Hypermobility 109: Breathing Issues in HSD

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- Slide handouts and recordings are available at: https://webspace.clarkson.edu/~lrussek/hsd.html

Who Am I?

- Professor Emeritus, Physical Therapy, Clarkson University.
- Staff PT, St. Lawrence Health System, Potsdam NY.
  - Clinical specialties: hypermobility, chronic pain, fibromyalgia, headaches, temporomandibular disorders
- Facilitator of the North America Allied Health Professionals ECHO
- Member of:
  - The Allied Health Working Group of the International Consortium of Ehlers-Danlos Syndromes and Hypermobility Spectrum Disorders
  - The National Academy of Sciences, Engineering and Medicine Committee on Selected Heritable Connective Tissue Disorders and Disability.
- Author of ”Chronic Pain” chapter in *Physical Rehabilitation* textbook for PT students
- Lrussek@Clarkson.edu
- https://webspace.clarkson.edu/~lrussek/
- I do free weekly Zoom lectures for people with HSD (see website)

I do not have any conflicts of interest to report

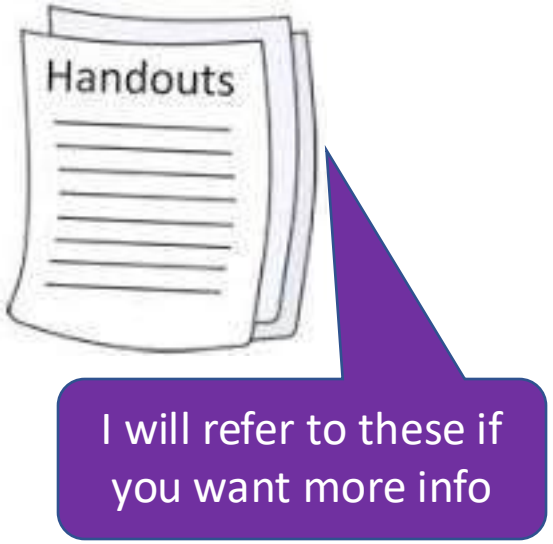
"HSD 101" Lecture Series Schedule

I will refer to these if you want more info

- HSD 101: Basics of HSD/hEDS and self-care
- HSD 102: POTS and POTS self-care, basics of MCAS
- HSD 103: Pain management in HSD/hEDS
- HSD 104: Safe exercise selection and progression with HSD/hEDS
- HSD 105: HSD/hEDS in children and teens
- HSD 106: Gut issues in HSD/hEDS, POTS, MCAS
- HSD 107: Fatigue in HSD/hEDS and POTS
- HSD 108: Headaches, migraines, and TMJ pain associated with HSD, POTS and MCAS
- HSD 109: Breathing dysfunctions in HSD
- HSD 110: Lumbar instability
- HSD 111: Cervical Instability, Part 2: diagnosis and PT (Part 1, anatomy is available on-line)
- HSD 112: Vagus nerve
- HSD 113: The importance of fascia
- HSD 114: Surgical and hospital precautions for HSD, POTS, MCAS
- HSD 115: Functional Neurological Disorder

Slide handouts and recordings are available at: https://webspace.clarkson.edu/~lrussek/hsd.html

Relevant Handouts Available



- https://webspace.clarkson.edu/~lrussek/research.html

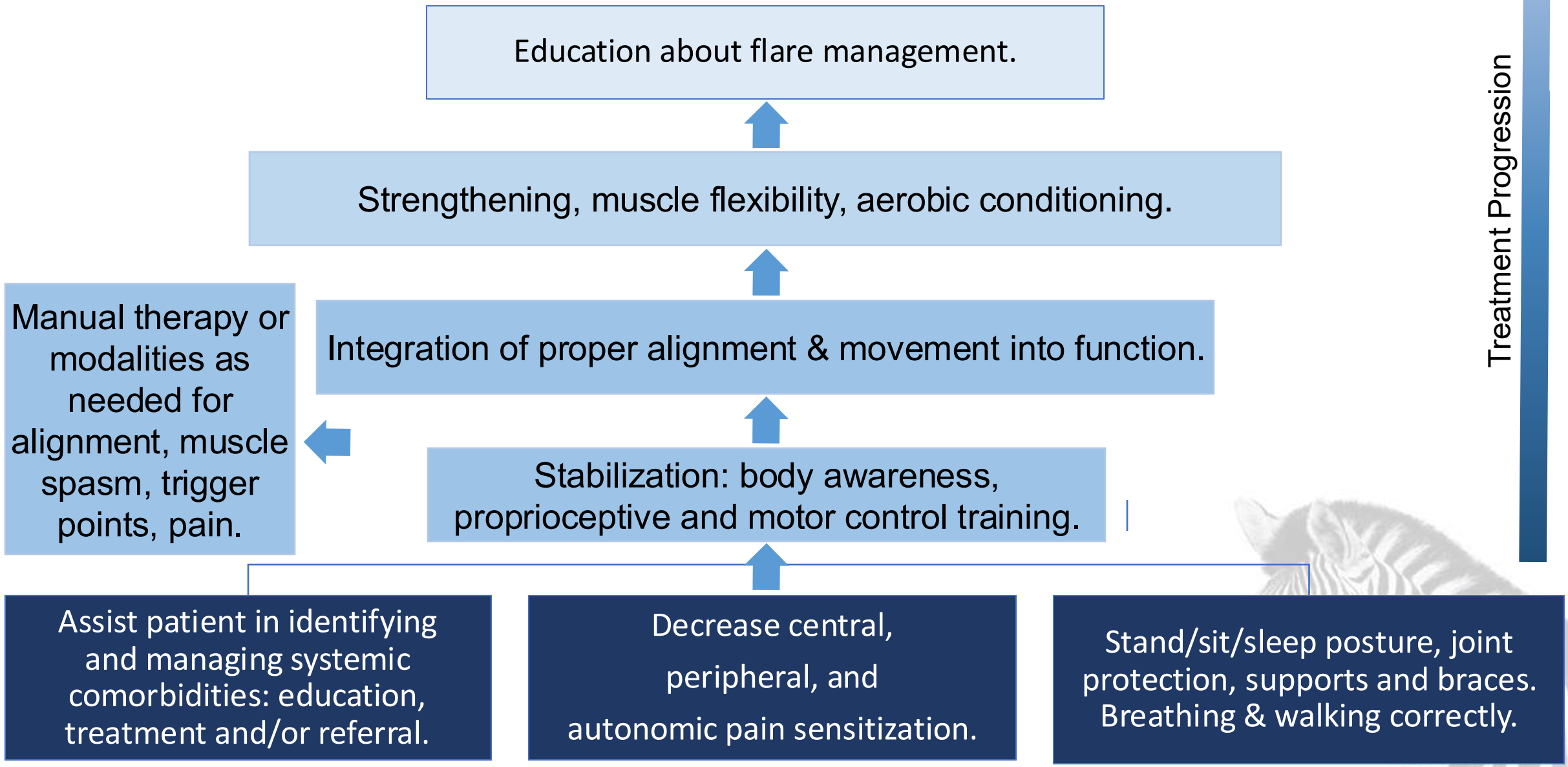
- **Self-Care Strategies**
  - Breathing. Breathing incorrectly can increase pain sensitivity, headaches, jaw pain, and more.
  - Posture. Good posture decreases strain on muscles and joints, and can prevent many problems.
  - Sleep Hygiene and Positioning. Sleep posture and sleep hygiene strategies.
  - Temporomandibular Disorder (TMD). TMJ self-care strategies.
  - Headache Trigger Points. Trigger points commonly causing headaches.
  - Heart-rate variability biofeedback. To Calm the central nervous system.
  - Starting to Exercise Ideas. Start an exercise program with breathing 'workouts'

Disclaimer

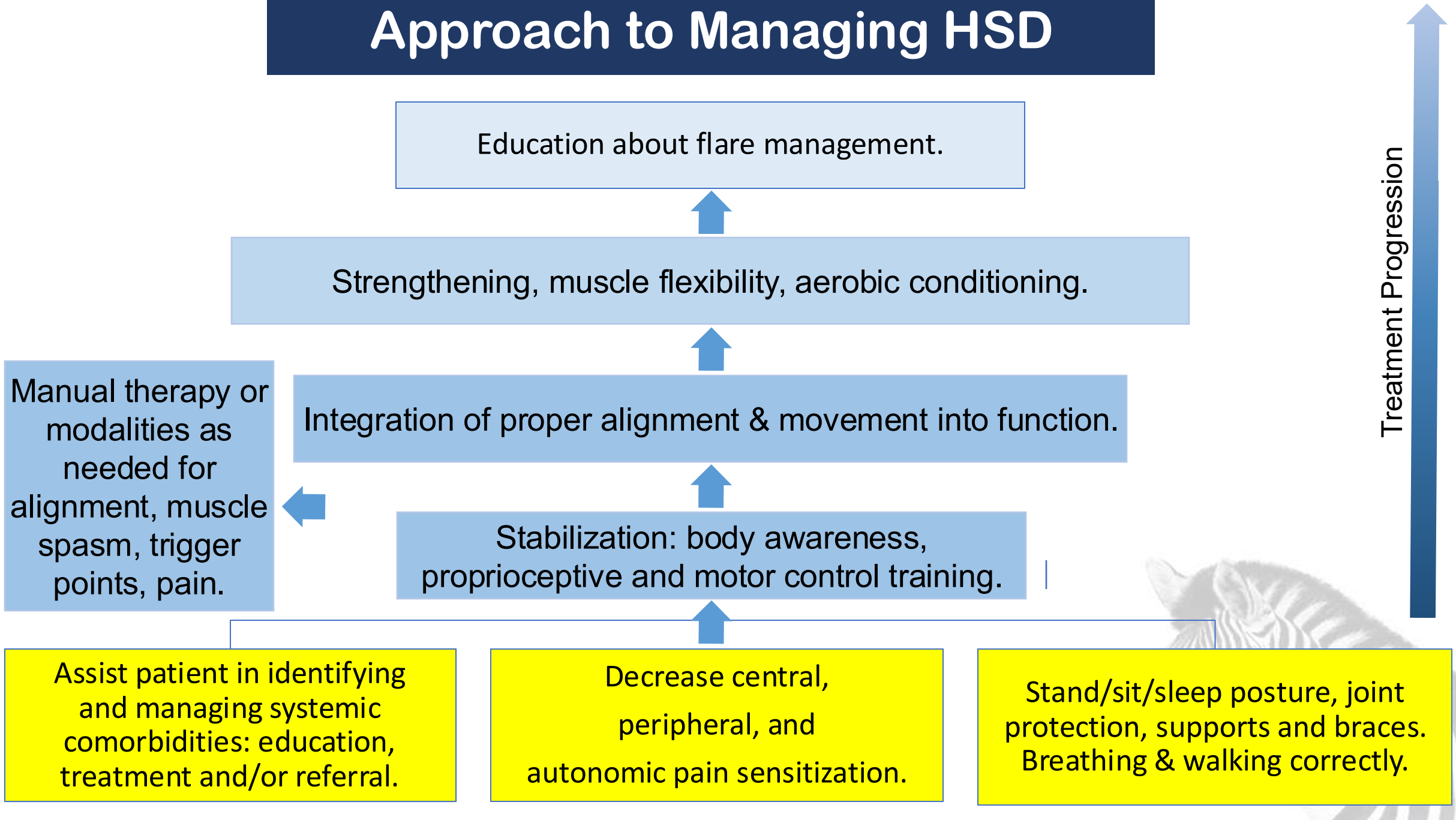
The information in this presentation is for general purposes, only, and may or may not apply to your situation.
Check with your health care provider
before starting any new treatment approach
to ensure that it is appropriate and safe for YOU.

This session has several optional breathing ‘exercises’.
Although these activities are safe and healthy for most people,
Do not do them if they are uncomfortable.

Approach to Managing HSD



Approach to Managing HSD



Objectives

By the end of this session, participants should be able to:

1. Describe how relaxed breathing should occur, and common ways that people do not breathe correctly
   - Problems with HOW we breathe
   - Problems with HOW OFTEN we breathe
2. List some of the health consequences of not breathing correctly
3. Explain or practice one or more healthy breathing patterns
   - Diaphragmatic breathing
   - Nose breathing
   - Slow breathing

- There are some “Optional technical info” slides that I will not discuss, but slides are available for you to review later.

Before We Start

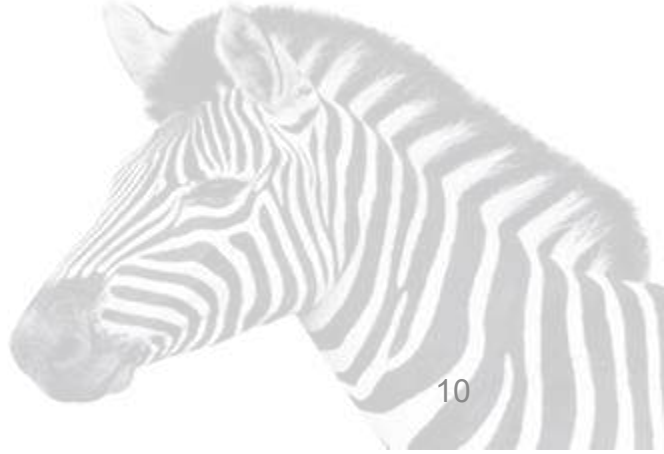
- Take one minute to assess your breathing
- Place one hand on your chest and one on your belly, and feel which hand(s) move
- Count how many breaths you normally take (one cycle is both in and out) while I time you for one minute

Just Breathe

Before We Start

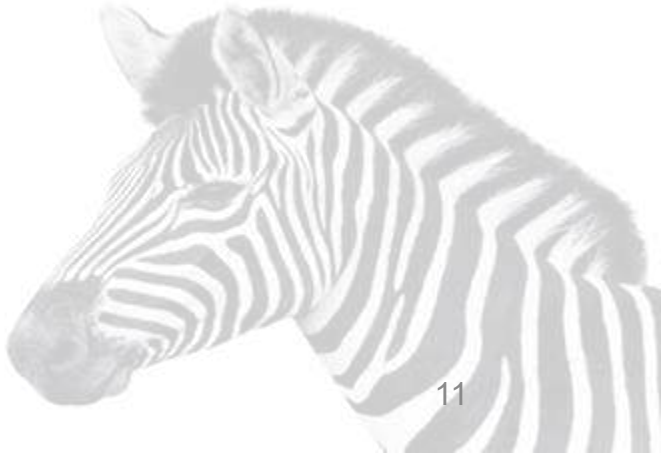
- At rest, only your belly should move when you breathe
  - Your chest should not move
- Normal breathing at rest can be 8-12 per minute
  - But ‘slow breathing’ practice at 6 per minute has many health benefits

