

The organist from fingertip to brain and back again
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To create music

- Complex interplay between the sensory (visual, auditory, tactile, position sense), motor (output to peripheral muscles) and centers in the brain processing higher order, interpretive functions.

- These include language processing centers, executive function, “limbic” emotional, memory centers, and cerebellar and basal ganglion input to promote orderly output and neuromuscular control

Movement

- Movement is a complex sequence of events that begin with input from the sense organs in the hand, eyes and ears that travel up the afferent sensory nerves to terminals in the spinal cord

- From there impulses travel up to the brain for processing and decisions are made as to what movements are to be executed.

In the Brain

- The nerve impulse travels up the sensory fibers to the midbrain and then on to receptor areas in the brain for touch, hearing and sight.

- They then pass through a complex series of inter-neuron switching systems that eventually connect to the motor cortex in the brain.

Cross sectional anatomy

- Sagittal section

- Frontal section

Gray Matter vs. White Matter

The Visual System

- Retinal fovea

- Retinal ganglion cells

- Optic nerve

- Geniculate nucleus in the
Thalamus

- 1° Visual cortex

- 2° higher order areas

- Decoding meanings

- Where, how
- Musical notes

The Auditory System

- Sound waves to electrical energy
- Eardrum vibrates
- Middle ear bones amplify/dampen energy
- To cochlear fluid chambers

■ Cochlea

Auditory system

- Organ of Corti = vibration membrane stimulates auditory receptor neurons (hair cells) differentiates different sound frequencies- traveling wave comes down
- Hair cell deflected send signal to otic nerve
- Point of maximal stimulation = varying pitches: **high freq** = cochlear base, **low freq** = cochlear apex. Encoded by brain, orderly maps

Auditory pathways

- Otic nerve –medial geniculate nucleus
- To primary auditory center
- Higher order centers for processing
- Filter noise, make sense of sound, type direction, meaning 360° reception

Auditory system

- With aging, loss of hearing at higher frequencies = loss of flexibility of basilar membrane
- Extremely sensitive to loud sounds and can damage neurons/hair cells “rock stars”
- Brain sends impulse to middle ear to dampen vibration to protect loudness and lower amplification process

The Peripheral Sensory System

Somato- sensory system

- Receptors located all over the body fire on/off
- Different receptors, pathways for different perceptions i.e. pain and touch
- i.e. pain, temp- free nerve ending
- fine touch discriminatory- size, shape and texture of objects Meissner’s corpuscles

- Located in the fingertips

Somato-sensory system

- Convey touch pain, temp and position sense from our sense organs about our bodies
- Position sense static and dynamic info from joints
- Combined w visual = personal space and space at distance, feedback about our body state

Joint stretch/position sense receptors

Bony anatomy of the finger

Flexor Tendon Anatomy

A typical neuron

Periphery to Spinal Cord

Sensory pathways

- Pain fibers straight up to thalamus
- Touch cross midline
- Thalamus
- Ventral posterior nucleus
- Primary sensory cortex
- Higher order-parietal lobe make sense of stimulus- mapping

Sensory cortex

Cortical sensory map

Homunculus

- Distortions=areas representing high sensory acuity
- Areas represent populations of neuron cell bodies in the grey matter

The Motor System

The Motor Cortex

Motor pathways

- Pre-motor, frontal cortex-execution, planning, sequential finger movement
- Pyramidal system-to contra-lateral side
- Extra-pyramidal
- Cerebellar input timing, , cognitive skill learning
- Sensory input

Back to the spinal cord

- From the contra-lateral motor cortex once the decision for what motion is desired the impulse goes back down through the spinal cord in the anterior motor trunks to motor nerves innervating the muscles of the arms and legs

Extra-pyramidal system

- Motor learning of automatic movement
- **Basal ganglia** nuclei, sub thalamic nucleus, substantia nigra, caudate nucleus, putamen, globus pallidus
- Feedback to cortex
- Thalamus

