Clerking for Biomechanics

& The Concepts of SMS:

why footwear matters.

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Systemic Disease = Tissue Change

Clerking a patient uncovers the nature of the tissues under load and is directly influenced by the heath and physical condition of the patient!

This informs us of the potential for dysfunction of mechanical properties within the lower limb.

WHICH IS A DIAGNOSIS?

- Hyper-pronation?
- Functional Hallux Limitus?
- Hallux Rigidus?
- Plantar Heel Pain?
- Achilles Tendinopathy?
- Anterior Knee Pain?

CLERKING BIOMECHANICS & SMS

- PROCESSES & PATHWAYS
- ASSESSING THE BODY SYSTEMS
- APPROACHING THE PATIENT
- ASSESSING THE STRESS-STRAIN RELATIONSHIP
- **S**HAPE **M**ATERIALS **S**HOE
- AIMS OF REHABILITATION & LIFESTYLE CHANGES
- AIMS OF SHOES AND ORTHOSES

PATIENT EVALUATION FOR BIOMECHANICS

WHY SHOULD WE DO IT?

- To give a diagnosis and a mechanism of injury = tt plan.

- FLAGS
- Process & Pathways: SOAPIER/ SIN/ OLDCARTS
- Assessing Body Systems: GRAGCELS
- Approaching the Patient: Asking the right questions!
- Aims of Clerking: Establishing the stress-strain relationship.

- Diagnosis then assessing the best treatment options.

PROCESSES & PATHWAYS

- Can help with a structured treatment plan.
- BEWARE
  symptom based assessment/treatment plans.
- The need to ramble off the path occasionally?

FLAGS

- RED……Health, MSK symptoms not related to weightbearing, wrong age of expected symptom, etc!
- ORANGE……psychological barriers (beliefs, associations, fears etc.)
- BLUE……occupational issues, including hobbies!
- BLACK!……social issues, family pressures, medical legal cases.
- PINK…… Positives, go for it attitudes. Can be good or problem!

SOAPIER

- **SUBJECTIVE**.....what the patient reports.
- **Objective** .....what the clinician sees, and finds on examination.
- **Analysis**.....what we perceive from the above (a diagnosis).
- **Plan**.....What are we going to do about it?

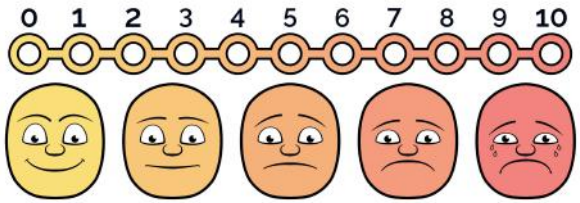
- **Intervention**.....**The treatment that we apply.**
- **Evaluation**.....**Check with the patient that tt is good for them.**
- **Re-evaluation**.....**Get them back/ check the treatment worked.**

BIO-PSYCHO-SOCIAL MODEL OF CARE

SYMPTOMS = SIN & OLDCART(S)

- SEVERITY……how bad is the symptoms/complaint.
- IRRITABILITY……..how easily are symptoms set off.
- NATURE……..everything else about the condition (pain description etc).

- **Onset……history of the problem.**
- **Location…….one finger test to one spot.**
- **Duration…….symptom patterns.**
- **Character……e.g. Burning stabbing, shooting, radiating, dull ache, etc**
- **Aggravating factors……..what upsets or helps it.**
- **Radiating or Referred……relative description….failure of one finger test.**
- **Temporal Patterns…….daily symptom complaint patterns.**
- **Severity ……AGAIN!**



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ASSESSING BODY SYSTEMS

Clerking the body systemically. **CRAGCELS**

WHY IMPORTANT?

- Cardiovascular = heart disease, vascular disease, anemia.
- Respiratory = COPD, asthma.
- Alimentary =IBS, Crohns.
- Genitourinary = urinary patterns and infections.
- Central Nervous System = Parkinson's, Motor Neuron Diseases.
- Endocrine = diabetes, hypothyroidism.
- Locomotor = DJD, tendinopathy, etc.
- Skin = psoriasis, etc.

