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Pathways in Focal Embouchure Dystonia

Research Pathways

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Handout TOC

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Embouchure Dystonia and the Overuse Syndrome: A Primer for Musicians

Denton Thomas, B.M., M.M., D.M.A.

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ABSTRACT

This brief will describe the major characteristics of focal dystonia, a neuromuscular disorder that affects roughly 1% of all musicians.[1] In roughly half of all cases, dystonic musicians are not able to return to full-time work as a performer, and must seek alternative means of financial support.[2] Discussion will center on the characteristics of embouchure dystonia in particular, and then contrast the condition with the common and painful overuse syndrome. Differences and similarities between these ailments will be identified with the goal of clearly separating the two for the medically-untrained audience.

FOCAL DYSTONIA

Since 1986, when Alice Brandfonbrener et. al. founded the *Performing Arts Medical Association* and started publishing *Medical Problems of Performing Artists*, understanding and appreciation of performance-related ailments has increased amongst doctors and performers.[3] The average musician's inherent lack of medical training has left the afflicted ill-equipped to identify or discuss much of this new information. The increasing awareness of focal dystonia in musicians today, for example, has not been equally balanced by general education of the afflicted population. Musicians at all levels are understandably uneasy discussing this amorphous condition.

In his thorough review of musician's "occupational cramp" Richard Lederman referred to the earliest known documented case of focal dystonia in a pianist (ca. 1840).[4,5] The cause of the disorder was determined to be 'neurological' at the time, but the exact cause is still not well known today. Chemical, genetic, and environmental factors may be blamed for these symptoms, but such factors are not universal.[6]

The symptoms of focal dystonia have received many labels because the root cause remains undetermined. This variety of names certainly obstructs discussion amongst music professionals. Though Lederman did make an effort to collect a few of these labels in 1988, the author has not encountered a thorough collection of names for the symptoms that suggest focal dystonia.[7] An updated list of common labels appears in table 1. This collection is neither exhaustive nor definitive, and only includes the common English words used. Notable, non-English dystonia research groups exist in Spain, Germany, Japan, and elsewhere, so some terms may come from translation. Some of these labels have different meanings for different communities. Terms which are argued or seldom-used are identified as such.

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1 Eckart Altenmuller. "Focal dystonia: advances in brain imaging and understanding of fine motor control in musicians." *Hand Clinics* 19, no. 3 (2003): 523-538.
2 Stephan Schuele and Richard J. Lederman, "Focal Dystonia in Woodwind Instrumentalists: Long-term Outcome," *Medical Problems of Performing Artists* 18, no. 1 (March 2003): 15-20.
3 Brandfonbrener, Alice. "From the Editor - 20 Years in Review: A Look Back and Ahead." *Medical Problems of Performing Artists* 20, no. 2 (June 2005): 63-65.
4 Richard J. Lederman. "Occupational Cramp in Instrumental Musicians." *Medical Problems of Performing Artists* 3, no. 2 (June 1988): 45-51.
5 M. H. Romberg, *A Manual of the Nervous Diseases of Man, Vol I*. Trans by E. H. Sieveking. London, Sydenham Society, 1853: 320-324.
6 A. Schmidt, Hans-Christian Jabusch, et. al. "Dominantly transmitted focal dystonia in families of patients with musician's cramp." *Neurology* 67 (2006): 691-693.
7 Lederman (1988).

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Table 1: Labels applied to symptoms of 'focal dystonia'[8]

listed by Lederman:[9]	*listed by Andrews:*[10]	*listed by Frucht:*[11]	*Colloquial:*	*Ambiguous or argued :*
craft palsies hand failure[12] musician's cramp occupational cramp occupation neuroses occupational palsies occupational spasms professional impotence professional neuroses writer's cramp	disobedient fingers[13] distonia musicians' cramp musician's palsy	auctioneer's dystonia lip-lock[14] shoemaker's dystonia tailor's dystonia telegraphists' cramp	motor tics (various) 'shakies' (brass players) yips (golf)[15]	lock lock-up stutter[16,17] tongue lock valsalva