Cerebellum

- Maintenance of equilibrium and posture
- Timing of learned skilled motor movement force, speed
- Correction of errors during ongoing movement
- Multiple motor and sensory maps too

Inputs to cerebellum

- Extra pyramidal
- Sensory input i.e. proprioceptive, visual systems
- Motor cortex to pons to cerebellum via collaterals of cortico-spinal tract

Outputs from cerebellum

- None to spinal cord
- Feedback to direct and indirect CS pathways via the thalamus to modify movement
- Learning a new movement sets up neural circuits in the cerebellum. With practice, cerebellar (Perkinjje) cells fire in a set sequence to set up automatic movements with specific timing.

Fine tune motor functions

- Consistency of coordinated motor movement after learning sequence improving with practice
- Cell firing sequence dictates rhythm
- Has memory component of learned movement
- Translate sheet music, initially uncoordinated, with practice learn to touch correct keys then adjust tempo, dynamics, expression and articulation ALL CEREBELLUM

The Limbic System

- Helps us engage with the world and integrates many brain systems and attaches emotion to information
- Experience pleasure, emotional texture, memory, personality traits, learning, executive function, decision making
- Complex interconnected nuclei

Parts of the limbic system

- Medial surface of the hemisphere, motor, sensory interaction, decision making, cortical inhibition.
- **Hippocampus**- learning and memory
- **Amygdala**- processing of emotions, emotional memory, fear
- **Ventral tegmental area**- drug addiction
- **Hypothalamus**- embarrassment blushing
- Complex feed back loops continuous mood regulation, comparison to the past, emotional coloring
- **Prefrontal and limbic association cortex** processing emotional info assist decision making

Learning to play

- Complex interplay between seeing the music notation, hearing what you play and the tactile (pressure) sensation being fed up to the various sensory processing centers in the cerebral cortex
- As learning progresses, cortical representation in the brain changes
- Receptive field become more “focused” to a specific activity and the overall sensory field enlarges

Decision tree

The decision is reached:

- Which movement is desired
- What body posture is necessary to execute that movement
- How hard should that movement be
- At what speed should the movement take place

To create plasticity:

Three training conditions

- “Learning” must occur with internal accommodation of new brain stimuli
- Progressive in level of complexity of inputs
- Repetition and effort.....paced learning... the timing of input stimuli

Playing long recitals

Involves:

- Visual memory of the score and hand position
- Auditory memory
- Analytic memory-while inexperienced musicians try to remember all the notes individually, pros see the whole tonal and cadential picture efficiently assembling large chunks of music into a coherent fluid whole.

Neuro-plasticity

- The motor fields involving position sense, movement coordination and control of the strength of muscle group contractions increase correspondingly

- As skills are mastered, and tasks can be performed automatically, the areas of representation shrink as less “brain power” is needed to perform tasks

The Neuron and Axonal Terminus

Synaptic transmission

Synaptic plasticity

- Synapses can multiply by sprouting new axon terminals with learning and memory

- Change in responsiveness of post synaptic receptors change in membrane potential

- Increased release of neurotransmitter

- Change in dendritic spine shape changing efficiency of neural transport can change dynamically with learning

Axonal sprouting after learning

Processing Music

- Primary auditory cortex- sharpening fundamental frequency

- Higher order areas in temporal lobe make meaning of the tones

- Emotional experience positive limbic endogenous reward system endorphin and dopamine release

- Hippocampus- ability to remember long sequences of music

- Cingulate cortex- decision making w/ regards the structure of the music and how it is to be played

Brain Mapping fMRI

- Imaging changes in cerebral blood flow and oxygen consumption during brain activation

fMRI study on music imagery and performance in pianists Meister 2003

- Studied the brains of keyboard music students with >18 years of playing experience

- Shown a piece of music right hand only

- After mastering the passage (Bartok- Mikrokosmos), they first read the music in an MRI then played the piece in the MRI on a silent keyboard. MRI scanned the sight reading segment then the “performance”.

During performance

- Activation 1° sensory-motor cortex L hemisphere

- Premotor cortex L

- 2° sensory L hemisphere

- Visual cortex 1° & 2°

- Bilateral cerebellum

During Music Imagery

- Same as performance but areas of activation smaller and don't include 1° sensory-motor areas –left hemisphere & right cerebellum which are silent

Performance vs. Imagery

- While the primary motor cortex is activated exclusively during performance, the “processing zones” are active in both states.
- Seen here in x-sectional fMRI

Stages in musical performance

- During imagery and planning bilateral premotor, parietal lobes active

Hearing music

- After primary processing in the auditory cortex, impulse move to language centers for processing then to the memory centers for storage in the limbic system

Haueisen and Knosche 2001

- Pianists when listening to well played piano music exhibit involuntary motor activity in the motor cortex of the brain.
- There are clear differences in the activation areas in the motor cortex between musicians and non- musicians for the thumb- finger areas
- In musicians there was activation prior to hearing notes indicating that they “knew” what notes and fingerings were “coming next”.

Music processing

- Limbic system
- “Reward” center
- Emotion prefrontal
- Memory area
- “Whistle a happy tune”

Playing music

Jancke and Shah 2000

- Primary and secondary motor areas of the brain were activated much less in skilled keyboard players than unskilled ones playing the same music.
- This suggests that long lasting intensive hand skill training of pianists leads to greater efficiency and preprogramming leading to a smaller amount of neuronal activation needed to perform tasks.

Musician’s vs. non musician’s

Brain

Professional Keyboard players have vastly increased grey matter in:

- Primary sensory-motor cortex
- Pre-motor and ant. sup parietal cortex
- Primary auditory cortex
- Cerebellum

This explains increased motor hand skills, auditory discrimination and increased processing and integration skills

Differences in music learning

Motor representation in keyboard players

- Musicians who started training early in life have greater inter-hemispheric connections between 2 halves of the brain (larger corpus callosum) better coordination between both sides of the brain

- Representation of the hand in the motor map is larger in musicians in both sides

- **Level of skill and practice time correlate**

- These differences are not innate but a result of years of training and the younger the musician starts his training the more profound the brain changes are (Norton 2005)

- There are increased numbers of synapses, glial cells, vascularity, and actual increased numbers of neurons in the hippocampus (memory center)

- In musicians left hemisphere is dominant in aspects of music melody and harmony

- Increased activation of left hippocampus genetic or training than non musicians

- Damage to language center will damage musical appreciation and writing areas i.e. Ravel– Wernicke aphasia amusia

- Limbic system- controls excitation/inhibition of sensory and motor impulses

When things go wrong !

- Disease or impairment can occur at any step in the process

- Because musicians perform tasks at a high rate of speed and proficiency in motions that have been practiced often times for decades, a small disturbance many be magnified far above the general population

Focal Dystonia

- Neurological disorder originating in the brain causing loss of coordination and motor control in the hand

- Called “writer’s cramp” or “occupational cramp”

- Involuntary cramping, curling, splaying of certain fingers

- In keyboard players- right hand

Focal Dystonia causes

- ?repetitive strain, prior trauma nerve compression?

- New techniques, changes in teacher or instrument, dramatic increase in playing time, pre- recital stress...”over-practice”

- High speed, high force, demanding productivity

Epidemiology

Altenmüller 2003

- 144 musicians with FD studied 1994-2001
- 81%♂, 19%♀, mean age 33 y.o.
- Mean duration of symptom 5.1 years
- 6% + family hx
- 28% keyboard players >95% dominant hand
- 66% while playing music only, 34% general tasks
- 74% no pain, 17% pain after onset of symptoms

