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# SPECIAL ISSUE


# Helping Musicians Achieve Peak Performance with Surface Electromyography/Video

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*For musicians, performance problems often go unnoticed at first and have several different starting points. Regardless of the starting point, the ''problem'' manifests physiologically as tension. It is useful for therapists, doctors, and other specialists to see clients perform. Corrections need to be made to their physical, mental, and emotional approach to performance. Retraining with surface electromyography biofeedback and video helps identify elevations in muscle tension and incorrect body alignment. Feedback-assisted retraining helps to bring about self-awareness and the skills to reduce tension and achieve optimal performance.*

For musicians, performance problems are often very subtle. They can go unnoticed at first and have several different starting points, which, oddly enough, are not in the fingers. We know that it takes many years of intensive instructive guidance and practice to develop the more complex levels of technique and interpretation. In overzealous efforts to achieve this, many musicians develop injuries through overuse and faulty technique.

In my lab at NYU I see many music students as well as professionals in the music field. I have observed that many musicians are not aware of body and hand alignment as well as levels of tension. Even those with a good technique often play with high levels of tension that they are unaware of and therefore do not always release properly. Common complaints among musicians are pain or discomfort in the neck and shoulders, discomfort or pain in the back, elbow, forearm, wrist or hand, and tiredness.

While overuse and incorrect technique can create problems, often the starting point is much more elusive, residing in the emotional or mental realm. The music world itself contains stressors such as the amount of self-generated pressure and the culture of silence surrounding technical problems, both of which often result in pianists playing with pain and discomfort. In cases such as focal dystonia, the contributing factor can have a neurological basis. Regardless of the starting point, the ''problem'' becomes addressed by our entire being, physical, mental, and emotional, manifesting physiologically as tension.

Since most tension and anxiety problems for musicians come from performing and practicing the music, it is useful for therapists, doctors, and other specialists to actually see them perform. Too often musicians come to me who have been diagnosed with carpal tunnel, focal dystonia, and other physical problems by professionals who never watched them on their instrument. Corrections need to be made to their physical, mental, and emotional approach to the instrument. Otherwise their hours of practicing will undo the rehabilitative work.

In an initial assessment I ask for a history of years of study, performance, illnesses, traumas, etc., to help pinpoint a possible cause or beginning of the ''problem.'' In several musicians I have observed a correlation between highly stressful life situations, such as injury, loss of job, interpersonal relationship problems, and so on, and the onset of their technical problem. For others I have observed a correlation between over-practice, change of teachers and/or change of technique, and performance anxiety with the onset of their problem. Many of them were not aware of the correlation until they began to talk about their history.

Some of the predisposing factors for piano-related injuries (which highlight the congruence between the medical and pedagogy fields) are poor posture, aspects of technique, repertoire that one is not accustomed to, excessive finger force, unnatural position of thumb or

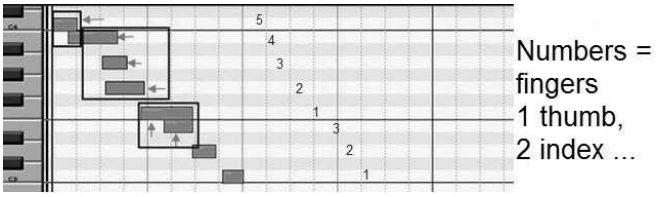


**Figure 1.** Piano roll notation of overlap of notes.

hand, hyper-extended joints or fingers, and repetitive overuse and over-practice.

In retraining with biofeedback, I work with monitoring muscle tension and multicamera video input, viewed on the computer screen, along with recording and playback of their performance to identify elevations in tension and incorrect body alignment. This also allows the musicians to observe themselves from viewpoints they do not always listen to and see while playing.

The playback is very important because an important part of the puzzle in retraining is that the result must be heard in the sound produced to have a more lasting effect. Music performance is about the aesthetic. When technical problems occur, in any instance, not just music, we tend to focus on the problem. This takes our attention away from other areas. It is imperative that musicians understand what to listen for as they perform. It is here that fine motor control is modulated by well-developed listening acuities and is essential for achieving the nuances of expressive timing and dynamics one has chosen.

