



ELECTROTHERAPY FOR MUSCLE STIMULATION

SHSS6065

Semester 1 - Week 7

Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives



Before we start...TUS – are you retaining information?

A quick quiz...



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Before we start...TUS – are you retaining information?

1. How deep does the therapeutic effects of the frequency 1MHz go?
2. Why do you need to keep the Rx head moving?
3. What is the Frenzel Zone otherwise known as?
4. What does BNR stand for and explain what it is?
5. What effect does the expanding and contraction of a quartz crystal cause?
6. What does acoustic streaming mean?
7. What effect does TUS have on mast cells?
8. What effect does TUS have on remodelling?



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

1. How deep does the therapeutic effects of the frequency 1MHz go?
Roughly 4cm. (5-6cm)
2. Why do you need to keep the Rx head moving?
Reduce the chance of standing waves
3. What is the Frenzel zone otherwise known as?
Near Field
4. What does BNR stand for and explain what it is?
Beam Non-uniformity ratio, near field interference, quality of TUS
5. What effect does the expanding and contraction of a quartz crystal cause?
Piezo-electric effect
6. What does acoustic streaming mean?
Eddying of fluids around vibrating structures such as cell membranes
7. What effect does TUS have on mast cells?
De granulation due to increased Ca ion permeability causing release of arachidonic acid
8. What effect does TUS have on remodelling?
Enhance functional capacity of scar tissue, influence collagen fibre orientation. Promotes change from Type III to type I, increases tensile strength



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Neuromuscular Electrical Stimulation (NMES)

- Unlike TENS and pain relieving ITF which stimulates afferent nerve fibres..
- NMES targets the **effluent** nerve fibres.
- In the same way our brain does when we want to consciously contract a muscle.



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Stimulation Values – Beat Frequency

- Sympathetic nerve = 1-5Hz
- Parasympathetic nerve = 10-150Hz
- Motor nerve = 1-50Hz
- Sensory nerve = 90-100Hz
- Nociceptive fibres = 90-150Hz
- Smooth muscle = 0-10Hz



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Muscle Stimulation

- Stimulation of **motor nerves**
- Low frequency (1Hz) → twitches
- 50Hz → tetanic contraction
- 'Sweep' of 10-25Hz → Muscle stimulation + ↓ **oedema**
- Also used to ↑ **blood flow**



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

WAIT...what else does a frequency of 1-50Hz target???



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

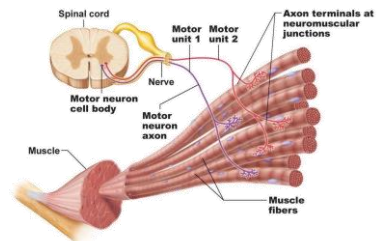
WAIT...what else does a frequency of 10-50Hz target???

Theoretically...

- 10-25Hz stimulates the reticular formation
- >50Hz blocks C-fibre transmission

...some pain relieving effects? – literature?

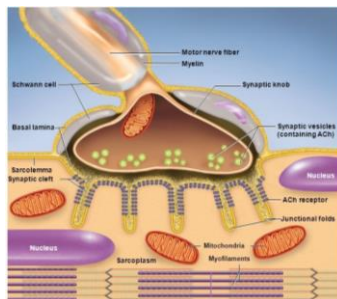
Neuromuscular Anatomy



(a) Axons of motor neurons extend from the spinal cord to the muscle. There each axon divides into a number of axon terminals that form neuromuscular junctions with muscle fibers scattered throughout the muscle.

© 2011 Pearson Education, Inc.

The Neuromuscular Junction



So, how does a muscle contract?

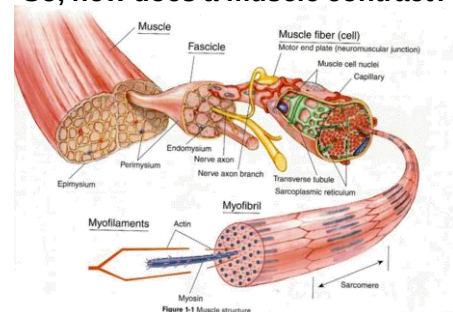


Figure 5-1 Muscle structure

Behaviour of Skeletal Muscle Fibres

1) Excitation

- Action potential in the nerve fibre leads to action potential in the muscle fibre
 - Nerve signal arrives at **synaptic knob**
 - **Acetylcholine** is released by **synaptic vesicles** in to the **synaptic cleft**
 - ACh binds to receptor proteins on sarcolemma of muscle fibre
 - Na^+ diffuses in to the cell, K^+ out causing an **end-plate potential**
 - **Voltage gated ion channels** open in response to EPP, ion movement causes an **action potential** – the muscle fibre is **excited!**