Risk factors

- Musicians playing instruments with the highest spatial sensory-motor precision
- Higher in classical vs. jazz or pop music where improvisation possible
- “Classical” music requires a high level of temporal accuracy in milliseconds continuously scrutinized by the performer and audience
- Long hours, high stress, perfectionism,
Animal Studies-primates
Byl et.al. 1996
- Trained to perform highly repetitive tasks requiring rapidly opening and closing the thumb and index to grasp a target.
- Early on a significant number developed symptoms of repetitive strain pain and after several cycles of pain/rest pain some of the animals developed “focal dystonia” and manifested a profound degradation in the “hand skin” representation in the somato-sensory cortex.
Primates con’t
- Increased size of the receptive field meant significant overlap with other parts of the hand and even the lower face
- There was no sign of any peripheral nerve or tendon pathology
- Clinical signs: involuntary finger movements, co-contraction of flexors and extensors, unable to release flexed postures, inability to perform fine motor movements quickly and accurately

Control primates

- Those primates that performed the tasks with fewer repetitions, more breaks, and shorter work periods did not develop any of these symptoms
- Pathophysiology
The mechanism of disease
- Alterations in the basal ganglia internal circuitry, and sensory thalamus
- Abnormal processing of sensory inputs and degraded representation of motor function
- Decreased cortical inhibition of adjacent hand and arm muscles when specific muscles stimulated (normally increased)

Human studies

- Patients with FD exhibit reduced position sense accuracy, decreased ability to distinguish forms when “blinded”, and diminished temporal spatial processing (the ability to distinguish between 2 stimuli separated by space or time)

- By cortical response mapping and MRI, these patients show de-differentiation of cortical representation with “blurring” of excitatory and inhibitory impulses in the brain of both sensory and motor function

The Homunculus in dystonia

- Changes in the representation in the brain of the arm, hand fingers in the motor or sensory cortex. Overlap of the representation of the fingers...”smudging” of the signal processing in the brain

Focal dystonia signs

- Early- small lapses in the usually instinctive ability to perform specific passages

- Widening of the “task specific” deficit

- Increasing practice nor resting, massage, acupuncture, PT helps this

- Loss of control, spasms. “the finger seems to have a mind of it’s own and not listening to what I’m telling it to do”

The problem!

Focal dystonia signs

- Co-contraction of agonists and antagonist muscles. Involuntary twisting end range postures.

- Task specific. Other activities even strenuous ones don’t seem to trigger it

- Can be so severe so as to end or dramatically alter a musician’s career i.e. Leon Fleisher, Gary Graffman

Focal Dystonia: Management

- There is no cure

- Retraining “starting all over” to play differently has helped- Dorothy Taubman

- Instrument modification

- Botulinium injection

- Mirror box therapy

- Change in cortical “map”

- Artane (trihexyphendyl)

- Rolfing

Management issues

- Botulinium toxin addresses the symptoms of muscle cramp but not the central problem in the brain

- Effective treatment must re-differentiate the cortical representation of the hand in the brain
 - Intensive, goal oriented, progressive learning based training
- Steps to rehabilitation
- Stop the abnormal movement
 - Establish a foundation of health and wellness: nutrition, hydration, stress management, aerobic exercise, instrument and technique modification
 - Selective “unaffected” finger splinting, focusing on the motion of the involved digits with improvement, splint were gradually removed (Candia 2002,2003)
 - Cortical reorganization demonstrated- reversible plasticity
- Experimentally....
- Prolonged immobilization of a limb leads to shrinkage of cortical representation of that limb and improve motor control especially in young patients with <1 year of symptoms, but with older more established disease it won't be enough (Liepert 1995) (Priori 2001)
 - Motor fatigue will also reshape representation in the motor cortex and improve symptoms (Pesenti 2001)

