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# Dystonia Arising from Occupations: The Clinical Phenomenology and Therapy

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## 1. Introduction

Dystonia is generally referred to belong to the generic terms, *muscle spasm* and *muscle stiffness*. *Muscle spasms* would be any involuntary abnormal muscle contraction, regardless of whether it is painful or not, that cannot be usually terminated by voluntary relaxation. *Muscle stiffness* is an involuntary muscle shortening that usually lasts for seconds to minutes, but may be sustained. Sustained muscle contraction may lead to posturing and even pain as seen in tetany, dystonia, spasticity, and contracture. Whereas *tetany* is brisk, short-lived, and associated with paresthesiae, *dystonia* is a slow, more sustained co-contraction of the agonist and antagonist muscles, that may characteristically be task-specific and abolished by “sensory tricks.”(1)

Limb Dystonia is a movement disorder characterized by excessive and overflow muscle contraction leading to abnormal limb postures (i.e. flexion, extension, twisting, abducting and adducting) and impaired movement. Limb dystonia may be focal (limited to a single body area), segmental (affecting at least two adjacent muscle groups), or a component of hemidystonia and generalized dystonia. It has been described in writers, typists, golfers, musicians, and many other occupations, and is often associated with markedly disabling loss of function.

Focal hand dystonia was first recognized by its characteristic impairment of specific tasks. It has a tendency to cluster in those with particular occupations so that it was once thought of as psychogenic in origin. The task specific focal hand dystonia arising from occupations (i.e. occupational cramp) include variants like writer’s cramp, musician’s cramp and sports’ cramp (e.g. golfer’s cramp). Embouchure’s dystonia, mainly affecting the lips, jaw and tongue, is included in this category. In task specific dystonia, primary sensory modalities are

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intact, although impaired spatial or temporal discrimination may be identified if specifically sought(2). The neurological examination is essentially normal except for the dystonic movements. Actions eliciting the dystonia may be performed slowly and irregularly but there is no ataxia. This chapter aims to highlight the phenomenology, pathophysiology, clinical course and management of occupationally-related dystonias. Not only are these forms of dystonias characteristically mistaken to have psychogenic origins, but also that these disorders impinge on the profession and quality of life of the affected individuals. We cap this chapter with a peculiar illustrative case if only to emphasize the precepts of the phenomenology and management strategy of this kind of a dystonia.

## 2. Phenomenology of task specific dystonias

Focal dystonia, as with other dystonic disorders, have common characteristic features that distinguish it from other hyperkinetic movement disorders. There is co-contraction of agonists and antagonist groups of muscles and the contractions result in abnormal limb postures. The contraction is of relatively long duration and sustained as compared to that of chorea or athetosis and usually involves the same muscle groups. This involvement of the same muscle groups termed “patterned” movements may remain focal or may, in time, involve contiguous body parts. In the latter case, the term segmental dystonia may apply.

There is a directionality and predictability of the movements somehow being stereotypical in character. Variability speaks more of a psychogenic dystonia rather than an organic one.

Another special characteristic of the dystonias is the response to certain “sensory tricks” whereby doing something else apart from the task may alleviate the dystonia such as chewing a gum while playing a wind instrument relieves the lip dystonia in some musicians. There is a tendency for the movements to worsen with fatigue, stress, anxiety.

Sometimes, the dystonic contractions can occur rapidly and repeatedly mimicking a tremor. The feature that distinguishes it from the latter is the relatively irregular occurrence of the dystonic tremor, the apparent increase in the tremor when the muscles involved are pulled opposite to the direction of its contraction and activation of the muscles not required for maintenance of that particular posture(3). For this chapter, we focus our attention to task specific focal dystonias or those occurring in situations whereby repetitive skilled movements are essential to its development.

The first symptom of focal hand dystonia is usually a feeling of tightness or loss of facility with a previously easily performed action, often accompanied by fatigue and aching in the affected arm and forearm that worsens with continued use. In the case of embouchure’s dystonia, there is initial feeling of tightness around the lip with somewhat difficulty in controlling lip and jaw movements. Pain, quite common in cervical dystonias, may not be as frequent in occupational dystonia. If indeed pain occurs, this could be part of muscle fatigue, myofascial pain component or corresponding joint changes. Overtime, there is involuntary posturing of the limb (or the lips, jaw or tongue in the case of embouchure’s dystonia) during the performance of the task. The symptom usually disappears with discontinuation of the task or with rest.

In due course, the abnormal movements may not only appear during the task but may also occur during other movements such as buttoning clothes, typing, holding a spoon. In some,

further progression may lead to the occurrence of some dystonic movements at rest however, this is not typical. Fixed dystonic postures are rare, and occurrence of “fixed posturing” puts psychogenic dystonia into the differential diagnosis.

The most common task specific focal hand dystonia is writer’s cramp (4) whereby writing brings about a variety of combinations of dystonic posturing. Muscles normally not used in writing are simultaneously activated during the task and this has been demonstrated with surface EMG recordings done while writing(5). Additionally, there is lack of muscle selectivity and prolonged muscle bursts in these patients. The abnormal movements start as soon as the hand holds the pen or after having written a few words. Patients normally describe an uncontrollable force that makes them grip the pen tightly, and as a result, normal fluidity of writing is lost and patients are unable to write undisturbed. Penmanship thence becomes slow, irregular and even illegible. Symptoms stop as soon as they stop writing.

A mirror image effect(4) may occasionally be observed whereby writing with the unaffected hand simulates or produces the dystonic posture on the affected hand. This emphasizes the importance of sensory input in the pathophysiology of focal dystonia as the phenomenon impacts on central motor programming. Sensory tricks such as touching the hand during writing may ameliorate the dystonia. It appears though that, as in cervical dystonia, the sensory trick may not abolish the dystonia when the disorder has become long standing.

Patients who exhibit the dystonia only when writing are considered to have simple writer’s cramp whereas those having difficulties with other tasks are considered complex forms of the latter.

As the symptoms of writer’s cramp progress, it may involve more proximal forearm muscles, elbow and the shoulder causing involuntary abduction. Occasionally, the other hand may become involved.

### **3. Phenomenology of musician’s dystonia**

In musician’s cramps, involuntary movements affect the limb while playing the instrument. Usually, the movements are similar as that of writer’s cramp whereby pain is not as striking as the loss of control. These movements may lead to severe impairment and may result in loss of functionality and occupation. Dystonia usually begins in just one finger and eventually spreads to involve other fingers and rarely skips fingers(6). The fingers most often implicated are the two ulnar digits (fingers IV and V). These two fingers are not designed for the prolonged, rapid, highly complex movements demanded in many of those patients presenting with focal hand dystonia. Frucht (6) likewise described that there is hypermobility of these joints when ulnarly deviating to grip instruments thereby producing a mechanical susceptibility of these fingers to the development of dystonia.

Hand movement requires a degree of fine motor control which entails the precise activation of the hand area in the sensorimotor homunculus and inhibition of other uninvolved muscles. In focal hand dystonia, there is evidence of lack of inhibition at multiple levels in the central nervous system. This lack of inhibition with simultaneous contraction of both agonist and antagonist muscles are integral in the development of writer’s cramp. Likewise, transcranial magnetic stimulation studies demonstrated

abnormal intracortical inhibition(7). This abnormality is demonstrated bilaterally on both hemispheres despite the unilaterality of symptoms. The gaba-ergic neurotransmitter systems responsible for widespread inhibition in both direct and indirect pathways of the corticostriatothalamocortical loop in the central nervous system are found to be reduced(8).

The major contributing factor in the development of focal hand dystonia appears to be the prolonged, repetitive use of the hand (2-3). The hands are represented in the primary somatosensory cortex in high resolution, and receptive fields are small and sharply differentiated, not including more than one finger (9-10). It is known that through repeated use, this representation in the somatosensory cortex is malleable through the process of sensory learning called neuroplasticity. Among trained musicians, there is enlarged cortical representation of the hands in the somatosensory cortex and auditory domains which demonstrates this normal plasticity(11). In focal hand dystonia, repetitive sensory stimulation during the execution of the skilled manual tasks might lead to maladaptive sensorimotor plasticity in susceptible individuals. This maladaptive sensorimotor plasticity leads to changes in the representation of the digits within the somatosensory and motor cortices of the brain. As a result, the brain is unable to distinguish between near-simultaneous sensory inputs to the cortex, disrupting sensory feedback to the motor system and consequently fine motor movements. Magnetic source imaging showed that representational areas in the brain seem to fuse among these patients with this dystonia (12).

On the other hand the vibration induced illusion of movement model suggest a mechanism whereby motor subroutines become corrupted when movements are over-learned in the fatigued state (13-15). In idiopathic focal dystonia, the muscle spindles become stiff and their elastic properties vary as they are stretched or what is termed as “spindle thixotrophy”(16-17). Compared to normal individuals, the muscle spindles become stiffer in dystonia, but then become more elastic after they are over-stretched. Thus, it is the inconstancy of elastic properties of the dystonic muscle spindle that leads to the motor subroutine corruption. These peripherally-induced mechanisms may elucidate two phenomena: (a) why idiopathic focal dystonia symptoms tend to affect skilled and heavily practiced movements; (b) why sometimes dystonic symptoms evolve with time (18-19). An illustrative case at the end of the chapter will be presented to embody these phenomena.

