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# Neurac – a new treatment method for long-term musculoskeletal pain

**Gitle Kirkesola**,
physiotherapist, specialist in manual therapy,
academic leader Redcord Clinic Lysaker, employed by Redcord AS,
e-mail: gitle.kirkesola@redcord.com

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**Gitle Kirkesola**, physiotherapist, specialist in manual therapy, academic leader Redcord Clinic Lysaker, employed by Redcord AS,
e-mail:
gitle.kirkesola@redcord.com

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**Summary:**

- The effect of current exercise therapy on long-term musculoskeletal pain is generally low and moderate at best. In this paper a new exercise treatment method, Neurac, is described with theoretical background, development, main principles, and documentation.
- Neurac is a treatment method that aims to regain normal functional movement patterns in patients with musculoskeletal disorders by using high levels of neuromuscular stimulation.
- This is an active treatment approach which has four main elements: 1. Body-weight-bearing exercises utilizing the Redcord sling system, 2. Controlled vibration to selected body parts, 3. Gradual increased resistance (workload), 4. No pain or no increase of existing pain.
- In addition, a newly developed vibration apparatus, Redcord Stimula, can be used to enhance neural adaptations.
- The Neurac method also includes testing procedures that evaluate the neuromuscular function of kinetic chains, with an emphasis on the integration of "local" and "global" muscle function.
- Neurac is founded on recent research that supports the use of body-weight- bearing exercises when loading the biomechanical chains. In addition, neuroscience and clinical trials suggest the use of vibration to increase neural drive and to decrease pain.
- The development of the new Neurac method has emerged from the S-E-T concept (Sling Exercise Therapy). The new method uses Redcord Trainer (formerly called TerapiMaster), a clinical workstation and a vibration apparatus.
- Documentation: Systematic clinical observations have shown promising results, but more research is needed to evaluate and further develop the efficacy of the Neurac method as a therapeutic tool.
- **Key Words**: Musculoskeletal pain, Neuromuscular function, Neurac, Redcord, Vibration, Physical therapy modality, Physical therapy specialty.

## Introduction

**"Troubling most and costing the most"**

Musculoskeletal disorders have for decades been the group of non-lethal disorders which are troubling most and costing the most (1). The five most important subgroups according to the "Bone and Joint Decade Report" are: neck problems, back and pelvic problems, joint disorders, osteoporosis, trauma, and soft tissue rheumatism (2). Norwegian studies have shown that about 80 percent of the adult population has made complaints relating to the musculoskeletal system in the previous year (1) and more than 50 percent of the population has experienced back pain. Furthermore, 30-40 percent of the population will have persistent neck problems. Among those over seventy years of age, degenerative joint disease and osteoporosis are the most prevalent causes of chronic illness.

In Norway, the total cost to society is estimated at 47 billion NOK per year. This exceeds the costs of the three other major health areas: cardiovascular disease, cancer and mental health (1). In primary care, there are about two million consultations annually just for back pain. It is estimated that about 20 percent of long-term and recurrent complaints account for about 80 percent of the overall costs.

