Neuromuscular and related aspects of musical performance[1]

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Various musculoskeletal and neurological conditions may impair musical performance. None seems age specific and only a few are directly related to playing. The latter are largely peripheral nerve compressive disorders. The nature of the complaint can usually be identified by examination and observation of the performer. Postural correction or compensation for infirmities such as osteoarthritis may provide relief. In younger players, tension may hinder performance and may respond to relaxation techniques, coaching, or a different instructor. In older performers, disease processes may affect the nervous system. Although many conditions are treatable, occupational cramp is as disabling to musicians as it is to typists, scriveners, and telegraphers. Its overall prognosis is poor indeed, and despite valiant efforts at treatment and retraining, career change is usually the ultimate outcome. The century-old argument of neurosis versus dystonia in such disorders remains unresolved.

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Musical performance is controlled and affected to a great extent by the neuromuscular system. The wide range of factors (such as the effect of aging and disorders commonly encountered in the elderly, musculoskeletal disorders, and neuromuscular diseases) are presented and their effect on the musical performer is discussed in detail.

The effects of aging on neuromuscular function in musicians

No behavioral data exist supporting the contention that neuromuscular or other functions necessary for musical

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performance decline in active players of any rank as a function of age. Musicians more than 60 years of age report no disability or impedance of performance not related to a specific disease process. In one instance, a major flutist was said by his assistant principal to be playing better than ever (personal observation). Critchley,[1] in referring to the effect of aging in musicians, cites only such conditions as gout, alcoholism, and mood disorders. He mentions several septuagenarians who played well.

General reaction time and performance studies in individuals more than 60 years of age indicate that the number of trials required to acquire new motor skills is greater than in younger persons. However, sexagenarian subjects of such studies ordinarily make fewer errors and this gain in accuracy results in attaining a skill about as quickly as younger subjects.

Involutional changes commonly encountered in elderly individuals, such as progressive reduction of ankle jerks and elevation of vibratory sensation threshold at the toes, ordinarily do not interfere with musical performance. Similar involvement of the fingers does not occur until much later in life. As far as is known, these conditions are not associated with disturbance of function or the capacity for musical performance. Electromyographic studies of elderly individuals in the absence of specific disease processes disclose little except a slight reduction in nerve conduction velocity, again without clear alteration of function.

Conditions commonly encountered in elderly persons that might affect musical performance

Tremor developing late in life without family history is often pejoratively referred to as senile tremor. Its clinical appearance, natural history (save age of onset), and pharmacotherapy are indistinguishable from similar tremors that occur through dominant inheritance (familial) or at random in younger persons (essential). It is often discovered subsequently that the person with an apparently random tremor has a similarly affected relative in the extended family, suggesting recessive inheritance. This disorder characteristically emerges or is more severe during activity. It is rhythmic, variable in extent, and occurs at a rate of 3 to 5 beats a second. Its amplitude is ordinarily less than 15° (2 cm at fingertips); myoclonus may coexist. This disorder may not interfere with function and can be tolerated as an inconvenience, although an occasional individual may suffer a more severe form. The tremor may involve the head, lips, tongue, and voice, in addition to the wrist, hand, and fingers. Reports of musicians suffering from this condition are only anecdotal. Tremors may well interfere with bowing or fingering; unwanted tremolo or vibrato may affect articulation and sound production. The condition is easily relieved with beta blockers. Moderate to high doses of propranolol (<360 mg/day) do not completely eliminate the disorder, but produce satisfactory relief. The use of beta blockers is usually safe in individuals free of asthmatic disorders, although postural hypotension and depression may develop in some patients. Depression may be avoided by the use of water rather than lipid-soluble agents (e.g., timolol maleate).

Peripheral nerve disorders such as symmetrical polyneuropathy, which may occur at any age, do not appear to have special predilection for musicians. The two commonest causes are related to diabetes mellitus and the use of alcohol. Ordinarily, the manifestations of milder disorders spare the upper extremities and do not interfere with musical performance.