The word *dystonia* is neither a musical term nor description of instrumental technique.[18] It is a classification of disorders which cause the involuntary spasm or contraction of muscles: *dys-* refers to an "inability", *-tonia* is "normal muscular contraction." Although there are many types of dystonia and differing symptoms, all forms of dystonia cause involuntary, patterned and repetitive muscle action.[19] Dystonias which are limited to a particular muscle or location of the body are called *focal*. Embouchure dystonia, for example, is a focal dystonia limited to the facial muscles used in wind instrument performance. Embouchure dystonia is also *task-specific*, meaning that it causes symptoms only when a patient engages in a particular activity or task (the act of playing their instrument).[20] Unfortunately, the task-specific nature of embouchure

8 Sheehy & Marsden, "Writer's Cramp – A Focal Dystonia." *Brain*, 105 (1982): 461-480. Sheehy & Marsden attached the label 'focal dystonia,' which became dominant over the last 25 years.
9 Lederman (1988).
10 Elizabeth Andrews. *Muscle Management for Musicians*. Scarecrow Press, Lanham, MD (2005). Although Andrews uses the term 'distonia,' it is very uncommon in English research. This respelling is most likely from either Italian or German translations.
11 Frucht, et. al. (2001).
12 George Vivian Poore. "An analysis of nine-three cases of writers' cramp and impaired writing power; making, with seventy-five cases previously reported, a total of one hundred and sixty-eight cases." *Med. Chirurg Trans* 70 (1887): 301-333. Lederman attributes this label in particular to the work of Poore's work with pianists. (*Translations of the Royal Medical Surgeons Society*)
13 Andrews (2005). Andrews' label "disobedient fingers" refers to dystonia of the hand found in string players, pianists, and guitarists.
14 Frucht, et. al. (2001). Interviews with performers who have encountered 'lip-lock' (including one diagnosed by Frucht) suggest that the term 'lip lock' is not a term which should be generally applied. 'Tongue lock' seems to be a more accurate description for some cases, though this is not discussed in the literature.
15 Robert Bell. "Pick it up, it's Good: Utilizing Solution-Focused Guided Imagery with Golfers Experiencing the Yips." Ph. D. diss., University of Tennessee-Knoxville (2006). Yips is agreed to be a focal, task-specific dystonia.
16 Per A. Alm. "On the Causal Mechanisms of Stuttering." Ph. D. diss., Lunds Universitet (Sweden) (2005).
17 Martin Edmond Cochran. "A Comparison of the Behavior and Characteristics of Speech Stuttering with Musical Stuttering (i.e. Valsalva Maneuver) in Brass Playing." D. M. A. diss., University of Alabama (2004).
18 On the topic of an embouchure dystonia lecture, a humorous, horn-playing colleague asked me: "What are you going to do, play a bunch of unfocused notes without any tone?"
19 "Dystonia Defined," in *Dystonia Medical Research Foundation* [brochure online] (accessed 1 November 2007) available from http://www.dystonia-foundation.org/pages/what_is_dystonia/26.php).
20 Steven J. Frucht, et. al. "The Natural History of Embouchure Dystonia." *Movement Disorders* 16, no. 5 (August 2001): 899-906.

dystonia has been known to disappear over time, spreading symptoms to similar motion tasks.[21,22,23]

Explaining the task-specific nature of dystonia has been a research challenge for many years. Indeed, this and other qualities helped bolster the early 20th-century belief that focal dystonia was completely psychogenic.[24] A neurological dysfunction, first hypothesized in the late 1800s, is now supported by the medical establishment. Symptoms still provide the main evidence for diagnosis, but current research focuses on the motor cortex. The basal ganglia in particular provides fine-motor control a task-specific basis, therefore some researchers now focus on this section of the brain.

Brass players seem to be at the highest risk for developing embouchure dystonia, though reed players have been diagnosed.[25,26] Trombone and tuba were previously identified as a high-risk instruments for jaw injuries.[27] Their risk factors for non-dystonic concerns include the position of the jaw, air flow, and the precise motor control and repetitive action required. This collection of factors may suggest why, relative to the brass playing population, there is an unusually high number of trombonists diagnosed with embouchure dystonia.[28]

A dystonia of the buccinator muscle (between the corner of the mouth and the cheek) produces an easily-observed, involuntary muscular contraction called a "lateral pull."[29,30] Tremor may develop as the dystonic muscle weakens, nearby muscles compensate and fatigue, or opposing muscles simultaneously contract.[31] Involuntary contraction deforms the embouchure and makes it extremely difficult to produce a consistent instrumental tone. Facility and accuracy suffer tremendously.

