Case 8 – I Thought I Was Relaxed

The Use of SEMG Biofeedback for Training Awareness and Control

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“I never realized that I braced my shoulders and held my breath while typing. Now I know the importance of not doing this and have tools to change.” (Secretary in training program, San Francisco State University)

Introduction

Stiffness, tightness, pain or other muscle discomforts and exhaustion are common experiences for many people who work long hours at the computer or for athletes who push their body physically. Muscle discomfort often limits what they would like to do and, as symptom intensity increases, their discomfort tends to interfere with their work or athletic performances. Muscle discomfort is often described as soft-tissue injury. Many people assume that discomfort is the result of aging – you just have to accept it and live with it and you just need to be more careful while doing your job or engaging in sports (Sarkisian, Hays, and Mangione, 2002). More commonly, people experience neck, shoulder, back, leg, arm, and head pain of varying degrees while working at their job or enjoying their hobbies (Buettner et al., 2008; Gerwin, 2001). Muscle pain, known as myofascial pain, is the primary cause for more than 30% of patients who visit their primary physicians with severe pain (Skootsky, Jaeger, and Oye, 1989). For adults the lifetime prevalence of neck pain is 66.7% (Côté, Cassidy, and Carroll, 1998); for adolescents the prevalence of

back, neck and shoulder pain is increasing and in 2002 the prevalence rate for
18 years olds was 45% for girls and 19% for boys (Hakala et al., 2002); while for
employees working at the computer more than 30% experience neck and back pain,
hand and arm pain, tingling and numbness, and exhaustion (Paoli and Merllié, 2001;
Chauhan, 2003). The European Agency for Safety and Health at Work (2007) has
reported that more than 25% of European workers complained of backache. The
largest increase in back pain is seen among computing professionals and technicians.
More than 25% of Europeans experience work-related neck–shoulder pain and 15%
experience work-related arm pain (De Kraker and Blatter, 2005) while more than
90% of college students report some muscular discomfort at the end of the semester
especially if they work on the computer (Peper and Harvey, 2008).

The common treatment strategies for muscle discomfort include heat, medica-
tions (e.g. nonsteroidal anti-inflammatory medication, muscle relaxants, or pain-
killers), massage and touch strategies such as Swedish massage, acupuncture,
Shiatsu, aroma-therapy massage, Alexander technique, Feldenkrais, chiropractic,
Rolfing, Somatics and therapeutic physical therapy manipulations and exercises
(Cram, 2003; van Tulder et al., 2003).

Although these therapeutic approaches are highly beneficial in reducing dis-
comforts, the pain symptoms often return. The return of musculoskeletal pain
symptoms suggests an ongoing dynamic muscle activation pattern, along with
increased sympathetic arousal, that contributes to the development and mainte-
nance of the chronic muscle discomfort. Muscle pain is aggravated by sympathetic
arousal which in turn may lead to trigger-point activation that also increases the
likelihood of referred pain (Gevirtz, 2006; Travell and Simons, 1983).

Lack of Muscle Tension Awareness

People are usually unaware of their muscle tension or autonomic arousal (Shumay
and Peper, 1997; Stein, Schäfer, and Machelska, 2003). This lack of muscle awareness
was recently demonstrated by Thorne et al. (2011) during a simple toe-touching
task, in which about 95% of participants reported feeling relaxed while in fact the
surface electromyographic (SEMG) recordings from their neck and back showed
significant muscle tension.

While muscle tension was recorded from the neck using a band pass filter set at
100–200 Hz, participants were asked to: (a) bend forward as far as possible to touch
their toes, while (b) hanging totally relaxed as possible, (c) returning gently to
standing position; and (d) rate their subjective experience (as shown in Figure 10.1);
92% of the participants were unaware of their muscle tension as shown in Figure 10.1.