Don't forget to consider age.

Using the Right Questions & Listening

- Closed Question; definitive answer.
  "Where does it hurt"?
- Open Question; invites explanation.
  "When does it hurt"?
- Searching Question; (avoid leading the patient).
  Good example: **"Does the heel hurt most at any particular time of the day?"**
  Bad example: **"Is the heel pain worse when you stand up"?**
- Probing Question; establishes patient perceptions.
  "Why do you think your pain is related to work"?

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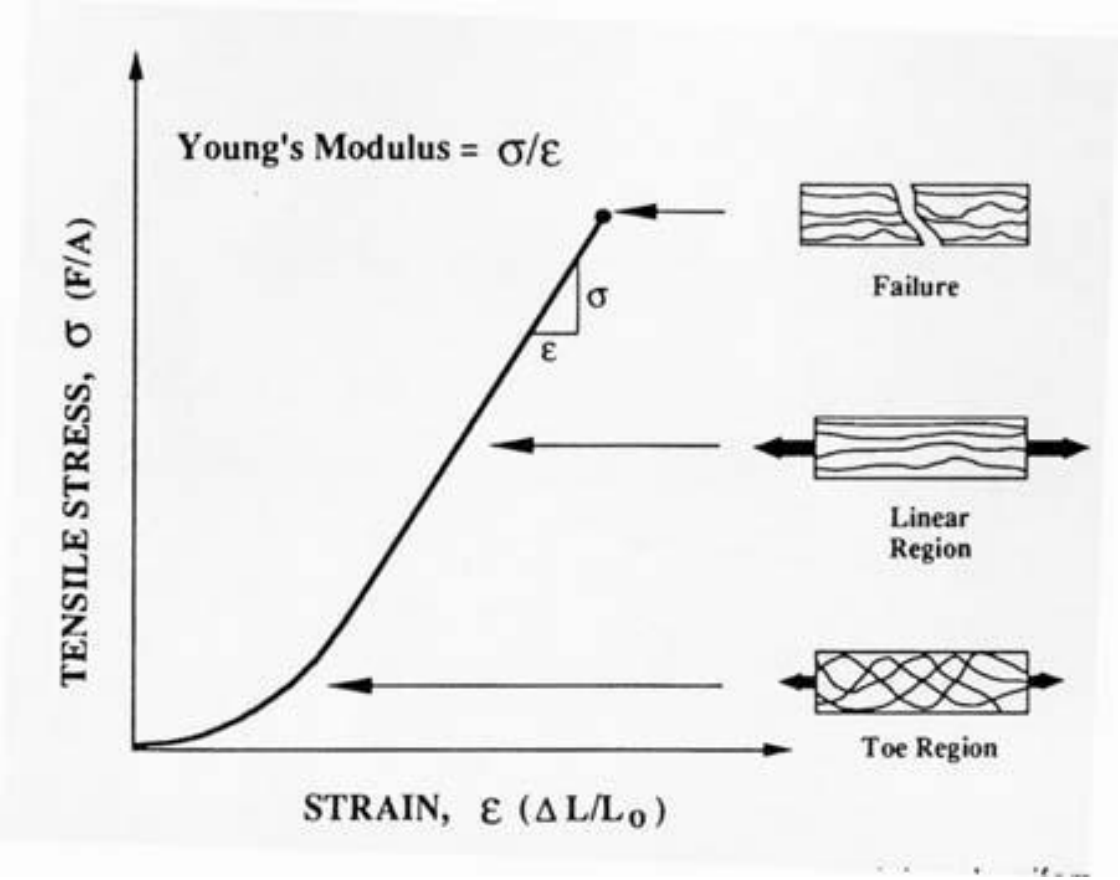
Assessing Biomechanics (stress/strain relationships)

HOW GOOD ARE MY PATIENTS TISSUES MECHANICALLY?