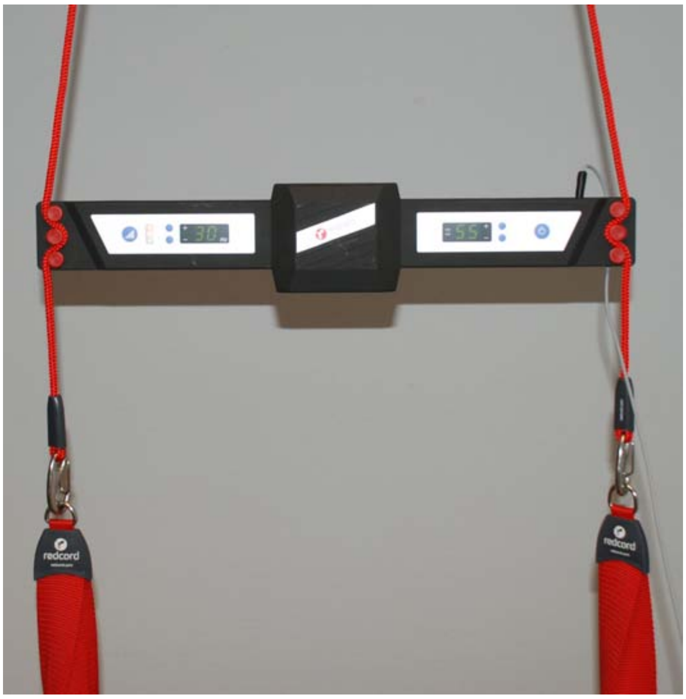

Figure 1: The vibration apparatus Redcord Stimula
Photo: Anita Oland Haugen

### Challenges in rehabilitation

These numbers tell us that we are facing extensive challenges in the field of physical therapy and rehabilitation. Several sources state that current treatment regimens are not sufficiently well documented. There exists very little specific or cause related research that proves any significant clinical effect from existing interventions, and any benefit seen may be just slightly more than measurement errors (3). This applies particularly to patient groups with long-term and non-specific problems, as found in 80 percent of neck and low back patients where the conditions are complex, involving psychosocial and somatic factors with neuromuscular components (3). The group of patients with long-term pain is particularly interesting because long-term pain can lead to considerable changes in both muscular and neural function. There is clearly a need for new and improved diagnostic and treatment methods.

### A new method

A new method called Neurac has been developed by physiotherapists. Neurac is a treatment method involving high levels of neuromuscular stimulation in order to reestablish normal functional movement patterns. The method is used to treat long-term musculoskeletal disorders which have caused pain and/or inactivity. The largest subgroups include patients with neck, back, pelvic, and shoulder disorders.

### Intention of the article

The main purpose of this article is to share thoughts and experiences about the treatment method, in order to help patients with long-term musculoskeletal pain. The article describes the theoretical background, development, main principles, and documentation of the Neurac method.

## Main section

### History

The Redcord Trainer was first introduced in 1991. The device was initially called TrimMaster, later renamed TerapiMaster and now named Redcord Trainer. After some years of developing exercise and treatment regimens, the usage of the apparatus was systematized and described in "Fysioterapeuten" in 2000 as S-E-T (Sling Exercise Therapy) (4).

In 2002 manual perturbation was added to the ropes of the Redcord Trainer, as this seemed to improve the treatment effect for some patients. Three years later the development of a mechanical vibration device was initiated, which could be attached to the ropes in the Redcord Trainer. The theoretical argument for this was that muscle spindles respond better to frequencies higher than those possible to achieve by manual perturbation (5). In addition, it was important to be able to regulate the vibration exposure by adjusting frequency, energy level and duration. It was also important to be able to apply exact settings from previous successful treatments, which is not possible with manual perturbation.

The vibration apparatus, Redcord Stimula, was put into production after two years (2005-2007) of development and testing on a large number of patients and medical conditions. The device was tested on about 800 patients with long-term pain in the neck, shoulder, hip, back, or pelvis. The testing was performed in Norway by seven physiotherapists in four physiotherapy clinics. After treatment with the Neurac method the patients were asked the following question:
*"On a scale from zero to five, where zero is no improvement and five is completely pain free: How has your pain altered from the start of the treatment until today?"*
The registration was carried out to provide a basis for further development of the treatment method and the device. The final version of the apparatus is microprocessor controlled and enables adjustment of vibration frequency, energy level, and duration, and thereby the total vibration exposure (Figure 1).

### The Neurac method

Neurac is a treatment method that aims to regain normal functional movement patterns by using high levels of neuromuscular stimulation.

By *functional movement patterns,* we mean movement performed normally and efficiently, regardless of whether it is a large or small region of the body. For example, the coordinated movement of the scapula and the humerus when the arm is lifted.

The Neurac method is an active rather than passive treatment approach, consisting of exercises or training. Exercises means the particular active movements performed using the Redcord Trainer apparatus. Training means to systematically and progressively expose the body to stress over time, with the aim of improving qualities that are the basis for performance ability (Gjerseth 2006).

The Neurac method has four key elements:
1) Body-weight-bearing exercises in the workstation using the suspen-

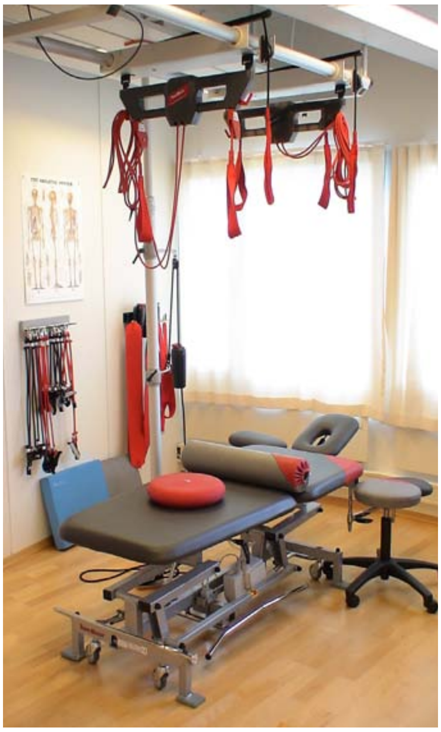

Figure 2: Redcord Workstation with sliding suspension, slings, and treatment table.
Photo Tonje Ruud Camacho