Just Breathe

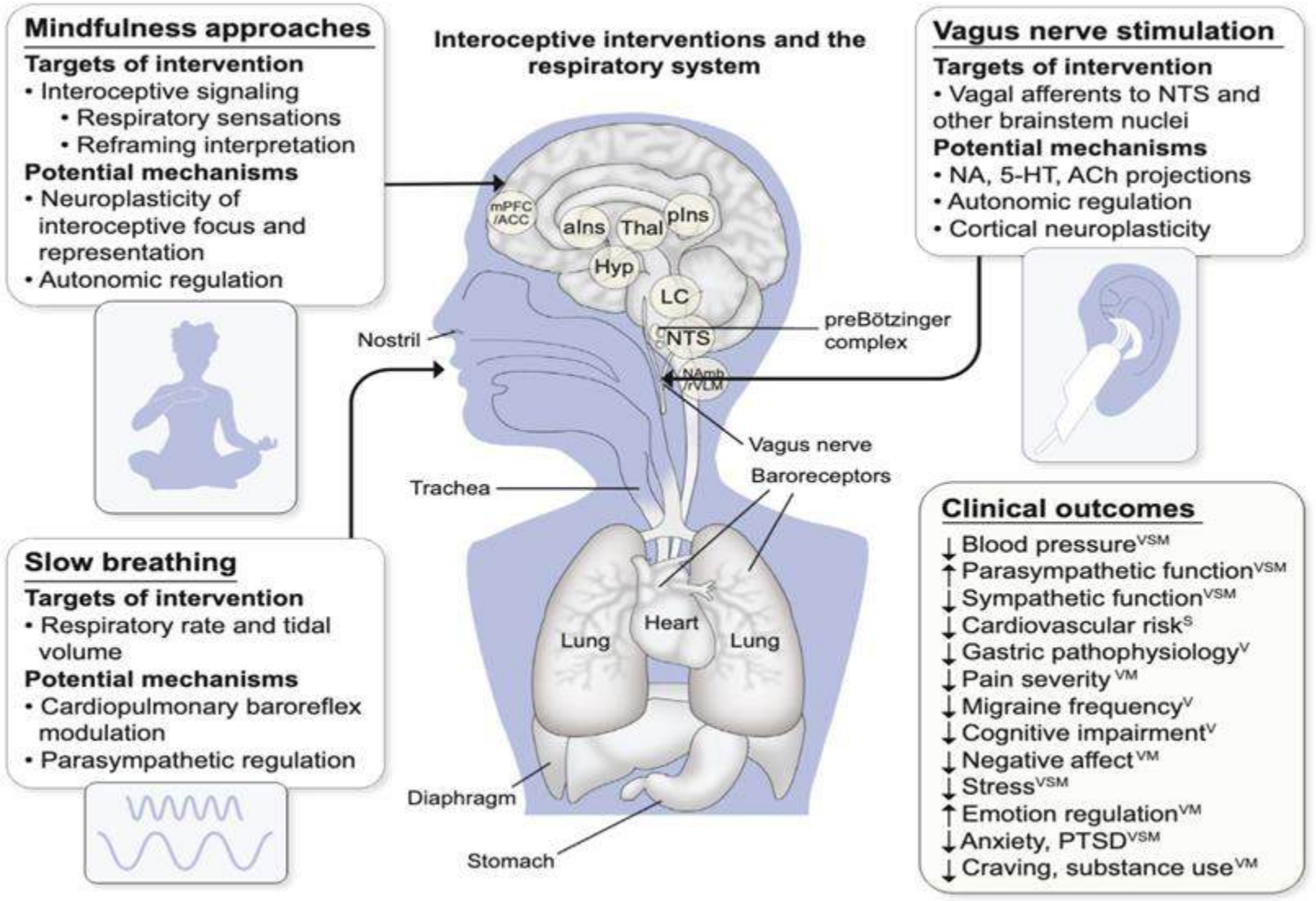


Breathing as Interoception

- Interoception is the sensation of our internal body state.
  - Contrast with special senses (e.g., sight, taste, etc), touch, balance, and proprioception (position awareness).
  - Includes awareness of breathing, fatigue, heartbeat, fullness, pain, etc.
- Interoception seems to be affected in HSD and chronic pain
- Breathing may provide a mechanism to improve interoception



Mindful Breathing and Interoception

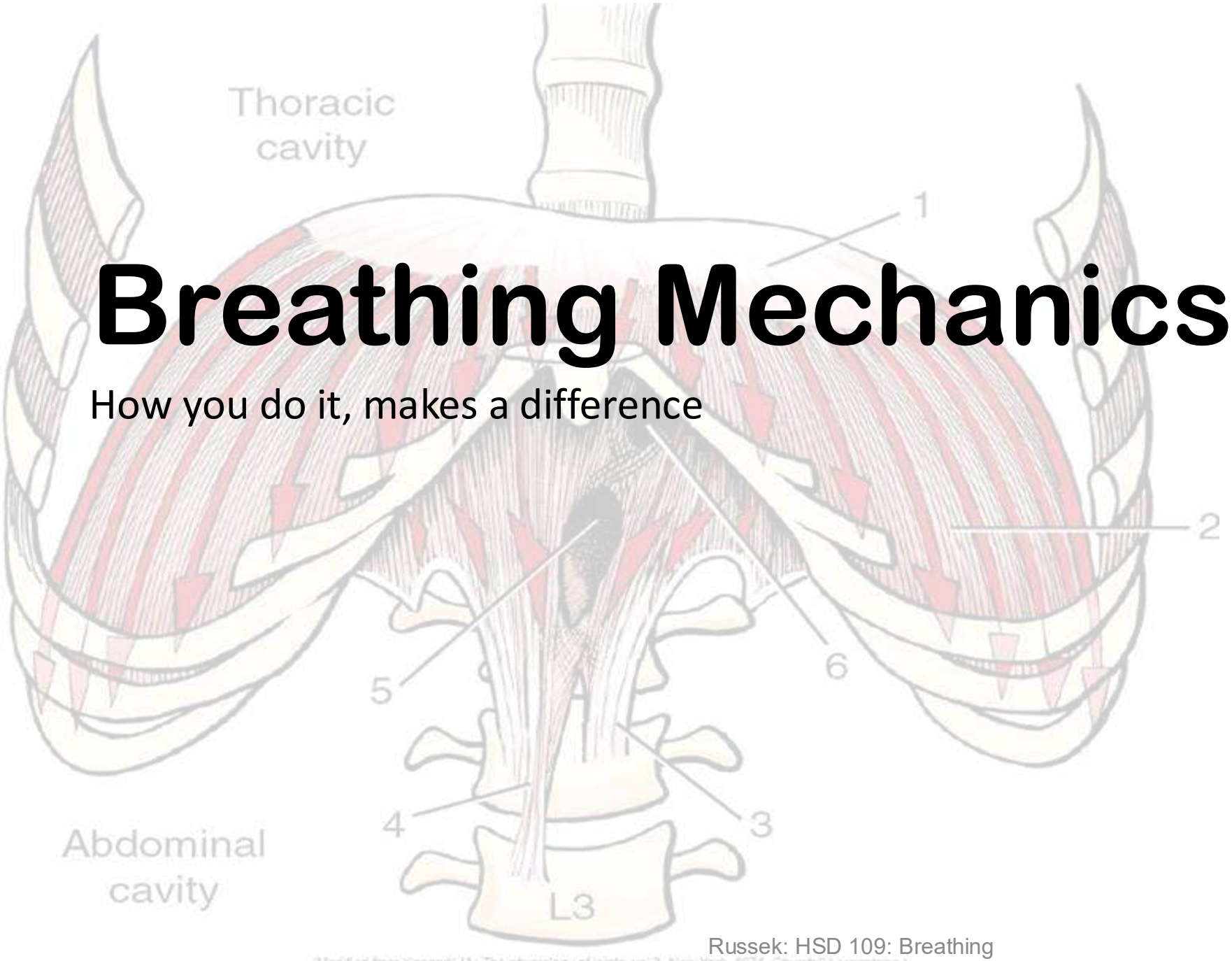


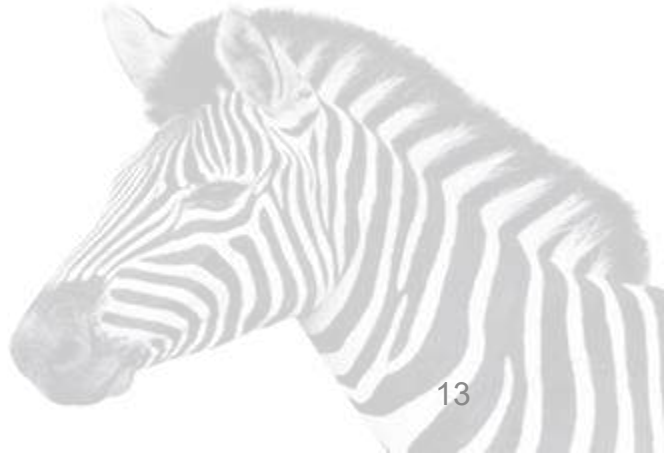
Optional technical info

Weng, 2021

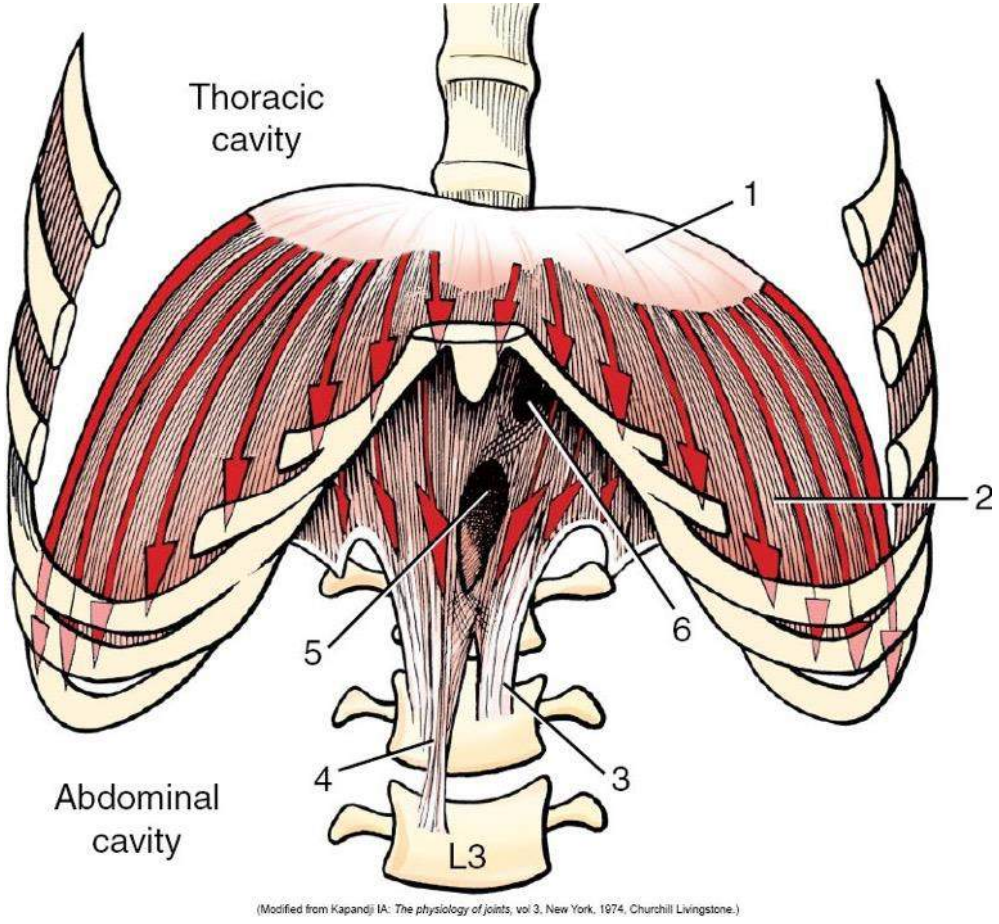
Breathing Mechanics

How you do it, makes a difference





The Diaphragm

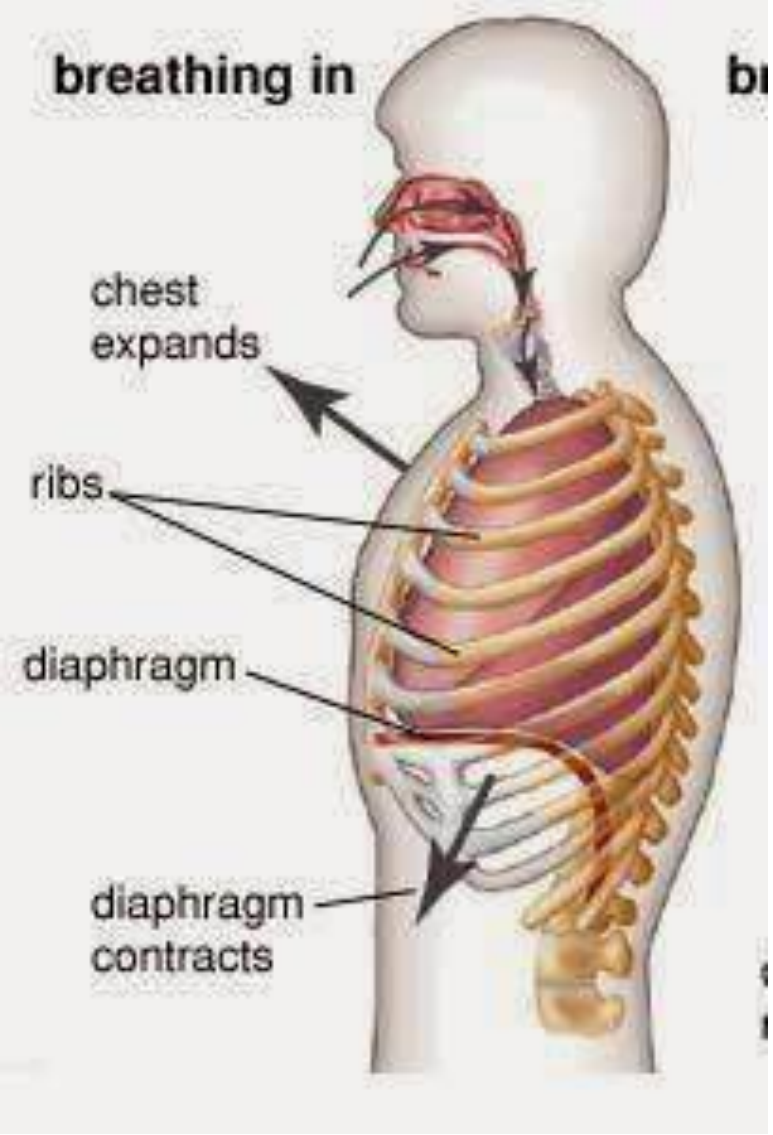


(Modified from Kapandji IA: *The physiology of joints*, vol 3, New York, 1974, Churchill Livingstone.)