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Behaviour of Skeletal Muscle Fibres

2) Excitation-Contraction Coupling

- The events that link the action potential on the sarcolemma to activation of myofilaments.
 - Wave of action potentials spread from the end plate in all directions.
 - Open voltage-gated ion channels in **T-tubules**
 - Channels in **Sarcoplasmic Reticulum** open and Ca^{2+} diffuses into **cystol**
 - Ca^{2+} binds to **troponin** of the thin filaments
 - Exposes active sites on **actin filaments** ready for binding to **myosin heads**.



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Behaviour of Skeletal Muscle Fibres

3) Contraction

- Muscle fibre develops tension and may shorten – **sliding filament theory**
 - **Myosin ATPase** hydrolyses ATP to form ADP and P_i = energy released
 - Energy allows **myosin** head to '**cock**'
 - Myosin binds with exposed actin to form a **cross-bridge**
 - ADP and P_i are released
 - Myosin **flexes** creating a **power stroke**



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

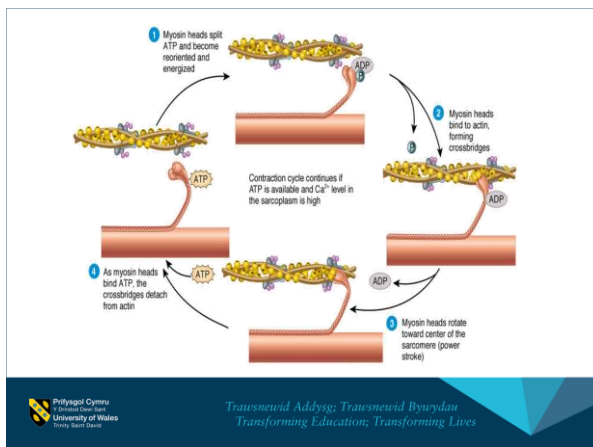
Behaviour of Skeletal Muscle Fibres

4) Relaxation

- Muscle fibre relaxes and returns to resting 'length'
 - Nerve signals stop arriving at the neuromuscular junction
 - Synaptic knob stops releasing ACh
 - Calcium ions dissociate from troponin
 - Tropomyosin moves back to a position blocking active sites of actin filament.



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives



Muscle Fibre Types

Type I [SO]

- slow oxidative
- vascular ++
- fatigue resistant
- (red fibres – old term)

Type IIa [FOG]

- Fast Oxidative Glycolytic
- Intermediate; some oxidative metabolism
- therefore some fatigue resistance

Type IIb [FG]

- Fast Glycolytic
- least oxidative; least fatigue resistance
- highest, fastest force production



Normal Contraction

Physiological Sequence is Asynchronous

- smooth, graded contraction determined by
 - No of motor units firing (spatial summation)
 - Rate of motor unit firing (temporal summation)
- Increase no of motor units in early contraction (to ↑ force)
- then increase firing rate to increase force further
- Type I MU fire first, then Type II. Type IIb brought in last of all



Electrical Stimulation Pattern

Synchronous firing pattern

- all MU's fire together
- Type II neurons are LARGER - therefore have a lower threshold, therefore fire first - reverse of the natural sequence.



Physiological Effects of NMES

- Short Term
 - Contraction
 - Altered local blood flow
 - Oedema reduction?
- Longer Term
 - Strength
 - Hypertrophy
 - Oedema reduction?



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

NMES for Strengthening

- NMES alone vs Combined with Exercise?
- High vs Low intensity
- Cross-over effect?
- Mechanism
 - The speed of response and lack of CSA change indicates **Neural Mechanism**
 - Literature questions a change in spinal motor pool activation, synaptic facilitation and muscle motor unit firing pattern



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Stimulation Parameters

- **Intensity**
 - Subjective!
 - Achieve a significant contraction with machine alone
 - Patient can join in with cycle.
- **Duty Cycle**
 - 1:1 – end stage rehab/fit patients
 - 1:9 – early rehab/very weak patients
- **Ramp**
 - Ramp up/Ramp Down
 - More physiological and more comfortable.



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Electrodes

- Both electrodes on muscle belly
- One near motor point
- larger electrodes are more comfortable – current density is reduced.
- Placement – longitudinally? – stronger contraction?



