obtained from each participant
- **A universal weight and height scale:** The children's weight and height were determined via a universal weight and height scale
- **Isokinetic dynamometer:** Muscular performance of the quadriceps and hamstring muscles of all children was evaluated by the Biodex Isokinetic Dynamometer (Biodex medical system, Shirley, New York, USA) with 3 pro multi-joint systems. It is available at the faculty of Physical Therapy, Cairo University. The system is provided with a computer (DELL) compatible device that collects, displays, stores the data and controls the movements of the dynamometer, it offers isokinetic, isometric, eccentric and passive modes for all joints of the body. The machine is provided with many attachments and isolation straps to secure the trunk, shoulder, knee and ankle joints. It provides the final results in the form of testing data chart, graph recordings of torque, speed, time, motion, work, power, different ratios and printed results. It is one of the most comprehensive computers driven, that can be used safely in assessment and rehabilitation in children. The participants were tested to measure performance parameters (power and peak torque) of quadriceps and hamstring muscles during the concentric contraction mode at 60 and 120° sec^{-1}
- **Six minute walk test:** It was selected to evaluate functional ability. It is a sub-maximal test of aerobic capacity. It is a useful and safe assessment tool can be used for children with chronic conditions. As well as, it allow assessment of walking ability and baseline cardiovascular function of people with chronic diseases or low levels of fitness (Whaley *et al*., 2006; Hassan *et al*., 2010)

Instrumentations for treatment

- **Therapeutic ultrasound:** Gemma-type pulson 330 BELGIUM MADE was used in this study. The device is a microprocessor controlled unit for continuous and pulsed US therapy. Intensity could be adjusted between 0 and 2 W cm^{-2} and frequency between 1 and 3 MHz
- **Treadmill apparatus (En tread):** The apparatus is 2.4 m long and 1/2 m width. The unit is formed of a belt, two cylinders and an axle along its width. This unit is adjusted for uphill walking (maximum 16 degrees). Parallel bars are attached on vertical beams at each side of the apparatus; its height was adjusted according to each child. The bars are independent of the slope mechanisms and thus remain at the same height and level when the slope is altered
- **Russian current:** Phyaction 787, Neitherlands stimulation unit was used with carrier wave frequency 2,500 Hz, modulated at 50 bursts sec^{-1} and a pulse duration of 200 μs (10/50/10 protocol meaning that 10 on, 50 sec^{-1} off and 20 stimulation cycles with burst modulation current at 50 Hz) (Abdel-Aziem and Ahmed, 2012)

Procedures for evaluation

Biodex isokinetic dynamometer: The evaluation was conducted for each child before starting and after termination of the treatment, two successive months. The Biodex Isokinetic Dynamometer (Biodex Medical System, Shirley, N Y) was used to evaluate power and peak torque of hamstrings and quadriceps muscles of the affected limb during concentric mode at two different velocities (60 and 120° sec^{-1}). Straps over chest, waist and the thigh were used to guarantee comfortable setting position for every child with proper support. The range of motion was set at 0-90° of knee flexion with allowing rest between speeds for 2 min. Warming up exercises for 5 min is necessary before starting testing protocol. Familiarization was conducted before the testing protocol using 5 repetitions at 120° sec^{-1}, then testing protocol was conducted form slowly to fast speed: 60 then 120° sec^{-1}.

Functional walking was determined by 6 MWT: Participants of both groups were allowed to walk on a 20 m unobstructed, rectangular pathway following the guidelines of the American Thoracic Society. The therapist followed him closely with a stopwatch in order to ensure safety and to measure the exact distance walked in 6 min. They were instructed to cover as many laps of the course as possible in 6 min without running. A chair was placed each 5 m distance in case of the child can no longer precede the test (Burr *et al*., 2011; ATS., 2002).

Procedures for treatment: The control group received a designed exercise program for 60 min; it was conducted three days/week for 8 successive weeks in the form of strengthening exercises, stretching exercises and gait training.

Treadmill training: The procedure and goals of exercise were explained to the child before starting training on treadmill. The participants were asked to firmly grasp the parallel bars of the treadmill by both hands, he was instructed to look forward and don't look downward on his feet during walking as this may cause falling. They were instructed to wear comfortable shoes. They were allowed to perform warming up for 5 min with a speed of 1.5 km h^{-1} and 0° of inclination. At the end of the session the participants were asked to walk on treadmill for another 5 min for cooling down.