sion and sling system (Figure 2).
2) Manual perturbation or measured vibration (using Redcord Stimula) to selected body areas.
3) Gradual increased resistance (workload).
4) The treatment should not provoke or increase pain.

A regular subjective and objective clinical assessment is performed before treatment with the Neurac method. In addition, a special battery of tests known as "Weak Link testing" is also performed using the sling system in order to assess the body's performance in body-weight-bearing positions.

Figure 3: Test of holding time in neutral position for the cervical spine.
Photo: Rune Stålesen

## Clinical communication

As part of the development and quality control of the Neurac method three clinicians – one with extensive experience, one with moderate and one with limited experience – were observed in the total of 17 consultations at Redcord Clinic Lysaker. The applied method is previously described by Lærum et al in 2006 (6). The results from of the qualitative study is integrated with the four main elements in the US-developed and internationally recognized consulting tool "The four habits model"(7).

This consultation model is now integrated with the Neurac method at the clinic and includes the following:
1. In the beginning of the consultation, focus on establishing trust with the patient.
2. Be patient oriented, assess the patient's expectations, preferences, understanding of the conditioning, anxiety, or "fear avoidance".
3. Show empathy by recognizing the patient's emotions.
4. Explain pain mechanisms, avoid dramatizing, discuss the progress plan and how and why the Neurac method might be an alternative for the patient.

The model embeds Neurac in a bio-psycho-social patient approach.

## The Neurac method: diagnostics

The Neurac method consists of two parts: diagnostics and treatment. The diagnostic part consists of two approaches: Test of isometric "holding time" in the neutral position and "Weak Link testing".

### *Test of holding time in the neutral position*

The test of isometric holding time in the neutral position aims to examine the function of the deep stabilizing (local) muscles in the back and neck.