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Strength Protocols: Athletes/Non Injured

- Frequency usually at around 60Hz +
- Stim intensity at max tolerance
- BUT can get an effect at 25-50% MVC (ISOMETRIC)
- PULSE WIDTH 300-400 μ s may be best
- Duty cycle relates to fatigue
 - If less fatigue resistant 1:8 - 1:5
 - Once less likely to fatigue drop to 1:3 - 1:2 - 1:1
- Ramp - no definitive rules, BUT with stronger stimulation use longer ramp. Usually 2-4 sec ramp up and 1-2 sec ramp down
- 8 - 15 max contractions / session ; 3 - 5 sessions / week ; 3 - 6 weeks for significant effect



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Protocol: Rehabilitation

- Lower Frequency – minimum for tetany 20-35Hz
- Longer Session
- Duty Cycle - minimise fatigue (1:4+)
- Strengthening
- Endurance
- Atrophic Muscle



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Muscle Strengthening

- 30 - 35Hz @ 400 μ s
 - (if you have a choice, longer pulses are advantageous over shorter pulses)
- 4 sec ON / 4 sec OFF (minimum) but usually 10 sec ON / OFF
- At least 15 mins alt days, but usually 30 min / day
- Need strong contraction (not just mild twitch) + voluntary as well



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Muscle Endurance

- 20Hz @ 400 μ s
- 2 sec ON / 2 sec OFF (minimum)
- at least 1 hr day
- Minimal contractions



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Very Weak Muscles / Marked Atrophy

- 10Hz @ 400 μ s
- 2 sec ON / 2 sec OFF (minimum)
- Minimum 1 hr day
- Minimal contraction



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

NMES - Blood Flow and Oedema

- Increase local blood flow
 - Via muscle stimulation
 - Superficial? Skin blood flow?
 - Suction Electrodes?
 - 1-50Hz or 10-25Hz?



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

NMES - Blood Flow and Oedema

- Reduce Swelling (secondary)
 - 10-25Hz
 - Muscle pump
 - Pain relief
 - 1-50Hz???
 - Suction Electrodes?



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

ITF for NMES Settings

- Constant/ variable beat frequency
- Control for time of beat frequencies
- Intensity control
- Vector setting
- Control of total time (10-20 mins)
- 2/4 pole
- Rubber electrode/ sponge pads



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Muscle Stimulation Choices

Tissue fluid exchange; muscle contraction	10-150Hz	Parasympathetic nerves Skeletal muscle
Increased blood supply	10-80Hz 0-10Hz	Skeletal muscle Smooth muscle
Contraction	1-50Hz	Muscle stimulation
Oedema	10-25Hz	Tissue and blood flow

Intensity

- Turn up GRADUALLY to maximum comfort level
- Monitor for accommodation and increase accordingly (1 minute)

Grade	Intensity	
5	Very High	Severe Pain, v.strong muscle contraction, tingling
4	High	Pain, strong muscle contraction
3	Medium	Weak contractions, muscle action, tingling
2	Low	Fine Tingling
1	Very Low	Threshold tingling
0	Zero	No effect

Pad Placement

- Trial and error for muscle contraction
- Consider the size of your pads
- About a pad distance between them
 - Small closely spaced electrodes increase superficial tissue irritation and can even cause a skin burn

Application

Competency	Comments
Equipment Checks (test machine, check connections/leads)	Test connection 4P test for strong but comfortable tingling
Client Communication (clear explanation of benefits & dangers, IC)	Language, aim of Rx, dangers, 3 key IC questions
Safety Checks (Contraindications, Sharp & Blunt)	Sharp and Blunt, CI's
Identify Rx aim & Set objective markers	Anatomy, VAS? ROM? SWELLING? STRENGTH?
Identify target tissue (inc palpation; nature & location)	Anatomy!
Prepare client (positioning, skin)	Clean skin, wash to increase conduction. Get them comfortable.
Beat frequency selection	machine setting: what are your aims?
2/4 pole selection	Size of Rx area? Clover leaf pattern
Sweep Ratio	Already set on this unit!
Intensity	Strong but comfortable tingling!
Rx time	Acute 5 mins +, chronic 10-30mins (neurotransmitter fatigue!)

Treatment Record

- 2pole/4pole
- Frequency applied
- Sweep settings (if applicable)
- Intensity/ reported sensation
- Duration
- Machine
- Area treated



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Post Treatment Advice

- Adverse effects
 - Increased Pain
 - Burns
 - Nausea
 - Vomiting
 - Dizziness/faintness
 - Headache
- Muscle Soreness
- Regularity of treatment



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives

Practice! - ITF and Compex



Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives