Original Article

Comparison between Russian and Aussie currents in the grip strength and thickness muscles of the non-dominant hand: A double-blind, prospective, randomized-controlled study

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ABSTRACT

Objectives: This study aims to compare the Russian and Aussie currents in the force gain and hypertrophy of the forearm muscles responsible for the grip.

Patients and methods: This double-blind, prospective, randomized-controlled study included a total of 30 healthy women (mean age: 20.2±1.7 years; range, 18 to 25 years) between May 2018 and July 2018. The participants were randomly divided into three groups: control group (CG, n=10), Aussie current group (ACG, n=10), and Russian current group (RCG, n=10). All three groups underwent a force test with a gripping dynamometer and the collection of images of the superficial and deep flexor muscles of the fingers with diagnostic ultrasound. The CG received a fictious current stimulus, while the other two groups received the designated stimuli from their currents. Further evaluations were performed after 24 h of the 12th application of the current.

Results: For grip, there were no significant differences in the moment of evaluation and interaction, while the effect size yielded certain points to advantages of force gain for the group using the RCG. The thickness of the superficial muscles showed a significant difference for the first evaluation between CG and RCG (p=0.014) and between RCG and ACG (p=0.010), indicating a larger effect size for RCG.

Conclusion: Our study results show that the Russian current is proven to be the mode which yields the most optimal results.

Keywords: Electric stimulation therapy, muscle strength dynamometer, skeletal muscle.

Neuromuscular electrical stimulation has served in a variety of tasks such as in improving muscle strength, increasing range of motion, reducing edema, decreasing muscle atrophy, tissue repair, and reducing pain. However, important limitations of the technique are reduced efficiency overall, compared to the voluntary contraction, and the development of neuromuscular fatigue. The way of delivering the current can be altered to decrease fatigue and optimize the force. To date, several variations have been used such as different frequencies, duration and pulse characteristic, cycle, intensity, ramp time, and duration and program frequency.[1,2]

The use of alternating mid-frequency or kilohertz (kHz) currents has increased in recent years owing to clinical beliefs about its comfort and greater effectiveness compared to low-frequency currents.[3] Given the inverse proportional relationship between current frequency and skin impedance, which functions as a capacitive barrier, the kHz currents present a characteristic of greater depth, which can be very useful when it is aimed at stimulating motor

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nerves, which are located more deeply, yet the evidence is still fragile.[4] The Russian current gained popularity by reports of Kots[5] with gain of strength in athletes, features as 2,500 Hz base frequencies, with bursts of 50 Hz and 50% full cycle. However, later studies have pointed out that higher torque can be generated with a new current, known as the Aussie current, with a base frequency of 1,000 Hz, and shorter burst duration, such as 2 and 4 ms, as being less unpleasant.[2,3,5]

For a change in the strength characteristics of the skeletal muscle, aiming at gaining, two adaptations may occur: neural and morphological. Neural adaptations are in charge of the activation ability of the muscle, with greater efficiency in the recruitment of fibers, reduction of the action of the antagonists and greater neural activation. Morphological adaptations are in charge of the increase of the transverse area of muscle.[6] Assuming that an electrical stimulation can generate the contraction maintained and, in this way, both neural adaptation and muscle hypertrophy, in the present study, we aimed to compare the medium frequency currents, Aussie and Russian, in the gain of strength and hypertrophy of the flexor muscles responsible directly for the grip.

PATIENTS AND METHODS

In this double-blind, prospective, randomized-controlled study, 30 healthy women (mean age: 20.2±1.7 years; range, 18 to 25 years) who were selected for convenience via direct invitation to the Physical Rehabilitation Center of the Universidade Estadual do Oeste do Paraná (Unioeste, Brazil) were included. *Inclusion criteria were as follows:* age between 18 and 30 years, being female, and no practicing regular physical activities. *Exclusion criteria were as follows:* a history of previous musculoskeletal dysfunction, acute inflammation in the application site to be investigated, metallic materials implanted in the application site, pregnancy, and having cardiopathy. The participants were randomly divided into three groups using opaque envelopes: control group (CG, n=10), Aussie current group (ACG, n=10), and Russian current group (RCG, n=10). All three groups underwent a force test with manual dynamometer and an image collection of the superficial and deep fingers flexor muscles with ultrasound, always in the non-dominant limb, to standardize procedures. The data were collected by a single assessor at all time points who was blind to group allocation. A written informed consent was obtained from each participant. The study protocol was approved by the Universidade Estadual

do Oeste do Paraná Ethics Committee (050898/2018). The study was registered in the Brazilian Registry of Clinical Trials (RBR-9GH6JS) and was conducted in accordance with the principles of the Declaration of Helsinki.

Intervention

To evaluate the thickness of the superficial and deep flexor muscles of the fingers, an ultrasound (Shimadzu SDU 450×l, Columbia, USA) was used with a 5-cm linear matrix transducer, 5 ~ 10 MHz, always kept at 90° with the skin of the volunteer. To determine the site of application of the diagnostic ultrasound, a tape measure was used on the anterior surface of the non-dominant forearm, measuring from the line between the epicondyles to the wrist joint and evaluating the middle region of the segment on the volar face, aiming to reduce influences of distinct points of the muscles.[7] For the collected images, the Kinovea version 0.7.10 software (Kinovea, France) was used to measure muscle cross-section.

Subsequently, the hand grip test was performed with a commercially available analog dynamometer (North Coast Medical Inc., CA, USA) with a scale in pounds per square centimeter (l/cm^2). The volunteers were seated in a chair, with their hips and knees at 90° of flexion, with feet flat on the floor; the upper limbs were positioned with the shoulder in adduction; elbow at 90° and neutral with respect to pronation-supination. Each volunteer was submitted to a period of adaptation to the dynamometer, with three repetitions maintained for 5 sec. After this period, the volunteer performed three contractions sustained for 5 sec, with 30-sec resting between each contraction. The display of the dynamometer was turned to the evaluator and requested that the volunteer remained in contraction for 5 sec, and used the evaluations mean (EV1)[8] always with verbal encouragement.

The CG was given a fictitious current stimulus, while the other two groups received effective stimulation. The ACG with a base frequency of 1 kHz, modulated at 50 Hz, and the RCG with a base frequency of 2.5 kHz, also modulated at 50 Hz. The currents had a rise time of 1 sec, maintained 8 sec, decreased 1 sec, rested for 10 sec, thus totaling 20 sec per contraction, generating three contractions per min and 30 contractions per session. 2×4-cm silicone rubber electrodes were used, and both positioned on the volar face of the forearm, the proximal was filled into the meatus region of the superficial and deep flexor muscles of the fingers and the distal in the

TABLE 1
Mean grip strength of the groups in both evaluation time points with effect sizes

Grip strength (1/cm²)	EV1	EV2	ES
	Mean±SD	Mean±SD	p
CG	6.6±1.3	6.5±1.9	0.06
RCG	5.8±0.9	6.5±1.0	0.74
ACG	7.6±1.9	8.3±2.2	0.38

EV: Evaluation; ES: Effect size; SD: Standard deviation; CG: Control Group; RCG: Russian Current Group; ACG: Aussie Current Group; For grip there were no significant differences according to the evaluation moment (F(1, 27)=3.7, p=0.66), but there was a difference in relation to the groups (F(2, 27)=4.3, p=0.025; RCG and ACG at the first evaluation) for the interaction, again there were no significant differences (F(2, 27)=1.1, p=0.338).

tendinous region of these. The sessions took four weeks, often three times a week. After 24 h of the 12th application of the designated current, a reassessment occurred with the mentioned instruments (EV2).

Statistical analysis

Statistical analysis was performed using the program BioEstat version 5.0[9] and IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. For the sample size, data from grip strength were used, a difference between the means of 1.0, standard deviation of 0.7 and power of 80% was taken into consideration, for 10 individuals per group. Data distribution was analyzed with the Shapiro-Wilks test. The comparison was performed with two-way mixed analysis of variance (ANOVA) (post-hoc of Šidák) and Pearson's correlation analysis was performed to evaluate any relationship between

the force and thickness according to the moment of evaluation, considering 0-0.3 negligible correlation; 0.3-0.5 weak; 0.5-0.7 moderate; 0.7-0.9 strong; and >0.9 very strong.[10] The effect size analysis of Cohen was also carried out according to the following classification: <0.2 trivial; 0.2-0.5 small; 0.5-0.8 moderate; and >0.8 large. A p value of <0.05 was considered statistically significant.

RESULTS

Of all participants included in the study, the mean height was 1.66±0.06 m, the mean body weight was 62.47±9.92 kg, and the mean body mass index (BMI) was 22.67±3.38 kg/m². All groups were matched for age and BMI values. There were no significant differences in the evaluation and interaction time points. The effect size was trivial for CG, small for ACG, and moderate for RCG (Table 1). This yielded certain advantages of force gain for the group using Russian current. However, due to even without a significant difference, the initial data for the electrostimulated groups were discrepant and due to the lower absolute values, the possibility of gain was greater for the RCG.

For grip, there were no significant differences according to the evaluation time point (F(1, 27)=3.7, p=0.66); however, there was a significant difference among the groups (F(2, 27)=4.3, p=0.025; RCG and ACG at the first evaluation) for the interaction, again there were no significant differences (F(2, 27)=1.1, p=0.338).

The thickness of the superficial muscles showed a significant difference for the first evaluation between CG and RCG (p=0.014) and between RCG and ACG (p=0.010). For the subsequent evaluation,

TABLE 2
Mean muscle thickness of the groups in both evaluation time points with effect sizes

	EV1	EV2	Muscle thickness (cm)
	Mean±SD	Mean±SD	ES
Superficial flexor			
CG	1.6±0.2	1.7±0.4	0.32
RCG	1.3±0.2	1.6±0.2	1.41
ACG	1.7±0.3	1.7±0.3	0.10
Deep flexor			
CG	1.9±0.4	2.0±0.4	0.40
RCG	1.7±0.5	2.0±0.3	0.39
ACG	2.3±0.7	2.3±0.4	-0.04

EV: Evaluation; ES: Effect size; SD: Standard deviation; CG: Control Group; RCG: Russian Current Group; ACG: Aussie Current Group; The thickness of the superficial muscles showed a significant difference in relation to the evaluation time points (F(1, 27)=6.5, p=0.017), but not for groups (F(2, 27)=2.9, p=0.070) and interaction (F(2, 27)=1.1, p=0.361). For the deep flexors, there was no significant difference in relation to the evaluation time points (F(1, 27)=2.6, p=0.120), nor for the interaction (F(2, 27)=1.2, p=0.322), while there were for groups (F(2, 27)=3.5, p=0.043).