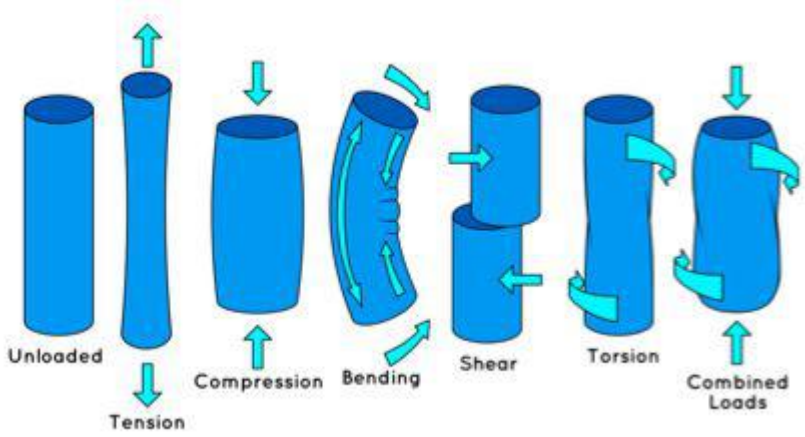


WHAT IS STRESS AND STRAIN

Stress = force over an area or in a system.

Strain = the change in dimensions of the material stressed (deformation).

Will my patient's tissues be too compliant or stiff/elastic or plastic?



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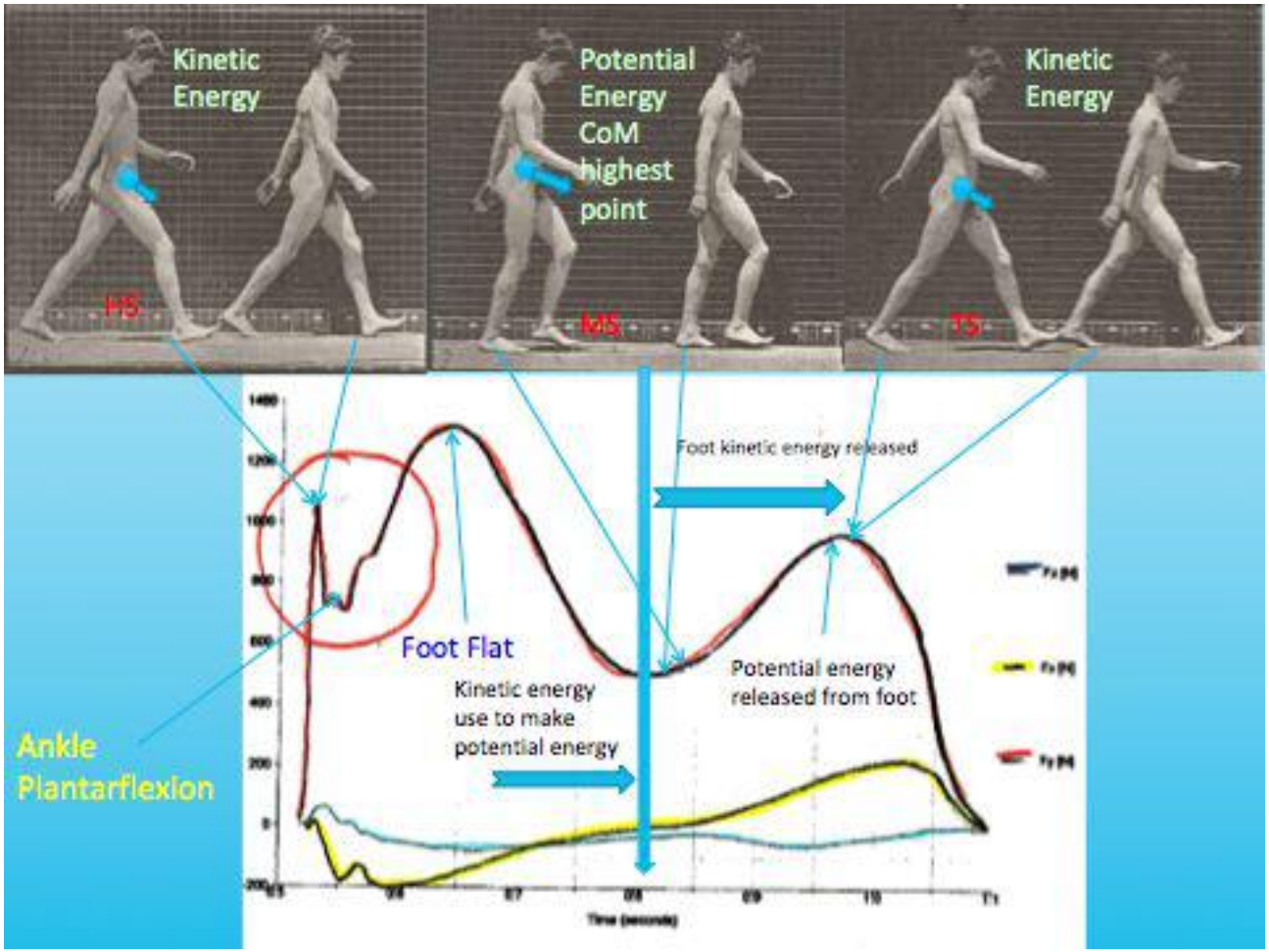
Compliance when required & stiff when required!



