FEATURE ARTICLE

Dysponesis Awareness Training: Surface Electromyographic Training for Increased Awareness and Facilitated Neck Muscle Relaxation

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This study investigated a simple biofeedback-assisted training protocol for increasing somatic awareness as well as reducing dysponesis. Twelve normal, healthy volunteers with no known musculoskeletal impairments (mean age of 23.8 years) were trained to increase awareness of “wasted effort” in the neck muscles during a simple bending task. Surface electromyography (sEMG) signals were recorded from the midcervical paraspinal muscles (C-5) while the subject performed a forward fold, also described as a “toe touch” movement. The quantitative measures of sEMG activity were compared to a subjective measure of neck muscle tension. During the pretraining measurements, 11 of 12 participants reported no subjective awareness of increased neck muscle tension while bending in a forward fold “toe touch” position. After approximately 10 minutes of “dysponesis awareness training,” all participants had measurable reductions in neck muscle tension, as well as reductions in the subjective sense of tension while performing the forward fold exercise, as compared to pretraining. The 11 participants who increased their self-awareness following training reported not only feeling decreased neck muscle tension but also increased general relaxation levels. The findings suggest that most individuals may be unaware of increased muscle tension during simple activities such as a forward bend, yet may rapidly learn how to reduce dysponesis, such as unnecessary neck muscle overexertion during a forward bend. Furthermore, sEMG dysponesis awareness training could be adapted to rapidly train individuals such as athletes to reduce unnecessary muscle use.

“I didn’t realize that my muscles were so tense until after the training. I feel a lot better.”—H.L.

“Great experience! I’m leaving with more confidence in myself because I can hold less tension in unneeded areas.”—C.F.

Introduction

The Importance of Neck Muscle Awareness

The muscles of the neck contribute importantly to awareness of body posture and position. For example, “articular receptors in the cervical spine” communicate information such as head orientation and movement. As well, the neck muscles contribute to proprioceptive processes related to the vestibulospinal and vestibulocular reflexes necessary for stabilizing the spine and orienting the eyes during head motion, respectively (Armstrong, McNair, and Taylor, 2008). The midcervical paraspinal muscles located at C-5 were selected as a useful surface electromyography (sEMG) recording location because they are related to activity in the upper extremities such as movement of the elbow, arm, shoulder, and head (Salvi, Jones, and Weigert, 2006).

Low awareness of unintended neck muscle fatigue, such as when people are unaware of unnecessarily tensing the neck muscles while bending to touch the toes, contributes to decreased neck muscle flexibility and regeneration (Madeleine, 2010; Schmid and Schieppati, 2005). Neck muscle fatigue due to overuse has been associated with various forms of discomfort, illness, and injury. For example, Edmondston et al. (2011) described increasing degrees of neck muscle extensor and flexor fatigue contributing to increasing reports of neck muscle pain and pathology. Although high awareness of head and neck muscle fatigue contributes to increased functioning, low awareness of head and neck muscle fatigue contributes to slowed recovery during neck muscle rehabilitation (Arm-
strong et al., 2008). For example, during rehabilitation of neck muscles following acute injuries, due to high-impact sports injuries caused by football and hockey accidents, or whiplash injuries caused by automobile accidents, patients with low levels of head and neck position sense had slowed recovery times (Armstrong et al., 2008). In contrast to acute injuries, chronic neck muscle injury often contributes to degenerative processes leading to various diseases of the joints of the spine (e.g., spondylarthropathy), particularly in the neck regions of the spine (Tsirikos et al., 2001).

Proper conditioning of the neck muscles, as well as raised awareness of neck muscle fatigue, has been shown to be an important contributor to reducing neck region cervical spine injury (Almosnino, Pelland, and Stevenson, 2010). Furthermore, neck muscle conditioning exercises coupled with increased sense of head and neck fatigue reduces the chances of concussions in contact sports (Viano, Casson, and Pellman, 2007). For example, Meyers and Laurent (2010) describe injury awareness among rodeo athletes, suggesting that both physical conditioning and psychophysiological conditioning exercises, such as muscle awareness training, are necessary to reduce rodeo-related neck injuries.