Following an initial rating of muscle tension, participants received SEMG
feedback while bending forward and touching their toes until they could successfully
relax their neck and back muscles while hanging down. The training was interactive
and included auditory feedback, as well as tactile and verbal coaching. SEMG
increases were indicated by an increase in auditory pitch and combined with verbal
cues such as “Drop you head, let it hang.” At other times, the practitioner would gently touch or move the head back and forth till the SEMG signal was low. The goal was to achieve success as defined by low SEMG activity while hanging relaxed. After the participants developed mastery of this skill (e.g. low SEMG muscle tension while hanging totally relaxed forward), the initial assessment was repeated without feedback. The results confirmed that mastery had been achieved without feedback as shown in Figure 10.2.

Figure 10.1 Initial assessment of Neck SEMG while performing a toe touch. Note how head is lifted even though the person reports feeling totally relaxed.

Pre-assessment of neck SEMG while performing a toe touch. Note the SEMG is increased even though the person reports being totally relaxed.

Figure 10.2 Toe touch after feedback training. Note the head is hanging down. Post assessment of neck SEMG while performing a toe touch. Note the SEMG is low and the person reports being relaxed.
These findings suggest that simple and brief muscle awareness training is possible with teaching techniques that achieve the targeted goal (Mcphetridge et al., 2011). In this study, all participants learned muscle tension awareness within a few minutes of training and were then able to hang down totally relaxed without any muscle tension. The SEMG feedback and the rapid success evoked an “Aha” experience such as

“I feel much more relaxed and realize now how unaware I was of the tension I’ve been holding unnecessarily.” (J.P.)

“I’m more aware of my neck tension and body movement.” (A.M.)

Clinically Relevant Findings

Clinically, a simple training protocol that illustrates recognizing and releasing covert muscle tension associated with toe touching creates hope. And, hope is a critical ingredient in motivating clients to continue to practices exercises to increase their health. It also generated an “Aha” experience which can be used for reframing illness and health beliefs. Furthermore, clinicians could adapt this protocol for making clients aware of a variety of dysfunctional muscle-tension patterns, and then train the client to develop mastery over their awareness of dysfunctional muscle-tension.

Psychophysiological, the training protocol illustrates that during simple movements such as toe-touching, or work tasks such as typing, people are: (a) generally unaware of excessive increases in muscle tension during the task performance, (b) tighten auxiliary muscles that are not necessary for performing the task (inappropriate co-contractions), (c) do not fully relax task-activated muscles after the task has been completed, and/or (d) do not relax muscles even momentarily during task performance (e.g. lack of surface electromyographic gaps/micro-breaks which prevents ongoing regeneration). These excessive and/or inappropriate efforts have labeled as “dysponesis” by Whatmore and Kohli (1974).

Dysponesis

Dysponesis consists of misplaced and misdirected efforts (from the Greek: dys = bad; ponos = effort, work, or energy). Although dysponesis usually refers to the striated muscular system, the concept includes any nonfunctional efforts, unnecessary work, or activation of physiological system (e.g. cardiovascular, respiratory, endocrine, etc.) that are part of sympathetic arousal and vigilance. Unfortunately, dysponetic activity in both the musculoskeletal and autonomic nervous system is covert, and most people are unaware of unnecessary bracing or tightening, or increases in blood pressure, respiratory or endocrine function while they are engaged in various tasks.

An example of dysponesis can be observed by doing the experiential practice threading a needle described below.
When performing the experiential practice of threading the needle, most people experience dysponetic and covert muscle bracing such as excessive neck, shoulder and trunk muscle tension that were unnecessary for the performance of the task. This bracing occurs when muscles are held tense for a long time period without episodic relaxation breaks (momentary rest periods). It tends to occur frequently as people use more and more small personal communication devices such as iPods, smart-phones, iPads, etc.

Optimum muscle functioning involves alternating between muscle activity and rest. The lack of episodic muscle relaxation to a resting baseline after use is an indicator of dysfunction that can be assessed with the Sella’s muscle tension protocols (Sella, 1995, 2003). In Sella’s (1995, 2003) protocols the person is asked to tighten a muscle for 9 seconds then relax it for 9 seconds, and repeat this five times. If the muscle tension does not return to a resting baseline level, it indicates that the muscle may not regenerate which suggests an etiology for myalgia.

The treatment of this myalgia would include teaching the person to relax the muscle before again tensing the muscle. The diagnostic power of Sella’s (1995, 2003) assessment is illustrated in the example of a 45-year-old female somatic therapist, who was trained in body movement and awareness and volunteered to be assessed. She was asked to raise her shoulders minimally until she became aware of the tension. However, during this task, she was unaware of the co-contraction of her right forearm extensors and the lack of return to the relaxed baseline in the upper right trapezius muscle as shown in Figure 10.3. When inspecting the data, the therapist hypothesized that this could be associated with stiffness and pain in her

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**Experiential practice: Threading the needle (Peper et al., 2008)**

Perform the task so that an observer would think it was real and not know that you are only simulating threading a needle.

Imagine that you are threading a needle – really imagine it by picturing it in your mind and acting it out. Hold the needle between your left thumb and index finger. Hold the thread between the thumb and index finger of your right hand. Bring the tip of the thread to your mouth and put it between your lips to moisten it and make it into a sharp point. Then attempt to thread the needle, which has a very small eye. The thread is almost as thick as the eye of the needle.

As you are concentrating on threading this imaginary needle, observed what happened? While acting out the imagery, did you raise or tighten your shoulders, stiffen your trunk, clench your teeth, hold your breath or stare at the thread and needle without blinking?

Most people are surprised that they have tightened their shoulders and braced their trunk while threading the needle. Awareness only occurred after their attention was directed to the covert muscle bracing patterns.
shoulders. She was totally surprised that the therapist had identified her actual symptoms. The SEMG had made the invisible visible.

Making the Invisible Visible

In clinical and educational practice SEMG biofeedback is a superb tool for demonstrating lack of muscle awareness as well as teaching control over muscle function and enhancing the client’s sense of control and mastery. In particular, SEMG feedback protocols facilitate making unseen muscle tension visible, unfelt muscle tension felt. The treatment strategy in muscle awareness protocol includes teaching the trainee to relax their muscles before using the muscles again. In addition the training focuses on transfer the learning into daily life patterns. To achieve of this mastery in real life practice may vary from one to 20 sessions (Peper, Harvey, and Tylova, 2006; Peper et al., 2008; Sella, 1995; Sella, 2003). The clinical applications of this approach are illustrated in the following examples of (a) improving health at the computer and (b) enhancing performance on an elliptical exercise machine.

Example 1: Improving Health at the Computer

Lack of muscle tension awareness is a common characteristic underlying many musculoskeletal disorders, where the person only becomes aware after it hurts (Peper, Harvey, and Tylova, 2006). A major cause of discomfort is the holding of chronic and unnecessary muscle tension which may lead to illness if unaddressed (Peper, Harvey, and Tylova, 2006). For example, Peper, Harvey, and Tylova (2006) demonstrated that 95% of employees, before receiving SEMG biofeedback training,
automatically raised their shoulders as well as maintained low-level tension in their forearms while keyboarding and/or using a computer mouse (mousing), as well as increased their breathing rates and decreased eye-blinking rates.

The structured assessment protocol as described in details by Peper, Harvey, and Tylova (2006) and Shumay and Peper (1997) is a powerful tool to identify common forms of musculoskeletal dysponesis while working on the computer. For example, almost every person while performing data entry tightens their shoulders and covertly holds that tension without interrupting it with episodic relaxation micro breaks. The protocol consists of assessment, discussion of the assessment and training with physiological signals monitored from the trapezius, deltoid, and scalene SEMG and abdominal and thoracic respiration.

**Assessment**

The client sits in front of the computer and is asked to relax with their hands on his lap for 1 minute, rest their hands on the keyboard and mouse while relaxed for 1 minute, perform data entry such as typing for 2 minutes, rest with hands on the keyboard and mouse for 1 minute, perform a mousing task for 2 minutes and then rest their hands on their lap for 1 minute. After the assessment, they are asked what they experienced. Almost all report some tension in their forearm as they typed or used the mouse. At the same time almost all were unaware of the increased tension in their shoulders as well as shallower breathing as illustrated in Figure 10.4.