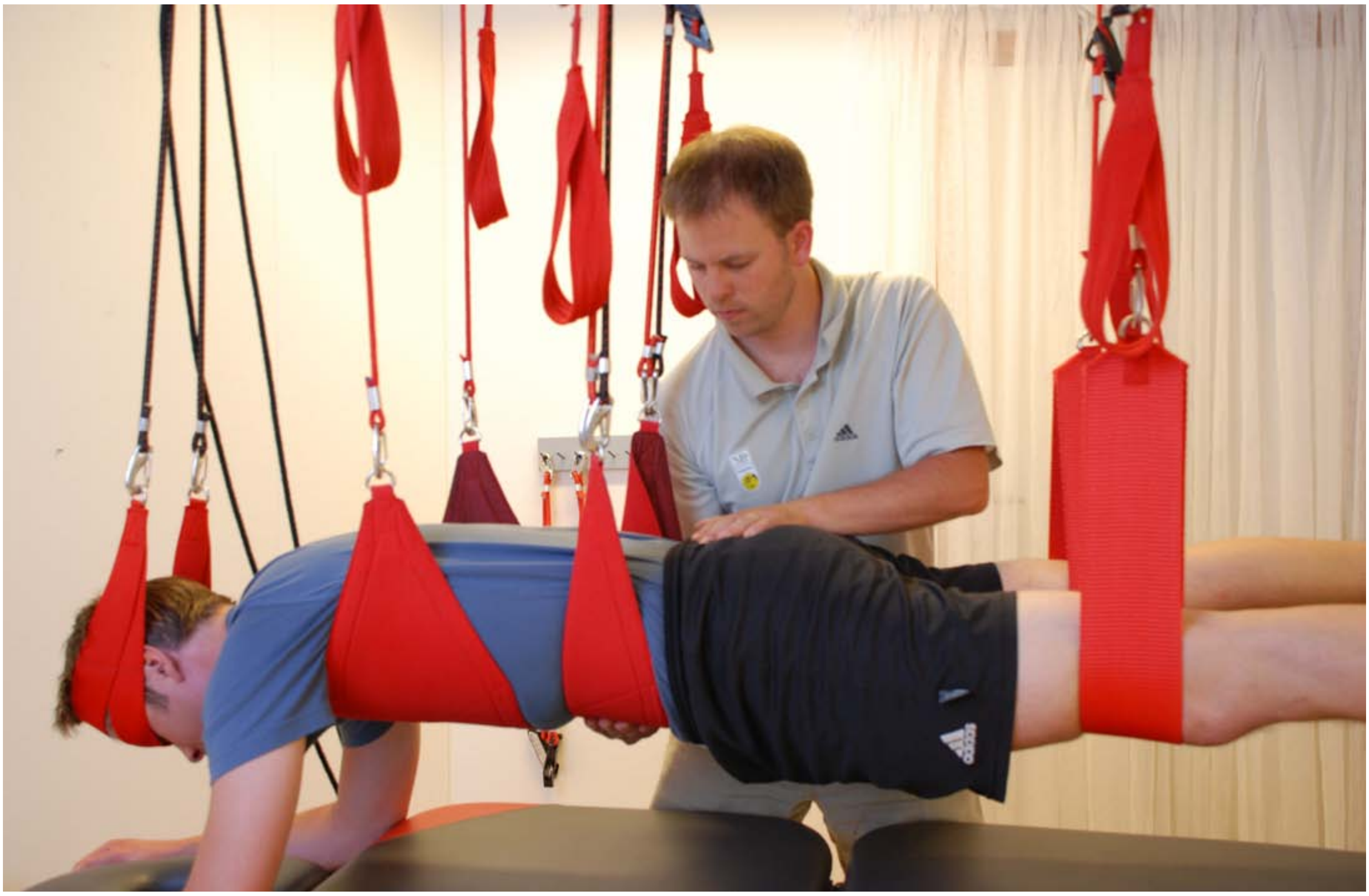


Figure 4: Test of holding time in the neutral position for the lumbar spine. Sling attached with elastic cords is positioned under the abdomen. Photo: Rune Stålesen

For the neck: The cervical spine is positioned in neutral position (normal lordosis) with the head in a sling. The therapist then facilitates a slight reduction of the cervical lordosis, which is maintained isometrically by the patient (figure 3). For the back: The patient is suspended by ropes and slings with the lumbar spine in a neutral position. The therapist then facilitates a slight reduction of the lumbar lordosis, and the position is held isometrically by the patient (figure 4).

The patient gives the therapist two signals: firstly, at the onset of fatigue and again when a rest is required. The therapist registers the time from the start of the test until each of the two signals. At the same time the therapist observes any increased tone in the global muscles of the patient, and the ability of the patient to maintain the desired position. Any changes from the starting position are noted. If fatigue occurs in less than two minutes, there may be impaired function of the deep stabilizing muscles. Testing of "holding time" for the cervical spine and the lumbar spine is normally performed before Weak Link testing is carried out.

*Weak Link testing*
The aim of Weak Link testing is to identify weaknesses in the kinetic chains and to identify impairments in the interplay between the deep stabilizing muscles and the superficial prime movers. In Weak Link testing the body is challenged in different body-weight-bearing positions. The therapist compares the patient's left and right side (figure 5). A Weak Link test is positive if: 1. There is an observable difference in performance between the right and the left side of the body, 2. Pain is provoked, 3. There is impaired performance on both sides compared to an expected level. Point 1 and 3 are clinically evaluated by the therapist.

## The Neurac method: treatment
Treatment with the Neurac method is performed in a workstation with the therapist present. Following the Neurac treatment, sling exercise can be safely performed with or without supervision by the therapist.

If reduced holding time in the neutral position is detected during the test procedure for the cervical or lumbar spine, Neurac treatment may begin in a similar position. The treatment consists of isometric holds, which are repeated as long as: 1.The exercise is performed correctly, 2. Pain is not provoked (or increased), 3. Holding time continues to improve before fatigue sets in 4. Holding time increases before rest is needed. The patient is frequently reassessed using regular active functional tests to see if the treatment has reduced the pain and/ or improved function and quality of movement.