According to previous studies (20) the correlation between peripheral trauma and hand dystonia remains controversial up to present. Even more bodies of evidence suggest a direct causal relationship. Moreover, ulnar neuropathy has been described in musician’s dystonia(21). However, it is of note, that even if the relationship between injury and the development of dystonia are common, not all patients with trauma develop dystonia. Hence, trauma in an individual with a specific vulnerability is proposed. Repetitive use of the hands under extreme pressures and expectations related to the tasks may however be gleaned as a form of trauma.

The pattern of focal hand dystonia varies and may involve various combinations of distal and proximal muscles, flexors and extensors and supinators or pronators and is dependent on which groups of muscles are more often used by the sufferer. For instance, in writer’s cramp, the dominant writing hand, the right, is more commonly affected. Finger flexors and wrist extension and flexion are commonly affected; Typist dystonia have variable affection



of both hands; in musician's dystonia, those playing guitars, pianos or other string instruments tend to have more affection of the finger flexors. If the bowing hand is affected in a violinist, then wrist flexors are more affected. The left hand would be more involved in those playing with the violin and the flute(6). The right hand would be more vulnerable in those playing with the guitar and with the keyboard (6). Lateralization is not so prominent in musicians who use both hands like woodwind players or in keyboard typing. The dictum is, the hand which is more frequently utilized is the more frequently affected. The striking observations by Frucht and colleagues (6) showed that in musician's dystonia, the dystonic movements are stereotyped and rarely varies in a given patient.

Other task specific dystonia involving the limbs are sports related and have also been described in golfers(22) and pistol shooters(23). Among golfers, the dystonia is manifested as freezing, tremor, or an uncontrollable jerking which leads to deterioration in golf performance.

A special type of task specific dystonia involves the lips, jaws and lower cranial muscles of musicians playing brass and other wind instruments. This is termed as embouchure's dystonia. The highly specialized control of the different lower cranial muscles is required for the right production of pitch, tone and volume. Patients initially complain of lip and mouth fatigue. Rarely would pain be complained. Symptoms typically start during the fourth decade in the absence of a clear history of trauma, dental prosthesis or temporomandibular joint disease. Frucht et al described the largest group with embouchure's dystonia. Lip pulling or lip locking phenotypes(24) and other groupings such as lip tremors, jaw closure, involuntary lip movement groups have been described(25). Eventually, the dystonia not only disrupts handling of instruments but eating, chewing and speaking may also be impaired.

#### 4. Epidemiology

According to the ESDE(26), the incidence of task specific dystonia range from 1.7 to 14 and the prevalence range from 7 to 69 per million population. Usually these occur more frequently in males (2, 26-27) and typically in the third to fourth decade of life. At least 1% of professional musicians are afflicted with dystonia(28). Although other movement disorders can occur in the same patient, the true prevalence of two types of task specific dystonias occurring in the same patient is not known (2, 26). Most commonly described movement disorder occurring in the setting of task specific dystonia is the coexistence of tremor. Tremor, is present in up to 48% of patients with focal hand dystonia, usually unilateral in the affected arm, and may be task-specific(9).

Not all patients involved in these occupations or musicians develop dystonia. Clearly there are other pathophysiologic mechanisms to consider such as environmental influences and genetics. Although most patients with musician's dystonia deny a positive family history, a report on autosomal dominant inherited forms have been made by Schmidt et al. (29). About 10 - 20% of task specific dystonias have a positive family history(30). Other risk factors such as increasing practice time, psychological stresses, anxiety, personality types have been implicated(27). At this point, the genetic underpinnings of focal hand dystonia, including that of musician's dystonia, have not yet been fully characterized. DYT1 mutation is an infrequent cause of task specific dystonia and has only been described in some cases of idiopathic dystonia and rarely in musician's cramp (2, 10).

## 5. Course and prognosis

In general, the course and prognosis for the different task specific dystonias are guarded. Majority of those with musician's dystonia are unable to return to their previous level of function and are forced to abandon their long passion for the instruments. In a study by Schuele et al. (31), a 13 year follow up of musicians with focal hand dystonia showed that only 38% of those who play string instruments were able to return to their careers. Those with writer's cramp, on the other hand, are rarely severely disabled. Majority of them can still continue writing despite the symptoms. The guarded prognosis of these patients also stem from the fact that only few have significant response to the different therapies available and that most of them tend to have the spasms spreading to contiguous muscle groups. Among the task specific dystonias, embouchure's dystonia is perhaps the most resistant to treatment(32).