Treating Neck Muscle Pain and Injury Using Biofeedback Raises Awareness
Biofeedback techniques have been used to treat pain and injury associated with neck muscle fatigue, as well as for preventative efforts such as raising awareness of neck muscle fatigue for improving neck muscle conditioning (Ma et al., 2011). Whereas preventing the likelihood of traumatic injury is possible among athletes through muscle awareness and conditioning exercises (Schmid and Schieppati, 2005), it is also possible to reduce injury by employing biofeedback techniques for raising awareness of unnecessary neck muscle exertion (Madeleine, 2010; Schleifer et al., 2008).

Biofeedback-Assisted Dysponesis Awareness Training
Whatmore and Kohli (1974) used the term dysponesis to describe types of unnecessary muscle effort such as tightening of muscles unrelated to the task. For example, it is unnecessary to maintain neck muscle tension while hanging down in, or after rising up from, a toe-touching task (Shedivy and Kleinman, 1977; see Figure 1). Low somatic awareness contributes to ongoing dysponesis or misuse of muscles unrelated to a task. Dysponesis has been categorized into four different groups: 1) excessively tightening muscles used for task performance, 2) unintentionally tightening muscles unnecessary for task performance, 3) maintaining muscle tension after the task has been completed, and 4) not allowing muscles to relax momentarily during task performance to allow ongoing regeneration (Peper, Booiman, Tallard, & Takebayashi, 2010). In the case of groups 3 and 4, sustained muscle contractions not only increase energy expenditures but can also cause chronic myofascial pain, tension headaches, backaches, joint pain, and cervical dystonia and have been highly correlated with stress (Lundberg et al., 1994). Whatmore and Kohli (1968, 1974) typically used the term dysponesis when describing patients, clients, and research subjects experiencing pathologic pain. This article intends to broaden using the term dysponesis to include not only people with pathological conditions, but also normal people who exhibit misplaced muscle effort or overexertion outside of their awareness, possibly leading to subclinical experiences of pain resulting from temporary forms of neck muscle dysponesis. The article intends to suggest that through biofeedback training, normal populations may achieve increasing levels of awareness and control of neck (or any) muscle activity and reduce inefficient muscle use, avoiding pain and or injury. Some brief examples of ways that sEMG biofeedback training has been used to increase awareness of dysponesis follows. Surface electromyography is an effective way to monitor the electrical signals produced by striated muscles and is a significant clinical tool in teaching patients sensitivity bodily sensations, increasing somatic awareness, muscle conditioning, and ongoing control and monitoring of dysponesis. Training to increase awareness of unnecessary/dysponetic muscle effort is possible through biofeedback, and dysponesis awareness training (DAT) has been described in various forms and protocols by several researchers who have successfully used biofeedback training techniques to address dysponetic muscle effort (Harvey and Peper, 2012). For example, Shumay and Peper (1995) described biofeedback training to reduce muscle strain and dysponesis among musicians who overexerted neck and shoulder muscles with little or no awareness of excess neck and shoulder activity while playing an instrument. Wilson, Peper, and Gibney (2004) described biofeedback techniques designed to foster an “aha” moment of awareness while reducing dysponesis among repetitive strain injury clients. Sella (2010) described DAT techniques in the context of neuromuscular education. Harvey and Peper (2012) described using wide-ranging biofeedback techniques for educating clients to raise awareness and reduce dysponesis. Moss and Wilson (2012) discussed types of athletic DAT in relation to avoiding
injury and to increasing playing field advantage. The common aspects of all DAT techniques are represented in the steps taken to raise somatic awareness, reflecting the part of biofeedback training that increases sensitivity to physical sensations and bodily experiences, especially related to muscle use (Cioffi, 1991). Dysponesis awareness training may occur through noninstrumented techniques, such as having a practitioner observe behavior and provide verbal feedback or through instrument-assisted techniques such as using biofeedback equipment to provide an objective measure of muscle use during training (Harvey and Peper, 2012).