For pianists, I record their playing on a Disklavier™ piano. This is an acoustic instrument equipped with laser sensors that records and plays back the notes played. The music instrument digital interface (MIDI) data can be analyzed and displayed with music sequencing software as a scrolling piano roll in retraining. Often musicians become so preoccupied with their fingers while playing that they become disengaged from the sound produced. In listening to the playback, they can critically assess their performance. The sequencing software's visual display of the performance as a piano roll gives feedback on the onset and offset of notes played. Pianists can see the accuracy of their technique. For example, one can see if fingers overlap while playing. Figure 1 depicts a piano roll showing a pianist's sloppy overlap of fingers in a descending C major scale.

The note bars highlighted by arrows in the boxes are held over into the next note to be played. In the first box there is an overlap of the 5th to the 4th, the 4th into the 3rd, and the 3rd and the 2nd played at the same time; the second box shows the thumb being held into the 3rd. The next graph shows improvements after working with

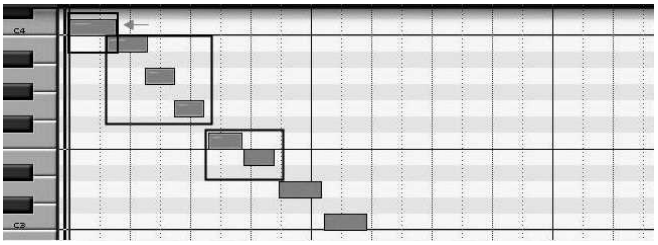

**Figure 2.** Piano roll notation showing improved legato playing: less note overlap (finger numbers the same as Figure 1).

Disklavier playback and piano roll (see Figure 2). There is only a slight overlap of the first three notes.

Feedback through online digital video recording, motion analysis, and surface electromyography (SEMG) is used in addition to the Disklavier and piano roll feedback. Although a pianist's hand may look relaxed on the surface, there is often a disturbance in the necessary tension-relaxation cycles in playing passages, which the SEMG records in terms of microvolts. Initial work is done with large muscle groups. I measure both shoulder and forearm muscles for tension measurements with camera views of the overall body alignment and close-up views of the fingers. The pianists are guided through a series of basic exercises as well as asked to play repertoire, in particular passages that are causing problems.

I begin with monitoring large muscle movement with several basic movements:

1. Raising and lowering the forearm: Good isolation of this movement primarily involves the bicep and tricep. Musicians often raise the arm from the trapezius and upper back muscles, which is not optimal for performance and maladaptive for muscle health.
2. For pianists, placing their hands on the keyboard; for other instrumentalists, holding the instrument and placing it in position to play: violinists raising it to the chin rest, flutists to their lips, etc. Trapezius readings vary depending on the instrument and placement. For pianists a good range is between 3 and 10 mv (if this reading is too high, the bench may be too low), violinists between 15 and 35 mv, flutists 15–35 mv, and other woodwind players under 20 mv.
3. Having them play a note and release the note while keeping their hands on the instrument. With good technique, there is a drop in the extensor and trapezius tension after the note release. A normal range for this simple exercise would be between 15 and 30 mv. Readings over 30 mv, with no dips below 10 mv, indicate a high level of static tension as well as no release during rest phases.