Therapeutic ultrasonic: The US was applied on the affected joint while the participant was in comfortable long sitting position. A small cushion was placed under the knee joint to achieve a relaxed comfortable position. The frequency of 1 MHZ was adjusted with a pulsed mode and intensity of 1.5 W cm^{-2}. Adequate amount of aqua sonic-gel was applied on clean skin around the knee joint. The ultrasound head was moved in a series of over lapping circles, transverse and longitudinal directions around the knee joint for 10 min.

Stretching exercises: In order to maintain length and elastic recoil of all soft tissue liable to be tight, stretching exercises protocol was prescribed to the participants of both groups. A comfortable position with adequate padding under the bony prominence to avoid laceration was guaranteed. Firm and comfortable grasp was applied proximal to the joint to firmly stabilize the proximal segment and distal to the joint to move the distal segment meanwhile gentle traction force was applied to the moving joint in order to avoid joint damage. To avoid post exercise soreness time for rest between sessions was allowed. Stretching was applied for 30 sec followed 30 sec rest and repeated 5 times/day and four times/week (Carolyn and Lynn, 2007).

Strengthening exercises for 30 min: Static lower limb exercises. Static quadriceps contraction sets (each set with 10 repetitions) was be performed five times initially as tolerated, two to three times per day (Jesudason and Stiller, 2002).

Straight-leg raise exercise: The sound leg was flexed for 90° at the knee joint; the affected lower limb is straight on the table, then the patient was asked to raise the affected lower limb straight to the level of the other leg. The exercises were performed in sets and repeated according to the participant tolerance (Vad *et al*., 2002).

Active strengthening exercises: Sit-to-stand from different seat heights, lateral step-up and half knee-rise were described for each patient to perform in sets. Each child was instructed performed five times initially, building up to 10 repetitions as tolerated (10 repetitions with 3 sets). The patients were instructed to perform each movement as slow as they could with 30 sec rest between each position two to three times per day (Eid *et al*., 2014).

The study group received the same program as the control group in addition to a designed protocol (10/50/10 protocol) of Russian current stimulation this is 10 sec on, 50 sec off and 10 stimulation cycles with burst modulation current at 50 Hz for 20 min for quadriceps femoris then the hamstrings . Two self-adhesive electrodes, 5×13 cm were placed on the participant's thigh: one electrode approximately 10 cm below the anterosuperior iliac spine in the proximal region of the quadriceps and the other over the distal portion of the quadriceps femoris, about 5 cm above the suprapatellar line, over the belly of the vastus medialis obliques muscle (Abdel-Aziem and Ahmed, 2012). The electrodes were then placed over the back of the thigh one electrode just below the glutei and the other one placed inferior just above the popliteal fossa. At each training session, the amplitude of current used was the maximum each participant could tolerate. All patients conducted their treatment program without any complications.

Statistical analysis: T test was conducted for comparing subject characteristics between both groups. Three-way mixed MNOVA was conducted to compare mean values of peak torque and power of knee flexors and extensors between study and control groups across two time periods (pre treatment and post treatment) and two velocities (60-120° sec^{-1}). Two-way mixed ANOVA was conducted to compare mean values of 6MWT between study and control groups across two time periods (pre treatment and post treatment). The level of significance for all statistical tests was set at $p<0.05$. All statistical tests were performed through the Statistical Package for Social Studies (SPSS) version 19 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

A- Subject characteristics: Table 1, showed the Mean±SD age, weight and height of the study and control groups. There was no significant difference between both groups in the mean age, weight and height ($p>0.05$).

B- Isokinetic variables

Peak torque of knee flexors: Table 2, showed that , there was no significant difference between both groups in knee flexors peak torque pre treatment at both velocities ($p>0.05$), while there was a significant increase in knee flexors peak torque post treatment in study group compared with control at both velocities ($p<0.01$).

There was a significant increase in knee flexors peak torque post treatment in the study group at both velocities compared with pre treatment ($p = 0.0001$) (Table 3).

Table 4 showed that, there was a significant increase in knee flexors peak torque post treatment in the control group at 120° sec^{-1} compared with pre treatment ($p = 0.03$) and non significant difference at 60° sec^{-1} ($p = 0.15$). There was a significant increase in knee flexors peak torque at 60° sec^{-1} compared to 120° sec^{-1} in both groups at pre and post treatment ($p<0.05$).

Table 1: t-test for comparison of mean age, weight and height between study and control groups

	Mean±SD				
Parameters	Study group	Control group	MD	t-value	p-value
Age (years)	13.77±1.1	13.83±1.11	-0.06	-0.16	0.86*
Weight (kg)	48.86±4.5	49.11±3.95	-0.25	-0.18	0.85*
Height (cm)	145.73±6.5	136.93±29.24	8.80	1.31	0.19*

Mean±SD: Mean standard deviation, MD: Mean difference, t-value: Unpaired t-value, p-value: Probability value, *: Non significant

Table 2: Comparison between study and control groups pre and post treatment

	Mean±SD			
Treatments	Study group	Control group	MD	p-value
Pre treatments				
Flexors peak torque at 60° sec^{-1}	24.35±8.00	23.91±8.37	0.44	0.8600*
Flexors peak torque at 120 sec^{-1}	19.35±7.36	19.45±7.86	-0.10	0.9600*
Extensors peak torque at 60° sec^{-1}	33.63±7.81	33.60±8.11	0.03	0.9900*
Extensors peak torque at 120° sec^{-1}	29.63±7.99	29.51±8.29	0.12	0.9600*
Flexors power at 60° sec^{-1}	5.54±0.48	5.39±0.53	0.15	0.3400*
Flexors power at 120 sec^{-1}	7.50±0.60	7.49±0.82	0.01	0.9600*
Extensors power at 60° sec^{-1}	16.53±1.46	15.68±1.78	0.85	0.100*
Extensors power at 120° sec^{-1}	20.93±1.38	20.20±1.45	0.73	0.1100*
6 MWT	276.38±22.27	273.46±21.13	2.92	0.6700*
Post treatment				
Flexors peak torque at 60° sec^{-1}	41.28±7.01	25.84±8.26	15.44	0.0001**
Flexors peak torque at 120° sec^{-1}	30.41±9.74	22.13±8.4	8.20	0.0070**
Extensors peak torque at 60° sec^{-1}	42.80±7.07	34.59±7.67	8.21	0.0010**
Extensors peak torque at 120° sec^{-1}	37.85±8.66	32.25±8.32	5.60	0.0400**
Flexors power at 60° sec^{-1}	12.20±1.02	8.58±0.76	3.62	0.0001**
Flexors power at 120° sec^{-1}	15.46±1.56	12.51±1.46	2.95	0.0001**
Extensors power at 60° sec^{-1}	23.46±1.68	20.41±1.82	3.05	0.0001**
Extensors power at 60° sec^{-1}	30.15±1.41	24.60±1.96	5.55	0.0001**
6 MWT	297.77±30.82	292.91±22.35	4.85	0.5700*

Mean±SD: Mean standard deviation, MD: Mean difference, p-value: Level of significance, *Non significant, **Significant, 6MWT: Six minute walk test

Table 3: Comparison between pre and post treatment in study and control groups

Groups	Mean±SD Pre treatment	Post treatment	MD	Change (%)	p-value
Study group					
Flexors peak torque at 60° sec^{-1}	24.35±8.00	41.28±7.01	-16.93	69.52	0.0001**
Flexors peak torque at 120° sec^{-1}	19.35±7.36	30.41±9.74	-11.06	57.15	0.0001**
Extensors peak torque at 60° sec^{-1}	33.63±7.81	42.80±7.07	-9.17	27.26	0.0001**
Extensors peak torque at 120° sec^{-1}	29.63±7.99	37.85±8.66	-8.22	27.74	0.0001**
Flexors power at 60° sec^{-1}	5.54±0.48	12.20±1.02	-6.66	120.21	0.0001**
Flexors power at 120° sec^{-1}	7.50±0.60	15.46±1.56	-7.96	106.13	0.0001**
Extensors power at 60° sec^{-1}	16.53±1.46	23.46±1.68	-6.93	41.92	0.0001**
Extensors power at 120° sec^{-1}	20.93±1.38	30.15±1.41	-9.22	44.05	0.0001**
6 MWT	276.38±22.27	297.77±30.82	-21.39	7.73	0.0001**
Control group					
Flexors peak torque at 60° sec^{-1}	23.91±8.37	25.84±8.26	-1.93	8.07	0.1500*
Flexors peak torque at 120° sec^{-1}	19.45±7.86	22.13±8.4	-2.68	13.77	0.0300**
Extensors peak torque at 60° sec^{-1}	33.60±8.11	34.59±7.67	-0.99	2.94	0.2300*
Extensors peak torque at 120° sec^{-1}	29.51±8.29	32.25±8.32	-2.74	9.28	0.0040**
Flexors power at 60° sec^{-1}	5.39±0.53	8.58±0.76	-3.19	59.18	0.0001**
Flexors power at 120/sec	7.49±0.82	12.51±1.46	-5.02	67.02	0.0001**
Extensors power at 60° sec^{-1}	15.68±1.78	20.41±1.82	-4.73	30.16	0.0001**
Extensors power at 120° sec^{-1}	20.20±1.45	24.60±1.96	-4.40	21.78	0.0001**
6 MWT	273.46±21.13	292.91±22.35	-19.45	7.11	0.0001**