## 6. Management strategies in occupationally related dystonias

Due to the high functional disability associated with these task specific dystonias, early recognition and institution of appropriate therapy is imperative. Treatment strategies are varied and include oral medications, chemodeneration, surgical approaches, limb immobilization, orthosis and physical therapy(9). Taken alone, perhaps only a handful of patients respond significantly with each of these regimen.

One non-pharmacologic intervention of interest nowadays is aimed at retraining the brain (i.e. sensorimotor retuning, SMR). Since these abnormal movements usually stem from abnormal plasticity and sensorimotor processing in the central nervous system, SMR has been devised to try to modify the cortical representation of the affected limb through immobilization. SMR is done wherein the uninvolved fingers are immobilized using splints while practicing sequential movements with their instruments at least an hour a day. This resulted in significant improvement in performance of pianists and guitarists for a 25 month follow up period(33), purportedly due to cortical remodeling. The involved side showed a much organized pattern simulating the normal side when evaluated with magnetoencephalography(34). Those playing wind instruments did not show improvement. Perhaps this is because of the anatomical constraints of muscles involved in this type of patients. A case report on one pianist (35)also showed improvement to pre-dystonia levels with SMR.

Another form of retraining is directed towards addressing abnormal sensory processing in these patients through braille reading which can improve spatial discrimination and symptoms in dystonia(36). A combination treatment with motor training and constraint induced immobilization of the dystonic hand has also been tried among musicians and showed some benefits(37). Patients with writer's cramp may also benefit from training individual fingers not involved in the dystonia (38-39). The advantage of SMR is that patients can be retrained in limiting activities that simulate the pattern which brought out the dystonia and hopefully prevent spread, thereby reducing disability. The only limitation seems to be the fact that symptoms recur as soon as they stop doing these exercises(36) and excessive retuning may again lead to maladaptive plasticity in these patients already with an inherent susceptibility. These training exercises need further validation in more large scale studies to assess long term benefits. In patients with embouchure's dystonia, Frucht (24)described some improvement when patients were asked to alter their technique by using

a different mouthpiece or a different instrument. One particular problem in these training techniques in embouchure's dystonia most especially is that, retraining may push the spread of the dystonia to other contiguous muscle groups if the patient continues playing. However, studies to demonstrate this phenomenon are lacking.

The first line treatment for focal dystonia is chemodenervation with botulinum toxin. It is proposed that the peripheral action of botulinum toxin A of reducing muscle spindle signals(17, 40) could alter the balance between afferent input and motor output, thereby secondarily affecting cortical excitability(41-42). In addition, it has been shown to help in reorganizing intracortical inhibition, albeit transiently (43-44). Botulinum toxin has been shown in several randomized controlled trials to be effective in the treatment of writer's cramp (45-46). Among musicians, improvement with botulinum toxin injections has been demonstrated in 57-68% of patients (32, 47). Not infrequently, injected patients may experience weakness. Response of embouchure's dystonia, is inconsistent and disappointing. In tasks whereby fine motor control is needed, the weakness may outweigh the benefits of the improvement in dystonia and this should be discussed thoroughly with patients. Long term follow up of 10 years with botulinum toxin use in musicians show that its benefits are sustained and antibody production has not been demonstrated(48).

A variety of oral medications may be initiated in patients with task specific dystonias. Anticholinergics, gabaergics or dopaminergics have been tried with relatively inconsistent results. Trihexyphenidyl showed improvement in a third of patients (33% from 144 patients in the series) with musicians dystonia(32). Oral medications are often limited by side effects. The generally poor response probably reflects the fact that the problem is in the central nervous system (altered neuroplasticity in the somatosensory cortex) and not peripherally.

## 7. Illustrative case of a dual dystonia

We have had the chance to see a patient suffering from dual dystonia affecting only keyboard typing and money counting (Figures 1 and 2). Her other hand movements were unaffected by other tasks (49).

This 42 year old female bank cashier presented with two types of task specific (money counting and keyboard typing) dystonias since 8 years prior. Her right middle finger, fourth and fifth digits would hyperextend at the proximal and distal interphalangeal joints while both her thumbs hyperextend at the metacarpophalangeal joint. She has no family history of any movement disorders and has had no previous trauma. Her neurological examination was entirely normal. On work up, her cervical MRI showed cervical spondylosis at the level of C3-C4. She had normal CBC, ESR, Thyroid function tests, Anti thyroglobulin antibody, ANA panel, serum ceruloplasmin, Na, K, ionized calcium, cranial MRI and routine nerve conduction studies. Electromyography showed sustained bursts of motor unit potentials in co-contracting muscles such as the flexor and extensor carpi radialis and ulnaris on the right. The surface polymyographic analysis showed co-contraction of antagonist muscles of both arms especially when the abovementioned tasks were performed.

