

Overview

There is a degree of confusion with regards this intervention, mostly caused by there being several 'names' or descriptions for the same intervention.

Essentially, this type of electrical stimulation employs what is referred to as a medium frequency alternating current (in the low kHz range - thousands of cycles a second), which is delivered in a pulsed (or burst or interrupted) output. The pulsing or bursting is at a 'low' frequency, and as a result, nerves will respond. It is primarily employed as a means to generating a motor response, though as will be seen (below), it has also been investigated as an electro-analgesia type intervention.

Russian Stimulation was probably the earliest name for this stimulation type. Several multi-modal stimulation devices include it as one of their options. Burst Mode Alternating Current (BMAC) is a more generic and more recently employed term, which is probably preferable. Aussie Stimulation (see below) is a play on the original Russian Stimulation, and is not especially insightful as a descriptor. BMAC is probably the term that could be used and should persist.

Russian Stimulation - History

The credit for the early work in this field is ascribed to Kotz, based in Russia. There is some difficulty in accessing the papers, and several of the key research findings were not included in the published work. Ward and Shkuratova (2002) have done some work on translating the early Russian language publications and summarising the issues raised. This summary is derived largely from their work, to whom credit is given. If you have an interest in the original work, you are strongly encouraged to access the Ward and Shkuratova (2002) paper. Selkowitz (1989) has also provided a very useful review of the background research.

Both the Ward and Shkuratova (2002) and the Selkowitz (1989) papers are supportive of the basic concept and broadly agree that this intervention has supportive evidence. It is suggested in the Selkowitz review that although there is evidence for an increased muscle force being generated with Russian Stimulation (hereafter RStim), there is little evidence that it is more effective than exercise alone nor was it evidenced that it was better than other forms of stimulation. That is not to say that it was considered ineffective - just that at the time of the review it did not 'outrank' other interventions.

Ward and Shkuratova include in their review, two early papers (Russian) and several papers since which have been published in English.

The 1971 Russian experimentation set out to establish the fundamental principle of this stimulation method. The timing (stimulation/rest/repetitions) protocols were considered as was the issue of treatment frequency. What has become known as the 10/50/10 protocol was identified as being effective (this essentially means stimulating for 10 seconds, leaving a 50 second rest period and repeating this sequence for 10 minutes (i.e. 10 stim/rest cycles) was indeed effective.

The stimulation was found to generate fatigue if delivered for more than 10 seconds (at maximal tolerable intensity). Various interpulse rest phases were tested ranging from 10 through to 50 seconds. Both the 40

and the 50 seconds rest were identified as effective, though some subjects appeared to start to demonstrate fatigue with the 40 seconds rest, hence the 50 second period was subsequently adopted.

Stimulation periods (9 or 19 days) and stimulation daily or alternate days were also considered. concluding that daily stimulation was more effective. The RStim was shown to be more effective than voluntary contraction alone (i.e. with no supportive stimulation).

The mechanism of the increased force generating capacity of the stimulated muscle was attributed to both a short term CNS adaptation and also to an increase in muscle tissue volume (this would be consistent with much of the NMES work carried out more recently).

The second of the two papers (Andrianova et al, 1971) - Kots is a co author - looked at kilohertz sinusoidal stimulation at various frequencies, in continuous and burst mode over the muscle belly and as a means of stimulating the nerve trunk.

The stimulation was applied at a range of 'medium' frequencies (100-500-1000-2500-3000-5000Hz) and it was found that as the stimulating frequency increased, there was a greater comfort for the recipient, and it was therefore (predictably) identified that a greater current could be delivered to the muscle with increased (higher) frequencies.

The researchers concluded that 2500Hz (2.5kHz) was the most effective frequency at which to stimulate muscle tissue (1000Hz or 1kHz was more effective for nerve trunk stimulation), stimulating for a 10 second duration. Using a 2500Hz stimulation at 10milliseconds means that the effective muscle stimulation is at 50Hz.