Mean±SD: Mean standard deviation, MD: Mean difference, p-value: Level of significance, *Non significant, **Significant, 6MWT: Six minute walk test

Table 4: Comparison between measurements at 60° sec^{-1} and 120° sec^{-1} in study and control groups

Groups	Mean±SD 60° sec^{-1}	120° sec^{-1}	MD	p-value
Study group				
Flexors peak torque pre treatment	24.35±8.00	19.35±7.36	5.00	0.0001**
Flexors peak torque post treatment	41.28±7.01	30.41±9.74	10.87	0.0001**
Extensors peak torque pre treatment	33.63±7.71	29.63±7.99	4.00	0.0001**
Extensors peak torque post treatment	42.80±7.07	37.85±8.66	4.59	0.0001**
Flexors power pre treatment	5.54±0.48	7.50±0.60	-1.96	0.0001**
Flexors power post treatment	12.20±1.02	15.46±1.56	-3.26	0.0001**
Extensors power pre treatment	16.53±1.46	20.93±1.38	-4.40	0.0001**
Extensors power post treatment	23.46±1.68	30.15±1.41	-6.69	0.0001**
Control group				
Flexors peak torque pre treatment	23.91±8.37	19.45±7.86	4.46	0.0001**
Flexors peak torque post treatment	25.84±8.26	22.13±8.40	3.71	0.0200**
Extensors peak torque pre treatment	33.60±8.11	29.51±8.29	4.09	0.0001**
Extensors peak torque post treatment	34.59±7.67	32.25±8.32	2.34	0.0030**
Flexors power pre treatment	5.39±0.53	7.49±0.82	-2.10	0.0001**
Flexors power post treatment	8.58±0.76	12.51±1.46	-3.93	0.0001**
Extensors power pre treatment	15.68±1.78	20.20±1.45	-4.52	0.0001**
Extensors power post treatment	20.41±1.82	24.60±1.96	-4.19	0.0001**

Mean±SD: Mean standard deviation, MD: Mean difference, p-value: Level of significance, *Non significant, **Significant

Peak torque of knee extensors: There was no significant difference between both groups in knee extensors peak torque pre treatment at both velocities ($p>0.05$), while there was a significant increase in knee extensors peak torque post treatment in study group compared with control at both velocities ($p<0.05$) (Table 2).

There was a significant increase in knee extensors peak torque post treatment in the study group at both velocities compared with pre treatment (p = 0.0001) (Table 3).

Table 4 showed that, there was a significant increase in knee extensors peak torque post treatment in the control group at 120° sec^{-1} compared with pre treatment (p = 0.004) and non significant difference at 60° sec^{-1} (p = 0.23). There was a significant increase in knee extensors peak torque at 60° sec^{-1} compared to 120° sec^{-1} in both groups at pre and post treatment (p = 0.0001).

Power of knee flexors: Table 2 showed that, there was no significant difference between both groups in knee flexors power pre treatment at both velocities ($p>0.05$), while there was a significant increase in knee flexors power post treatment in study group compared with control at both velocities ($p = 0.0001$).

There was a significant increase in knee flexors power post treatment in the study and control groups at both velocities compared with pre treatment ($p = 0.0001$) as it is shown in Table 3.

Table 4 shows that, there was a significant decrease in knee flexors power at $60° sec^{-1}$ compared to $120° sec^{-1}$ in both groups at pre and post treatment ($p = 0.0001$).

Power of knee extensors: There was no significant difference between both groups in knee extensors power pre treatment at both velocities ($p>0.05$), while there was a significant increase in knee extensors power post treatment in study group compared with control at both velocities ($p = 0.0001$) (Table 2).

Table 3 showed that , there was a significant increase in knee extensors power post treatment in the study and control groups at both velocities compared with pre treatment ($p = 0.0001$).

As shown in Table 4, there was a significant decrease in knee extensors power at $60° sec^{-1}$ compared to $120° sec^{-1}$ in both groups at pre and post treatment ($p = 0.0001$).

C- 6MWT: Table 2 showed that, There was a significant increase in 6MWT post treatment in the study and control groups compared with pre treatment ($p = 0.0001$). While there was no significant difference between both groups at pre and post treatment ($p>0.05$) (Table 3).

DISCUSSION

Hemophilia is genetic disorder causing long life consequences including chronic pain, weakness, atrophy, reduced physical activity, recurrent joint, muscle bleeds, low self steam and psychological problems. Muscle mass loss is typical in hemophilic arthropathy. It might be due to long-term immobilization after repeated bleeds, or due to reduced physical activities (Querol *et al*., 2006; Falk *et al*., 2005). Hemophiliacs generate significantly lower levels of force when compared with healthy subjects (Gomis *et al*., 2009).