COMPLIANT - DECREASING COMPLIANCE-STIFFENING

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BIOMECHANICAL CLERKING PRINCIPLES

- **Associate or disassociate the information from the symptoms/complaint.**

1. Normal stress on Normal tissues = normal strain.
2. Abnormal stresses on Normal tissues = abnormal strain
3. Normal stresses on Abnormal tissues = abnormal strain
4. Abnormal stresses on Abnormal tissues = abnormal strain
5. Poor adaptive neurological response to stress (sensorimotor system).

Combination of point 5 with any of the above.

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Tissue stress/strain group 1

1. **Normal stress on normal tissues. = Shouldn't be in clinic!**

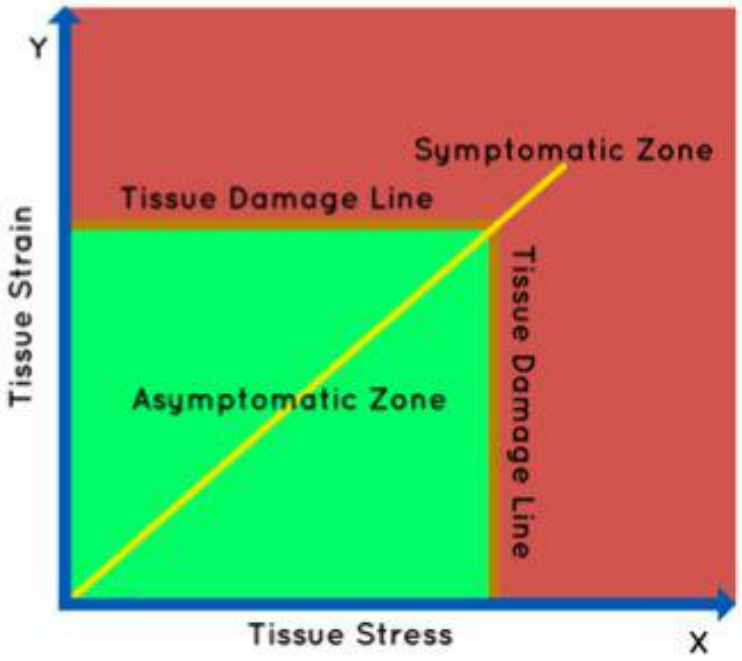
2. NOT PRIMARILY DYSFUNCTIONAL
   but local abnormality issues or start of systemic.

- Foreign objects; dog hairs, glass, thorns, metal shards etc
- Infections; verrucae, Reiter's, Lyme's disease, etc
- Tumours; fibromatosis, lipomas, osteomas, etc (hopefully not sacromas)
- Inflammatory; RA, PsA, Reiter's etc
- Environmental mismatch; Vit D deficiency, poor footwear, poor work posture
- Fatigue;.....changes mechanical properties of tissues (sports, runners)