The continuous vs burst protocols were evaluated (i.e. continuous 2500Hz or 2500Hz burst at 10ms intervals). There was no significant difference in the maximal force generated, but the burst mode generated the same result with less current having been applied (50% less). The recommendation is therefore that the stimulation should be applied with a 2500Hz carrier medium frequency sinusoidal alternating current, burst at 50 Hz (10ms ON : 10ms OFF) at a maximum tolerable level.

The resulting stimulation pattern from this work (and one assumes some incidental research which was not reported in these 2 publications!) is :

Base Frequency : 2500Hz (2.5kHz)

Burst @ 50Hz

10ms ON : 10 ms OFF (50% duty cycle)

Stimulation delivered thus for 10 seconds

Rest period of 50 seconds

Repeated 10 cycles

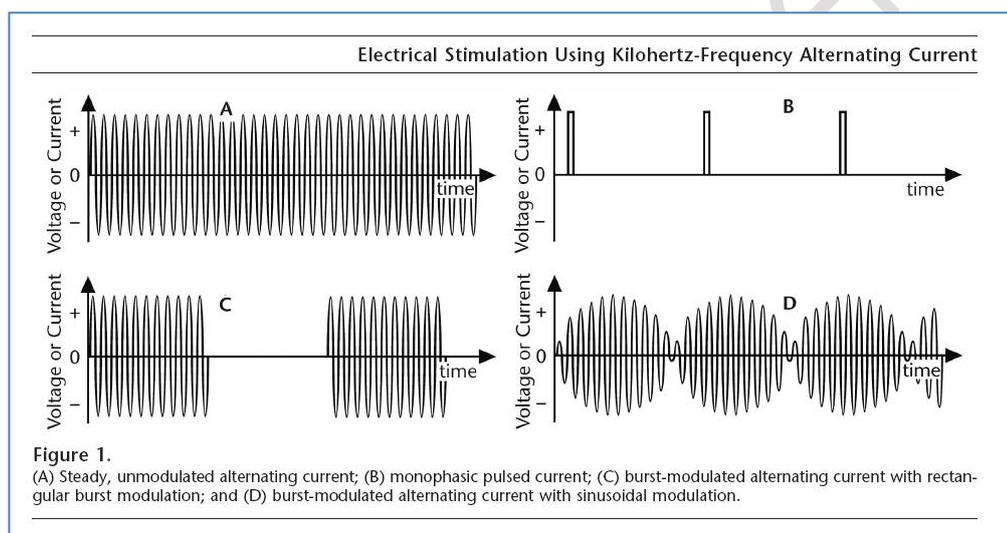
Daily

Maximum tolerable intensity

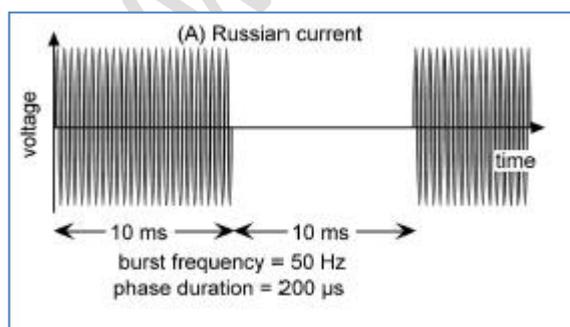
The increases in force resulting from these protocols varied between about 30 - 56%. For example, in one trial using stimulation for 18 days to the calf, there was an evidenced increase in maximum torque of 45% comparing the initial to the final measurements.

There have been a lot of critical comments made of this work. Clearly, many people have had difficulty in accessing the original papers, though the Ward and Shkuratova (2002) review should assist. There were no placebo inclusion in the work. The volunteers were all young (15-17 yr) very fit and healthy athletes (Olympic hopefuls). This can not therefore automatically be transferred to the clinical realm with any guarantee that it will be as effective on patients. Ward goes on to provide a well considered discussion which should be essential reading for those with an extended interest in this area.