Within the large body of literature (e.g., Geisser et al., 2005) on measurement of muscle tension in the neck and spine, the flexion-relaxation phenomenon (FRP) is of particular interest to this discussion. As described by Yoo, Park, and Lee (2011), the FRP is a normal part of muscle activation that “originates from the lumbar region and is defined as an electrical silence response in the erector spinae muscles during a full forward-bending trunk posture.” Watson, Booker, Main, and Chen (1997) developed a measure called the flexion-relaxation ratio, “a comparison of the maximal sEMG activity during 1 s of forward flexion with activity in full flexion.” Pialasse, Lafond, Cantin, and Descarreaux (2010) studied speed of movement as well as loading effects on the flexion relaxation phenomenon in the cervical/neck region of the spine. They found that “although the cervical FRP seems to share similarities with what has been described in the lumbar region, it may be modulated by different factors” such as loading of the cervical spine. It should be noted that whereas the FRP related to lumber or cervical spine studies is an important factor, especially when investigating pain patients, this study was more focused on the application of biofeedback training in normal populations to raise awareness of unnecessary muscle tightening, such as in the neck during a simple forward bend toe-touching exercise.

This study describes a biofeedback-assisted DAT protocol for increasing subjective awareness of neck muscle tension while performing a simple toe-touch body fold with the goal of reducing dysponetic neck muscle activity. For this study, DAT focused on increasing awareness of
unintentionally tightening muscles unnecessary for the toe-touching task and maintaining muscle tension after the task had been completed.

**Subjects and Methods**

**Subjects**

Twelve students attending San Francisco State University, ages 19 to 31, volunteered for extra credit as part of a class project following the guidelines set forth by Institutional Review Board (IRB) of the Office of Human and Animal Protections to ensure the well-being of research participants. Inclusion criteria stipulated that all participants be normal, healthy adults. As some participants regularly engaged in various physical activities ranging from yoga and dance to skateboarding and surfing, only those with no known neck or back injury could participate. Additionally, there were no exclusion criteria based on age or sex because awareness of neck muscle activity (e.g., position, stability, or repositioning accuracy) does not appear to vary by age or gender (Armstrong et al., 2008).

**Psychological and Physiological Equipment Measures**

Physiological signals were recorded using a Procomp™ physiological recording instrument running Biograph™ 2.0 software (Thought Technology, Ltd.). Surface electromyography was recorded with a MyoscanPro™ sensor with the band pass filter set between 100 and 200 Hz. An sEMG triode electrode was placed on the left midcervical paraspinal muscles positioned at C-5, with the grounding electrodes pointing away from the vertebrae. A subjective measure of somatic awareness in the neck was used for this study, with participants rating their neck and back muscle tension level on a scale from 0 = none to 10 = maximum tension.

**Methods**

Each participant completed an intake evaluation packet, which included demographic details, questions about neck and back injuries, current physical/sports activities, and subjective ratings of their current level of neck and back muscle tension on a scale of 0–10 (0 = none; 10 = maximum tension). After the sEMG sensor was attached, the DAT protocol consisted of a pretraining measurement, sEMG awareness training, and posttraining measurement as follows.

Dysponesis Awareness Training procedures, part 1: pretraining measures. The subject was asked to stand relaxed while facing away from the biofeedback monitor to ensure that the participant did not receive any visual feedback. Then the participant performed the following sequence: 1) Standing quietly and relaxed for 2 minutes. 2a) Bending gently in a forward fold in an attempt to touch the toes (toe-touch position); 2b) hanging relaxed for about 20 seconds (see Figure 1); and 2c) slowly returning to standing upright. 3) Standing relaxed for 2 minutes. Subjective measures of neck and back muscle tension on a scale from 1 to 10 (none to maximum tension) were obtained for each of the three parts of the sequence.