In various patients, many of whom are elderly, thickening of ligaments is likely to cause compression of peripheral nerves, which may interefere with musical performance by altering the control of movement or more often contactual and proprioceptive sensation in the hand, thus reducing the ability of the performer to accurately and quickly control movement, pressure, and placement of the fingers on keys or strings. The commonest of these conditions is the so-called carpal tunnel syndrome,[2,3] which results from compression of the short recurrent branch of the median nerve within its tunnel of transit through the volar carpal ligament. This condition is not unique to musicians, although strong pressure exerted against the wrist predisposes the ligament to thickening. The condition that narrows the carpal tunnel results either from some concurrent medical disease such as polymyalgia rheumatica or hypertrophic degenerative osteoarthritis (which in itself leads to carpal tunnel stenosis); long-term exertional stress on the wrist, particularly with the part extended; or a combination of the two. Sustained pressure against this ligament

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is a likely part of musical practice in pianists, harpists, and tympanists. In some piano players who have suffered disturbance of function in the hand, the cause has been direct trauma secondary to technique with subsequent development of neuromuscular decompensation or an inflammatory disorder. This has then left the hand painful and partially immobilized with consequently impaired performance.

There is a shift in the relative density of fast and slow twitch muscle fibers in aging with reduction of the former. Additionally, with prolonged use of a part, there may be an increase in the number of muscle cells supplied by a single nerve fiber. This is probably related to continued workplace trauma, but in most individuals appears to have little demonstrable effect on function. The matter, however, has not yet been studied critically.

Primary muscle disease is relatively uncommon. When it occurs in older patients it is likely to reflect either a chronic inflammatory disorder of the muscle (chronic polymyositis) of varied cause or the exposure of the patient to some toxic substance, often a drug, such as glucocorticoid. The myopathic process is usually identified by weakness of proximal limb muscles. The neck, hip, and trunk flexors, shoulder elevators, abductors, and flexors are among those most likely to be affected early and are usually the most severely impaired. Such a condition interferes with most musical performance, since the arms, hands, and fingers are used to play most musical instruments, particularly the violin, viola, flute, and piccolo. Additionally, involvement of the anterior neck muscles and those of the ventral trunk, especially the abdominal wall (often called "diaphragm" by musicians and voice coaches), interferes with both sound production and support in wind players and singers. Since many older individuals suffer mild degrees of degenerative diseases such as emphysema or have lost some ventilatory function, the superimposition of muscle weakness provides a serious barrier to musical performance even though the myopathy itself has not been caused by playing or singing.

Wind players share with vocalists dependence upon control of the musculature of the head. There appear to be no known clear-cut neuromuscular conditions specifically related to old age in musicians. Incidental impairment of musical performance involving the musculature of the head usually results from *disorders of cranial nerves.* With respect to wind players, disorders of the facial musculature affect the formation, direction, volume, speed, and shape of the air column. Disorders of muscles of the trunk and neck alter support and volume. Facial muscles are innervated by the trigeminal (fifth) and facial (seventh) nerves. The former control the position of the jaw and modify, along with the tongue and palate (glossopharyngeal [ninth], vagus [tenth], and hypoglossal [twelfth] nerves), the shape of the upper airway. Inability to alter readily the configuration of this cavity results in an air column that retains a fixed form, significantly changing the character of the sound produced, rendering it far less flexible than required even for amateur performance. In most wind and brass players, the shape of the air column is further altered by contraction of the muscles of the face. Innervated by the facial nerve, these are unique structures as they originate from and attach to skin. They control movements of the lips and cheeks, which are necessary to form the embouchure. The head segment muscles or their innervation may be affected by a variety of disorders. The best known is Bell's palsy, which is believed to result from viral infestation and results in paralysis usually of one side of the face. Although recovery is usually complete within six weeks, occasionally a patient is left either with weakness or postparalytic facial spasm. Left with a new embouchure or one over which control is imperfect, the player must learn to use new facial musculature. This commonly requires many months, during which the player is often quite apprehensive. The player may be able to adjust the position of the instrument so as to take advantage of the effective and functioning residual musculature. On the other hand, those who play instruments with large fixed mouthpieces like tubas and trombones may not be able to prevent leakage of air.