As a final comment on the early work, it is reasonable to conclude that this type of electrical stimulation does result in an increase in muscle force (torque, strength) especially when combined with voluntary exercise. It is argued that at the very least, an individual who is undertaking both the stimulation and a voluntary exercise programme will be participating in a greater amount of work, thus the results might reasonably be expected to be better. It is also suggested that whilst the RStim component probably has a greater effect on the Type II (fast) fibres, the voluntary exercise component may have its dominant effect on the slower (Type I) fibres, thus an improved overall result.



from Ward (2009)



from Ward et al (2006)

The figures above and left (credited to Ward, 2009 and Ward et al, 2006) illustrate the stimulation being applied. In the classic Russian Stimulation, the 2500Hz is modulated (or burst) at 50Hz using 10ms ON and 10ms OFF periods (illustration C in the upper figure).

The Ward and Shkuratova (2002) review also mentions several other reasonably early papers (i.e. before 2002) which have evaluated RStim.

Delitto et al (1989) report a case study in which an elite weightlifter was treated with this stimulation and who made significant strength improvements over and above those obtained from training alone. The trials from Delitto et al (1988); Snyder-Mackler et al (1994 and 1995) employed RStim post ACL surgery. The RStim was compared with voluntary exercise programmes, and significantly higher force gains were made with the RStim protocol. In the 1994 paper, the RStim was compared with an NMES type (home use) protocol. There were significant advantages to the clinic based RStim programme. Snyder-Mackler et al (1989) compared RStim with Interferential Therapy (IFT) and an NMES (muscle stimulation) protocol. The IFT resulted in significantly less muscle force generation in response to the stimulation. The highest average force results were obtained with RStim, but these were not significantly different from those obtained from the NMES stimulation. Finally in this group, the 1988 study from Snyder-Mackler et al compared an electrical stimulation protocol with a voluntary exercise protocol post ACL surgery. The stimulation was at 2500Hz burst at 50Hz (i.e. RStim). Quadriceps and hamstring co-contractions were undertaken (exercise and stim groups) with a 15 second hold/stim followed by 50 seconds rest. The results (gain in strength) obtained with the RStim group were significantly better than those undertaking exercise.

Laufer et al (2001) compared three stimulation modes : 50Hz, modulated from 2.5kHz : 50Hz monophasic NMES : 50Hz biphasic NMES. All subjects (healthy volunteers, not patients) were randomly treated with all stimulation modes. Both the NMES type stimulations generated an advantage over the 2.5kHz stimulation. Interestingly, the biphasic NMES gave the strongest result in this instance. The 2.5kHz AC (effectively RStim) not only generated the weakest muscle force output but also gave rise to a more rapid fatigue response. This was a carefully controlled experiment giving rise to challenging results.

The Selkowitz research includes the paper from 1985 comparing an RStim (only) protocol with voluntary exercise (only) for the quads. The stim was delivered 3 x weekly for 4 weeks and resulted in significant increases in isometric strength compared with the exercise only group. The recent Selkowitz et al (2009) paper comparing a 2500 and a 5000Hz carrier frequency stimulation demonstrated a clear and significant advantage to the use of the 2500Hz stimulation.

In addition to the significant review and experimental work undertaken by Selkowitz (references at the end of this paper), Ward and his team in Australia have probably undertaken the most widely published series of investigations in this area. There is a list of relevant papers in the references at the end of this material. What is included here is a very brief summary of an extensive research programme and literature review material which the reader is strongly encouraged to access and read the originals.

Ward et al have not only conducted a useful series of experimental and review work, but have modified the approach, using a more general term BMAC – Burst Mode Alternating Current to describe this stimulation, and more recently coining the phrase ‘Aussie Stimulation’. The paper span the years 1998 to date, and in fairness to the volume of work undertaken, only the key issues are highlighted here. A full reference list is provided which the reader is strongly encouraged to consult for the details of the research and for the insightful and extensive discussions which are included.