Dysponesis Awareness Training procedures, part 2: sEMG audio biofeedback training. The trainer and participant reviewed the recorded pretraining sEMG data. Audio biofeedback was then demonstrated for each subject, where muscle activity increases were linked to an increasing pitch. Participants were instructed to explore different positions of their body to identify how various postures were associated with excess or unnecessary effort of the neck muscles (e.g., dysponesis of the neck muscles) as they moved into a forward fold position. Then participants were instructed to allow their head to drop toward their chest as they leaned forward, and slowly bend down vertebrae by vertebrae. All subjects learned to relax their neck muscles by allowing the head to drop/hang forward while bending in a forward fold to touch the toes. The median DAT time was about 10 minutes per subject. Training continued until each subject mastered the technique of relaxing neck muscles while hanging in the forward fold, both with and without feedback.

The posttraining measurement procedure was identical to the pretraining measurement procedure.

Data were analyzed for violations of normality and sphericity: No observations of extreme skewness or kurtosis were observed, and Mauchly’s (1940) test of sphericity (W = 0.163) was not violated. Because there were no violations to assumptions of normal distribution, variance or sphericity assumptions, it was decided to proceed with a repeated measures analysis of variance (ANOVA) technique, useful when there are small yet well-defined samples.

**Results**

**Objective sEMG Measurements**

Median sEMG measures, measured in microvolts (μV), for the parts of the DAT protocol are presented in Table 1.

After performing a one-way ANOVA with repeated measures on the effects of DAT protocol on sEMG during the toe-touching forward bend task, the following was observed:

1. Pretraining standing relaxed—there was no significant effect of DAT on sEMG muscle tension measures while standing relaxed pretraining, $F(1, 23) = 0.089, p = .76$, n.s.
(2A) Bending—there was a significant effect of DAT on sEMG muscle tension measures while bending forward to touch the toes, $F(1, 23) = 30.55, p = .001, \omega = 0.74$, indicating that as DAT increased, muscle tension decreased.

(2B) Hanging—there was a significant effect of DAT on sEMG muscle tension measures while hanging to touch the toes, $F(1, 23) = 15.44, p = .001, \omega = 0.61$, indicating that as DAT increased, muscle tension decreased.

(2C) Rising—there was a significant effect of DAT on sEMG muscle tension measures while rising after touching the toes, $F(1, 23) = 14.03, p = .001, \omega = 0.60$, indicating that as DAT increased, muscle tension decreased.

(3) Posttraining standing relaxed—there was no significant effect of DAT on sEMG muscle tension measures while standing relaxed posttraining, $F(1, 23) = 0.842, p = .36$, n.s.

All subjects learned to relax their neck tension during the posttraining measurement period as compared with the pretraining measurement period. Prior to the dysponesis awareness training protocol, median sEMG measurements were 9.4 $\mu$V ($SE = 0.151$), compared to 3.06 $\mu$V ($SE = 0.152$) after the training as graphically represented in Figures 2–4.

### Subjective Awareness

Mean subjective awareness measures for the parts of the DAT protocol are presented in Table 2.

There were no significant differences between pretraining and posttraining measures of self-reported muscle tension at time 1 or time 2A–C.

On average, subjects reported experiencing significantly less muscle tension while standing at time 3 posttraining ($M = 2.45, SE = 0.578$) than standing at time 3 pretraining ($M = 4.27, SE = 0.541$), $t(11) = 3.76, p = .004, r = 0.62$.

### Table 1. Pre- and posttraining sEMG median microvolt levels for Standing, Bending, Hanging, Rising, and Standing positions.

<table>
<thead>
<tr>
<th></th>
<th>Standing Relaxed (1)</th>
<th>Bending Task (2A)</th>
<th>Hanging Task (2B)</th>
<th>Rising Task (2C)</th>
<th>Standing Relaxed (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretraining sEMG ($\mu$V)</td>
<td>4.14</td>
<td>11.03</td>
<td>10.53</td>
<td>10.65</td>
<td>4.91</td>
</tr>
<tr>
<td>Posttraining sEMG ($\mu$V)</td>
<td>3.91</td>
<td>3.61</td>
<td>2.16</td>
<td>4.06</td>
<td>4.03</td>
</tr>
</tbody>
</table>

*Note. Numbers represent median microvolts ($\mu$V) of sEMG activity.*
There were no significant correlations between pretraining measures of self-reported muscle tension and pretraining measures sEMG μV activity.