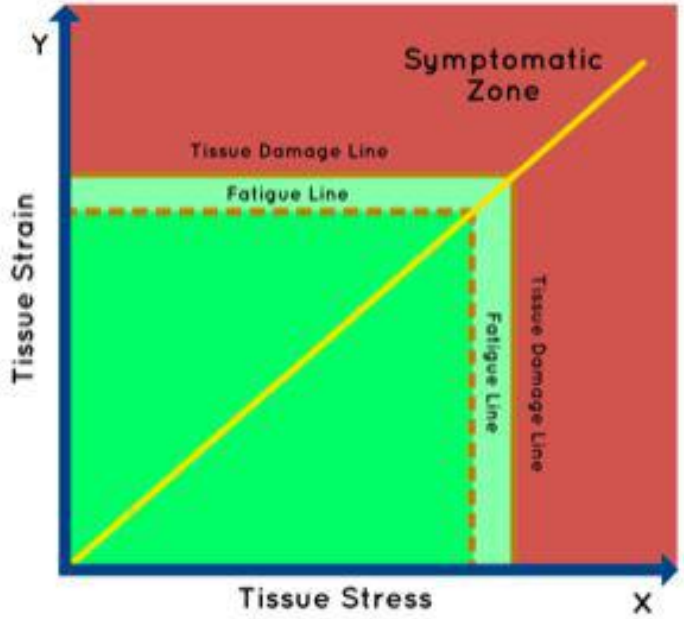
Also pain sensitive (Fibromyalgia, psychosocial)

Normal stress/strain relationships

Normal Healthy Tissues



Fatigued Tissues



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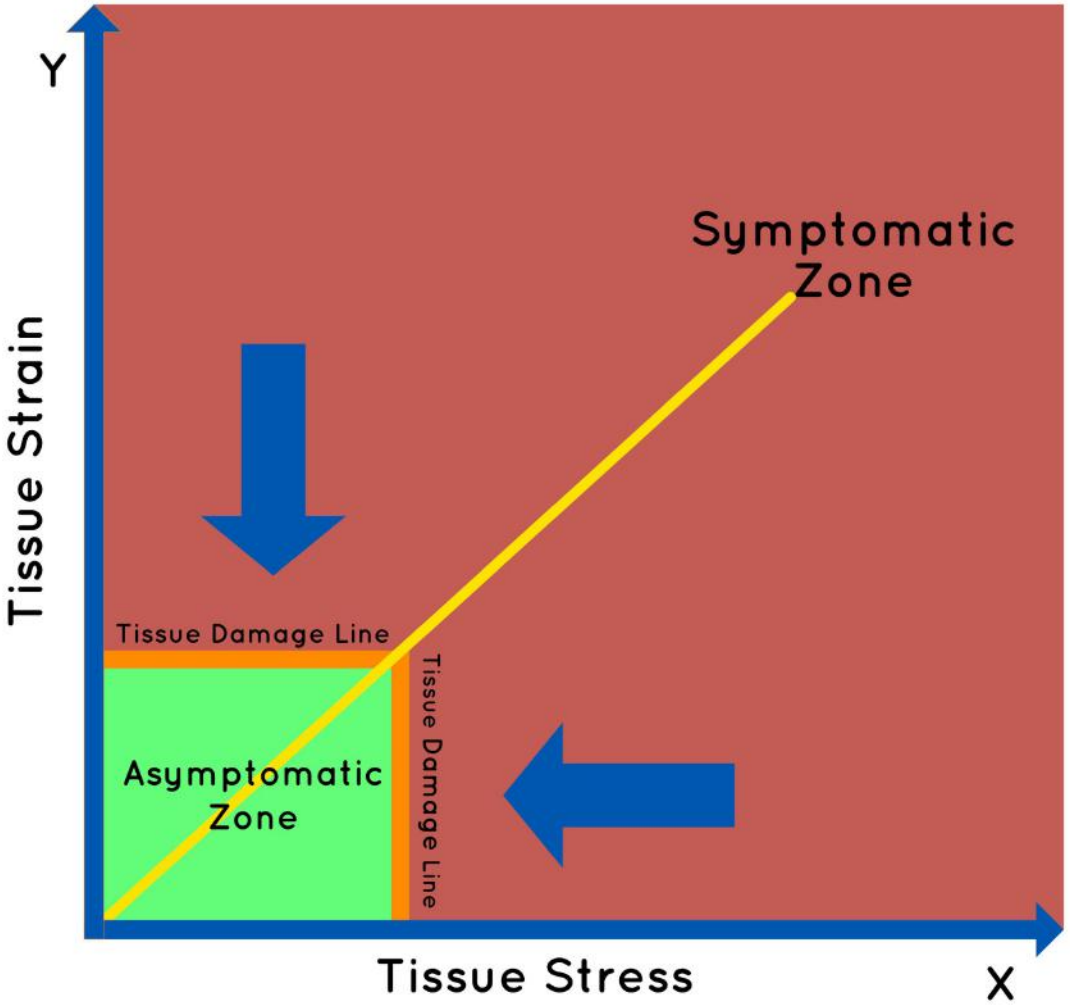
Abnormal Stress on Normal Tissues