**Figure 10.4** A representative recording of a person working at the computer. Note how (a) the forearm and shoulder (deltoid/trapezius) muscle tension increased as the person rests her hands on the keyboard without typing; (b) respiration rate increased during typing and mousing; (c) shoulder muscle tension increased during typing and mousing; and (d) there were no rest periods in the shoulder muscles as long as the fingers are either resting, typing, or mousing.
The clinical intervention consists of discussing the physiological assessment recordings, training the person to reduce shoulder tension and/or take episodic micro breaks to relax the static muscle tension to 1 uV (the absence of any muscle contractions) and breathe slower while working.

**Discussion of the Assessment**

The discussion of this short assessment is used to change the beliefs of the subject and describe the rationale of the training protocol. The discussion provides an opportunity for an “aha” moment as the person becomes aware of the covert tension and/or shallow breathing. The discussion is also an opportunity for teaching the person about muscle fatigue mechanisms. For example, Lin *et al.* (2002) stated that “Muscles rich in type II fibers are more susceptible to fatigue in part because their glycolytic metabolism causes acidification of the muscle bed under repeated use,” suggesting a mechanism for why some muscles fatigue quickly if regenerative micro breaks do not occur.

Another technique for illustrating the need for muscle regeneration and micro-breaks is the simple experiential exercise called *lifting your leg*. In this exercise the person is asked to just lift their foot up from the ground as if they are taking a step and freeze in this location. When the person is asked to hold up their leg in a static position, they can only do it for about a minute or so before awareness of fatigue sets in. In contrast, if they were walking, fatigue would take a long time because the leg muscles continuously alternate, relaxing after every short contraction so that there is a continuous flow of nutrients and removal of the metabolic waste products as shown in Figure 10.5. Similarly when people are captured by the computer and without interruptions, they tend to hold static neck and shoulder tension and only become aware of the tension when they begin to feel discomfort such as pain or burning.

**Training**

The training process consists of SEMG training recorded from the forearm and the trapezius, deltoid and/or scalene muscles. The components consist of awareness training, recognizing tension in the neck and shoulders, as well as being able to drop the arms to the lap until the SEMG is at minimal levels. A final step finally includes being able to perform these tasks correctly without feedback. For an extended description of muscle awareness training procedures designed for reducing dysponesis, see Peper and Gibney (2006) and Peper *et al.* (2008) Unit 1, Exploring Dysponesis. The number of treatment sessions varied depending on the muscle-tension awareness skills to be mastered. The challenge for the person is to remember to take the micro-breaks, relax the shoulders and maintain slower
breathing while working. When clients practice at work, they overwhelmingly report less neck and shoulder pain and more energy at the end of the day. As one participant said after integrating many micro-breaks at work, “There is life after five.” This implied he had much more energy at the end of the day than before (Peper, Gibney, and Wilson, 2004).

Example 2: Enhancing Performance Working out in the Gym on an Elliptical Machine

I would much rather put my effort into productive exercise as opposed to exerting unnecessary energy which did nothing more than to hinder my abilities and efforts to work at my fullest potential. This awareness will be beneficial in improving my posture while working out, reducing my stress and fatigue and hopefully making the workout more enjoyable with less strain on my body. (Marie Tallard)
A healthy 51-year-old woman attending a biofeedback training program was assigned homework to identify misdirected efforts and to reduce it. While doing her homework, she observed minor episodes of dysponesis but did not think that it significantly impacted her daily life in any way. However, the next morning when she did her usual workout on the elliptical machine in the hotel fitness room, she suddenly noticed that her shoulders were extremely tense and that she was gripping the handlebars of the equipment with all of her might.

**Discovery of Dysponesis**

She was amazed by the discovery of increased muscle tension in her shoulders as well as her hands because she had never realized that she needlessly tightened her shoulders, arms, and hands while using equipment that only required using the arms for balance purposes. In fact, she reported that bracing her shoulders, arms, and hands on the elliptical machine felt very familiar.