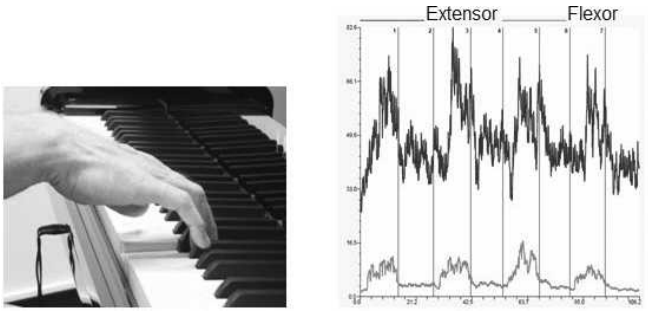


**Figure 3.** Raise wrist position and SEMG graph of five-finger exercise performed. Top line: extensor; bottom: flexor.

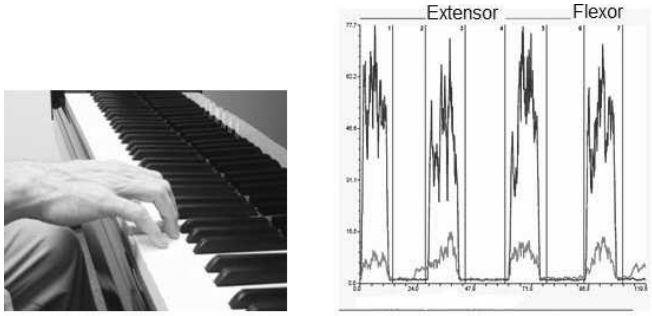


**Figure 4.** Lowered wrist position and SEMG graph of five-finger exercise. Top line: extensor; bottom line: flexor.

4. I then ask them to play an excerpt from a composition that is giving them difficulty or pain. This is where you often see very high tension levels for extended periods, 160 mv and higher. This can be caused by improper hand and body alignment, static loading of tension, fear of difficulty of the passage, repertoire that is too large for their hand size, weak or injured muscles, and often a combination of several of the above.

Here I must explain that some musicians do play with high tension readings and do not seem to suffer injury. Why? There are several explanations, the most common being that their muscles are in good condition and they do release static tension during rest phases (indicated by dips on the graphs), and that the musicians' individual physiological profile can handle the power level they exert. However, when you see a musician who has come to you because they are injured or in pain, less is more, especially with the possibility of the muscles themselves being injured. They are not only in need of strengthening but of being taught how to prevent further problems. A relaxation-based technique is a solid grounding on which they can rebuild their performance levels.

Figures 3 and 4 provide an example of how SEMG measurements of extensor carpi radialis (blue line) and