Learning based sensori-motor training

- Start by improving sensory differentiation with non stereotypical hand engagement
 - Start with least involved digits and progress
 - Diverse tactile modalities, position sense, movement sense, 3-d object manipulation i.e. Braille reading, embossed letters, textures
 - Sensory-motor and fine motor tasks activate proprioceptive and fine motor feedback
- Sensory-motor learning cont'd
- ‘Partial tasks’, similar tasks, ‘shadow’ playing. Basic hand motions on instrument
 - Repetitive daily schedule. Supervised paced learning
 - Progressive task difficulty until “target” task reached. Home exercises.
- Pedagogic retraining
- Playing limited to tempo level and force that diatonic movement would not occur
 - Splint adjacent fingers to limit compensatory movements
 - Visual feedback with mirrors or TV showed patients when diatonic movements occurred
 - Feldenkrais body awareness of non dystonic movement
- Michael Houstoun
- Biomechanical correction- myofascial release. acupuncture. Postural correction
 - General cardiovascular fitness
 - Change height of stool, music
 - Rubber gloves
 - Covering the keys with tape

- Fingertip sensitization
- Sensory reeducation, motor retraining (splinting the compensating finger)
- retraining

Treatment outcomes

Altenmüller

- At 8.4 yrs after onset and 3.4 yrs after rx.
- 1% symptom free, 52% improved, 35% unchanged, 11% worse
- 29% changed professions, 57% students quit
- Artane: multiple side effects 33% improved
- Botox:1 shot-49%, >1 shot -57% improved. Must shoot 1° muscles.

Outcomes cont'd

- Retraining- 50% improved Rx: 28 months
- Practicing “unspecific” technical exercises 54% better
- Our study, 71% stayed in music @8.4 yrs
- Lederman et.al. 50% remained
- Tubiana et.al. 35/145 returned to public performance
- Music students 12/21 changed careers= current recommendation

Organ Technique

Early vs. later technique

- Playing staccato is less energy efficient and creates large forces across finger joints than legato.
- 1700's- “ordinary touch”- articulate legato
- Hand Shifting, finger skipping
- Post 1820's- legato articulation developed. Need to avoid aural “smudging”. Managing the rests
- Until 1900's staccato rare in scores.

Organ vs. piano

- Expressiveness produced by control of rhythm and articulation not by the pressure of the key strike
- “Playing from the finger joints down”...Bach
- Finger controls the sound until the finger is raised
- Sound is constant w/o decay
- Key release as important as key strike

Posture

- Elbow relaxed suspended close to the body
- Wrist and forearm level with fingertips

- Fingers in resting on the keys at all times
- Precise key release to tightly control the rests and spaces between articulated notes

Tracker organ

Playing stressors-tracker organ

- Wide reaches –coming down on weighted keys
- **Finger substitution** for legato playing- holding notes while playing other voices-
- **Finger crawling** (not a problem on piano- sustaining pedals) hand is continuously stretched
- Adding the “weight” of multiple keyboards

Finger substitution/crossing

- Shorter finger placed under the playing finger
- Longer finger placed over the playing finger
- Critical to control keys so no break in tone occurs
- Tracker organs finger pressure increases with every pipe opened.
- Mainly feel the difference with coupling keyboards

Articulations

- Pattern by which finger control the pattern of sound by how each individual keys are depressed, sharpness of depression and quickness of release. Increased strike speed for staccato “bounce”.
- “Early” Pre Baroque- no thumbs more finger substitution, more cross over.
- Thumbs- “tucked under”

In conclusion.....

- Our understanding of brain processes in general and in musicians in particular is still in its infancy, but great strides have been made over the past decade.
- We will eventually uncover the genetic and neurological basis of “musical talent” and directly impact the learning process.
- Focal dystonia will be a treatable disease

Thank You

Upper extremity disorders in Keyboard players
American Guild of Organists- Annual Meeting
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Playing Hurt

The ICSOM Study 1988

- 47/48 ICSOM orchestras reported 82% of musicians reported a “medical problem”
- 72% indicated that the problem affected their performance
- Peak age: 35-45

Hochberg 1983

“Keyboard and string musicians present with the greatest number of hand and arm problems”

- Right arms are affected twice as often as left arms
- The ring and small fingers are most commonly affected
- Female musicians are far more likely to be affected than men (Smaller hand size, small joint laxity) in overuse pain but less likely in movement disorders

Factors that impact

- Poor physical conditioning
- Long uninterrupted playing with multiple repetitions
- Poor posture, technique, practice routine
- High stress: internal and external (deadlines)
- Peer and family pressure to “succeed”
- Depression