Performance quality may be equally affected by a dystonia at another site (muscles of the mouth, tongue, neck, throat, etc.) but many areas are obscured by the mouthpiece and neighboring musculature. Intermittent symptoms help make observation and diagnosis difficult.[32]

It is notable that pain is not normally a symptom of embouchure dystonia. Some individuals will present to practitioners due to pain, but the primary concern is more likely to be a loss of facility or tone. At least in the case of embouchure dystonia, pain is more likely to be due to complications than the dystonia itself.[33]

For dystonia in large muscle groups (notably the hands, legs, and arms), botulinum toxin or other chemical injections may provide relief.[34] Unfortunately, chemical and physical treatments of embouchure dystonia are either not sustainable or

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21 Interview with [anonymous trumpet player diagnosed w/ dystonia]. 8 November, 2007. Some performers have called this 'jumping'. It is a valid concern for long-term quality of life.

22 Interview with Don Kneeburg, trombonist diagnosed with dystonia. 2 November 2007. Prof. Kneeburg's dystonia has spread from performance to other daily activities including eating and drinking.

23 Robert Thayer Sataloff, Alice G. Brandfonbrener, and Richard J. Lederman, eds. *Textbook of Performing Arts Medicine*. New York: Raven Press, 1993: 193-198.

24 Ibid.

25 Hans-Christian Jabusch and Eckart Altenmuller. "Epidemiology, phenomenology, and therapy of musician's cramp" in *Music, Motor Control, and the Brain*. Oxford, New York: Oxford University Press, 2006: 265-282.

26 Lederman (1988).

27 Howard, James and Lovrovich, Anthony. "Wind Instruments: Their Interplay with Orofacial Structures." *Medical Problems of Performing Artists* 4, no. 2 (June 1989): 59-72.

28 Jabusch and Altenmuller (2006).

29 Interview with Don Kneeburg and the author. November 2007. Professor Kneeburg's dystonia contorts the cheek muscles on one side, an easily observed cause for decreased embouchure efficiency.

30 Frucht (2001).

31 Richard Lederman. "Tremor in instrumentalists: influence of tremor type on performance." *Medical Problems of Performing Artists* 22, no. 2 (June 2007).

32 Sataloff, et. al. (1993).

33 Ibid.

34 A. J. Lees, N. Turjanski, et. al. "Treatment of cervical dystonia hand spasms and laryngeal dystonia with botulinum

completely ineffective.[35]

OVERUSE SYNDROME

Because of the wide-spread knowledge of the overuse and repetitive strain (RSI) syndromes, these topics will only be covered briefly here. Discussion will identify only the main characteristics of overuse with the goal of clearly separating it from dystonia.

Dr. Richard Norris made a concise but thorough review of overuse syndrome in his *Musician's Survival Manual*.[36] In short, overuse is just as it sounds: a condition which occurs when a physical body part is stressed beyond its limit.[37] Muscular fatigue leads to trauma in muscle, tendon, bone, or other tissue. "Tendonitis" is a familiar form, but strains, sprains, and tears are all forms of overuse. Symptoms of overuse generally include tightness, swelling, and fatigue. In the embouchure, symptoms are the same as in other muscles: pain, redness, and sensitivity to touch and use.[38] On the brass instrument, overuse affects tone (causing an "airy" or unresonant sound), range, flexibility, and endurance. Long-term, chronic overuse is called "repetitive stress," and risks the eventual disability of the muscles and joints involved.[39]

Once damage has been done, treatments for overuse depend upon the severity of the injury. Rest is often the first treatment option. An ISCOM survey of more than 2000 professional players found that rest was effective for 84% of the injured individuals who were willing to try.[40] Various types of injuries were present, but rest quite often worked. Norris qualifies that rest does not necessarily mean completely putting away the instrument: periods of rest and mental practice sessions, interspersed throughout the complete practice day, may be most effective in some cases.[41] Chemical and surgical options are necessary for some cases, but non-traditional treatments may help specific cases (massage, yoga, Alexander Technique, etc.).[42]

Following injury, post-treatment retraining and rehabilitation prescriptions must not be ignored. Physical therapy and a review of proper instrumental technique may help avoid another injury. Norris describes a sample program for instrumentalists recovering from stress, culminating in practice sessions that have a "maximum 50 minutes play with minimum 10 minutes rest".[43] He also reiterates the importance of a proper warm-up, and provides common-sense advice for building up to strenuous materials and practice sessions.