In the current study, we selected isokinetic test to evaluate the muscle strength before and after 8 weeks of treatment. Muscle peak torque, expressed in Joule (J), is the action of strength over a specific distance or, precisely, the action of torque during the range of motion. A low value indicates that the energy expenditure during the range of motion is not adequate. Muscle power, expressed in Watts (W), represents total work divided by contraction time or, precisely, energy expenditure during a contraction over a certain time which clinically represents the amount of energy that the muscle can waste over a shorter time to generate torque and can be altered due to some muscle functional deficit (Borda *et al*., 2012).

The aim of this work was to study the alteration of muscle function and mobility after Russian current stimulation in children with knee hemarthrosis. After the 8 weeks rehabilitation period, the participants showed a significant increase of isokinetic parameters (power and peak torque) and in 6 min walking test results.

The findings of our work showed that RC was effective in increasing the strength of quadriceps and hamstrings muscle and moreover, it showed a significant improvement in functional ability in hemophilic children. There was no previous studies examined the effect of RC stimulation muscle performance and functional ability in children with hemophilia.

Our results were coincident with the findings of previous studies which revealed that NMES is a method to restore normal muscle function more effectively than voluntary exercise alone (Avramidis *et al*., 2011; Stevens-Lapsley *et al*., 2012a, b).

It is strongly supported that, the NMES induced contraction intensity correlates positively with strength gain, as well as it is believed to enhance the sensorimotor cortex regions of the brain, such that higher current intensities increased cortical activity. At higher intensity there is significant increase in number of motor units activated and this allow for greater force output (Stevens-Lapsley *et al*., 2012b). It is also believed that, NMES help to recruit deep muscle fibers even at lower training intensities, because the stimulated nerve fibers are distributed throughout the muscle. Short-term electrical stimulation in healthy individuals was found to increased maximal voluntary strength by 12% which was accompanied by neural adaptations (Maffiuletti, 2010). Primary and secondary motor and somatosensory areas of the cortex showed increased MRI activity during sub-threshold peripheral stimulation of the afferent nerves of the hand (Kimberley *et al*., 2004).

Angelopoulos *et al*. (2013) studied the effect of NMES on skeletal muscle microcirculation. They found that, NMES has a positive effect on microcirculation. It increases O_2 uptake in healthy volunteers. These changes seem to be related to the quality of the muscular contractions.

Talbot *et al*. (2003) and Rosemffet *et al*. (2004) reported that, SES is an efficient method to improve muscle strength in patients with chronic pathologic disorders such as osteoarthritis.

Gomis *et al*. (2009) found significant improvement in the maximum isometric force which increased by 4.6% in patients with hemophilic arthropathy after undergoing 24 SES sessions. The study conducted by Abdel-Aziem and Ahmed (2012) also revealed that, RC is an effective way to improve the muscle strength and functional abilities in patients with burn.

The current work showed a significant improvement of functional abilities using 6-MWT test. It is well known that there is strong correlation between maximum walking speed and quadriceps muscle strength (Abdel-Aziem and Ahmed, 2012).

Improvement of 6-MWT can be attributed to the increase in stride length due to improved ROM, endurance, cardiopulmonary efficiency, circulation and muscle strength. These factors allow comfortable and efficient gait. Increased confidence, social well-being, improved body image and decreased fear of movement or injury all are believed to improve functional walking (Mulvany *et al*., 2010).

This study has several limitations. The small number of participants might limit the generalization of the study results. The children who participated in this study were all aged between 12 and 16 years old. Further studies are recommended to target different ages to enable comparisons of the results across different age groups. The total amount of training time that the two groups received was also different. This is because all children received the same amount of a designed rehabilitation exercise program while, the children the study group received additional time for Russian current stimulation. This might, account for the differences between the two groups. During the study, the children attended three sessions each week. Such a schedule was determined based on the assumption that outpatients would be less inclined to attend more frequent sessions. This limits the generalization of our results to intervention programs that have a different schedule, such as four times a week or even once a day. Future investigations should compare the effectiveness of different treatment schedules as well as the mechanisms underlying the effect. The lack of follow-up for the children in both groups might be considered another limitation of the study. We suggest that future studies control these potential sources of bias.

CONCLUSION

The changes that took place as a result of our treatment using RC may help reduce the very marked muscle atrophy that limits and often prevents hemophiliacs from performing activities of daily living, improving strength and mobility.

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