Self-reported muscle tension posttraining was significantly related to sEMG μV activity only when people were hanging for 20 seconds (2B), \( r = 0.654, p = .029 \).

Eleven of 12 subjects reported being completely surprised that their neck sEMG μV activity showed any muscle tension because they had rated themselves as having very little tension. Furthermore all subjects reported that sEMG feedback increased their self-awareness of neck and back muscle tension and allowed them to be more deeply relaxed during the forward bend/toe-touch movement. By the end of the training, all subjects anecdotally reported that they would apply somatic awareness to other physical activities outside of the training setting.

Discussion
This study demonstrates that prior to sEMG DAT, subjects were seldom aware of their actual sEMG muscle activity while bending forward to touch their toes. This study
confirmed that many people unknowingly experience covert, sustained muscle contractions while performing various tasks involving neck muscles. More importantly, the study showed that subjects can rapidly learn to raise awareness of dysponesis in the neck and back muscles while folding forward.

When beginning to bend forward to touch the toes, 11 of 12 participants lifted their head slightly, possibly to look out in front of them, causing an increase in neck muscle sEMG activity. The one participant who did not show a significant increase in sEMG activity was a trained ballerina who from the beginning of the study displayed proper body mechanics. One explanation of why participants lifted their head while bending down is a reflexive hypervigilence to look for danger; however, all of the participants were in a safe classroom environment, so it is more likely that participants were reflexively holding their head out in a “sky diving” position (sometimes also referred to as a “parachute” reflex, “plantar” reflex, and/or “Landau” reflex) rather than anticipating danger. In all cases sEMG levels in the neck muscles were greatly reduced when participants allowed their head to drop toward their chest as they leaned forward, slowly bending down vertebrae by vertebrae.

Some anecdotal participant reports suggested surprise at the sharp contrast between their subjective ratings of muscle tension and the actual sEMG measurements. Dysponesis awareness training may be used to show people that they are totally unaware of their muscle tension, which results in a powerful “aha” experience.

Whereas participants trained in yoga and dance (N = 5) demonstrated much lower initial sEMG levels prior to training, in contrast with participants who reported physical activities with less fluid body mechanics and more quick, concise movements (i.e., surfing, skateboarding, karate), the numbers are too small to make a statistical comparison based on type of physical activity. It was also observed that participants who had been trained in yoga or dance (N = 5) required fewer minutes of training. sEMG feedback can be used in teaching athletes from yoga practitioners to surfers to promote somatic awareness. This increased awareness and mastery in reducing dysponesis may also prevent muscle tension headaches, repetitive strain injury, and other muscle injuries, myofascial disorders, or cervical dystonias. This study demonstrated that dysponetic patterns that result from simple movements such as folding forward to touching the toes can be reduced with muscle feedback.

**Study Limitations**

Whereas this pilot study suggests a promising protocol for reducing dysponesis, there may be a selection bias present in the participants who were students aiming to please the researchers. Even though this may be possible, it is more likely that the participants were unbiased in their participation because they received extra credit. Another possible limitation of the study is the small number of participants; however, the effect size estimates are large (Kirk, 1996) for the differences in sEMG activity for the pretraining and posttraining periods, suggesting that the even a small number of participants could reveal a practically significant difference between those who receive and those who do not receive DAT.

It should be noted for future researchers that, even though this study did not exam deep neck flexor endurance levels, there has been one report of men compared to women having greater levels of awareness of deep neck flexor endurance levels (Domenech, Sizer, Dedrick, McGalliard, and Brismee, 2011). Further investigations are needed to determine the appropriate sEMG activity in the whole kinetic chain of muscle activity involved in the simple act of toe touching.

**References**


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