If a Weak Link test is positive, treatment may begin in the position that the test was performed. This treatment consists of dynamic movements rather than static holds, always starting at a level where the patient can successfully perform the exercise in a coordinated and pain free fashion. The patient's own bodyweight can be unloaded if necessary by suspending


Figure 5: Example of a Weak Link test: Supine Pelvic Lift with increasing difficulty. Picture 1 and 2 show how the sling attached with elastic cords under the pelvis unloads bodyweight. The unloading can be gradually reduced to make the exercise more challenging. In picture 3 and 4 the elastic cords have been removed.
Photo: Tonje Ruud Camacho

Figure 6: Side-lying "bridge" performed in a sling.
Photo: Rune Stålesen

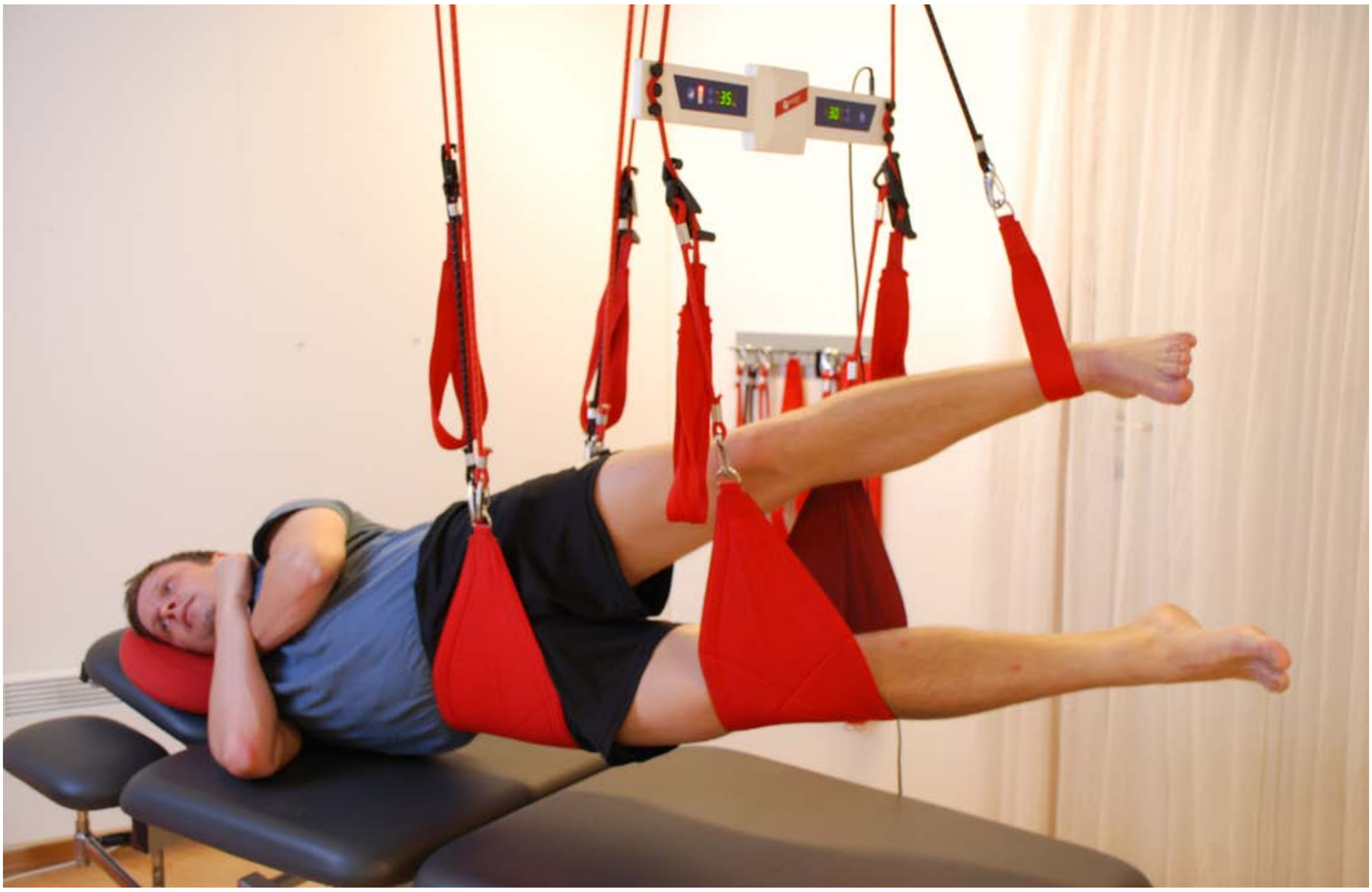

Figure 7: Example of treatment in body-weight-bearing position using vibration. Side-lying hip abduction, with sling under the pelvis attached with elastic cords to reduce bodyweight. The elastic cord support is gradually reduced.
Photo: Rune Stålesen