Extrinsic factors

- Sports participation 35%
- Household accidents 24%
Lacerations, crush injuries
- Motor vehicle accidents 11%
- Falls 23%

Sports Injuries

Highest in school and recreational amateur musicians

Presentation of Disease

- Musicians are affected in two ways:

- conditions caused by playing
- outside activities that cause disease or injury that have special impact on musicians

Predominant complaints

- Pain
- Weakness
- Tightness
- Numbness
- Loss of muscle control

Playing can cause:

- Chronic neck strain; cervical disc disease cervical joint degeneration
- Rotator cuff tendonitis
- Thoracic outlet syndrome
- Low back strain
- Peripheral tendonitis
- Compressive neuropathy

Treatment modalities

- Physical (exercise) therapy
- Medications oral and injected
- Technique change
- Instrument modification
- Practice regimen change
- Acupuncture
- Surgery

Low Back and Neck problems

- Dynamic movement of muscles and joints can be maintained over long periods as it allows continuous blood flow to the area.
- Static postures limit blood flow causing muscle fatigue and constriction and unrelenting pressures on low back discs and facet joints.

The low back anatomy

Poor postures

- Prolonged forward bending will strain the back and neck.
- Neck strain will radiate down the shoulders and arms and back pain will radiate down the legs
- Forward torso flexion with arms out stretched exacerbates the problem
- Numbness in the fingers and toes follow as nerves are compressed in the arms and legs

What can go wrong

Disc Problems

- Prolonged forward flexion of the back and neck will compress the discs between the spinal vertebrae
- The spinal discs have a tough rubbery outside and a gelatinous center
- Leaning forward will force the “jelly” to the back of the disc adjacent the nerve roots. If there is any preexisting injury causing a weakness or crack in the back of the disc, a bulge or hernia can result

The Cervical Spine

Back and neck

- Twisting movements cause shearing of the disc tissue hastening degeneration.

- Disc bulges or herniation will cause pressure on spinal nerve roots causing local or radiating pain down the arms (neck) or legs (back)

Risky Postures

- Standing or sitting for prolonged periods
- Neck: tilting, rotating, head cock in flexion or extension
- Torso: bending, twisting, leaning forward or backward
- Shoulders: lifting, twisting, rolling forward

Management

- Initial management includes postural adjustment, NSAIDs, muscle relaxants, oral steroids, firm supportive mattress, cervical pillow and physical therapy
- If there is unremitting pain or + neuro or systemic findings then imaging is needed
- X-ray, CT scan, MRI +/- contrast
- Surgery for specific lesions only

Conservative treatment

- Conservative treatment is not synonymous with non-operative treatment
- Conservative treatment is usually the most simple straightforward approach to achieve the optimal result
- This can be non-operative or operative depending on the circumstance

Home stretches

Non-operative treatment

- Is not open ended
- At 6-12 weeks tissue atrophy and weakness set in if the primary problem is not addressed
- The best outcomes occur when the treatment allows the earliest return of movement and strengthening

Surgery can be extremely beneficial to musicians if the indications are strict and a well planned rehabilitation and return-to-play program are executed

Rotator Cuff Anatomy

Shoulder Bursa

Trapezius muscle

shoulder shrug, moves scapula, arm raise

Rotator Cuff Tendonitis/Bursitis

- Pain, worse at night that can radiate up the side of the neck or down the lateral arm (about 1/3)
- Weakness with painful inability to raise the arm at the side or around the back
- Over time joint stiffness develops (frozen shoulder)

Mechanism

- Degeneration in Supraspinatus muscle from chronic overuse with loss of blood supply to its tendinous insertion on the humerus causes a superior migration of the humerus under the acromion.
- Impingement and bursal inflammation follows.
- Left alone a degenerative rotator cuff tear will follow