Lesions of the trigeminal (fifth) nerve, which interfere with motility of the jaw, are rare. The major function of this nerve is that of sensation of the lips, tongue, and face, which enables the instrumentalist to sense the position of the instrument relative to the mouth, the shape of the embouchure, the pressure of the lips against the horn, and the direction of the airstream. While adjustment of many of these is by ear, a musician with even a small area of sensory loss on the

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lower lip suffers marked inconvenience (personal observation). Additionally, a player learns to associate certain labial postures with the sounds he hears. The absence of the sensory mechanisms permitting him to recognize where his lips and tongue are makes performance difficult. Sensory disturbances involving the trigeminal nerve may result from trauma. The nerve that supplies the upper lip emerges from the infraorbital foramen and supplies a triangular wedge of skin extending from the middle of the orbit to the entire upper lip on its own side. The nerve is often bruised in direct facial trauma. The lower portion of the lip is supplied by the mental branch of the inferior alveolar nerve, which emerges through its own foramen and supplies the lower half of the lip. This is occasionally injured during dental operations and anesthesia, leaving permanent loss or prickling and tingling. A woodwind player suffering from this had no difficulty with sound production, although his comfort while playing was significantly altered (personal observation). The ninth and tenth (glossopharyngeal and vagus) nerves, which supply the palate and musculature of the pharynx and the hypoglossal nerve, which in turn supplies the tongue, are infrequently affected except as part of more general diseases that are themselves debilitating and interfere with performance. The trigeminal (most often), glossopharyngeal, and vagal nerves may occasionally be affected by a form of neuralgia. It is believed to result from extrinsic compression of the nerve as it emerges from the brain stem. Stimulation of the skin or mucosal surface is followed by severe lancinating pain throughout the territory of the involved nerve. The spasm of pain, although brief, is severe, intense, and overwhelming. It always interferes not only with musical performance but also with eating, bathing, shaving, the application of cosmetics, and talking. Since the so-called trigger zones that provoke the attacks are commonly around the lips or within the mouth, performance becomes impossible. The symptom may be relieved by medication, which itself may cause the patient to be drowsy. Alternatively, the nerve may be decompressed surgically.

Occasionally, myasthenia gravis simultaneously involves all of the structures mentioned above. It regularly reduces ventilatory function and affects the head segment, especially facial and pharyngeal muscles. Despite various treatments most patients are left with a sufficient reduction of all motor function so that performance is seriously hampered if not impossible.

Far more common as sources of disability in older musicians than disorders of cranial nerves or head segment muscles are the consequences of lesions of the brain and brain stem, as their effects are usually widespread and result in spasticity of the head segment muscles and loss of the capacity to integrate the motor structures mentioned previously. This leads to inability to regulate and control the interaction of the body parts that produce the air column needed to play a brass or wind instrument or to sing. In younger players, the commonest causes for such forms of motor deficit are multiple sclerosis and injury. In older persons, the cause is almost always related to cerebrovascular disease with multiple small infarcts, commonly associated with hypertension or diabetes. The resulting loss of central control of this musculature is pseudobulbar palsy, any degree of which sufficiently interferes with the flexibility and endurance of the motor apparatus cited previously, resulting in incapacity to perform effectively. The limitations of the medical examination often make this difficult to document. Persons suffering pseudobulbar palsy generally have not been able to return to performance and seldom achieve their prior performance level in either sound or volume production. These conditions, unfortunately, are common, but many are preventable. Those associated with hypertension do not become apparent for many years and could be prevented through early detection and treatment compliance, thus extending a performance career possibly as much as 10 to 13 years.

Musculoskeletal pain, tensions, spasms: their recognition and relief

Musicians of all ages suffer a variety of muscular and skeletal symptoms,[1,2,4–7] most of which occur in the absence of specific pathology. In a few instances, however, the symptoms derive from a variety of specific disorders. Disorders referred to the neck, shoulder, upper limb, and back constitute most of both varieties.