Overuse and repetitive stress injuries can usually be avoided. Proper rest and planning are the best methods of prevention.

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toxin." *Journal of Neurology* 239 (1992): 1-4.

35 Jabusch and Altenmuller (2006).

36 Richard Norris. *The Musician's Survival Manual: A Guide to Preventing and Treating Injuries in Instrumentalists*. San Antonio, TX: International Conference of Symphony and Opera Musicians, 1993: 1-11.

37 Ibid.

38 Interview with Jeremy Stanek, trumpeter diagnosed with dystonia. 3 November 2007.

39 Richard Lederman and Leonard Calbrese. "Overuse Syndrome in Musicians." *Medical Problems of Performing Artists* 1, no. 1 (March 1986): 7-11.

40 Martin Fishbein, Susan Middlestat, et. al. "Medical Problems Among ICSOM Muscians: Overview of a National Survey." *Medical Problems of Performing Artists* (March 1988): 1-8.

41 Norris (1993).

42 Fishbein, Middlestat, et. al. (1988).

43 Norris (1993).

DISCUSSION

Overuse syndrome and a plethora of other problems are inevitable when a musician ignores fatigue and pain. Poor technique and inconsistent practice are also risk factors, but fatigue and pain will lead to injury.[44] Rest is the first solution, but prevention is best. Any loss of technique due to overuse may be regained through practice, so loss of practice time should not be seen as an investment, not a discouragement. Mental practice and alternative musical endeavors (composition, reading, listening) may be chosen to maximize the use of recovery time. To prevent overuse, teachers and performers must stay completely honest and aware of their instrumental technique and practice methods. When fatigue or pain arise, rest. Review proper form and technique, and consider whether practice habits over the preceding weeks have been appropriate. If rest does not help, seek medical advice as soon as possible. Proceeding with pain risks permanent damage.

Unlike overuse, dystonia generally does not give a painful warning sign. This makes it a unique challenge to diagnose and prevent. Because the condition is neurological (physical changes occur in the brain, not at the site of the symptoms), it does not respond well to rest or traditional treatments. To the brass performer, possible symptoms will seem like under-practice or over-practice: loss of tone, reduced accuracy, loss of dynamic or expressive range, reduced range or endurance, a consistent chip or tremor on a certain pitch or range. Along with these symptoms, the task-specific nature of dystonia also supports the incorrect self-diagnosis of 'not enough practice'. When pain is absent, practice and rest are well-balanced, and the musical product is deteriorating due to a persistent motor challenge, a medical specialist may be helpful in diagnosing the cause.

In 1988, Lederman completed his discussion of occupational cramp by noting that the the only sensible treatment options will provide "... temporary help while searching for and modifying the triggering technical flaw(s) or other predisposing factors."[45] Curiously, the situation has not much changed over the last two decades. Jabusch and Altenmuller (2006) made a plea to continue the search for a "behavioral component" to dystonic development and treatment, and encouraged interdisciplinary efforts to "... identify 'beneficial behavior' on the instrument."[46] These are certainly calls for musical and pedagogical research.

Frucht, et. al. (2001) collected both photographs and videos of various forms of embouchure dystonia in the 1980s and 1990s.[47] These are useful for review of a few specific cases, but the author is currently searching out further photographic and video documentation of performers with embouchure dystonia. Interviews with pedagogues, performers, and medical researchers are also underway, another step towards documentation. Recordings and interviews will be a significant resource for both performers and teachers at all levels, and may provide observational and prevalence data for the medical establishment.

[end Thomas – Embouchure Dystonia and the Overuse Syndrome]

44 Ibid.
45 Lederman (1988).
46 Jabusch and Altenmuller (2006).
47 Frucht, et. al. (2001). Wiley Interscience (electronic database) carries the full-text and supplements to *Movement Disorders*.