Management

- For the keyboard: avoid forward droopy shoulders, leaning backward or overarching the upper back
- Check for shoulder weakness apart from the pain. Careful physical exam check for instability, initial x-ray ..calcifications,OA
- One cortisone injection in the subacromial space and /or the AC joint
- NSAID'S, rest, ice, physical therapy

Management

- Over 75% resolve with above measures
- With persistent pain, further imaging needed...MRI to check for rotator cuff inflammation/tear
- Rule out gall bladder, cardiac, lung, neck problems
- Arthroscopic or open rotator cuff decompression or repair
- Post op rehabilitation

Lateral Epicondylitis

(tennis elbow)

Presentation

- Pain at the lateral border of the elbow
- Can last for years, cyclic
- Worse with overhand lifting
- Progressive arm weakness

Management

- Rest, ice and splinting
- Counterforce band
- Avoidance of over-handed lifting
- Rehabilitation exercise
- Steroid injection
- PRP injection
- Coblation
- Open surgery

Tennis Elbow Surgery

Peripheral compressive neuropathies

- Carpal tunnel syndrome
- Cubital tunnel syndrome
- Radial tunnel syndrome

- Myo-fascial pain syndrome

Carpal Tunnel Syndrome

Carpal tunnel anatomy

- 9 tendons and the median nerve enter the hand between the thenar and hypothenar muscles
- Tenosynovial thickening crowds out the nerve increasing pressure in the canal

- Pressure on the nerve cause the classic symptoms
- Poor posture while using the keyboard will increase pressure and symptoms

Risky postures

- Sustained wrist flexion extension, pinching
- Repeated micro-trauma by repetitive motion i.e. repeated up and down motion of the wrist causes swelling of the teno-synovium
- Holding the phone, driving, vibration

Symptoms

- Radiating night pain into the fingers and up the forearm, constant waking at night
- Numbness into thumb index middle fingers (can involve the whole hand)
- Severe clumsiness, loss of control, weakening grip,
- Progressive difficulty with activities of daily living.

Management

- Technical, activity modifications
- Avoid extremes of flexion/extension and ulnar deviation (especially in forte playing)
- Keep wrist in neutral and avoid “roman arch technique” or “wrist cycling”
- Use whole forearm to raise and lower the hand
- While practicing take frequent rest breaks

Management

- Beware of non musical activities that can stress the wrist
- Computer use, knitting, bicycle riding, scissors,
- Wrist braces for night use to maintain neutral position while sleeping
- Nerve and tendon gliding exercise
- Contrast baths
- Electro-diagnostic studies
- Surgical intervention open or endoscopic
- “Return to play” rehab program

Nerve and Tendon Gliding Exercise

Electro diagnostic Studies

Cubital tunnel anatomy

Cubital tunnel syndrome

- Entrapment of the ulnar nerve at the elbow
- Prolonged elbow flexion
- Numbness in the 4th and 5th fingers
- Weakness in the intrinsic muscles of the hand
- Shooting pain into the hand from the elbow
- Muscle atrophy in the hand--posturing

Management

- Night bracing in a long arm brace in 30° flexion
- Nerve gliding exercise
- Avoid prolonged elbow flexion postures
- Avoid repetitive elbow flexion/extension
- Avoid putting direct pressure on the elbow
- Surgery- ulnar nerve release/ transposition

- 75% can be treated non- operatively

Thoracic Outlet Syndrome

Thoracic outlet syndrome

- Compression of the nerves and arteries, and veins exiting from the chest and neck by the muscles at the side of the neck, collarbone and the first rib
- More common in women with long necks and sagging shoulders, tight pectoral shoulders, tight neck muscles, collapsed chest posture.
- Double crush syndrome

Thoracic Outlet Syndrome

- Common in people who have prolonged arm lifting postures
- Superficial breathing causing the scalene muscles to elevate the rib cage decreasing the space for the arteries and nerves
- Symptoms include whole arm pain, numbness and weakness in the hand skin color and temperature changes
- PT effective in > 90% the rest need resection of the first rib

Arm nerve glides-1

Arm nerve glides-2

Arm nerve glides-3

Fibromyalgia

- “fibrositis”. myofascial pain syndrome.
- Extremely common female> male x 10
- Trigger points involving muscles tendons ligaments up to 18
- Aching, stiffness, fatigue especially in am.
- Sleep disturbance
- Improper body mechanics
- Intramuscular “knotting” scarring with reduced blood flow

Fibromyalgia-2

- Chronic pain worse with repetition, poor posture, stress, cold
- Not progressive, will not become arthritis
- Physical exam, labs are normal
- ?psychosomatic illness?