part of the body in slings supported by elastic cords. The patient then performs 4-6 repetitions followed by 1-2 minutes of rest. The assistance from the elastic cords is gradually reduced, thereby progressively increasing the load. The procedure is repeated as long as: the workload of the exercise can be increased, pain is not provoked, the exercise is performed correctly, or the patient does not feel fatigued or wants to stop. The therapist may manually perturb or shake the ropes to make the exercise more challenging. The patient is reassessed by Weak Link testing as well as functional tests to evaluate the effectiveness of the treatment in reducing pain and/or improving function and quality of movement.

Recently, a three-stage model for Neurac treatment has been developed for the use of the vibration device Redcord Stimula.

*Step 1:*
Static body-weight-bearing exercise with vibration. The patient is positioned in a body-weight-bearing position by the therapist (figure 7). Elastic cords are used to unload bodyweight. Controlled vibration is applied using the vibration device. The exercise is gradually made more difficult by reducing the elastic cord support. The procedure is repeated until improvement in static function has been obtained or the patient fatigues. If pain occurs, the exercise is stopped. An alternative pain free exercise may then be tried, using the same treatment principles.

*Step 2:*
Dynamic body-weight-bearing exercise with vibration. The patient is positioned in the same starting position as in "Step 1" and then performs dynamic movements while vibration is applied. A low number of repetitions (4-6) are performed in each set.

*Step 3:*
As in "Step 2", but without vibration.

After the treatment, the patient is encouraged to participate in an individualized exercise program with a progressive increase in difficulty. The exercise program should be performed three times per week for at least three months. The patient is seen every three to four weeks at the clinic for follow-up and modification of the training program.

## Effects and side effects of Neurac treatment

The workload and the level of unsteadiness involved in the exercises can be accurately progressed from very easy to extremely difficult. Thus, sling exercise can be used by patient groups ranging from very low functional status to top level athletes.

We often experience that the patient can obtain immediate improvements associated with the Neurac treatment. Typical improvements include reduced pain, improved quality of movement, and enhanced function. Signs of improvement are used by the therapist to decide whether the treatment approach should be continued or if another approach should be implemented. Successful treatment with Neurac demands that pain is not provoked. If the patient has chronic pain, the Neurac treatment should not aggravate this pain. Pain and discomfort are normally avoided if the correct Neurac method is followed.

Side effects such as temporary nausea, dizziness or other autonomic responses of the treatment may be experienced in a few cases. This appears more prevalent in patients with long-term neck pain. Systematic investigation into the side effects of treatment with Neurac has not yet been undertaken, but it will be initiated in the future.

## Theoretical background

This section presents knowledge from various literature searches over several years. The references come from empiric scientific studies, which are considered to be valid and reliable. The knowledge is presented because it has influenced the development of the Neurac method to date.

*Kinetic Chains*

The terms "open kinetic chain" and "closed kinetic chain" were first described in 1955 by Steindler, who redefined them again 22 years later (8). He defined open kinetic chain as a type of exercise where the distal part of an extremity is free to move, in contrast to closed kinetic chain where the distal part is fixed. Recently there has been a lot of focus on stable versus unstable surface, weight-bearing versus non-weight-bearing, exercises for single joints versus multiple joints etc. (9-13). There is some confusion about these terms.

Today there is some agreement that the use of the terms open and closed kinetic chains is inappropriate. In several scientific publications researchers disapprove of the use of these terms (14-16).

In physiotherapy and sports there has always been focus on finding exercise regimens that enhance performance and at the same time are gentle to joint structures. Exercises in open kinetic chain have been used for isolated training of single joint muscles (17-18), while exercises in closed kinetic chain have been considered more "functional" because of increased antagonistic muscle co-activation (19). Increased co-activation of synergists and antagonists has been measured in some weight-bearing exercises (20-21). The term "body-weight-bearing exercise" has been used in the Neurac method to describe exercises that encourage co-activation of synergists and antagonists.

*Stability training*

Physiotherapy has a rich tradition of prescribing exercise for patients with disorders of the back and the neck. Twenty years ago, Bergmark described a stabilization model for the lower back where he used the terms "local" (deep) – and "global" (superficial) muscles (22). This model has later been developed and renewed by Mottram and Comerford (23), among others. These classification systems have attracted considerable interest in physiotherapy, and a large number of articles have been published in this field. A lot of focus has been placed on rehabilitation and training of the deep stabilizing muscles, especially m transversus abdominis and the deep portion of m multifidus. Recently, however, specific rehabilitation of such muscles has been criticised (24-25). Several researchers and clinicians, Kibler among others, point out the importance of integrating both deep and superficial muscles to achieve optimal stability (26).