In one of the early papers (Ward and Robertson, 1998) the effect of stimulation carrier frequency was evaluated in terms of sensory, motor and pain thresholds. The main point of the work was to establish the carrier frequency (between 1 and 35kHz) which was able to generate the most effective motor response with the least sensory discomfort. The results indicate that all three thresholds decreased from 1 through to

10kHz, above which they rise again. The most effective motor stimulation carrier frequency with the least sensory stimulation and least pain was at 10kHz which was therefore suggested as being preferable if muscle activity was the priority with minimal discomfort. All stimulation was 'burst' at 50Hz (as with the RStim based stimulation).

An extension to this work is reported (Ward and Robertson, 1998) in which the carrier frequency which generated the greatest torque was considered (range from 1 to 15kHz, all burst at 50Hz). Whilst it has been established that the 10kHz carrier generated the muscle contraction accompanied by the least discomfort, this work showed that using a carrier of 1 kHz resulted in the greatest torque and that carriers of 2 – 4 kHz were probably the best compromise between high torque and discomfort. This work was further refined (Ward and Robertson, 2001) when differing stimulations were compared, and amongst other things, confirmed that carrier frequencies greater than 10kHz are not useful in clinical rehabilitation.

The Ward et al (2006) paper compared torque and discomfort with 4 different types of stimulation – 2 of which were kHz burst at 50Hz (RStim: 2500Hz and Aussie Stim at 1000Hz). The two other currents were NMES type stimulations (one with a 200 microsec pulse duration and 20ms interpulse interval, and the other with a 500 microsec pulse and a 20ms interpulse interval). In short, the RStim generated lower torque than the other three stimulation modes. The RStim and the Aussie Stim generated less discomfort than the NMES (monophasic) pulsed modes. It was suggested that the Aussie Stim was the most effective when both torque production and discomfort were taken into account. The Vaz et al (2012) paper concludes that pulsed current is less uncomfortable than Russian stimulation when eliciting 10% MVIC muscle contraction.

More recent papers from this stable have extended these concepts and evidence further. The Ward and Oliver (2007) paper considers hypoalgesic effects (cold pain threshold), comparing an NMES type stimulation at 50Hz and the 1kHz AC at 50Hz (Aussie Stim – now more properly called BMAC). Both were found to be effective in raising the cold pain threshold, though there was no significant difference between them. Ward and Lucas (2007) evaluated variations of the burst duration with 1 and 4kHz BMAC type stimulation. The shorter duration bursts (2-4 msec) appeared to be more effective and the authors suggest that these are likely to be more effective than either interferential therapy or Russian Stimulation in clinical practice, though this needed to be confirmed with clinical trials. This scenario is evaluated as a great summary and review paper (Ward, 2009). The Bellew et al (2014) paper evaluates BMAC type stimulation using a cross over design demonstrating its capacity to elicit strong contractions, though with greater discomfort than with other medium frequency stimulation, having previously demonstrated (2012) that Interferential and BMAC were advantageous when compared with classic Russian stimulation.

Lastly, Ward et al (2009) compared BMAC and TENS efficacy for experimental cold pain effects. Both generated significant changes, though they were not significantly different from each other. The authors suggest however that as the BMAC stimulation generates less discomfort than the TENS, there may be a clinical advantage to its use. The Ward and Chuen (2009) paper carries out a further evaluation of burst duration effects with BMAC, confirming that the short duration bursts (1-4msec) appear most effective. The point is made once again that this is shorter than the burst durations employed with either interferential therapy or RStim, and thus BMAC should be considered as a clinical option.

Summary :

Various forms of 'medium frequency' (kHz range) electrical stimulation have been advocated for motor stimulation effects, and more recently, for hypoalgesia. Russian Stimulation (at 2500Hz or 2.5 kHz) has been shown to be effective in increasing muscle strength and torque generation. Modification to use different

carrier frequencies has resulted in a variant – BMAC which may become more useful in the clinical environment as it appears to be both more effective and generates less discomfort.

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