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Predisposition & Background Research (Citations)

BACKGROUND

(lay literature)

1. Jeffrey Schwartz and Sharon Begley. “The Mind and the Brain: Neuroplasticity and the Power of Mental Force.” Harper Perennial, New York: 2002.

2. Oliver Sacks. “Musicophilia: Tales of Music and the Brain.” Knopf: 2007.

3. David Amen. “Change Your Brain, Change Your Life.” 1998. (reprinted 2004, etc)

RESEARCH

(medical journals)

1. Musicians are, on average, more plastic than other members of the general population. Likely a trained/learned response to practice.

Thomas Munte, Eckart Altenmuller, and Lutz Jancke. “The Musician’s Brain as a Model of Neuroplasticity.” *Neuroscience* 3 (June 2002): 473-478.

2. fMRI scans show musicians w/ embouchure dystonia have an overactive sensorimotor response. This is not a task-specific response, so it may not be acquired/learned.

Haslinger B, Altenmuller E, Castrop F, Zimmer C, Dresel C. “Sensorimotor overactivity as a pathophysiologic trait of embouchure dystonia.” *Neurology* 74 (2010): 1790-1797.

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Fletcher, Excerpt – Hirata et al Confirm Abnormal Maps in Embouchure Dystonia

SUMMARY

This article is often referenced in dystonia literature. It follows the somatosensory studies performed on focal hand dystonia patients (Byl, McKenzie, Candia, et al). The study tested eight brass players with dystonic symptoms limited to their playing, eight non-musicians (controls), and four brass players without dystonia (second control group).

Yoshihiro Hirata, Matthias Schulz, Eckart Altenmüller, Thomas Elbert, and Christo Pantev. "Sensory Mapping of Lip Representation in Brass Musicians with Embouchure Dystonia." *Neuroreport: For Rapid Communication of Neuroscience Research* 15, no. 5 (April 2004): 815-18.

EXCERPT

Dr Seth Fletcher provides a thorough summary of Hirata et al's work. Fletcher concludes:

Fletcher, Seth David. "The Effect of Focal Task-Specific Embouchure Dystonia upon Brass Musicians: A Literature Review and Case Study." D. M. A. diss., The University of North Carolina Greensboro (USA) (2008). [PDF available online from The University of North Carolina Greensboro]

Results of the gap detection test indicated that patients and controls showed no difference in sensitivities between fingers in each hand when viewed as a group or when compared between groups. Data for lip sensitivities indicated that healthy musicians demonstrated a higher sensitivity threshold (i.e., ability to perceive weaker stimuli) than controls and that patients' upper lips showed lower sensitivity in most cases – 10 of 16, with 2 others showing lower sensitivity in their lower lip – than healthy musicians or control subjects. The MEG data showed that subjects' lip representations of their affected/unaffected lips were respectively similar and that both fingers and lips were mapped in the same order as in the normal somatosensory homunculus. While the order of representation was shown to be normal – little finger, ring finger, middle finger, index finger, thumb, ..., lips – the spatial representation between digits and lips was found to be closer together in patients than in controls. Specificially, the point of cortical representation of the thumb was laterally closer to the lips in patients.

Byl & McKenzie Abstract – Behavioral Retraining of Focal Hand Dystonias

SUMMARY

Nancy Byl et al show that focal hand dystonia patients can be retrained using methods to restore normal cortical sensorimotor representation.

ABSTRACT

Byl, NN. McKenzie, A. - Department of Physical Therapy and Rehabilitation Science, UCSF/SFSU Graduate Program in Physical Therapy, University of California-San Francisco, 94143, USA. byl@itsa.ucsf.edu