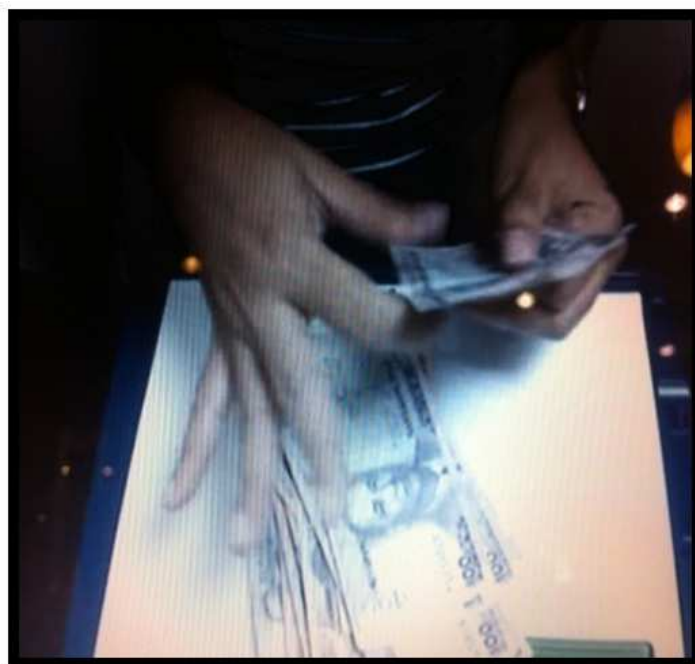
The following treatment options were tried but with no satisfactory results: levodopa, benzodiazepines, anticholinergics, baclofen and pregabalin. She even tried acupuncture, massage and physical therapy. Finally, botulinum toxin injection (*abobotulinumtoxinA*) was



initiated as follows: To right flexor carpi radialis and flexor carpi ulnaris(100U each), extensor digitorum communis (75 units) and left extensor pollicis longus (35 units). The injections resulted in improvement on money counting but there was minimal response on keyboard typing. Prior to injection, it was the patient's wish (and thus our aim) that she sustains her job as a cashier by mainly improving her money-counting, as we were not optimistic to abolish both dystonias in one injection setting. She continued to improve in the same manner from subsequent 4-monthly injections.



a



b

Fig. 1. Dystonia while counting money



a



b

Fig. 2. Dystonia during keyboard typing

## 8. Conclusion

Task specific dystonia is phenomenologically distinct and remains to be a challenging disorder to treat. An inherent susceptibility is yet to be defined but it appears that repetitive muscle movement is the integral to the development of abnormal and maladaptive plasticity, loss of intracortical inhibition and abnormal sensory processing. Task specific dystonia tends to be disabling. Botulinum toxin remains in the first line of treatment in those presenting with focal limb dystonia. Embouchure's dystonia is even more challenging, a disorder. SMR remains an attractive management option. Multi-modal treatment approach may likely optimize outcomes.

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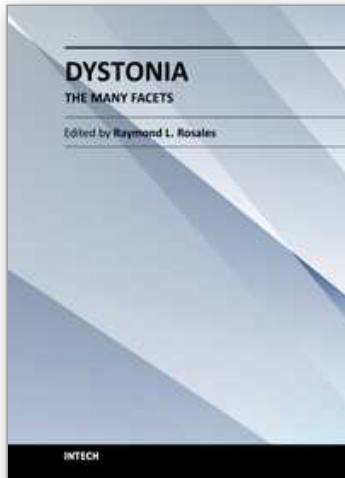
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## **Dystonia - The Many Facets**

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Dystonia has many facets, and among those, this book commences with the increasingly associated genes identified, including a construct on how biology interacts with the dystonia genesis. The clinical phenomenology of dystonia as approached in the book is interesting because, not only were the cervical, oromandibular/lingual/laryngeal, task-specific and secondary dystonias dealt with individually, but that the associated features such as parkinsonism, tremors and spasticity were also separately presented. Advances in dystonia management followed, and they ranged from dopaminergic therapy, chemodenerivation, surgical approaches and rehabilitation, effectively complementing the approach in dystonia at the clinics. A timely critical pathophysiologic review, including the muscle spindle involvement in dystonia, is highlighted at the book's end.

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