- The primary muscle for relaxed breathing
- Coordinates with abdominal and pelvic floor muscles
- Stabilizes the lumbar spine
- Irritation of the diaphragm refers pain to the shoulders
- 14+ accessory breathing muscles are normally active only in strenuous breathing

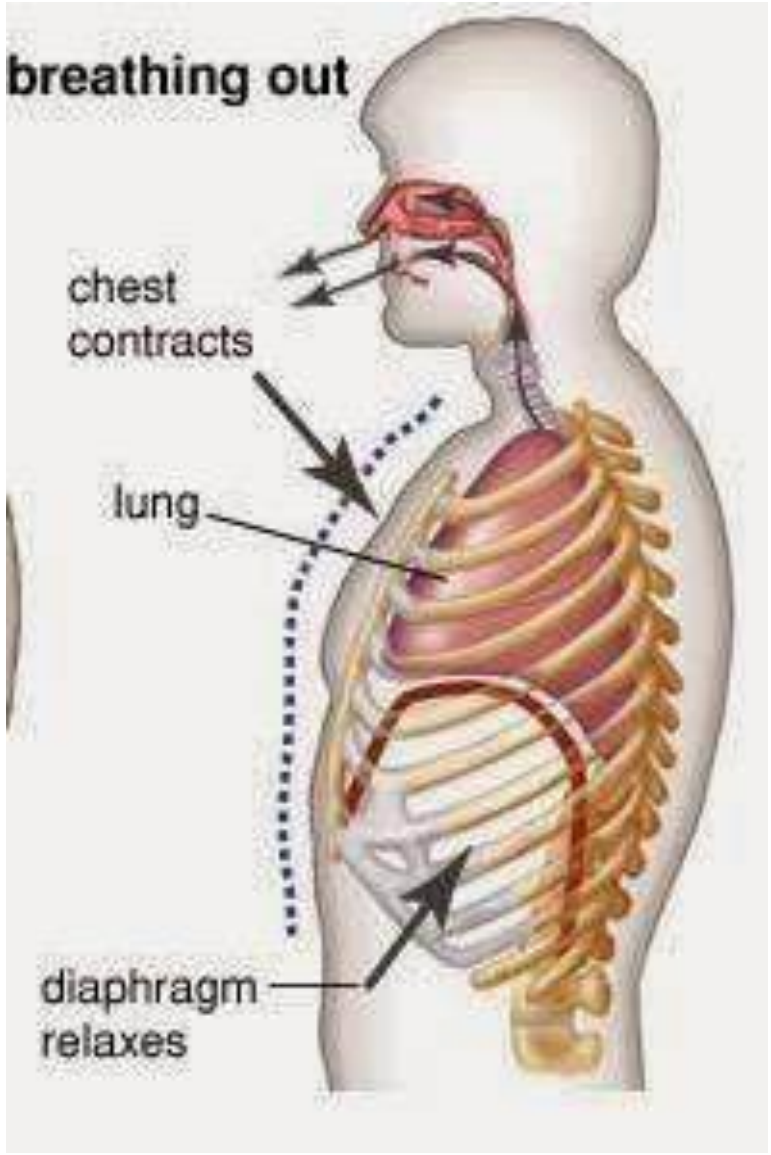
(Kocjan, 2017)

Relaxed Diaphragmatic Breathing



- The diaphragm pulls air into the lungs by pulling down
- When it contracts, it pushes on organs in the belly, making the belly go out
  - Diaphragmatic breathing is “belly breathing”
- When the diaphragm contracts, it also lifts the ribs
- Intercostal (rib) muscles help lift ribs

Relaxed Exhalation



- When we exhale, elastic recoil pulls the diaphragm and ribs back to their original positions
- This normally does not require effort

Breathing Muscle Activation

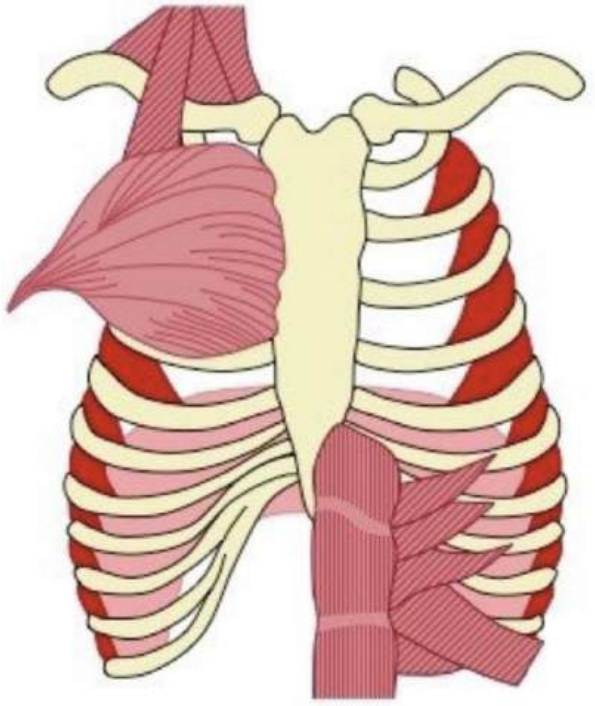
Muscles of Inspiration

Core Muscles

- External intercostals
  (contracts to elevate ribs)
- Diaphragm
  (contracts to expand thoracic cavity)

Accessory Muscles

- Sternocleidomastoid
  (contracts to elevate sternum)
- Pectoralis minor
  (contracts to pull ribs outwards)



Muscles of Expiration

Core Muscles

- Internal intercostals
  (contracts to pull ribs down)
- Diaphragm
  (relaxes to reduce thoracic cavity)

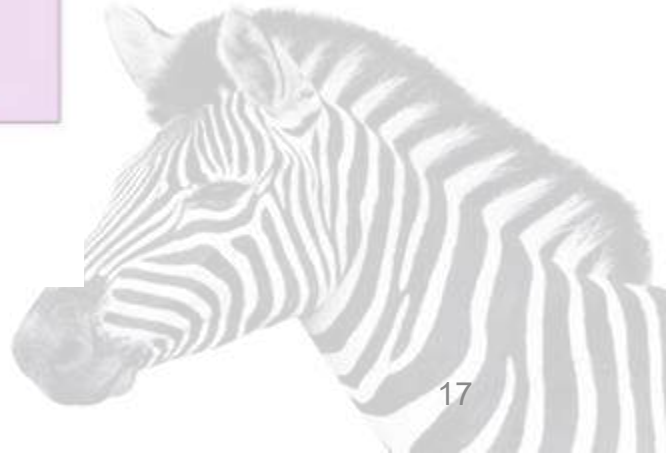
Accessory Muscles

- Abdominals
  (contracts to compress abdomen)
- Quadratus lumborum
  (contracts to pull ribs down)

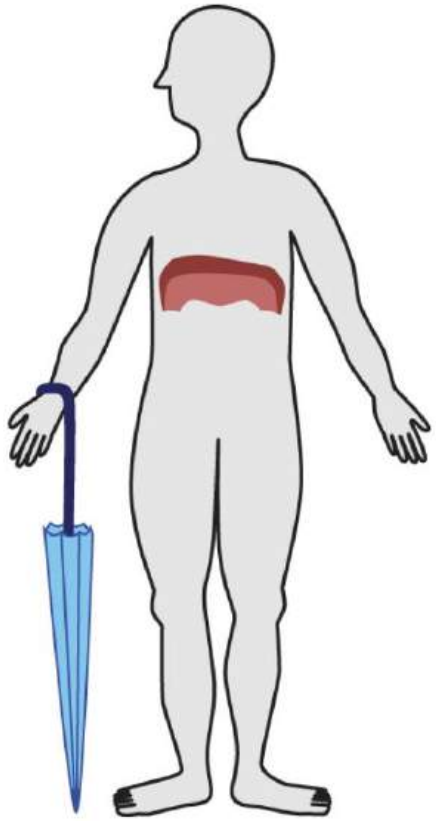
Relaxed Breathing

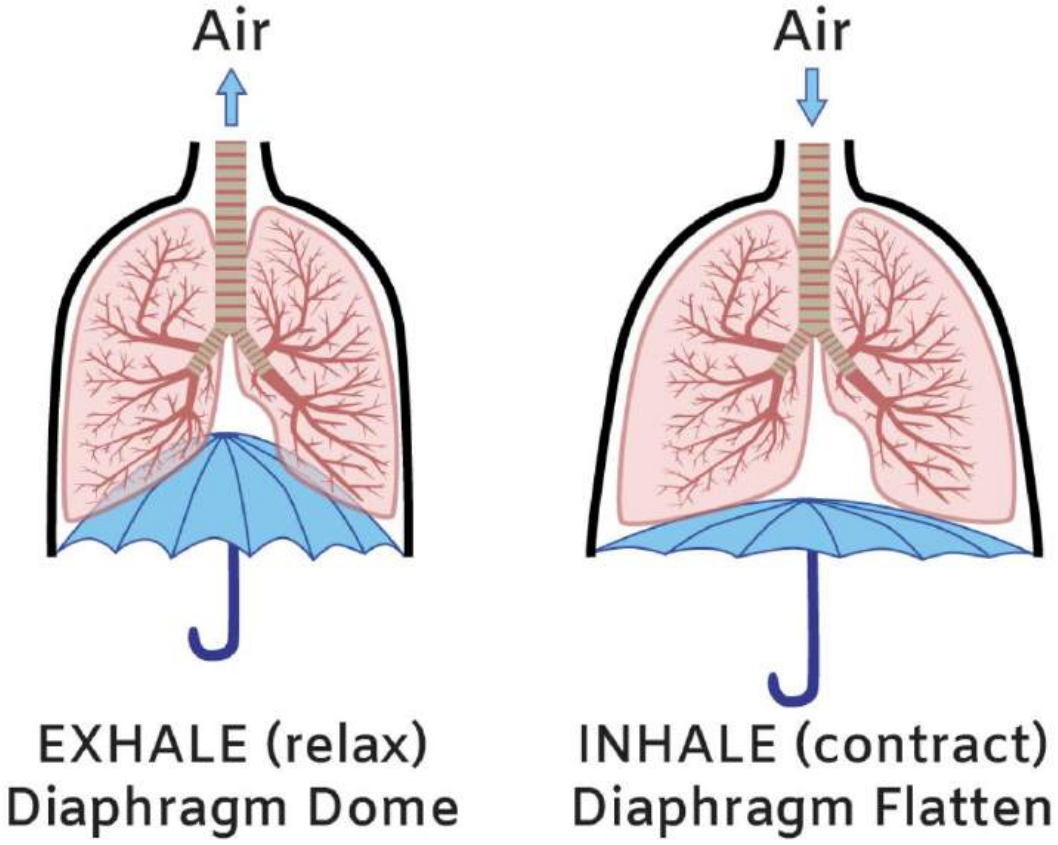
Strenuous Breathing

Image credit: Bioninja.com

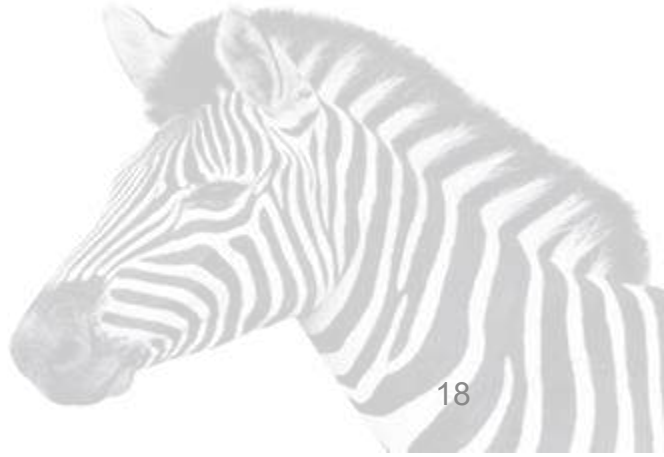


“Umbrella” Diaphragmatic Breathing

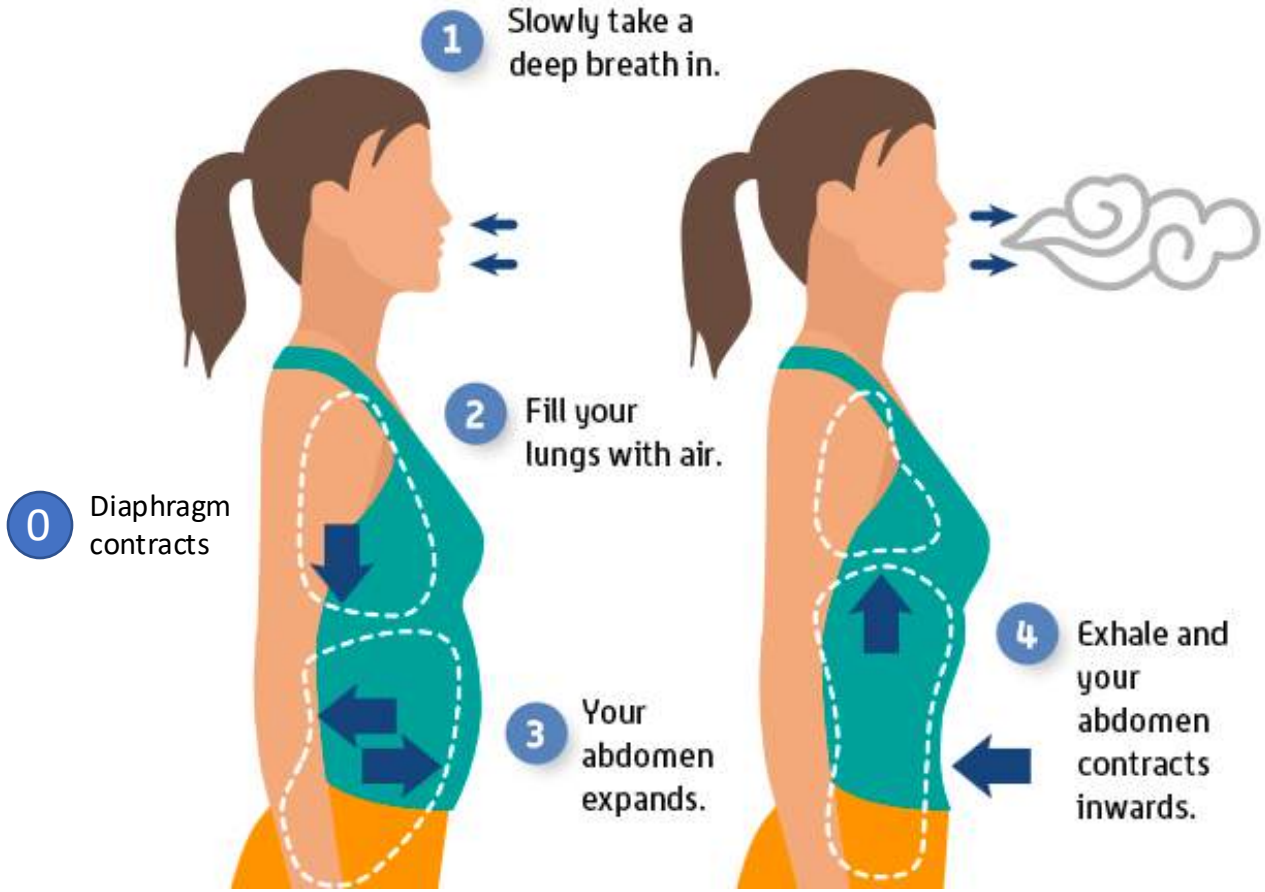


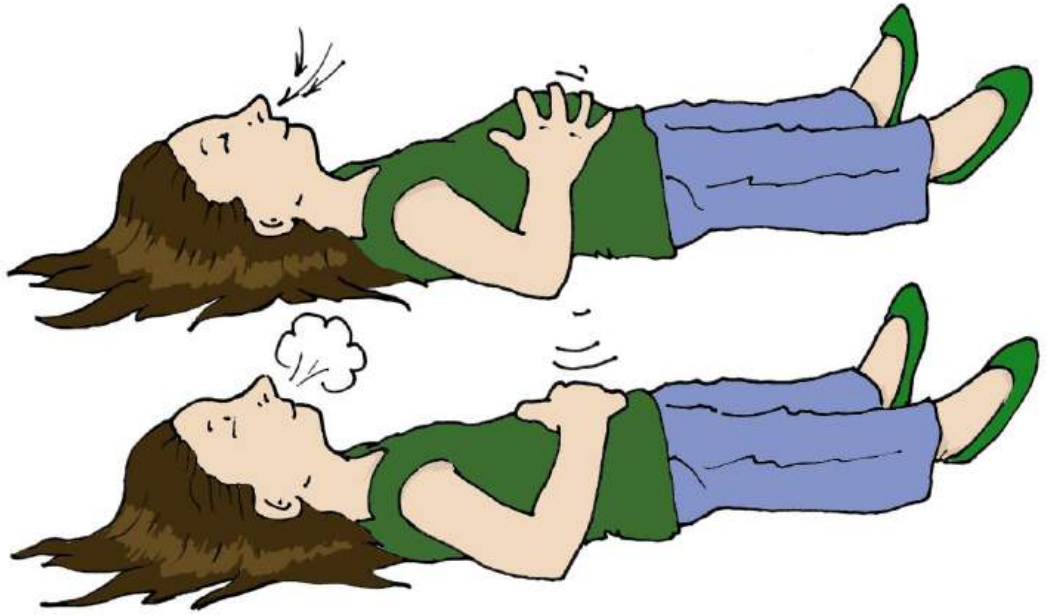


- Breathe into your lower ribs and belly
- Expand lower ribs in all directions
- Chest should not rise