The principal *conditions affecting the neck* are attributable to diseases of its ligaments, joints, and intervertebral disks. The former two are much more common and may secondarily result in compression of nerve roots, spinal cord, or both. In the common degenerative disease, cervical spondylosis, atrophy of the intervertebral

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disk and of the vertebral bodies are combined. The formation of bony spurs or osteophytes, true arthritis of the apophyseal joints, and thickening of ligaments lining the vertebral canal commonly follow. Shortening of the neck regularly occurs, as may reduction in tilting, turning, and gliding. Despite significant change in the structure of the neck, the patient is often asymptomatic except for painlessly limited motion and the sense of grinding or crunching (crepitation) as the neck moves. The patients who become symptomatic usually complain of stiffness after a period of relative immobilization. They may be wakened from sleep by discomfort; and limitation of turning or tilting becomes more prominent. In addition, when the neural foramina or vertebral canal are affected, one or more nerve roots, the spinal cord, or both may suffer encroachment. Nerve root involvement may result in tingling and numbness in the hands or fingers, cramping, muscle atrophy, and weakness, causing enfeebled finger movements, which usually leave the patient able to perform, but with diminished dexterity, as long as sensation is preserved.[2] Musicians who have simultaneously lost the senses of contact and position are incapacitated as they are as unable to control finger movements without looking.[1]

Herniation of a cervical interverbral disk may produce pain in the arm, compression of the spinal cord, or both. It is ordinarily associated with severe pain, limitation of flexion and extension, and some sensorimotor disorder of the hand, and performance disability.

Disorders of the shoulder are extremely common. In general, they result in some degree of painful loss of motion, either owing to traumatic, inflammatory, or fibrosing processes affecting ligaments and tendons, the shoulder capsule and its bursae, or osteoarthritic degeneration of the shoulder joint. Most patients, particularly heavily muscled and brawny men, will, regardless of activity, suffer diminished range of motion in the shoulder with aging. String players may suffer such severe involvement of the right shoulder that bowing is too painful to permit performance. Treatment of disorders of the shoulder joint is extremely time consuming and difficult.

In the *upper limb*, the interosseous joint between the radius and ulna ordinarily functions smoothly. However, it may be subject to disease processes, particularly those associated with inflammation, thickening, and contracture of various ligaments, tendons, and aponeuroses. These may simply cause pain in the elbow or forearm or alternatively be associated with compression of a branch of the ulnar or radial nerve, weakening some intrinsic muscles of the fingers and blunting sensation of the fourth and fifth digits or, in the case of the latter, impairing extension of the wrist and fingers and sensation on the back of the forearm and hand. These conditions are most commonly caused by forceful rotation of the forearm, such as that produced by turning screws in hard wood, or carrying a heavy case with the elbow extended. Inflammatory disease such as rheumatoid arthritis may give rise to symptoms in the same location. Disorders of the radioulnar articulation are likely to produce symptoms and functional impairment, since the forearm is used in playing most musical instruments.

Hand disorders are common, particularly in harpists and pianists. Compression of the median nerve is associated with numbness of the index finger, spreading to the middle finger or thumb, and occasionally cramping of the muscles at the base of the thumb. Compression results from entrapment of the nerve at the base of the thumb within the volar carpal ligament, e.g., with overextension of the wrist. In some cases, the symptoms are intermittent and may be corrected by changing position. Occasionally, pressure of the instrument against the radial side of the index finger may give rise to numbness and tingling in the volar pad. This almost always occurs from physical pressure against the digital nerve and is readily corrected by changing the point of contact.

A common complaint, particularly in conservatory students and young players, pertaining to the upper extremity is a sense of tension or cramp commonly experienced with movement of the ring and small fingers of either hand. This problem has been known for years[8] in piano, wind, and string players and seems in the latter to occur more commonly on the left. It arises partly from the difficulty in flexing the little finger independently of the ring finger owing to common aponeurosis. Ordinarily, patients with this complaint are without evident structural or other motor abnormality. Tightness and discomfort about the embouchure accompany cramping in the hand.

The *low back* is often a source of severe pain or discomfort to musicians who must sit for long periods, often with the spine slightly extended,

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thus accentuating the angle between the fifth (or lowest) lumbar vertebra and the sacrum. In older musicians, there may be concurrent arthritis or spondylosis of the lumbar spine similar in nature to the condition previously described in the neck. Lumbar spondylosis may be complicated further by narrowing of the spinal canal. Lumbar canal stenosis or a localized form affecting the lateral recess may render the regional nerve roots susceptible to postural compression, causing pain, numbness, cramp, and weakness in the legs. Symptoms resulting from this condition may be alleviated by a variety of postural alterations and exercises, which have in common facilitation of lumbar spine flexion and flattening of the lumbosacral joint.