The term "core stability" has now become an everyday expression for most people working with low back rehabilitation. A large number of scientific publications exist in this field, particularly measurement and descriptive studies. However, there is a lack of clinical outcome studies demonstrating high methodological quality. Even today, there is little consensus about what "core stability" really is. Some perceive it as the deep stability provided by muscles close to the joints, while others claim that total activation of deep and superficial muscles is required to achieve sufficient intra-abdominal pressure to provide stability (25).

By using body-weight-bearing exercises, the Neurac method intends to activate both deep and superficial muscles, and to optimize the coordination between them.

It has been documented that compared to healthy subjects, patients with long-term neck disorders have impaired function of the deep cervical muscles (27) and increased fatigue of the superficial muscles (28). In a randomized controlled trial with 56 patients, Falla et al. (2006) showed that m sternocleidomastoideus and mm scalenii got stronger and less fatigued after endurance strength training, compared to specific exercise of the cranio-cervical flexors (29). As a result, they recommended that focus should be placed on treatment and exercises that activate both the deep and the superficial muscles.

At Redcord Clinic Lysaker, Oslo, we have observed using real-time ultrasound that body-weight-bearing exercises performed in a sling suspension system activate local (m transversus abdominis) and global (m obliquus internus and m obliquus externus) muscles in people without back pain. In contrast, patients with long-term back pain have impaired activation of m transversus abdominis when performing the same exercises. In some of these subjects we have seen that body-weight-bearing exercises in sling suspension combined with vibration can result in involuntary activation of m transversus abdominis. Therefore, controlled vibration has become an integrated part of the Neurac method. Our impression is that more patients achieve co-activation of deep and superficial muscles with this approach compared to using non body-weight-bearing exercises. This is supported by subsequent improvements in function and quality of movement, as well as reported pain relief.

*Vibration training*

The first platforms for "Whole Body Vibration" came in the 1990's. Since then there has been an increasing interest for vibration platforms in treatment and training of both patients and healthy individuals. Many studies have been published on the effect of Whole Body Vibration, though with variation in the quality of methodology. For example; a 2007 systematic review of untrained adults and elderly women showed, with moderate to strong evidence, that such exercise may have a positive effect on muscle function in the lower extremities (30). The conclusion was based on 19 studies with acceptable scientific strength. In the same year another systematic review showed none or minimal effect of Whole Body Vibration on muscle strength and jump capacity compared to similar exercise without vibration (31). This review was based on 12 studies of healthy, trained and untrained, male and female subjects.

Another randomized controlled trial involving 22 female ballet dancers showed that Whole Body Vibration exercise was effective. When vibration training was performed before the ballet training, regular ballet training was more efficient than the same training without vibration (32). After eight weeks, the vibration training group showed significantly greater jump height and force production in the lower extremities than the control group. This relates to healthy individuals, but what about patients?

Several individual studies show effect of Whole Body Vibration on patients with different disorders. A randomized controlled trial with 16 hemiplegic patients showed a temporary effect after one single treatment (33). Another randomized controlled trial published in Spine in 2008 used 20 healthy males (34), and showed that eight weeks of absolute bed rest caused atrophy of m multifidus and a lengthened lumbar spine. More interestingly, the study also showed that vibration training reduced atrophy. The subjects who got two daily session of vibration training (each consisting of 5-10 minutes of simulated weight-bearing exercises in bed by pushing the feet against a vibration plate) showed significantly less atrophy of multifidus and less lengthening of the lumbar spine compared to the control group. The latter group did not perform any exercise.

Patients with reduced balance and gait function (63 women and 4 men) performed exercise with or without Whole Body Vibration in a quasi-experimental study (35). The intervention group of 40 individuals showed significant improvement after two months of routine exercise plus vibration training once a week for four minutes. The control group of 27 individuals did only routine exercise without vibration. In addition, another randomized controlled trial which included 20 patients with reconstructed ACLs (36) showed that those who received conventional exercise for proprioception and postural stability combined with Whole Body Vibration got better neuromuscular control than those who only received conventional exercise.