- Stress too high for healthy tissue mechanics.
- Lower patients strength increased the risk.
- E.g, ankle sprains, falls, twists (**HIGH FORCED EVENTS**).

Once injured tissues are abnormal



Normal stress on abnormal tissues

Tissues incapable of coping with normal mechanical demands of life:

Examples:

- Diabetes (other endocrine diseases).
- Connective tissue disorders.
- Cardiovascular, alimentary, respiratory diseases.
- Previously damaged tissue.
- Elderly (weakness/atrophy/hormonal changes.

Kinematics can appear normal yet patient can't tolerate normal stresses .

(how much pressure causes a diabetic ulcer?)

Pressure Ulcers in Diabetes.

- Why hasn't a specific peak pressure been associated with the development of ulcers?

Degree of glycation of proteins/ischaemia etc variable in tissues

- Soft tissue damage starts deep in the tissues not at the surface. (interface between different material structures
- (e.g. bone/soft tissues)

- The interface between two materials with different material properties concentrates stress.

- The interface between bone and soft tissue is particularly vulnerable, because mechanically quite different.

Abnormal Stress of Abnormal Tissues

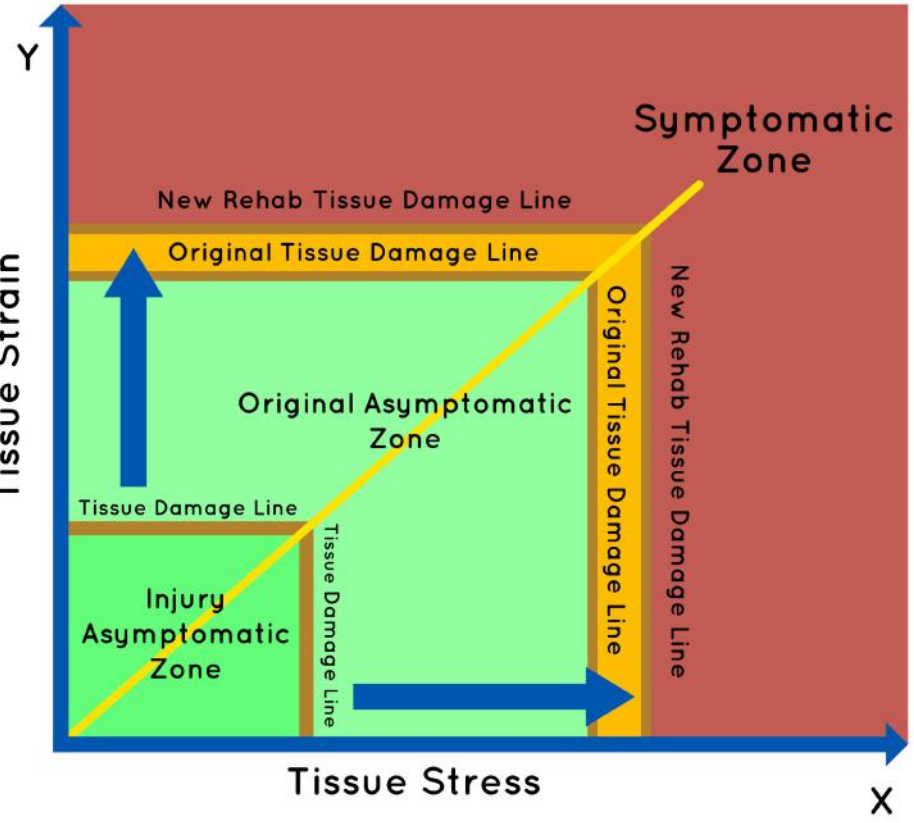
Tissues that can cope with normal stress are exposed to abnormal stresses:

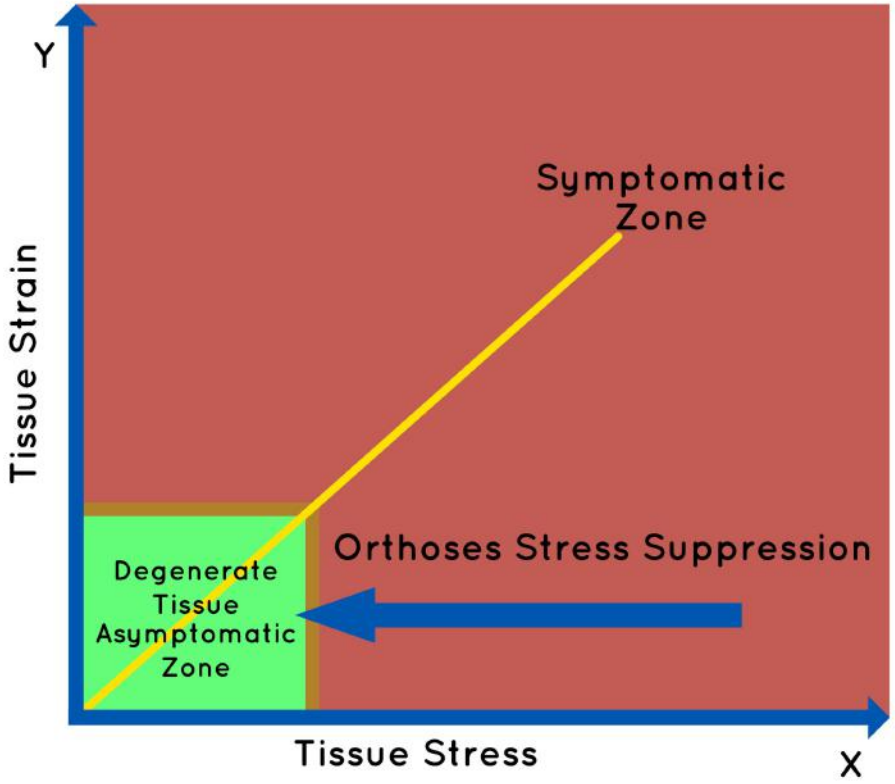
- Injured tissue repeatedly exposed to high stress.
- Pathological tissue exposed to high stress.
- Degenerated tissue exposed to high stress.
- Poorly aged tissues exposed to high stress.
-

eg. Glycosylation, vascular insufficiency, and any other collagen disease processes.

Usually a combination of abnormal alignment and motions are seen in gait and possibly stance.
The catch-22 situation. Pathology concentrates pathology.

Treatment Aims Through Tissue Stress





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Designing a treatment plan!

- Can conservative intervention resolve/improve the problem?
- Rehabilitation & lifestyle modifications!
- Appropriate shoe &/or orthoses!

SHAPE MATERIAL SHOE

Aims of rehabilitation of the foot

1. To improve flexibility:
   - compliance failure.
   - motion failure, abnormality in plane dominance of motion..
2. To improve stability:
   - Loss of ability to adjust compliance & stiffness inadequately
3. To improve tissue mechanics.
   - Biological response

Aims of life style changes

- To avoid provocative stresses that cause tissue damage.
- To increase generalised health and strength of tissues (biological response).
- To promote recovery of max tissue mechanical properties if possible.
- Specifics to nature of tissue damaged and disease processes.