Herniation of a lumbar disk may also occur. As with the degenerative diseases just mentioned, playing is not the cause, but may cause intensification of pain resulting from nerve root compression. When severe, this may prevent playing.

Examination

In addition to the complete physical examination, the history must concentrate on the factors that bring about or relieve the symptoms, since the musician's symptoms almost always relate to some aspect of performance. The complaint of neck pain, for example, may be understood by inquiring into the height of the music stand, the placement of the player in relation to the conductor, the position in which the head must be held in order to look from the baton to the score, and any limitations imposed by eyeglasses. Players who complain of cramping in the fingers of the left hand may do so only when playing certain pieces. Alternative fingering may be found for a difficult passage. It is useful to know what effort the patient has made to accommodate his or her posture, embouchure, or stance. The personal relationships between the player, his colleagues and competitors, and teacher should be elicited particularly in the case of students and young players. Inquiry into past reactions to tension, emotional disorders, family relationships, and the use of chemical substances should be made. The musician should be observed while playing his instrument with the upper half of the body undraped. It may also be necessary to examine the patient in the situation in which he becomes symptomatic. Musicians often ignore their symptoms, particularly young players with joint disorders such as minor degrees of rheumatoid disease with inflammatory arthritis for which highly specific medical treatment may be required.

Prevention and treatment of posture-related symptoms

The neuromuscular conditions just described may be dealt with in three contexts:

1. Personal prophylaxis, as in the recognition and treatment of hypertension,
2. A direct response to a specific episode of illness, such as the joint disorders or recognition of an emotional disturbance, and
3. Relaxation and exercise programs, introduced as preventive measures, designed to relieve tension and maintain joint mobility.

In the absence of specific disease such as herniated disk or diabetes mellitus, most treatment of the neuromuscular and articular disorders are based upon altering posture and restoring range of motion. Neck disorders are most often relieved by changing the height of the patient's chair, adjusting the height of the music stand, altering the inclination of the desk, use of a cushion, or constructing eyeglasses that enable the player to look alternately at the score and the conductor with ease. For severely presbyopic patients, eyeglasses with a three-quarter lens can be constructed over which the patient may glance at the conductor and then quickly find and read the score through the lens. In some myopic patients with distance accommodation difficulty, a crescentic upper spectacle and enlargement of the musical text may be helpful. We have found 115% enlargement, which may be carried out on many office duplicating machines, to be useful.

Painful limitation of motion at the shoulder, except in the context of trauma or enforced immobilization as may occur with myocardial infarction, rarely appears abruptly. Most patients with this disorder gradually become aware of mild periodic aching discomfort or limitation in the shoulder when dressing or reaching backward. Simple active shoulder exercises should be used regularly. For example, with the patient seated before a mirror, with shoulders exposed, the arm is raised to 90° with the elbow held at a right angle. The arm is actively, but slowly rotated backward as far as comfort permits and then carried forward in the same manner. Movement should be to the point of tightness or aching where gentle pressure to move farther should be

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maintained briefly. Each shoulder is moved an increasing number of times a day. The objective is to maintain and increase the free active range of motion. The shoulder should not be forced as this may injure the joint. Ballistic exercises in which the limb is flung are to be eschewed for the same reason. Restoration of lost motion requires many weeks and exercise should not be tried when the joint is painful. Swimming may be a useful adjunct.

Disturbances of rotation of the forearm should be identified and treated specifically. Usually such conditions respond to alteration of posture or the manner in which objects are carried. Lost range of motion is restored by the method described for the shoulder. Peripheral nerve compression syndromes affecting the hand may be treated either surgically or by postural correction. The disturbances of cramping in the hand usually result from tension and may be dealt with by techniques to be discussed.

A useful maneuver for relieving low back discomfort in a sitting position is to obtain a flexion of the lumbar spine of about 15°. This lowers the tension on pain-sensitive structures in the ventral portion of the vertebral canal. This effect may also be accomplished directly by having the patient bend forward slightly or indirectly by flexing the hips. The orchestral musician may accomplish this by sitting with his feet on a small stool so that his hips are slightly flexed. A block of wood 3 to 4 inches high may suffice. In other instances, chairs may require modification. Patients with lumbar spine disease should maintain a regular exercise program designed to flatten the lumbosacral joint and maintain mobility. Sleeping with a board placed under the mattress or sleeping on the floor is recommended and a back cradle should be used in a vehicle not equipped with an appropriately designed seat. A simple back cradle made by inserting several layers of newspaper in a pillow slip and placing it behind the back is ordinarily sufficiently firm yet flexible enough to allow the patient comfort while sitting in a soft chair or riding. Squatting rather than bending and twisting is recommended.