Recent studies show that rapid, nearly simultaneous, stereotypical repetitive fine motor movements can degrade the sensory representation of the hand and lead to a loss of normal motor control with a target task, referred to as occupational hand cramps or focal hand dystonia. The purpose of this prospective follow-up study was to determine whether symptomatic patients in jobs demanding high levels of repetition could be relieved of awkward, involuntary hand movements following sensory discriminative retraining complemented by a home program of sensory exercises, plus traditional posture, relaxation, mobilization, and fitness exercises. Twelve patients participated in the study. They all had occupational hand cramps, as diagnosed by a neurologist. Each patient was evaluated by a trained, independent research assistant before treatment and three to six months after treatment, by use of a battery of sensory, motor, physical, and functional performance tests. Care was provided by a physical therapist or a supervised physical therapist student in an outpatient clinic. Patients were asked to stop performing the target task and to come once a week for supervised treatment that included 1) heavy schedules of sensory training with and without biofeedback to restore the sensory representation of the hand, and 2) instructions in stress-free hand use, mirror imagery, mental rehearsal, and mental practice techniques designed to stop the abnormal movements and facilitate normal hand control. Patients were instructed in therapeutic exercises to be performed in the home to improve postural alignment, reduce neural tension, facilitate relaxation, and promote cardiopulmonary fitness. Following the defined treatment period, all patients were independent in activities of daily living, and all but one patient returned to work. Significant gains were documented in motor control, motor accuracy; sensory discrimination, and physical performance (range of motion, strength, posture, and balance). This descriptive study that includes patients with occupation-related focal hand dystonia provides evidence that aggressive sensory discriminative training complemented by traditional fitness exercises to facilitate musculoskeletal health can improve sensory processing and motor control of the hand.

PMID: 11129254 [PubMed - indexed for MEDLINE]

SEE ALSO

Byl, N. N., and A. McKenzie. "Treatment Effectiveness for Patients with a History of Repetitive Hand Use and a Focal Hand Dystonia." *Journal of Hand Therapy* 13 (2000): 289-301.

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Candia et al – Effective Behavioral Retraining of Focal Hand Dystonia

SUMMARY

Study detailing successful retraining of focal hand dystonia in musicians.

V Candia, C Wienbruch, T Elbert, B Rockstroh, and W Ray. "Effective behavioral treatment of focal hand dystonia in musicians alters somatosensory cortical organization." *Proc Natl Acad Sci USA* 100 no 13 (2003): 7942-7946.

COMPLETE ABSTRACT

Victor Candia * , Christian Wienbruch *, Thomas Elbert *, Brigitte Rockstroh *, and William Ray

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Edited by James L. McClelland, Carnegie Mellon University, Pittsburgh, PA and approved April 18, 2003 (received for review February 21, 2003)

New perspectives in neurorehabilitation suggest that behavioral treatments of movement disorders may modify the functional organization of central somatosensory neural networks. On the basis of the assumption that use-dependent reorganization in these networks contributes to the fundamental abnormalities seen in focal dystonia, we treated 10 affected musicians and measured the concomitant somatosensory changes by using whole-head magnetoencephalography. We found that effective treatment, using the method of sensory motor retuning, leads to alterations in the functional organization of the somatosensory cortex. Specifically, before treatment, somatosensory relationships of the individual fingers differ between the affected and unaffected hands, whereas after treatment, finger representations contralateral to the dystonic side become more similar to the less-affected side. Further, somatosensory finger representations are ordered more according to homuncular principles after treatment. In addition, the observed physiologic changes correlated with behavioral data. These results confirm that plastic changes in parallel with emergent neurological dysfunction may be reversed by context-specific, intensive training-based remediation.

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Thomas, Excerpt – Checklist for Retraining: Areas of Concern

The following outline summarizes five main areas which may compromise a brass performer's skills: overuse, faulty technique, psychological imbalance, other biological factors, and neurological factors. This list is not meant to be exhaustive. Instead, it aims to attract pedagogical discussion and behavioral research on specific challenges.

1. Address Overuse
- rest from practice[48,49]
- consider effects of other daily uses (other physical work or activities)[50]
- assess the practice routine (integrate rest, variety)[51,52]
- keep & review a practice journal, practice notes, etc.
- diet, water, general sleep & rest habits

2. Address Technique
- blowing/air technique (a la Kagarice)[53]
- embouchure technique (esp. noting range breaks)[54]
- time concept (oscillating or discrete) and entrainment for coordination[55,56]
- mental focus[57,58]

3. Address Psychological and Emotional Stress
- acquire professional medical/psychological assessment[59,60,61,62]
- integrate activities for focusing, general mental & physical health[63]
- seek guidance from individuals who have experienced similar performance difficulties[64]