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Aims of Foot Orthoses

- Increase forces on some areas
- Decrease forces on other areas
- Change the areas of loading increasing or decreasing pressures.
- Using material properties to change loading rates.

YOU CAN NOT MAGIC FORCE AWAY!

What does the evidence tell us that orthoses do?

Effect of Foot Orthoses

- Change kinematics.
  Short L, Chockalingam, 2014
  Halstead et al, 2016

- Change the location and extent of pathology on diagnostic image!
  Only one example: Halstead,et al,2014

- Reduce Symptoms:
  Halstead et al, 2016.
  Welsh et al, 2010

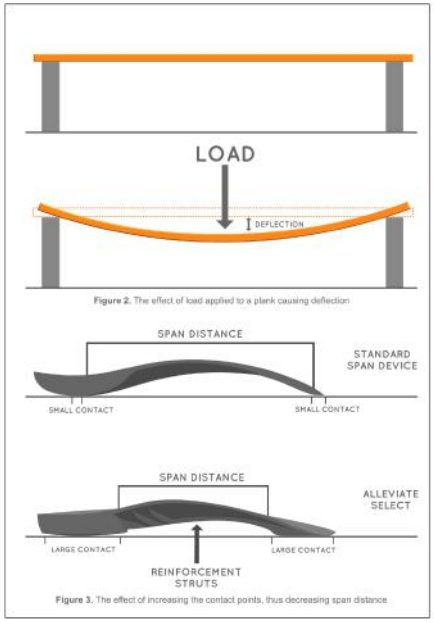
- Reduce Falls:
  Wylie et al, 2017

Properties of foot orthoses affected by

- The material the orthosis is made from:
  Carbon, Polyprop composites. EVA (shores) other.

Dictates the material properties of the orthoses
  Do we need compliance or stiffness or both?

- Does the orthosis act as a spring or a dampener or both?



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Properties of foot orthoses affected by

- Changing forces around the axis of rotation….getting forces to the relevant/best position to the axis of rotation.
- Posting and heel lifts etc.

- Redistributing forces/pressure away from pathology.
- E.g. metatarsal pads, first metatarsal cut outs etc.

- Blocking motion or increasing motion:
- Posts, arch profiles, dells, trenches, etc

Aims of footwear in healthcare

- To create a protective, adventitious environment for the foot.

- To maximise compensation of any deficiency in function. (increased shock attenuation/forefoot rockers etc)

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Foot orthoses and Shoe

- The foot moves independently to the orthosis and the shoe.
- The shoe and orthosis moves together
  (from Maryn Shorten, Q & A Staffs Uni Conference 2018).
- The orthosis can influence the shoe flexibility.
  Shank dependant/Span device.
- The shoe can influence the orthosis stability.

Torsion stability

DO YOU KNOW WHAT WE MEAN?

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References

- Halstead J, Keenan A_M, McGonagle D, Conaghan P, Redmond A. (2014). An exploration into the effect of foot orthoses on bone marrow lesions associated with mechanical foot. *Jornal of Foot & Ankle Research.* 7(suppl):A1. https://.jfootankleres.com/content/7/52/A1.

- Halstead J, Chapman GJ, Gray JC et al. (2016). Foot orthoses in the treatment of symptomatic midfoot osteoarthritis using clinical and biomechanical outcomes: sa randomised feasibilty study. *Clinical Rheumatology.* 35(4):987-996.

- Short L, Chockalingam N. (2014). Kinematic comparison of functional foot orthoses produced to three different manufacturing protocols: An exploratory study. *OA Musculoskeletal Medicine. 10,2(2):14.*

- Welsh BJ, Redmond AC, Chocalingham N, Keenan A-M. (2010). A case-series study to explore the efficacy of foot orthoses in treating first metatarsophalangeal joint pain. *Journal of Foot & Ankle Research.* 3(17): https://jfootankleres.com/content/3/1/17.

- Wylie G, Menz HB, McFarlane, Ogston S, et al. (2017). Podiatry intervention versus usual care to prevent falls in care homes: pilot randomised controlled trial(the PIRFECT study). *GMC Geniatrics.* 17: 143 https://doi.org?10.11877.017.0541-1

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