“Belly Breathing”: Old View





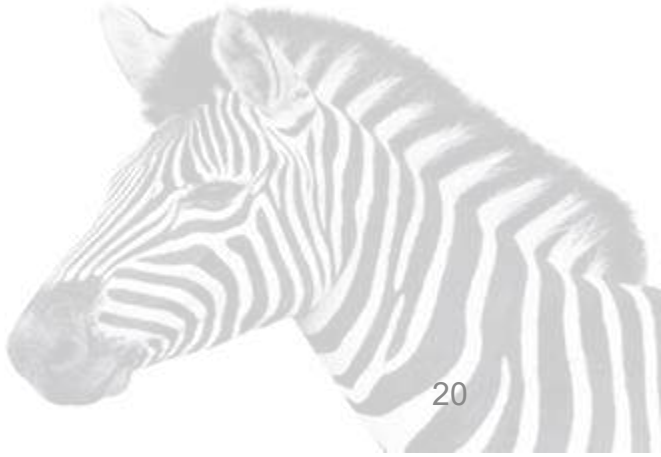
NOTE:

- DB when upright (sitting/standing) is more work for your abdominals.
- DB lying down is more work for your diaphragm. Put a weight on your belly to further strengthen the diaphragm

https://onepointhealth.com.au/physiotherapy/the-what-why-how-of-diaphragm-breathing/ https://webstockreview.net/image/breath-clipart-relaxing/300073.html

“Umbrella” Breathing: New View

- Place hands on lower ribs
- Expand lower ribs in all directions as you inhale
- Chest should not rise

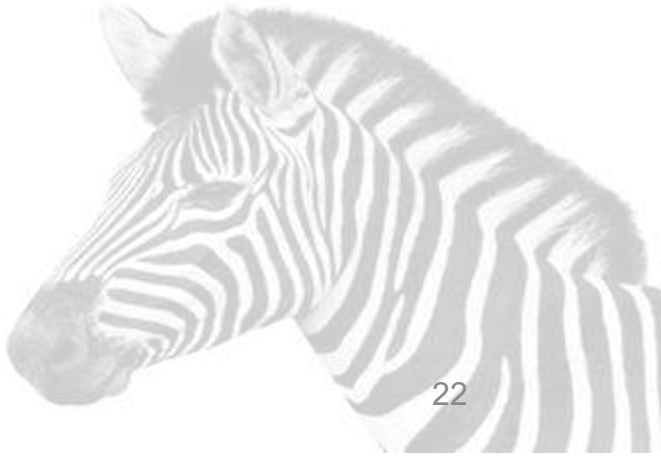


Inadequate Rib Expansion

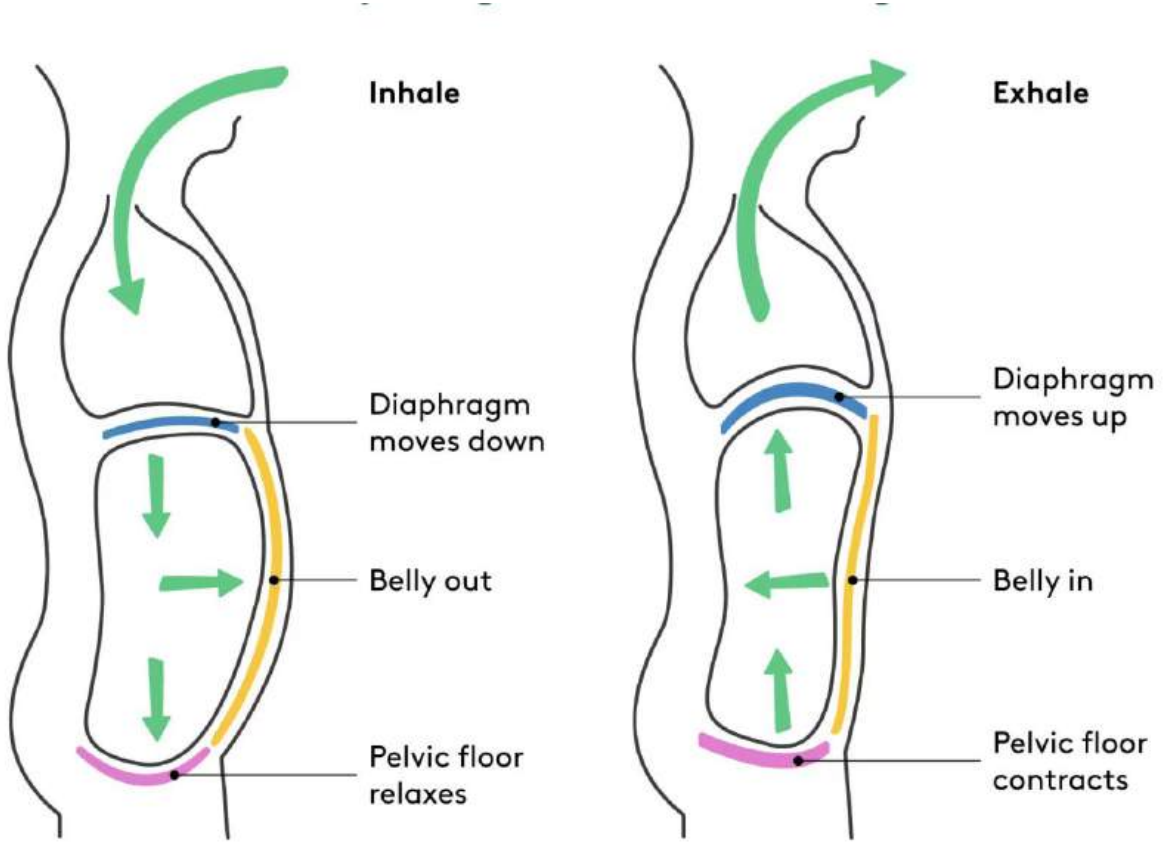
- Your lower ribs should expand 2.5”-3” when you go from maximal exhalation to maximal inhalation.
- Measure just below the breasts.
- If you have less rib expansion, you can improve rib expansion by inhaling rapidly through a straw. This strengthens your inhalation muscles and improves movement of lower ribs.

Singing for Breathing Re-Education

- Singing with voice projection (i.e., singing loudly) activates both the diaphragm and abdominal muscles
  - Diaphragm to inhale
  - Abdominals to forcefully exhale
- Singing also activates the vagus nerve, which causes a relaxation response
- Plus singing can be a fun and social activity
- Chanting and resisted yoga breathing may also work this way
- Singing can be as effective as treadmill walking for people who are deconditioned. (Philip, 2021)



Breathing and the Pelvic Floor



- Inhalation: diaphragm and pelvic floor both move down
  - Diaphragm contracts down
  - Pelvic floor relaxes down
- Exhalation, diaphragm and pelvic floor both move up
  - Diaphragm relaxes up
  - Pelvic floor contracts up (kegel)
- Breathing may be helpful for managing urinary incontinence

(Toprak, 2022)

https://www.hingehealth.com/resources/articles/diaphragmatic-breathing-pelvic-health/

Breathing

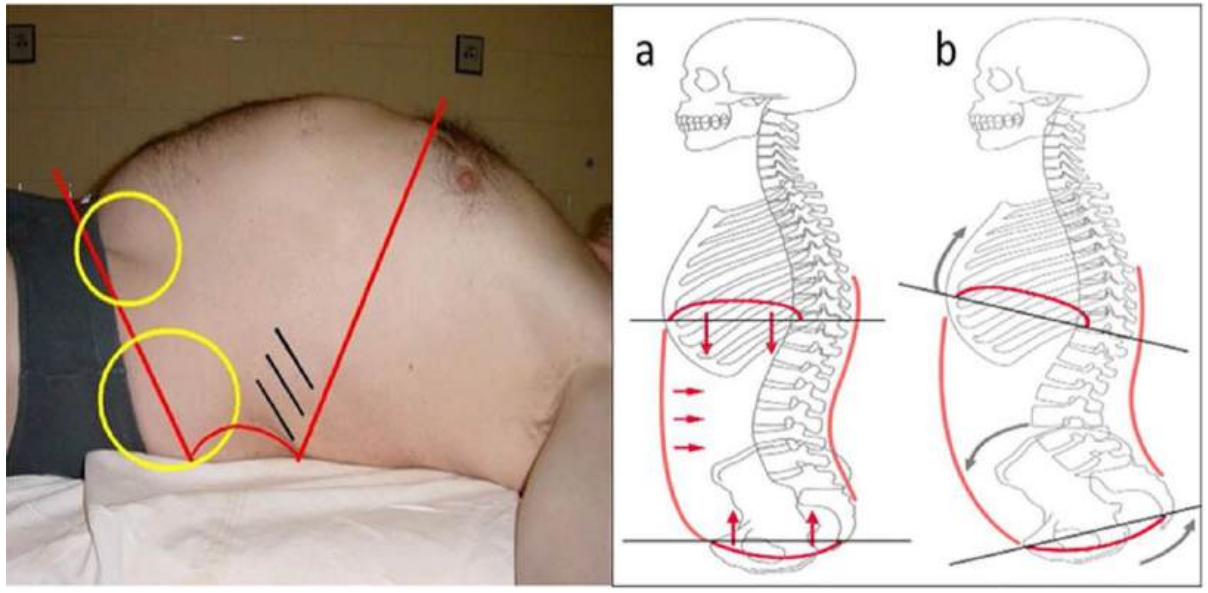
Diaphragm Dysfunction

- Overuse of accessory muscles of breathing in the neck and chest
- Problems with swallowing and sleep apnea, sleep disturbance
- Asthma, shortness of breath, decreased exercise/activity tolerance
- Increased arch in the low back (lordosis), lumbar and pelvic instability
- Low back muscle spasm; low back and sacroiliac joint pain
- Weak hamstring and abdominal muscles
- Decreased heart function
- Decreased lymphatic fluid movement through the body, increased fluid build-up
- Anxiety, psychological stress and increased sympathetic nervous system activity
- Migraine

HSD 111: Lumbar instability

(Kocjan, 2017, Bordoni, 2018; Hamasaki, 2020; Liu, 2023)

Diaphragm & Lumbar Instability



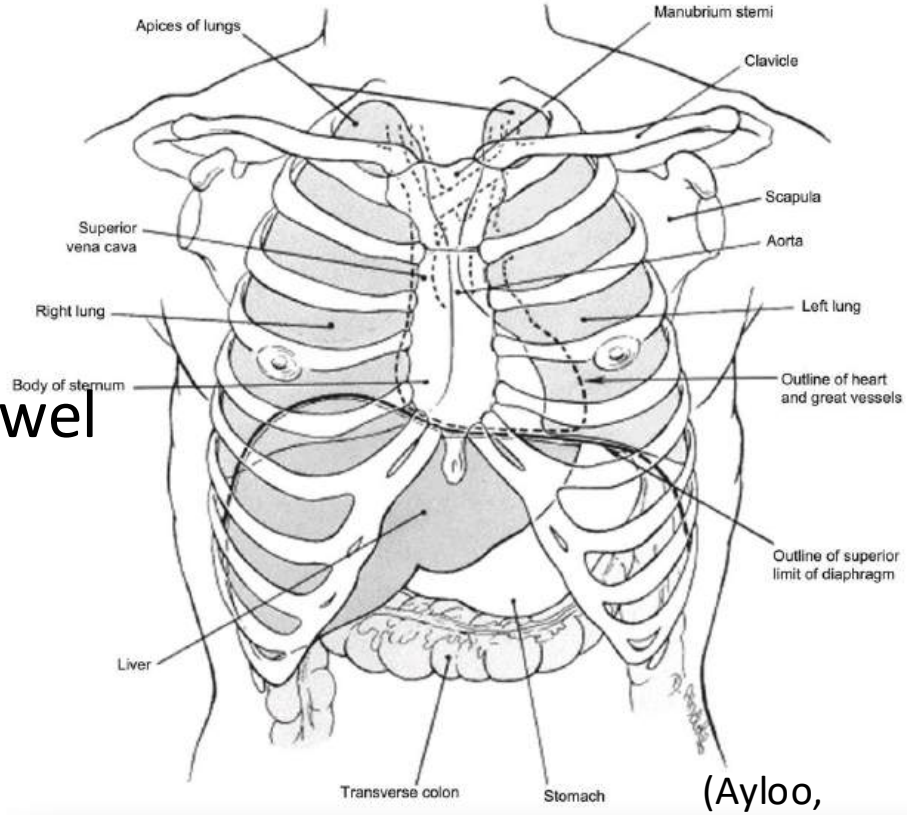
- “Open Scissors Syndrome” (b) occurs when the abdominal muscles do not stabilize the spine during inhalation.
- Should activate diaphragm, abdominals, and pelvic floor muscles together.
- Lower ribs should expand in all directions: Umbrella Breathing

(Zdrhova, 2022)

Diaphragm and Gut Function

HSD 106: Gut Issues in HSD, POTS, MCAS

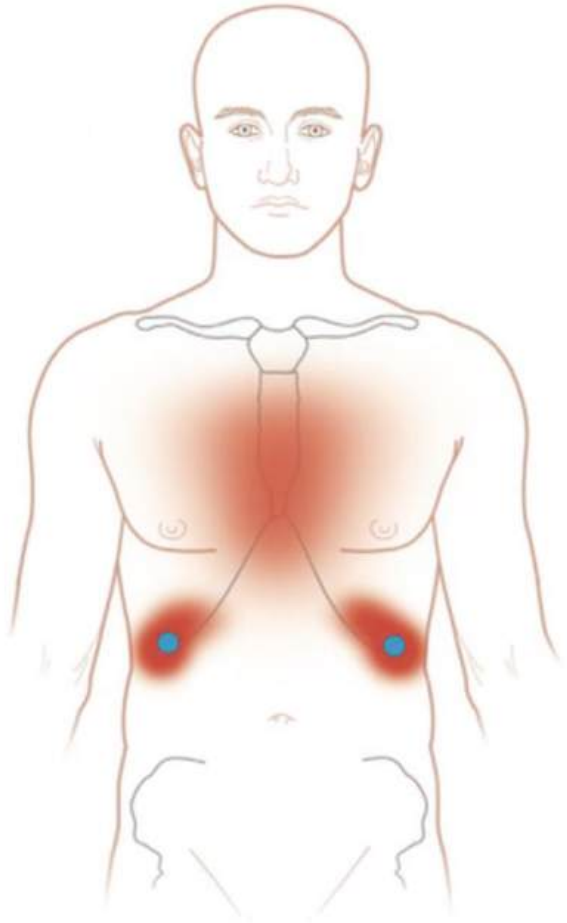
- Dysfunction in the diaphragm increases gastroesophageal reflux
  - Diaphragm exercise is an effective treatment for GERD
- Lack of coordination between diaphragm and abdominal muscles is associated with irritable bowel syndrome (IBS)
- Decreased diaphragm function increases pain sensitivity in the gut
  - Diaphragmatic motion “massages” the vagus nerve, decreasing inflammation and gut-related pain
- Diaphragmatic breathing can treat GERD, constipation and eating disorders