Fibromyalgia management

- Lifestyle modification
- Aerobic exercise, yoga, massage (deep tissue...massage balls)
- Relaxation techniques—biofeedback
- Sympathetic therapy- E-stim
- Neurontin,Lyrica

- Rolfing, Alexander techniques

Thumb basal joint arthritis

- Osteoarthritis
- Presents in late 40's early 50's
- Pain, deformity, loss of strength, motion, dexterity
- “grinding” at the thumb base
- Progressive
- Loss of cartilage in the trapezium and ligament support at the metacarpal base

Basal Joint OA Management

- Early- NSAIDS, joint protection splinting, activity modification, contrast baths with ROM
- Steroid injection
- Surgery: Trapezeotomy, interposition arthroplasty w/wo tendon transfer “Artelon” implants
- Early disease- Arthroscopy

Artelon implant

X-ray appearance

- Before surgery
- Post op

Dequervains Tenosynovitis

DeQuervain's tenosynovitis

- Progressive thumb sided wrist pain made worse with forceful thumb flexion
- Made worse by playing in ulnar deviation of the wrist (wide reaches)
- Steroid injection, braces, surgical release
- While playing the keyboard, minimize thumb angle under the hand when playing arpeggios if possible

Trigger digits

Trigger digits

- Painful locking and popping when trying to flex and extend a finger or thumb
- Eventually fingers are stuck in one position
- More common in diabetics but cause really unknown
- Steroid injections 1 or 2
- Surgical release

Ganglion Cysts

Ganglion cysts

- Harmless mucous filled sacs that grow out of the wrist or finger joints or tendon sheaths
- Can cause wrist pain and weakness
- Aspiration common with high recurrence
- Surgery successful in about 90%

Nolan 1992 Med-art world congress

“ the recurring tragedy among musicians are the inordinately long periods of disability so often associated with easily correctable conditions...”

Technical notes

- The use of curved hand keyboard position reduces flexor tendon tensions and resultant force in finger joints
- Average force of keystrokes inversely proportional to playing experience
- Greater keyboard proficiency leads to effortless keyboard strike if the fundamentals are sound from an ergonomic viewpoint

Knishkowsky and Lederman 1986

- Thoracic outlet syndrome-1st rib resected (2/9) improved
- Carpal tunnel syndrome (2/4) released, improved
- Ulnar neuropathy (1/3) released, improved
- Medial epicondylitis 1 improved but changed careers.

9 Professional musicians

- 7 chronic conditions
 - 5 returned to highest level of playing
 - 2 did not
- 2 acute conditions
 - both returned to highest level

Dawson 1990 MPPA

- 486 musicians
- 6-87 years old
- 52% male
- 48% female

End Results

- 66 Patients
 - Asymptomatic 88%
 - Persistent difficulty 12%
 - Complete return to play 79%
 - Modified return/ no return 21%

Poor prognosis/ long rehab time

- Late presentation
- Laceration
- joint contractures
- Nerve/ tendon injuries

Why is surgery usually a last resort?

- Many physicians and surgeons fail to see the benefits.
- Musicians think that they will be harmed by the surgery
- Musicians feel that surgeons are unfamiliar with their needs
- Fear of “losing control”

In general, surgery patients recover faster than non-surgical

Long term maintenance

- General conditioning

- Yoga
- Stress, Time management
- Repertoire, style change
- Ultimately, instrument or professional change

Thank You !