**"We often experience that the patient can obtain immediate improvements associated with the Neurac treatment.**

The explanatory models that are given in the literature for the effects of Whole Body Vibration focus mainly on increased input from muscle spindles to the central nervous system. Muscle activation increases due to "neural adaptations" (37-41). In view of this, the Neurac method now includes a mechanical vibration device (Redcord Stimula). The purpose is to apply vibration to selected body parts during pain free, body-weight-bearing exercises with controlled and adjustable frequency, energy level, and duration.

## Pain and its impact on force and motor control

Recent laboratory studies show that pain has great impact on the ability to generate force. One trial showed that experimental pain reduced force generation measured by maximal voluntary isometric contraction, and that this was caused by central mechanisms. Another similar study showed that the brain reduced the signal output to muscles in a painful area (42). Furthermore, laboratory studies with repeating dynamic high velocity movements have shown that experimentally induced pain changes the central strategies for motor control (43-44).

In a laboratory study, experimental pain was induced to m vastus medialis in healthy individuals. This led to temporary reduced motor control of the knee and instability during gait (45). Other studies on patients with anterior knee pain have showed impaired coordination of motor units in m vastus medialis and m vastus lateralis (46-47). Laboratory studies have also been conducted on patients with long-term back pain. When these patients perform rapid movements of the trunk or an extremity, the activation of local muscles in the low back was delayed compared to healthy individuals (48-51). Similar muscle discoordination was seen in a study with experimentally induced pain (52).

Since it is well documented that both pain and inactivity reduce muscle force and normal activation patterns, we believe that treatment approaches should initially focus on optimizing the latter. The problem is that pain often makes it difficult or impossible to exercise patients to improve strength, power and endurance. However, we often see significant pain reduction after a single Neurac treatment session, especially when applying vibration using the Redcord Stimula. In many cases this enables patients to perform regular exercise immediately after such a treatment, and thereby have the opportunity to improve strength, power and endurance. But how do we explain this?

It has long been known that proprioceptive signals from low threshold mechanoreceptors can block pain signals in the spinal cord and thereafter prevent them from being registered in the brain (53). Particularly important in this context are signals from muscle spindles, which react strongly to vibration stimuli (54-55). The combination of vibration and pain free body-weight-bearing exercises used in the Neurac method may the refore be effective for pain reduction in many patients with long-term disorders.

**Status and need for documentation**

It is acknowledged that there is an urgent need to document the effects of the newly developed Neurac method. Specifically, there is a need for randomized controlled trials for patients with long-term musculoskeletal disorders. Furthermore, there is a need for studies that investigate the underlying mechanisms of this form of treatment and training, both with and without different types of vibration.  There is also a need for cost-benefit studies. A mechanism study on the Neurac method has recently been conducted in Denmark. The study, which is presently under publication, examined the short-term effects of Neurac with vibration treatment on cervical muscle activation and neuromuscular control in women with long-term neck pain.

## Summary and conclusion

It is well documented that long-term musculoskeletal disorders represent the health related problem which "troubles most and costs the most" both in Norway and internationally. Innovative and improved treatment options are therefore needed. Neurac is believed to be a step in the right direction. The method provides high-levels of neuromuscular stimulation with the use of suspension, slings and applied vibration. Clinical experience suggests that this form of neuromuscular stimulation helps to regaining normal function through normalizing movement patterns in patients with musculoskeletal pain. The method has four main elements: 1. Body-weight-bearing exercises in the Redcord workstation using the suspension and sling system, 2. Controlled vibration of selected areas/ body parts, 3. Gradual increased resistance (workload), 4. No pain or no increase of existing pain.

As a part of the treatment with the Neurac method, the patients get individualized exercise programs, which they can eventually perform independently. The purpose is to further develop and maintain improvements over time. The method includes a diagnostic element that tests for weak muscles/muscle groups or impaired coordination between deep stabilizing muscles and superficial prime movers (Weak Links). Clinical experience with the Neurac method tells us that improvements can occur fast, often during the first treatment. Recent literature provides support for the principles of the method, both for treating and training patients as well as top level athletes. However, there is a need for Neurac specific scientific investigation that reaches beyond clinical experience, so that the Neurac method can play a role in the evidence based treatment of patients suffering from long-term musculoskeletal disorders.

**Acknowledgement**

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**Disclosure**

Gitle Kirkesola is employed by Redcord AS, he is a course instructor in the Neurac method, and as the idea maker, he receives a small fee per sold Stimula.

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