Occupational cramp, palsy, and tension and their relief

The symptoms encountered most commonly, particularly in young players, are related to the inappropriate and incomplete mechanical resolution of muscle tension regardless of cause, which are also likely to be resistant and recurrent. The sources of tension are determined by the convergence of endogenous and external factors. The symptoms range from cramping, immobility, or abnormal patterns of movement of the fingers to discomfort about the lips. Endogenous factors include the shape of the dental arch, span of the fingers, posture, and range of motion of the wrist. Some can be corrected. Wherever possible, external factors should be identified and manipulated. This may mean finding another teacher, playing under different circumstances, or engaging a coach. A student who plays at a job two or three nights a week with complete comfort may find that learning difficult passages or pleasing a demanding teacher results in cramp, as he cannot relax his forearm and hand. Most patients can be taught relaxation methods. Skilled coaches may be found throughout the country, and self-instruction literature is available.[7,9] The Alexander technique is being taught in several conservatories.[7,9] It is one of several methods in which assumption of a particular posture elongates the spine, flattens the lumbosacral angle, and shifts the body weight to the plane of the posterior vertebral bodies or roughly the line of the nucleus pulposus. The resulting redistribution of body weight relieves the muscles of the limb girdles and is often highly successful in promoting comfort. Related to it are systems of neck movement and exercises that may be applied specifically for discomfort arising in one or another part of the body including the forearm and hand.

One consequence of posture disorder is numbness of the hands and fingers from sloping and depression of the shoulders. This sometimes is called the shoulder or thoracic outlet syndrome. The symptoms result from compression between the clavicle and first rib of the medial and lateral cords of the brachial plexus. Evidence in support of a vascular element does not exist. Direct and electromyographic studies indicate that the signs and symptoms are related to posture. The patients usually become symptomatic as the arms fall into adduction and internal rotation when sleeping or upon holding an instrument, which requires the arms to be abducted and externally rotated. The patient is most likely to feel prickling and tingling in the middle, ring, and little

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fingers, which are relieved by shaking the hands. Elevation and retraction of the shoulders is almost always curative.

Drugs for the relief of tension range from alcohol and narcotics to so-called muscle relaxants. The drug in wide use at present is propranolol, which blocks the autonomic effects of tension and anxiety, including sweating, tachycardia, and tremor. Although it has the advantage of little habituation, a far more sensible approach would be to resolve the underlying problems.

The syndromes described in this section, which are characterized by cramp and stiffness often with uncontrolled movement are often grouped as occupational cramp or occupational palsies. Since their description in the last century, argument concerning their nature has occupied much of the relevant neurological literature. Some[1,10] have seen them as dystonias, while others[4] have regarded them as responses to environmental pressures. It is likely that more than one condition and hence more than one explanation exists, particularly when the features develop in later life and involve nonmusical activities. Parkinsonism, cerebral tumor, multiple sclerosis, and pseudobulbar dystonia secondary to hypertensive vascular disease have been found.[2] Hochberg et al[3] have discovered pain-producing orthopedic conditions to which the cramp represents an unsuccessful attempt at postural adaptation. Critchley[1] cites Flesch and Havas in this connection, calling attention to a variety of psychological factors (stage fright, emotional disorders, preoccupation with technical challenges, perfectionism, and phobias regarding intonation and other performance faults) and errors in training. The latter, according to Flesch, may give rise to disorders of bowing (right arm) and finger pressure (left hand). Critchley, after considering various aspects of occupational cramp, believes a "breakdown" to have occurred at a "physiological level rather than at a particular anatomical site." The cases he cites are those of older persons for whom he advised a period of rest followed by consultation with a teacher for appraisal of the players' technique before rehabilitative practice. He sees the future for them as grim despite all forms of treatment.

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