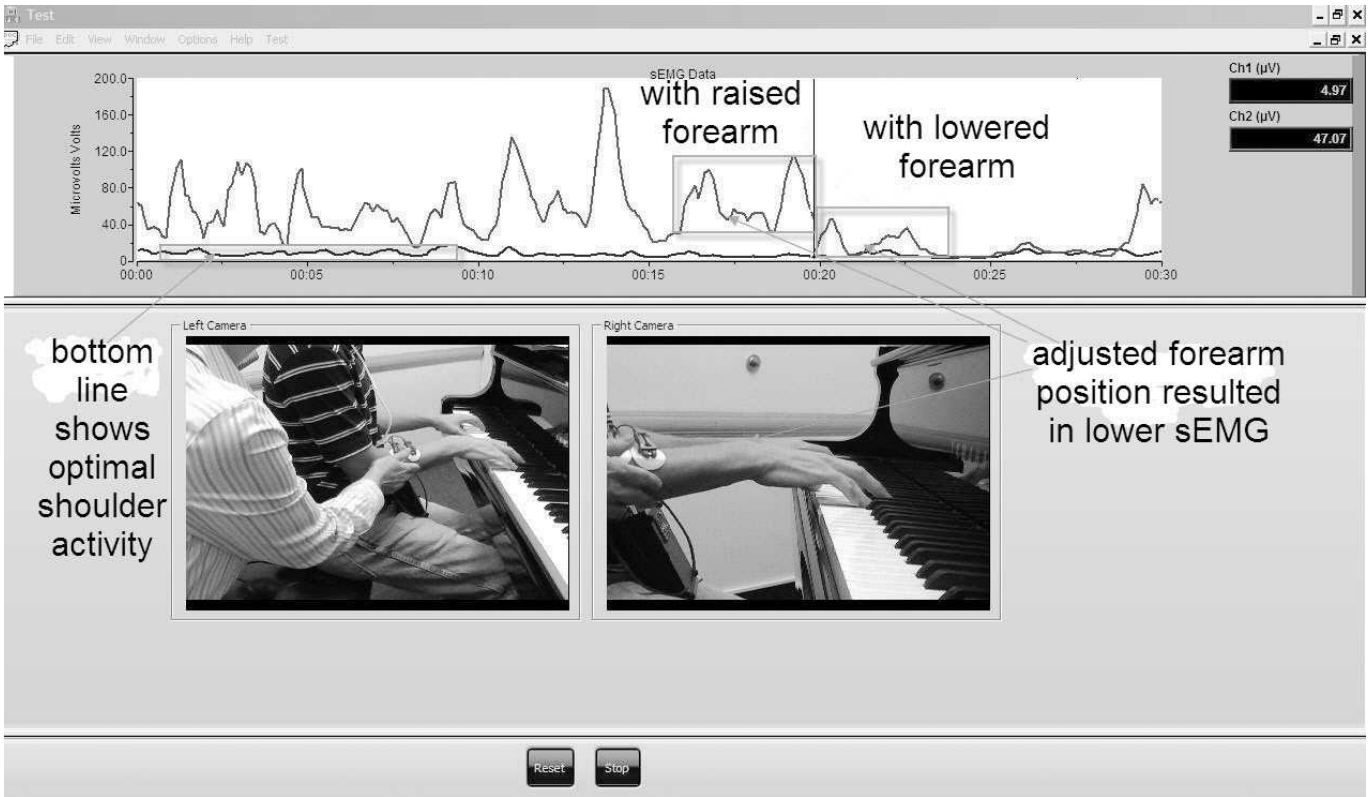


**Figure 5.** Differences in SEMG activity of forearm extensor with adjusted forearm alignment.

flexor carpi radialis (red line) in the forearm synchronized with digital video recording can provide feedback regarding the efficacy of optimal technical movements. The time code was synchronized to the video clip. The pianist was instructed to play an ascending and descending five-finger exercise four times with rest periods in between. Surface electrodes were attached to the skin on the forearm extensor and flexor. On the graphs in Figures 3 and 4, line numbers 1, 3, 5, and 7 mark the end of action phases; lines 2, 4, 6 and 8 mark rest phases.

In Figure 3, the student's wrist is raised high with the hand hanging down toward the keys. The extensor reading is high in the resting phase as well as in the action phase. This indicates that the pianist did not relax the arm during the resting phases. The pianist was unaware of how high the wrist was positioned and of any tension in the arms during the resting phase.

The pianist was instructed to repeat the five-finger exercise after receiving feedback from motion analysis and SEMG measurements of muscle tension, lowering the wrist and concentrating on relaxing during the resting phase.

Figure 4 shows the wrist height lowered to the height of the hand. There was a significant change in the extensor in both the resting and active phase. These changes indicate a more controlled tension-relaxation cycle during performance. Pianists are able to feel the difference in their arms and replicate the wrist position in subsequent exercises.

I address problems with finger movement through the video and SEMG display. Minute changes in finger and hand position can be tracked that would be invisible to the eye during performance. MIDI recording and playback is very helpful in bringing awareness to the sounds produced. I have observed that, when the musicians begin to focus on the sound, their fingers relax and they have better technical control. A picture is worth a thousand words; in Figure 5 the screen provides quantitative feedback.

The next step is to set up a retraining plan, with most musicians coming for weekly visits. In the sessions, I work on technical exercises: for example, with a pianist, chords, scales, and small pieces of intermediate repertoire where they can begin to incorporate the correct movements with minimal tension. Once the musician has achieved a lower tension level and corrected body alignment problems the sessions are stretched out to twice a month or once a month as progress allows. It is a slow process, but it is well worth it. Musicians who retrain their technique successfully go back to their playing commitments without problems. Those that are looking for a quick fix are only putting bandages on the problems, not finding solutions.

Just like athletes, pianists need to care for their bodies and build stamina and healthy muscles, especially of the upper body and lower back. I suggest that swimming, stretching, yoga, Pilates, tai chi, cardio, and light weight training be incorporated into their routines. Warm-up exercises, breaks for stretching, and technical exercises done slowly and mindfully are crucial.

Feedback-assisted retraining helps to bring about self-awareness and the skills to reduce tension and achieve optimal performance. This psychophysiological approach can provide relief for a variety of neuromuscular performance problems encountered by musicians and may provide effective interventions for other performing artists as well. The combination of strenuous repetitive motion and performance anxiety is common throughout the performance world, from the musician to the dancer, to the juggler to the acrobat, as well as their counterparts in the sports world, the gymnast, figure skater, runner, and many others.

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