(Ayloo, 2013)

(Zdrhova, 2023 ; Liu, 2023 ; Hamasaki, 2020; Bordoni, 2018)

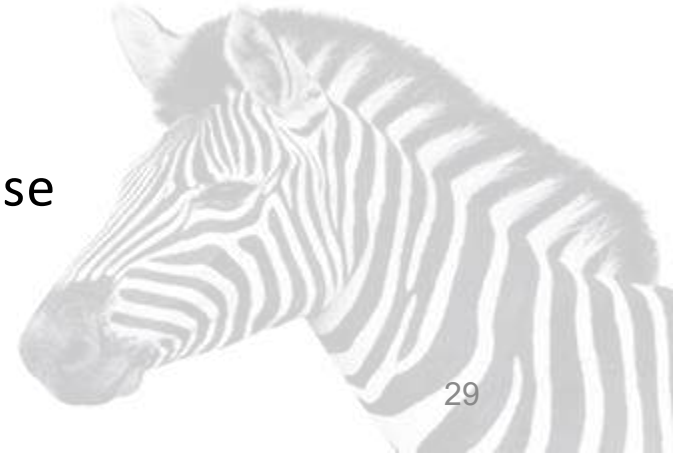
Diaphragm Trigger Points



Diaphragm - Typical Referred Pain Patterns

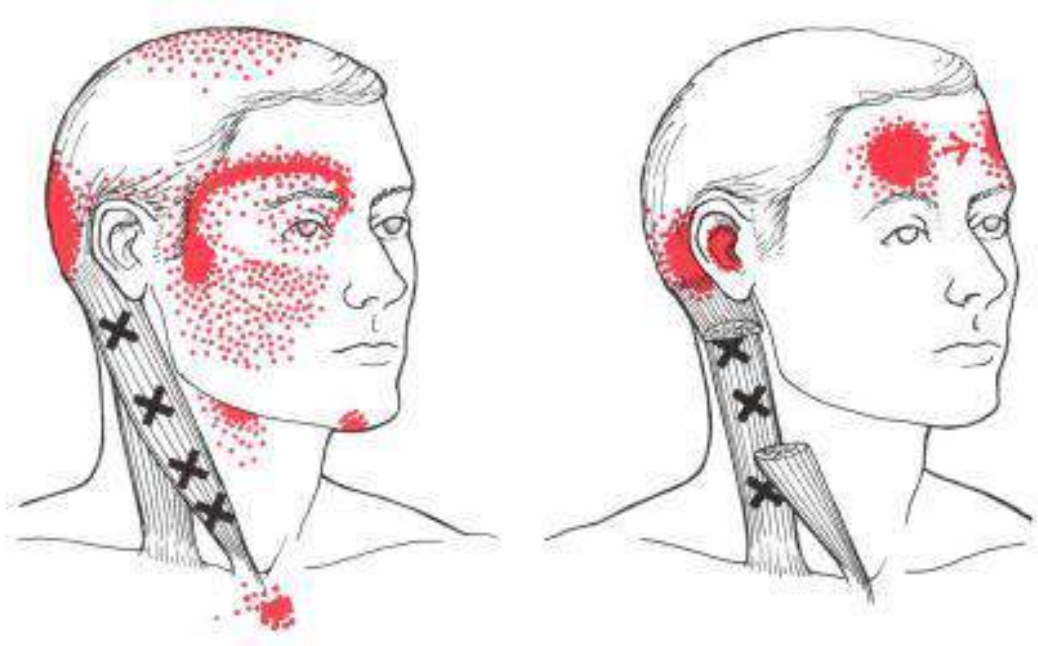
https://www.thelasher.com/blogs/video-blog/trigger-point-therapy-treating-the-diaphragm

- Feels like a “stitch”
- Can cause anxiety, aggravate asthma or breathing problems
- Aggravated by:
  - Poor posture
  - Weak abdominals/abdominal surgery
  - Abdominal muscle trigger points
  - Pectoralis major trigger points
  - Emotional overload
  - Lumbar instability
  - Coughing, vigorous exercise
  - Asthma



Headache Trigger Points

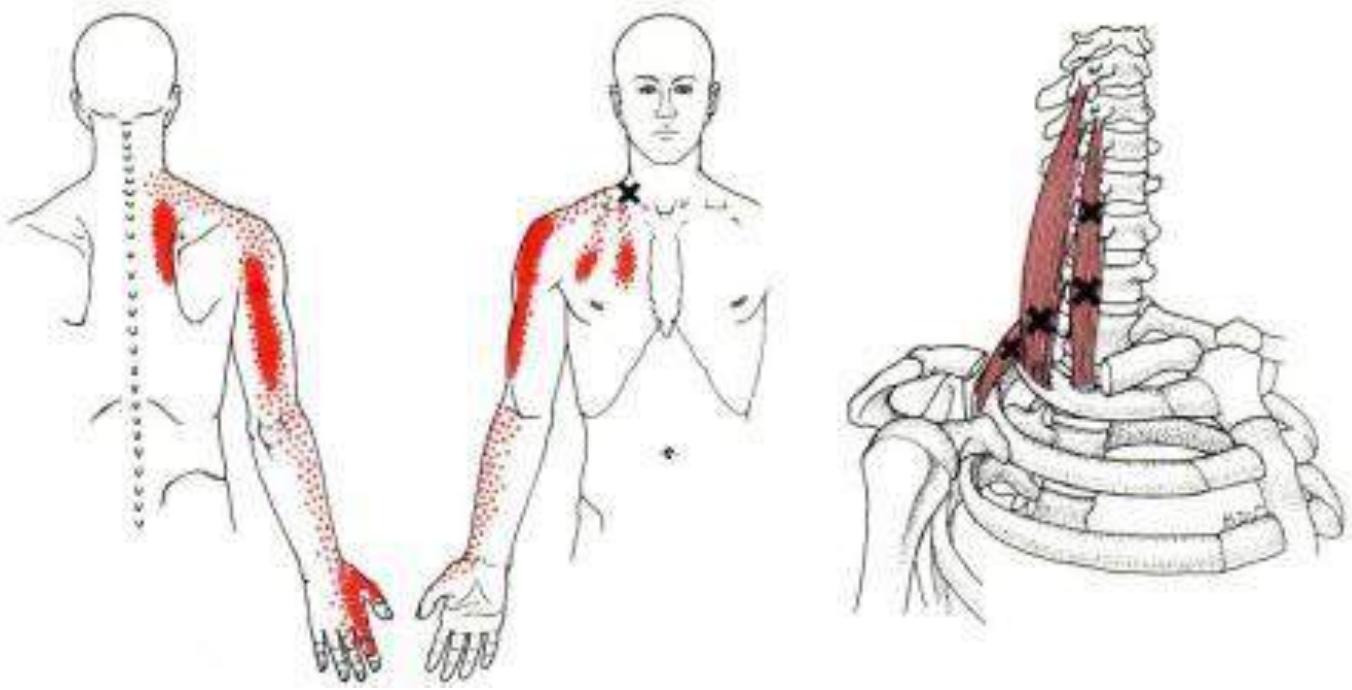
Accessory Breathing Muscles: SCM



- Sternocleidomastoid (SCM) trigger points can cause:
  - Headaches,
  - Ringing/fullness in the ear,
  - Sinus congestion,
  - Nausea,
  - Dizziness
- Tight SCM can cause forward head, which can increase cervical instability

http://www.triggerpoints.net/muscle/sternocleidomastoid

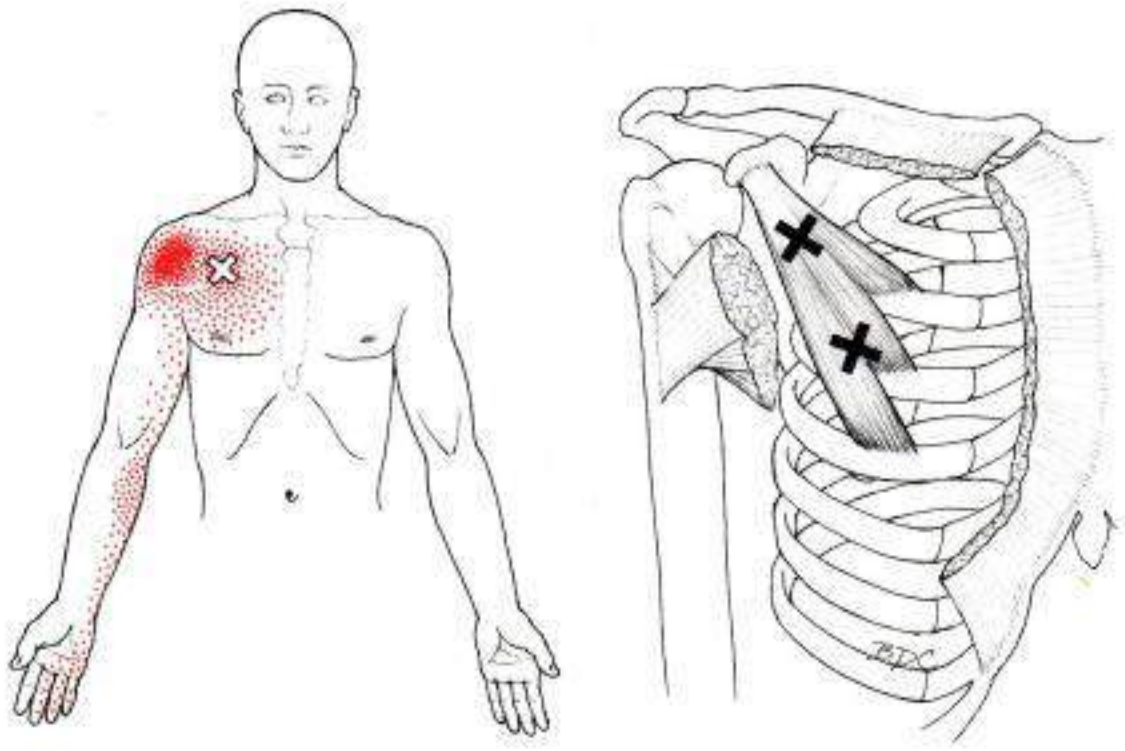
Accessory Breathing Muscles: Scalenes



http://www.triggerpoints.net/muscle/scalene

- Scalene trigger points can cause:
  - Chest and upper back pain,
  - Pain and numbness radiating into the arms and hands
  - Can feel like a heart attack
- Tight scalenes can cause:
  - Thoracic outlet syndrome (Pain, numbness and/or swelling into the arms and hands)

Accessory Breathing Muscles: Pectoralis Minor

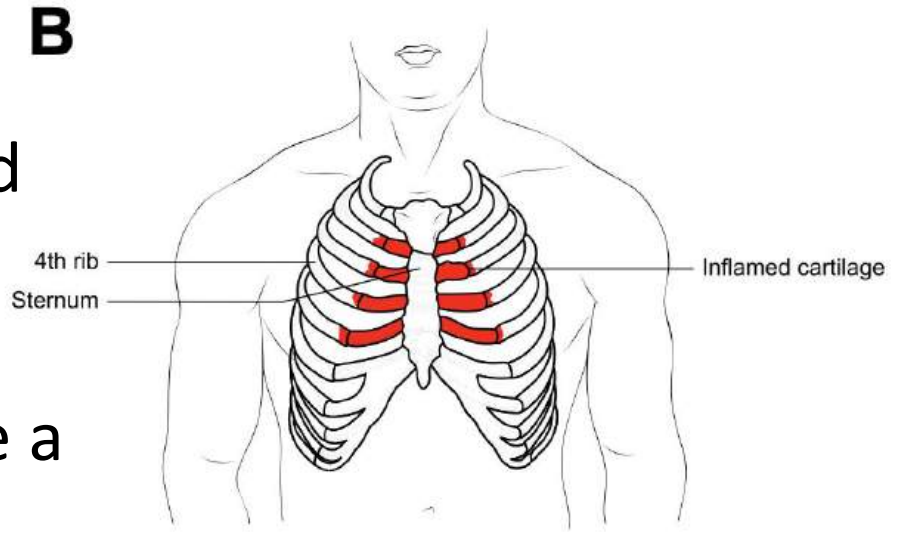


http://www.triggerpoints.net/muscle/pectoralis-minimus

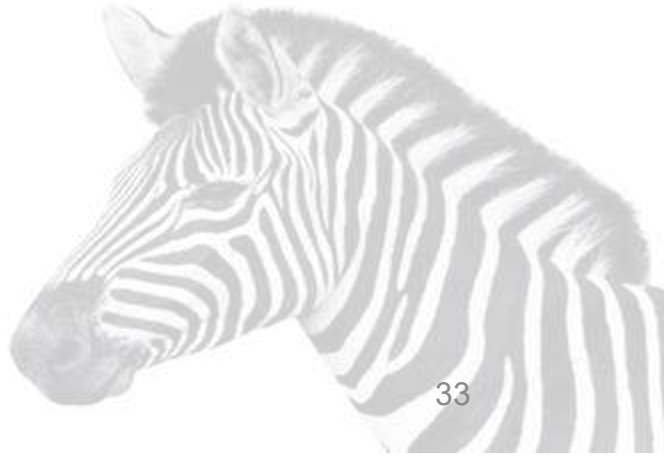
- Pectoralis minor trigger points can cause:
  - Chest and shoulder pain,
  - Pain radiating into the elbow and hands
- Tight pec minor muscles can cause or aggravate:
  - Costochondritis by pulling on ribs (Zaruba, 2017)
  - Thoracic outlet syndrome

Costochondritis

- Irritation of the cartilage between the ribs and sternum (breastbone)
- Usually ribs 2-5 (upper chest)
- Pain is aching, sharp, or pressure. Can feel like a heart attack
- Aggravated by deep breathing (inspiration),
  - Also by exertion, certain trunk & shoulder movements
- Tender where ribs connect to sternum
- Positive “crowing rooster” maneuver

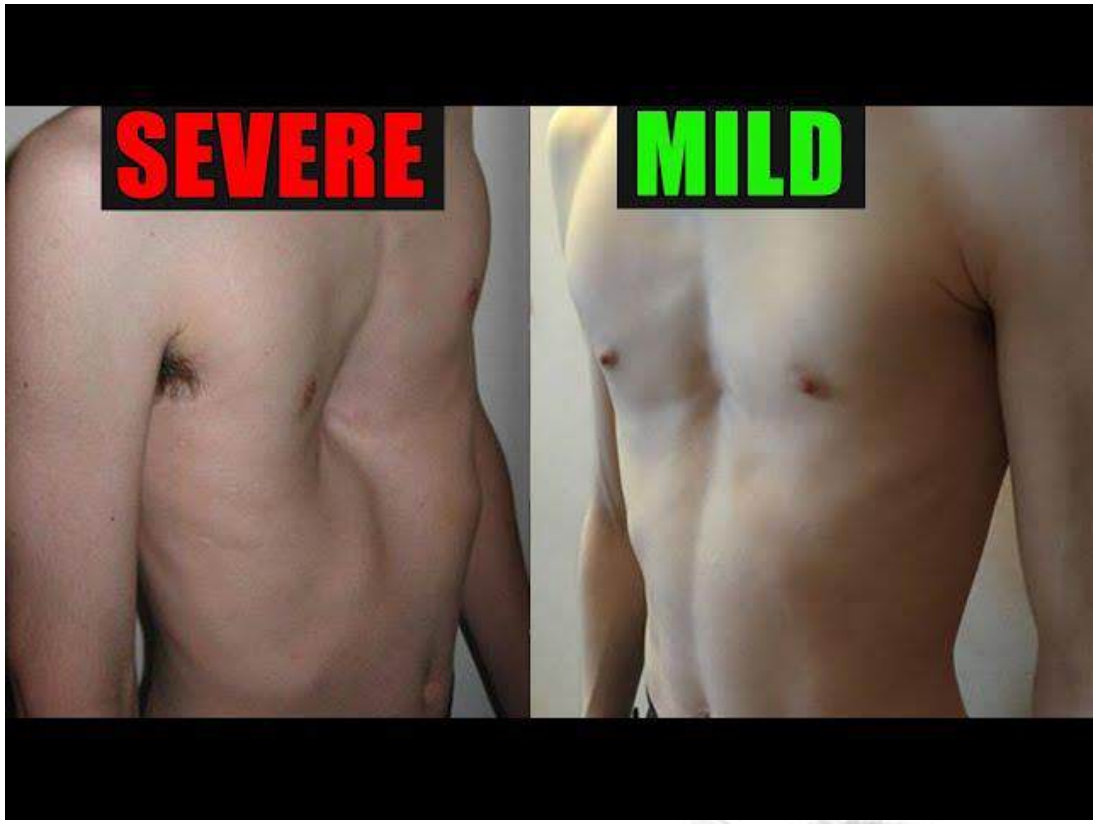


(Ayloo, 2013; Zaruba, 2017)



Pectus Excavatum

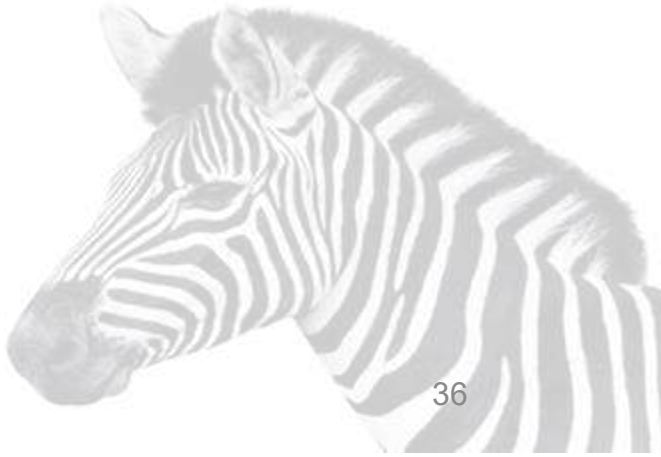
- More common in EDS
- Sometimes, there are no physical symptoms
- Decreased exercise tolerance
- Fatigue
- Respiratory problems
- Palpitations or tachycardia
- Chest pain
- Dizziness
- Symptoms overlap with POTS!



Why Are People with HSD Vulnerable?

- Diaphragmatic breathing can be inhibited by:
  - Overactivity of abdominal muscles attempting to stabilize an unstable lumbar spine
  - Use of incorrect abdominal muscles to stabilize the lumbar spine
  - Overactivity of the pelvic floor muscles attempting to stabilize the sacroiliac joint
  - Stress and anxiety
  - Poor posture
  - And… women have been told to suck in their guts to look good!
- People with HSD have decreased body awareness and often use muscles incorrectly
- Joint laxity contributes to rib hypermobility; subluxed ribs cause pain and muscle spasm

Questions?



Nose Breathing is Essential!

- Improves function of the diaphragm
- Helps prevent colds, flues, allergies by filtering air
- Improves oxygen absorption, air flow and blood flow in the lungs
- Improves parasympathetic nervous system activity (good), which calms and relaxes the body, slows heart rate and improves digestion
- Improves position of the tongue, which improves alignment of teeth
- Decreases likelihood of snoring and sleep apnea
- Decreases temporomandibular problems (compared to mouth breathing)

Ruth, 2015

Hazards of Mouth Breathing

HSD108: Headaches, migraines, and TMD

Chronic mouth breathing may contribute to:

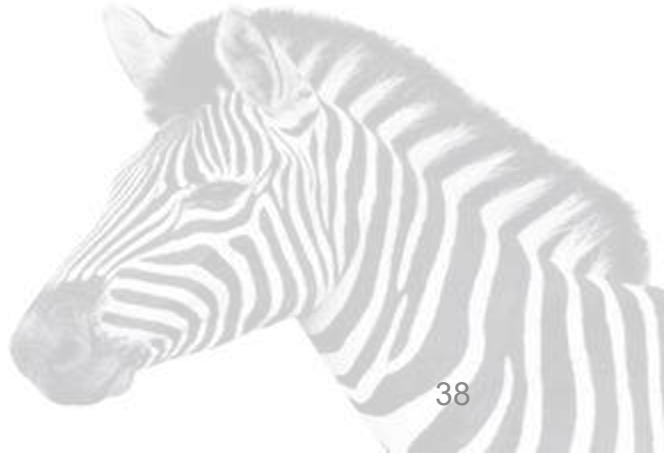
- Introduction of unfiltered, poorly humidified air into the lungs
- Upper-chest breathing (inefficient and tiring)
- Chronic over-breathing
- Greater incidence of snoring and sleep apnoea
- Bad breath, dental decay, gum disease
- Dysfunction of the jaw joint (temporomandibular joint disorders)
- Narrowing of the dental arch, jaw and palate
- Crowded and crooked teeth
- Open bite, malocclusion (teeth not fitting together properly)
- Greater potential for relapse of orthodontic corrections
- Dysfunctions of the muscles around the jaw and lips
- Loss of lip tone with the lips becoming flaccid
- Noisy eating, speech and swallowing problems
- Trauma to soft tissues in the airways
- Enlarged tonsils and adenoids

Adapted from Graham T (2012)

Mouth breathing changes the shape of your jaw, changes your teeth, obstructs breathing and swallowing, leads to forward head posture.
https://youtu.be/CBYwxndys2E

Breathing

(Ruth, 2015)



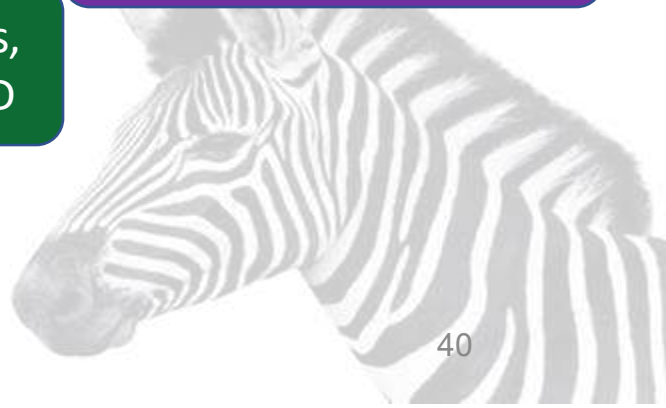
Breathing

The Effects of Mouth Breathing

- https://youtu.be/CBYwxndys2E
- Changes tooth alignment
- Changes tongue position and use of muscles in the throat and neck
- Leads to forward head
- Compromises health due to loss of benefits of sinus filtration.

Why Are You a Mouth Breather?

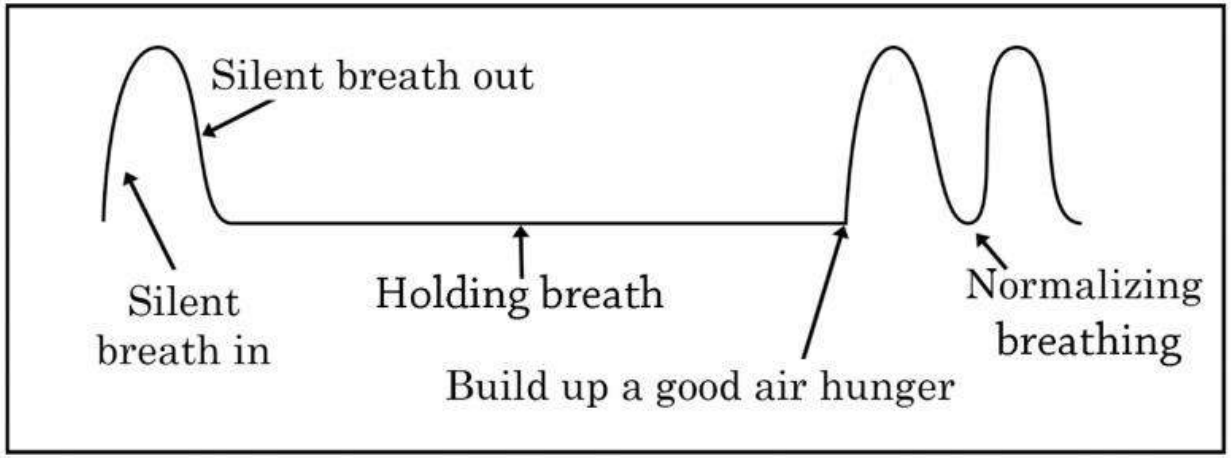
- Try to figure out why you are a mouth breather – fix the cause!
  - Chronic congestion from MCAS
    - Managing MCAS
    - HSD102: POTS & MCAS
  - Sinus congestion caused by SCM trigger points
    - Headache Trigger Points
    - HSD108: Headaches, migraines, and TMD
  - Habit, not associated with congestion



To Help Improve Nose Breathing

- Nose strips
- Mouth tape

Decongestion Nose Exercise



If you are hypermobile, keep neck movement small and controlled, or tip your torso forward instead

"To decongest the nose, instruct the student to perform the following:

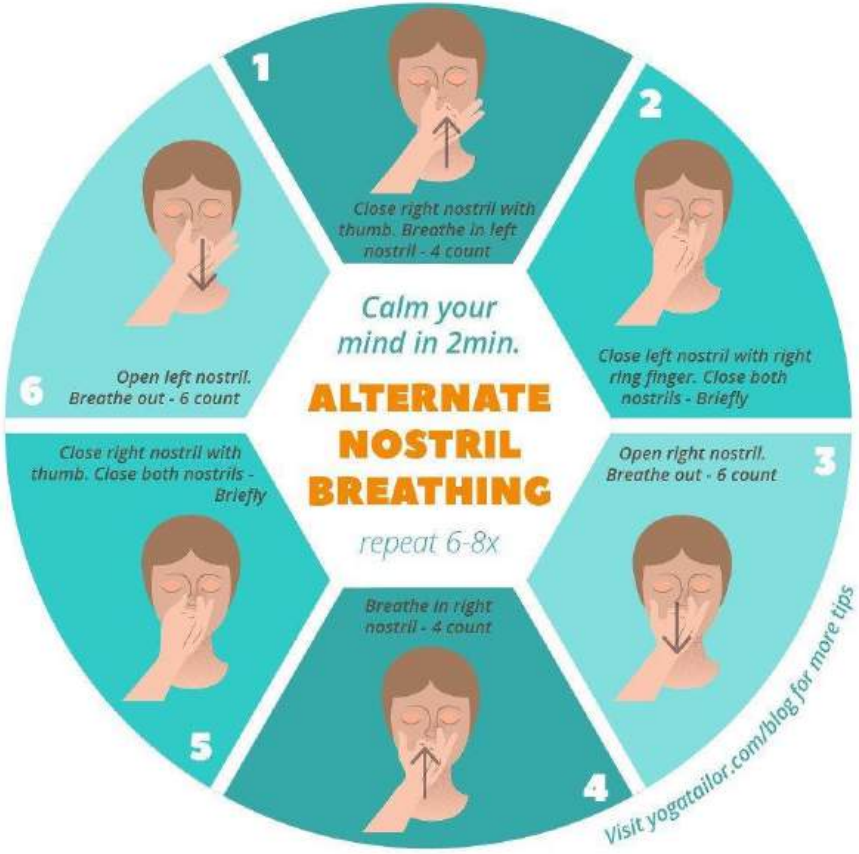
- Take a normal breath in and out through your nose;
- Pinch your nose with your fingers to hold your breath;
- As you hold your breath, move your body or gently nod your head up and down;
- Hold your breath for as long as you can—until you feel a strong air hunger;
- Let go of your nose and breathe through it as calmly as possible.
- Repeat 6 times with a 30–60 s rest between each repetition."

(McKeown, 2021)

video of Buteyko
https://youtu.be/vKKO8DC3cgo

Single Nostril Breathing

- Alternate nostril breathing is a common yoga practice
- Left nostril breathing improves vagus nerve function and parasympathetic activity
  - It causes relaxation
- Right nostril breathing increases sympathetic activity
  - It stimulates energy



https://www.angelaprior.com/blog/nadi-shodhana-breathing-meditation

(Pal, 2014)

Importance of Nitrous Oxide

Optional technical info

- Nose breathing increases nitrous oxide (NO) levels by stimulating NO production in the sinuses
- NO in the blood decreases blood pressure and increases oxygen absorption in the lungs
- NO is antifungal, antiviral, and antibacterial
- NO improves cardiovascular health and immune function

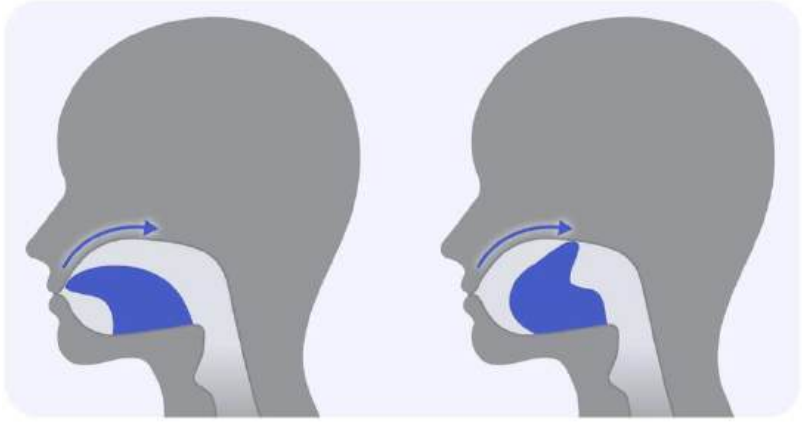
(Ruth, 2015)

Nose breathing is healthier than mouth breathing

Sleep Disordered Breathing (Apnea)

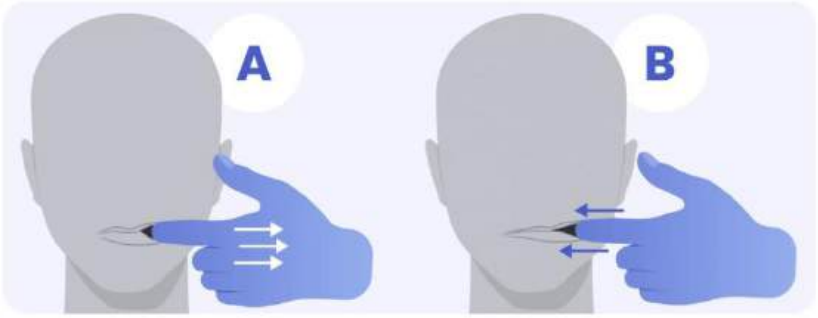
- Sleep disordered breathing (obstructive & central sleep apnea)
  - 6x more common in HSD/EDS than general population (Sedky, 2019)
- Management:
  - Alter sleep position
    - 50% of sleep apnea is due to sleeping on your back https://www.sleepassociation.org/sleep-apnea/positional-sleep-apnea/
  - Mouth & tongue exercises:
    - https://www.sleepfoundation.org/snoring/mouth-exercises-to-stop-snoring
  - Improve breathing overall
  - CPAP (Continuous Positive Airway Pressure) is the traditional approach

Myofunctional (Mouth) Exercises



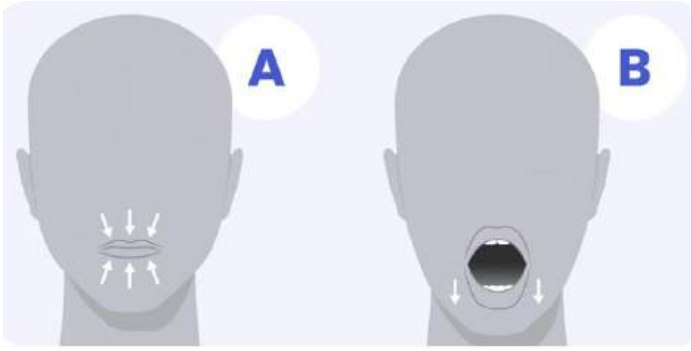
Tongue Exercise #2: Tongue Stretch

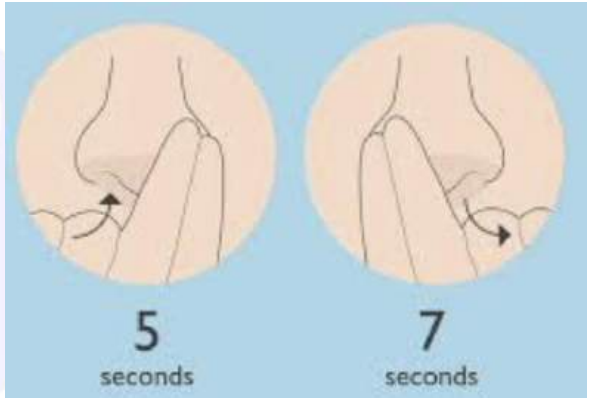
- Stick out your tongue as far as you can. Try to touch your chin with your tongue while looking at the ceiling. Hold for 10 – 15 seconds and increase the duration gradually. Repeat 5 times.
- Purpose of Exercise: Increase tongue strength



Tongue Exercise #3: Tongue Push Up

- Stick your tongue upward against the roof of your mouth and press your entire tongue against it. Hold this position for 10 seconds. Repeat 5 times.
- Purpose: Improve tongue and soft palate tone and strength



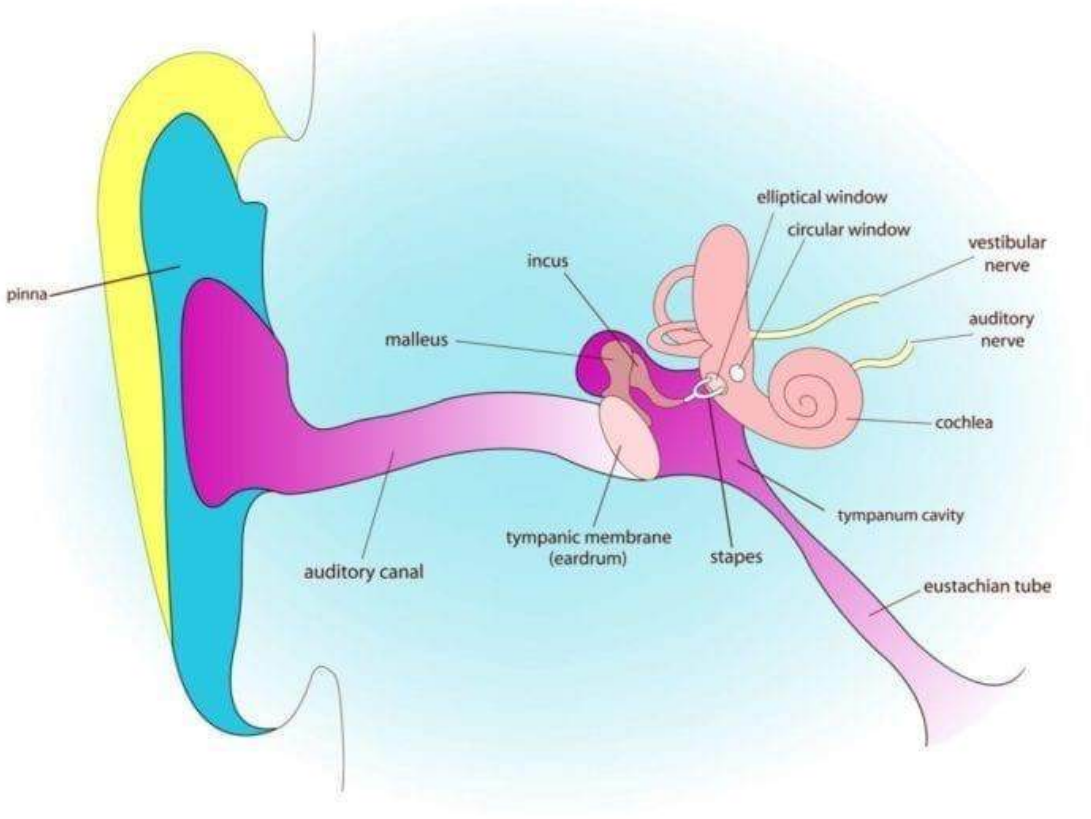


https://www.sleepfoundation.org/snoring/mouth-exercises-to-stop-snoring

Tongue Exercise #4: Tongue Push Down

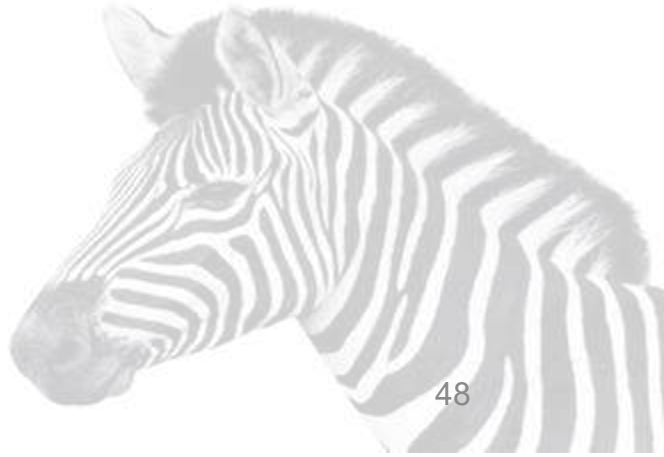
- Put the tip of your tongue against your lower front teeth and then push the back of your tongue flat against the floor of your mouth. Hold this position for 10 seconds. Repeat 5 times.
- Purpose: Improve tongue and soft palate tone and strength

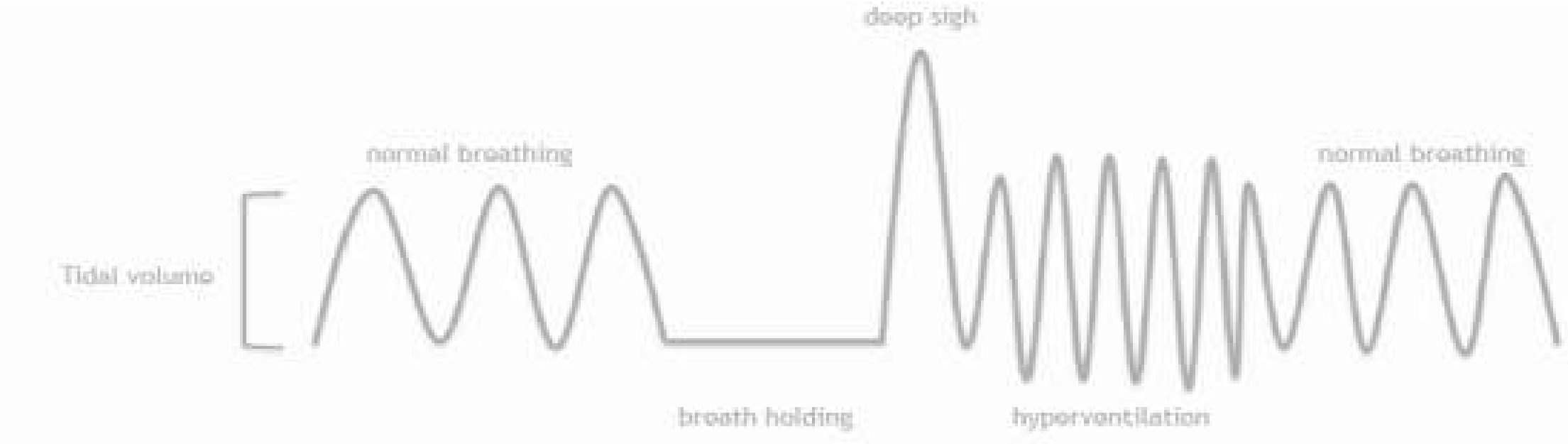
Eustachian Tube Blockage



- Symptoms:
  - Ears feel plugged or full
  - Sounds seem muffled
  - Feel popping or clicking in ears
  - Pain or ringing in ears (tinnitus)
  - Balance problems
  - https://familydoctor.org/condition/eustachian-tube-dysfunction/
- Treatment
  - Buteyko breathing (Zeng, 2019)

Questions?

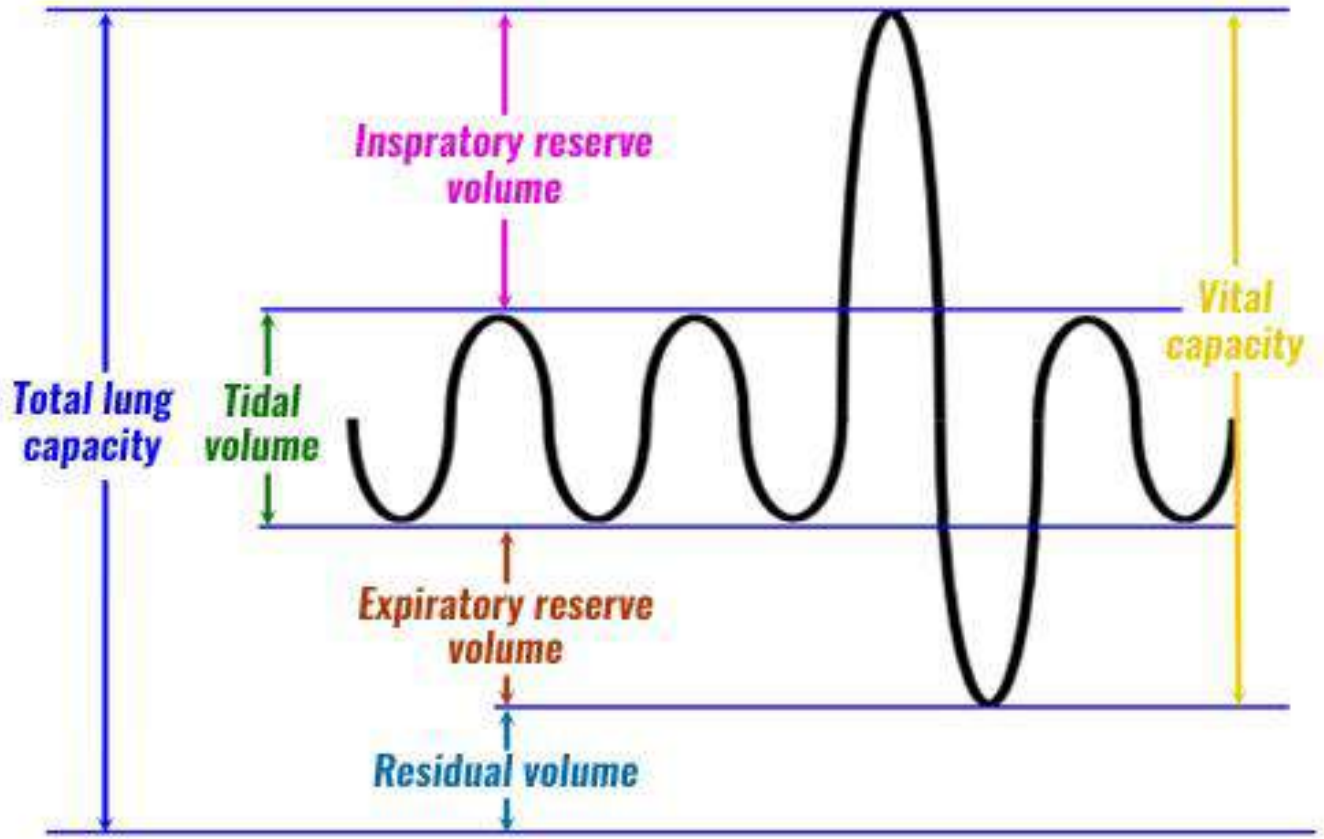




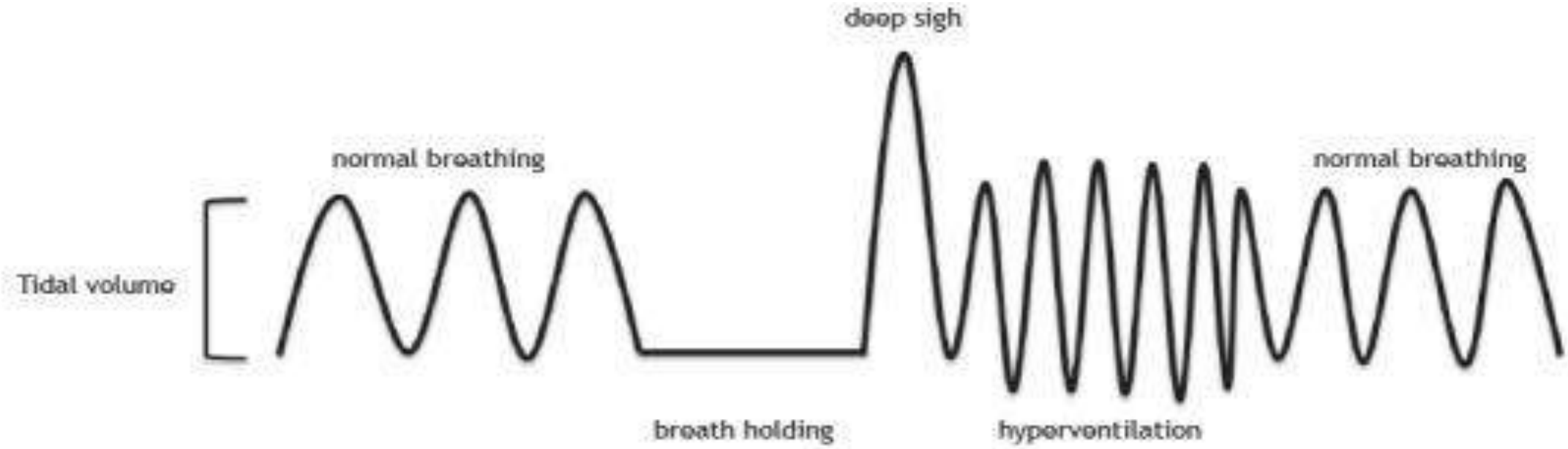
Slow Breathing

How fast you do it, makes a difference

Breathing Rate and Pattern: Terminology



Dysfunctional Breathing Patterns



Vidotto, 2019

Benefits of Slow Breathing

- Optimal function at 6 breaths/minute (4 seconds in, 6 seconds out)
  - Exhalation longer than inhalation is beneficial
- Improved diaphragm mobility and function
- Improved efficiency of breathing
- Increased heart function
- Improved heart rate variability (HRV), a measure of autonomic function, and improved parasympathetic function
- Improved vagus nerve function (improves gut function)
- Improved response to position changes (e.g. standing)
- “Over-breathing” (too fast and/or too deep) causes many of the problems

(Russo, 2017)

Cultural History of Slow Breathing

- Almost every culture has a chant or prayer that slows breathing to ~ 6 breaths/min
  - Catholic: Ave Maria and rosary prayers
  - Buddhist: Om Mani Padme Hum
  - Kundalini yoga: sa ta na ma
  - Hindu, Taoist, Native American, Japanese, African, Hawaiian all have chants or prayers that synchronize breathing to ~6 breaths/minute

James Nestor: Breath, The New Science of a Lost Art

- Yoga, Tai Chi, and qigong have thousands of years of human experience for slow, controlled breathing

Slow Breathing Practice

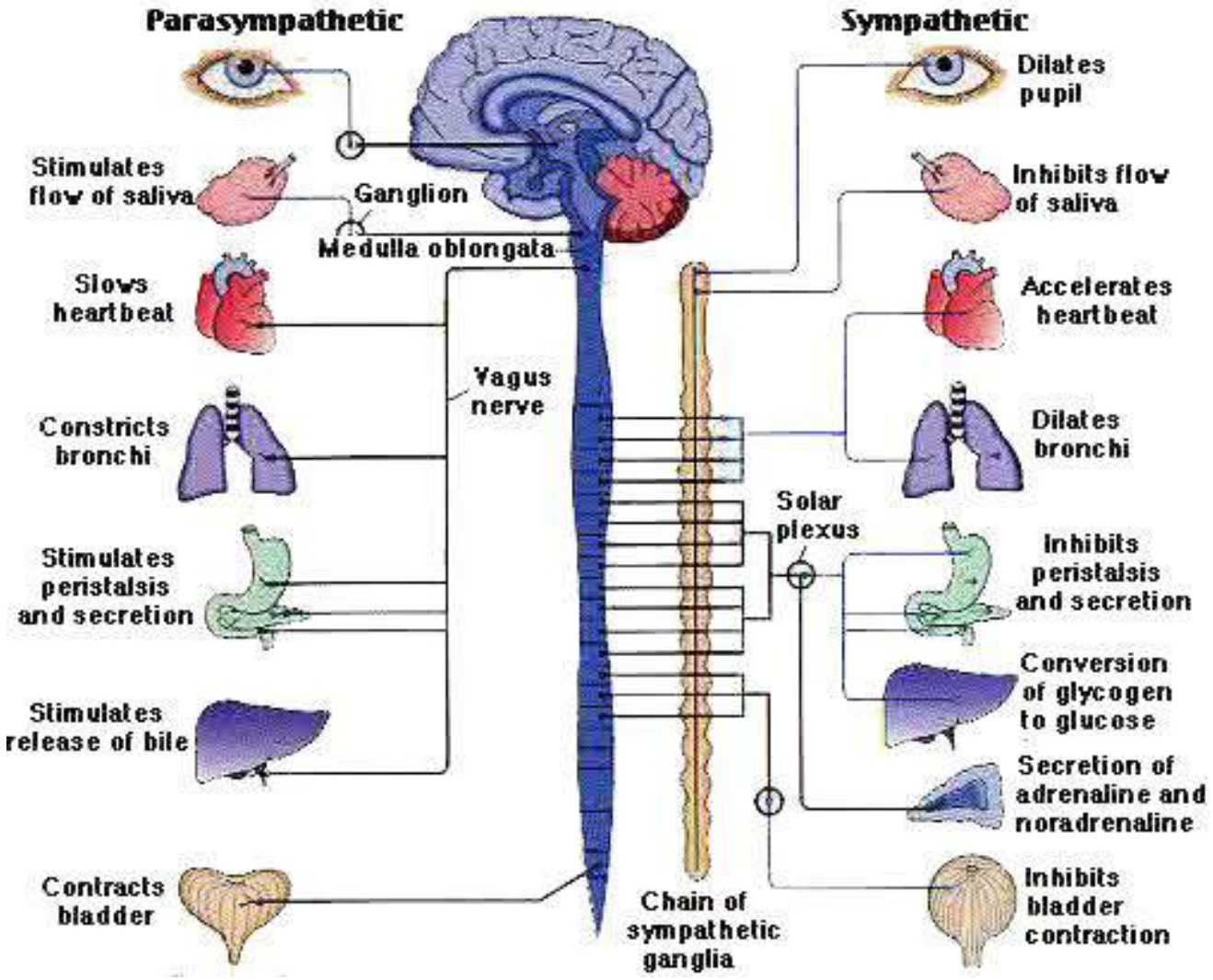
- **Slow breathing**
  - https://youtu.be/GBL8b3LG5Pg?si=17VbDruDLI9WQeld
  - Apple Watch & Fitbit also have slow breathing functions
  - 4 seconds in, 6 seconds out
  - If this is uncomfortably slow, count faster than seconds, but keep the same proportion between inhale/exhale

- It is normal to feel a little light-headed or 'air-hungry' at first
  - Don't try to breathe quite so slowly if these symptoms are distressing
- It may take several weeks for the nervous system to reset

The Autonomic Nervous System

Optional technical info

“Rest & Digest” or “Feed & Breed”



“Fight or Flight”

http://autonomicdysfunction.com/autonomic-nervous-

The Vagus Nerve

Optional technical info

- Controls much of the parasympathetic nervous system
- Slow, deep breathing activates the vagus nerve, which increases parasympathetic activity (inducing a relaxation response)
- The vagus nerve also sends signals back to the brain, and activation of the vagus nerve creates a sense of peacefulness
- "Heart rate variability" is a measure of parasympathetic function
  - Higher HRV indicates higher parasympathetic function
  - There are HRV biofeedback apps that use your smartphone camera to measure HRV: Smartscan™ is free and gives real-time feedback
  - Dedicated HRV biofeedback devices: Inner Balance™

Biofeedback

Vagus nerve self-care resources:

- https://sass.uottawa.ca/sites/sass.uottawa.ca/files/how_to_stimulate_your_vagus_nerve_for_better_mental_health_1.pdf
- YouTube exercises: https://youtu.be/L1HCG3BGK8I or self-massage: https://youtu.be/LnV3Q2xIb1U
- https://www.rewiretherapy.net/vtp (looks good, but costs $ and I haven't tried it)

Importance of CO_2

Optional technical info

- Breathing too much decreases CO_2 levels in the body
  - This is called “over-breathing” (more than 8-12 breaths/minute)
- Slowed breathing increases CO_2 levels, which helps to:
  - Decrease blood pressure, and vasospasm related to migraines
  - Fully release oxygen to the tissues
  - Stimulate digestion through release of gastric acids
  - Decrease airway constriction in asthma
  - Decrease constriction of intestinal organs
  - Decrease fatigue
  - Decrease pain

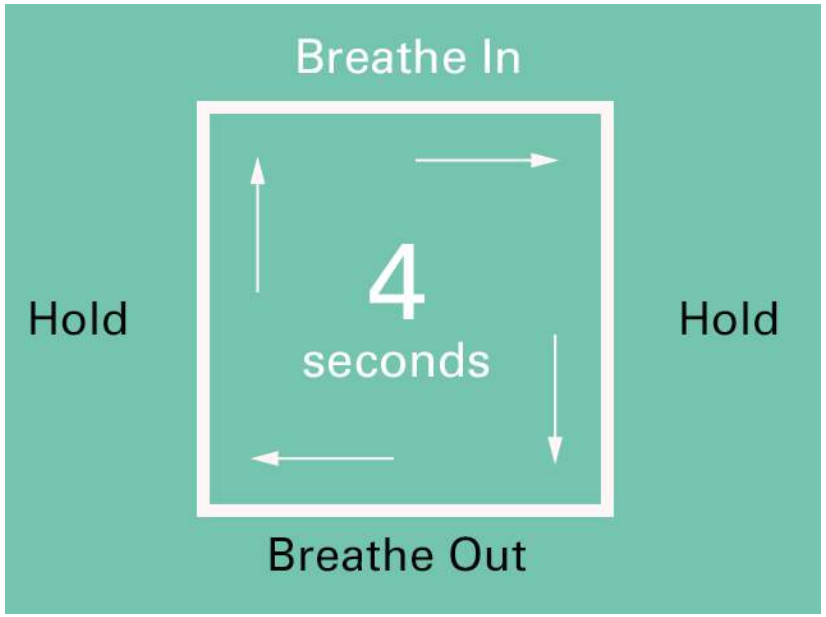
→ Slow breathing is healthy

https://breathing.com/blogs/respiratory-chemistry/blood-carbon-dioxide-and-at-the-end-of-this-article-a-simple-exercise-to-when-wanted-increase-it

So, How Should We Breathe?

- **First, don't get stressed about your breathing!**
- Yoga, Qigong and Tai Chi all teach breathing patterns that have been shown to be beneficial.
  - Sometimes breathing with body movement is easier.
- Biofeedback apps can help cue slow or diaphragmatic breathing
  - Apple Watch, Fitbit, Breathmix, Breath Meditation and many more
  - Heart rate variability (HRV) apps reviewed at: https://www.imore.com/best-apps-tracking-your-hrv-heart-rate-variability
- Practicing slow breathing can make you light-headed at first.
  - This usually goes away with practice, but you can decrease how much you slow your breathing until you adapt

Other Breathing Practices



- Box breathing:
  - Breathe in 4 seconds
  - Hold 4 seconds
  - Breathe out 4 seconds
  - Hold 4 seconds
- If this is too slow, start with 3 sec each
- www.webmd.com/balance/what-is-box-breathing

4-7-8 breathing (another option)

1. Inhale through your nose for a count of 4
2. Hold your breath for a count of 7
3. Exhale through your mouth making a swooshing sound for a count of 8

Repeat only 4-8 times per session, 2x/day
Video of Dr. Weil explaining:
https://youtu.be/p8fjYPC-k2k

- **Buteyko breathing**:
  https://innovativemedicine.com/wp-content/uploads/2017/04/Buteyko-Breathing-Guide.pdf
  - https://youtu.be/tKaUEVnducI (McKeown)

Summary

- Breathing is more complicated than one might think
- There are several common ways to breathe poorly
  - Chest breathing instead of belly (diaphragmatic) breathing
  - Mouth breathing instead of nose breathing
  - Fast breathing or “over-breathing”
  - Not coordinating the pelvic diaphragm with the respiratory diaphragm
- Research shows that:
  - Breathing exercises decrease pain, fatigue, and stress, and improve mood and function. (Busch, 2012; Tomas-Carus, 2018)
  - Diaphragmatic breathing decreases GERD and constipation (Zdrhova, 2023; Bordoni, 2018)

Resources on Breathing

- Andre C. Proper Breathing Brings Better Health. Scientific American. Jan, 2019. Available at: https://www.scientificamerican.com/article/proper-breathing-brings-better-health/ (popular science article)
- Focused on research findings, with breathing exercises at the end:
  - Nestor J. ***Breath: The New Science of a Lost Art*** (book)
- Yoga based practice
  - Moselle V: ***Breathwork: A 3-Week Breathing Program to Gain Clarity, Calm, and Better Health*** (book)
- Effects of mouth breathing: https://youtu.be/CBYwxndys2E

Scientific References

- Ayloo A, Cvengros T, Marella S. Evaluation and treatment of musculoskeletal chest pain. *Prim Care*. Dec 2013;40(4):863-87, viii.
- Bordoni B, Morabito B. Symptomatology Correlations Between the Diaphragm and Irritable Bowel Syndrome. *Cureus*. Jul 23 2018;10(7):e3036.
- Boyle KL, Olinick J, Lewis C. The value of blowing up a balloon. *N Am J Sports Phys Ther.* 2010;5(3):179-188.
- Busch V, Magerl W, Kern U, Haas J, Hajak G, Eichhammer P. The effect of deep and slow breathing on pain perception, autonomic activity, and mood processing--an experimental study. *Pain Med.* 2012;13(2):215-228.
- Hamasaki H. Effects of Diaphragmatic Breathing on Health: A Narrative Review. *Medicines (Basel)*. Oct 15 2020;7(10).
- Kocjan J, Adamek M, Gzik-Zroska B, Czyżewski D, Rydel M. Network of breathing. Multifunctional role of the diaphragm: a review. *Adv Respir Med*. 2017;85(4):224-232.
- Liu H, Wiedman CM, Lovelace-Chandler V, Gong S, Salem Y. Deep Diaphragmatic Breathing-Anatomical and Biomechanical Consideration. J Holist Nurs. 2023 Feb 3:8980101221149866. Epub ahead of print. PMID: 36734111.
- McKeown P, O'Connor-Reina C, Plaza G. Breathing Re-Education and Phenotypes of Sleep Apnea: A Review. *J Clin Med*. Jan 26 2021;10(3).
- Pal GK, Agarwal A, Karthik S, Pal P, Nanda N. Slow yogic breathing through right and left nostril influences sympathovagal balance, heart rate variability, and cardiovascular risks in young adults. *N Am J Med Sci.* 2014;6(3):145-151.
- Philip KE, Lewis A, Buttery SC, McCabe C, Manivannan B, Fancourt D, et al. Physiological demands of singing for lung health compared with treadmill walking. BMJ Open Respir Res. 2021;8(1).
- Russo MA, Santarelli DM, O'Rourke D. The physiological effects of slow breathing in the healthy human. *Breathe (Sheff)*. Dec 2017;13(4):298-309.
- Ruth A. The health benefits of nose breathing. Nursing in General Practice. 2015. Available at: https://www.lenus.ie/bitstream/handle/10147/559021/JAN15Art7.pdf. Accessed 7/1/20.
- Sedky K, Gaisl T, Bennett DS. Prevalence of Obstructive Sleep Apnea in Joint Hypermobility Syndrome: A Systematic Review and Meta-Analysis. *J Clin Sleep Med.* 2019;15(2):293-299.
- Tomas-Carus P, Branco JC, Raimundo A, Parraca JA, Batalha N, Biehl-Printes C. Breathing Exercises Must Be a Real and Effective Intervention to Consider in Women with Fibromyalgia: A Pilot Randomized Controlled Trial. *J Altern Complement Med.* 2018;24(8):825-832.
- Toprak N, Sen S, Varhan B. The role of diaphragmatic breathing exercise on urinary incontinence treatment: A pilot study. *J Bodyw Mov Ther*. Jan 2022;29:146-153.
- Vidotto LS, Carvalho CRF, Harvey A, Jones M. Dysfunctional breathing: what do we know? *J Bras Pneumol*. Feb 11 2019;45(1):e20170347. .
- Weng HY, Feldman JL, Leggio L, Napadow V, Park J, Price CJ. Interventions and Manipulations of Interoception. *Trends Neurosci*. Jan 2021;44(1):52-62. doi:10.1016/j.tins.2020.09.010
- Zaruba RA, Wilson E. Impairment based examination and treatment of costochondritis: A case series. *Int J Sports Phys Ther*. Jun 2017;12(3):458-467.

Thank You!

Questions?