TABLE 3
The relationship between grip strength and the muscle thickness in each group and evaluation time points

	CG		RCG		ACG	
	p	r	*p*	r	*p*	r
Superficial flexor						
EV1	0.646	0.166	0.121	0.522	0.830	0.078
EV2	0.390	0.390	0.420	0.288	0.343	0.335
Deep flexor						
EV1	0.202	-0.297	0.297	0.367	0.206	0.437
EV2	0.984	0.007	0.108	0.539	0.085	0.570

CG: Control Group; RCG: Russian Current Group; ACG: Aussie Current Group; EV: Evaluation; ES: Effect size.

however, there was no significant difference. Again, the effect size was larger for RCG. For the deep flexors, there was a significant difference between the RCG and ACG (p=0.047) in the first evaluation (Table 2). The thickness of the superficial muscles showed a significant difference among the evaluation time points (F(1, 27)=6.5, p=0.017), but not for groups (F(2, 27)=2.9, p=0.070) and interaction (F(2, 27)=1.1, p=0.361). For the deep flexors, there was no significant difference in relation to the evaluation time points (F(1, 27)=2.6, p=0.120), nor for the interaction (F(2, 27)=1.2, p=0.322), but there were for groups (F(2,27)=3.5, p=0.043). CG - Control Group; RCG - Russian Current Group; ACG - Aussie Current Group; EV - an evaluation; ES - effect size; SD - standard.

In any of the time points, there was no significant correlation between the strength and thickness of the flexor muscles (p>0.05) (Table 3).

DISCUSSION

Neuromuscular electrical stimulation has been extensively used in the field of rehabilitation and sport from restoration and prevention of atrophy to reeducation and muscle strengthening.[11,12] The present study attempted to investigate the effects of two forms of kHz currents on the force gain and thickness in essential muscles to manual grip, which was the superficial and deep flexors of the fingers. Muscle strength gain, as well as trophic gain, albeit discreet, were observed mainly related to the Russian current.

The kHz currents have gained prominence and expanded their use in clinical and laboratory environments, despite many controversies about their actual results.[2,13,14] In the study by Dantas et al.,[15] the authors compared Russian versus Aussie current, as well as two other low frequency currents, with 200 or 500 μs phase duration. They observed lower torque with the Russian current compared to the other modalities, as a percentage of the maximum voluntary contraction, but without differences in the discomfort levels. Similar results were obtained by Ward et al.,[5] but both Aussie and Russian had lower levels of discomfort compared to low frequency currents. Medeiros et al.[16] also compared 1 and 4 kHz, with two low frequency currents, with similarities in phase duration, and observed that they presented similar levels of induced torque and discomfort.

The majority of studies comparing such current forms seek to analyze the torque obtained and comfort of stimulation,[17] different from the present study which aimed to confirm changes in isometric strength, as well as morphological characteristics (muscle thickness). There were significant differences with the therapies adopted, although there were no significant differences for the interaction, and there were differences between the groups, and the effect size was in favor of the Russian current group. It should be taken into account that, although no volunteers had any orthopedic alterations prior to electrostimulation, the RCG values were lower in the initial evaluation than in the other groups; therefore, the potential gain was higher for this group, which is one of the limitations of the present study. However, there were significant gains which can be explained by the use of vigorous contractions being performed by the volunteers with potential for muscle strength gain,[18] by the productions of neural adaptations, resulting in an increase in efferent discharge,[19] by an increase in the afferent neural input,[20] and in the excitability of the motor cortex.[21]

The evaluation methods used are simple but reliable. The use of manual dynamometers is a

reliable and valid form for quantification of forces,[22] for the grip strength in addition to a direct measure of muscle strength, and is used in several other clinical applications, such as body strength indicator[23] and even the nutritional status of the elderly.[24] It is recommended to carry out at least three evaluations, with a body positioning pattern, using verbal encouragement.[25] Such care was adopted in the evaluations carried out in this study, using the average grip strength of three measures, with a similar position for all volunteers and with verbal encouragement to hold. The use of ultrasound images to assess muscle thickness has gained credibility, as it is related to measurements performed by other more traditional methods such as magnetic nuclear resonance,[26] which provides information regarding muscle thickness with a high reliability.[27] However, further studies using other forms of analysis such as electromyography and isokinetics may provide more information.

The limitations of this study are the relatively small sample size, as well as the absence of more in-depth evaluations such as muscle biopsies, which are suggestions for future studies.

In conclusion, the present study results suggest that, even if discreetly, both currents yield gains in the muscle strength, while the Russian current is able to produce muscular hypertrophy.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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