Observing and reflecting about her dysponesis as a homework exercise, she became aware of associated thought and emotional patterns. She realized that this problem originated several years ago when she fell from a treadmill while running. Since that time, she has been slightly afraid of falling and more cautious while using any equipment at the gym. Although she pushes herself to exercise daily because of the health benefits, daily exercise is an ongoing struggle as she despises the aches and pains associated with working out. She realized that these negative thought patterns may also have contributed to the physical stress that she feels when exercising. After becoming aware of her tight shoulder, arm, and hand muscles while gripping the bar, she tried to relax her muscles more often. She then struggled with a continual loss of attention and awareness of the tension. The moment her attention and awareness drifted, she would fall back to her dysfunctional pattern of gripping the handlebars with every ounce of strength.

**Biofeedback Training to Correct Equipment-related Dysponesis**

The next morning during an actual workout on the elliptical machine she self-monitored her shoulder and arm tension with SEMG using a portable SEMG biofeedback device (Myotrac produced by Thought Technology Ltd) with the bandpass filter set from 100 to 200 Hz. The basic feedback training is shown in Figure 10.6.

She initially placed the triode electrodes first on the right and then the left mid to upper trapezius muscles. The auditory signal provided immediate feedback of her shoulder muscle contractions. Any auditory signal meant that dysponesis was occurring. With the auditory feedback, she immediately reduced the tension in her shoulders. She quickly realized that, although the problem was rectified in the
shoulders, it was still present in her arms. She then moved the electrodes to her arms and was able to reduce the muscle tension in the arms.\(^2\)

Her mastery in controlling the SEMG activity of her upper trapezius and forearm extensors was monitored without giving her feedback. The SEMG triode electrodes were placed on the right and left upper trapezius and right and left forearm flexor and amplified with Myoscan Pro sensors (bandpass filter 100–200 Hz) and recorded with Thought Technology Ltd, Procomp Infinity system using version 4.1 software. She was instructed to work out on the elliptical machine in her normal/tense and newly learned relaxed pattern. A comparison of her “tense” workout to her “relaxed” workout at the same workload intensity revealed: (a) that her SEMG from her left and right upper trapezius and left and right forearm muscles showed high muscle activation as compared to the relaxed workout and, (b) her right side showed more muscle activity than her left side, as shown in Figure 10.7.

\(^2\) In this case, the shoulders can be relaxed because the hands are holding the side bars of the elliptical machine. We generally do not recommend this type of elliptical machine because it limits the natural cross-crawl movement patterns and often causes the person to tense their shoulders and back. An improved elliptical machine that mimics the normal walking movement patterns encourages the person to move their arms as well as their legs. In that case, the upper trapezius muscles would be activated as the arm goes forward and relax when the arm comes back. This cross movement crawl pattern enhances hip, spine and shoulder coordination.
The SEMG data also showed that during the “tense” versus “relaxed” workout, the SEMG did not return to baseline. The lack of return-to-baseline can be seen more easily when the SEMG amplification range is changed from 0–100 μV to 1–10 μV as shown in Figure 10.8.

![Figure 10.7 SEMG during Normal/Tense versus Relax workouts on the elliptical machine. During her habitual workout the left and right upper trapezius as well as the left and right forearm flexors are continuously activated while during the relaxed workout, the SEMG is much less active and returns continuously to baseline. In both conditions the right side shows more SEMG activity than her left side (with permission from Peper et al., 2010).](image)

The SEMG data also showed that during the “tense” versus “relaxed” workout, the SEMG did not return to baseline. The lack of return-to-baseline can be seen more easily when the SEMG μV amplification range is changed from 0–100 μV in Figure 10.7 to 1–10 μV in as shown in Figure 10.8.