48 Richard Norris, *A Guide to Preventing and Treating Injuries in Instrumentalists* (San Antonio, TX: International Conference of Symphony and Opera Musicians, 1993), 8.
49 James Howard and Anthony Lovrovich, "Wind Instruments: Their Interplay with Orofacial Structures," *Medical Problems of Performing Artists* 4, no. 2 (June 1989): 70.
50 Richard Norris, *A Guide to Preventing and Treating Injuries in Instrumentalists* (San Antonio, TX: International Conference of Symphony and Opera Musicians, 1993), 9.
51 Ibid., 103-108.
52 Simon Overduin, Andrew Richardson, Courtney Lane, Emilio Bizzi, and Daniel Press, "Intermittent practice facilitates stable motor memories," *The Journal of Neuroscience* 26 no. 46 (15 November 2006): 11890-11891.
53 Jan Kagarice, interview by author, 1 June 2007, Las Vegas, Nevada, electronic notes.
54 James Thompson, *The Buzzing Book* (Vuamarens, Switzerland: Editions Bim, 2001): 8.
55 Sam Burtis, interview by the author, 7 January 2008, telephone interview and electronic recording.
56 Justin London, *Hearing in Time: Psychological Aspects of Musical Meter* (Oxford: Oxford University Press, 2004): 20-21.
57 Amra Hodzic, Ralf Veit, Ahmed A Karim, Michael Erb, and Ben Godde, "Improvement and Decline in Tactile Discrimination Behavior after Cortical Plasticity Induced by Passive Tactile Coactivation," *The Journal of Neuroscience* 24, no. 2 (14 January 2004): 445-446.
58 Jeffrey Schwartz and Sharon Begley, *The Mind and the Brain: Neuroplasticity and the Power of Mental Force* (New York: Harper Perennial: 2002).
59 Interview with Anonymous 2, 2008.
60 Stefan Sanders, interview by author, 23 May 2007, Austin, Texas, electronic notes.
61 Interview with David Scragg, 2007.
62 Vanessa Lim, Eckart Altenmüller, John Bradshaw, "Focal Dystonia: Current Theories," *Human Movement Science* no 20 (2001): 902-903.
63 Interview with Stefan Sanders, 2007.
64 David Vining, interview by the author, 7 & 14 March 2007, telephone interview and electronic notes.

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Thomas, Excerpt – Checklist for Retraining: Areas of Concern

(cont'd)

4. Address Other Factors

- search for genealogical/familial trends (predisposition)[65]
- review medical history - physical injuries, pharmaceutical / drug usage, etc.[66]
- consider dietary, mineral, glycemic risks[67,68]

5. Address Possible Neurological Changes

- do not reiterate activities that cause offending symptoms (avoid reinforcing habits)[69,70,71]
- address complications or alternative causes of symptoms
- avoid compensation (alternative fingerings, equipment, air attacks, etc.) as a long-term solution[72]
- explore medical treatments that reduce symptoms or enhance neuroplastic response
- acquire pedagogical/musical guidance for practice methods and scheduling[73,74]
- design and implement exercises that transition between existing skills and desired skills[75]

[end Thomas, excerpt – Checklist for Retraining]

65 Jabusch and Altenmüller, 2006: 266.
66 Eric Mohlo and Stewart Factor, "Possible Tardive Dystonia Resulting from Clozapine Therapy," *Movement Disorders* 14 no. 5 (1999): 873-874.
67 N. C. K. Tan, A. K. Y. Tan, Y. Y. Sitoh, K. C. Loh, M. K. S. Leow, and H. T. L. Tjia, "Paroxysmal Exercise-Induced Dystonia Associated with Hypoglycaemia Induced by an Insulinoma," *Journal of Neurology* 249 (2002): 1615.
68 Per A. Alm, "On the Causal Mechanisms of Stuttering" (Ph. D. diss., Lunds Universitet, Sweden, 2005).
69 Interview with David Vining, 2007.
70 Kevin Roberts, interview by author, 13 February 2007, Austin, Texas, electronic notes.
71 Scragg, 2007.
72 Mark C. Davis, "Fearless: Badi Assad tackles exotic music and fights a debilitating disease," *Guitar Player* (1 March 2006): 58.
73 Interview with David Vining, 2007.
74 Interview with Jan Kagarice, 2007.
75 Interview with David Vining, 2007.