**Performance Benefits of Reducing Shoulder and Arm Dysponesis**

By reducing the dysponesis in her shoulders and arms, she noticed that much less effort was required to complete the same workout and she decided to step it up to the next more challenging workout level. She was able to complete the workout program at a higher level and noticed less fatigue upon finishing. The following day she worked out without the biofeedback equipment and continued to be aware of any dysponesis. As the workout progressed, dysponesis was minimal and she progressively stepped-up her workout to the next level whenever possible. She was extremely encouraged by this discovery and with her efforts to “fix” the problem. She realized that she would much rather put her effort into productive exercise as
opposed to exerting unnecessary energy which hindered her abilities and efforts to
work at her fullest potential.

This awareness of dysponesis and the ability to drop her shoulders were beneficial
in improving her posture while working out, reducing stress and fatigue and making
the workout more enjoyable with less strain on her body. She reported after the
training: “I am 51 years old and am not willing to accept that I am not capable of
making physical improvements. My task will now be to maintain this awareness in
order to break this bad habit 100% of the time and to transfer this discovery to other
areas of my workout as well as to my daily life. When this goal is achieved and new
habits are permanently formed I believe the benefits will be obvious in my everyday
life and not just in the gym.”

At a six-month follow-up, she continues to observe her dysponesis during
workouts and daily activities. At her home gym, she was able to keep her shoulder
and forearm muscles relaxed while performing the elliptical workout and she reports
making steady and significant progress. She has been able to increase the difficulty of
her workout to include numerous periods of high intensity movement and extend
her workout by 15 minutes daily without feeling tired. More importantly, she has
generalized the concept of dysponesis awareness and reduction into other areas of
her life. For example, she became aware that gripping the steering wheel made her
feel much more stressed while driving and when she relaxed her shoulders and arms,
she felt much calmer and able to handle the difficult driving situations. In addition, she has become much aware of poor posture and muscle tension while writing, working at the computer, working with clients, cooking, sewing, reading, sleeping, and even relaxing. Her awareness of these situations has helped her to take control and make the necessary changes to reduce the physical stress that she encounters every day. This in turn has helped to alleviate mental stress and fatigue.

**Discussion**

The teaching examples presented in this chapter illustrate the efficacy of the evidence-based SEMG biofeedback approach in the assessment and reduction of dysponesis. The success of using an experiential teaching approach is based upon the following components:

- Biofeedback training presumes an integration of mind and body; that thoughts such as memories, and emotions affect the physiology and vice versa. This is based upon the psychophysiological principle stated by Green, Green and Walters (1970) that “Every change in the physiological state is accompanied by an appropriate change in the mental emotional state, conscious or unconscious, and conversely, every change in the mental emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state.”

- Identification and reduction of dysponesis during simulated or actual task performance (e.g. toe-touching or, working out on the elliptical machine) is useful in training. The training focuses upon changing the use of a person’s body so that the dysfunctional patterns are changed and eliminated when the person performs their tasks after learning new, healthy muscle use patterns.

- Immediate feedback allows clients to experience success and hope which provides motivation for continued practice and for further improvement.

- Mastered skills learned in the office need to be transferred and generalized into daily life and while performing other tasks. Thus, the awareness of dysponesis followed by the reduction of dysponesis needs to be practiced in the daily activities at home, at work, and while performing sports and hobbies. This can be enhanced through teaching clients how to monitor their behavior and changes and record these observations on logs. People need to change their behavior in real life and not just during the office training session.

In summary, dysponesis contributes to the development and maintenance of illness. Learning to be aware of and reduce dysponesis may significantly help in reducing illness and improving health. SEMG monitoring and feedback makes the unaware muscle dysponesis aware and visible. With SEMG feedback, clients can learn voluntary control to inhibit dysponesis. Biofeedback protocols assist in developing the internal somatic/sensory awareness necessary for improving health. We recommend that children and adults are taught dysponesis awareness and
inhibition to prevent illness onset since, prevention is much easier and much more
cost effective than treatment.

I am amazed how many areas of my life need improvements. My awareness has been
most helpful in changing my actions. (Marie Tallard)

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Author Query

1. We have modified the citation of figure 10.6. Please check for correctness.