OML

Leading Rehabilitation
Through Technology

Salisbury NHS Foundation Trust

Neurophysiology applied to FES set-up

Paul Taylor and Vicky Parry

Stimulation waveform

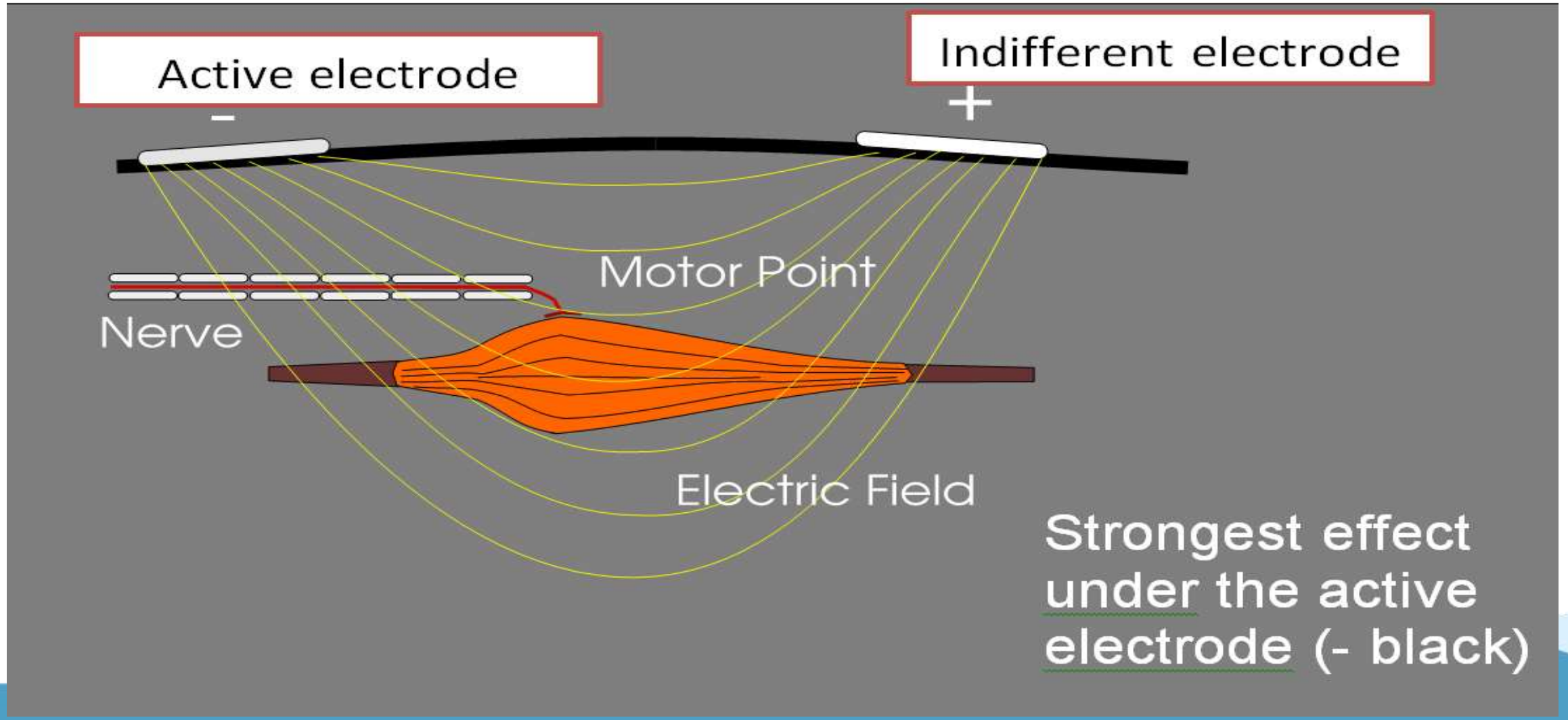
What it is

Why it makes a difference

When to change it

Functional Electrical Stimulation [FES]:

The production and control of movement in paralysed muscle by application of electrical impulses for the purpose of functional use



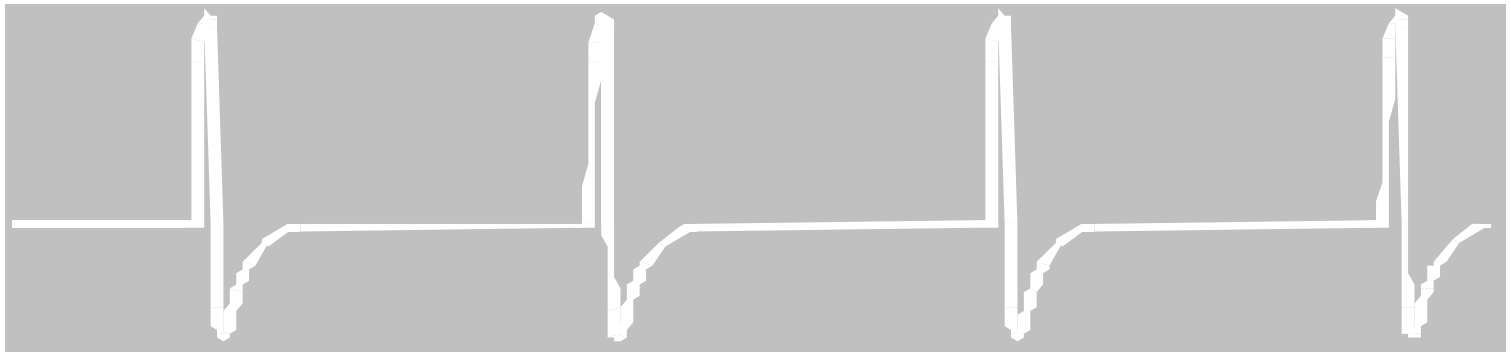
Output waveform

Asymmetrical biphasic

Strong positive pulse followed by weaker but longer negative pulse

SYM.	
ASYM.	■

Stronger response under active electrode (black pin)



Symmetrical biphasic

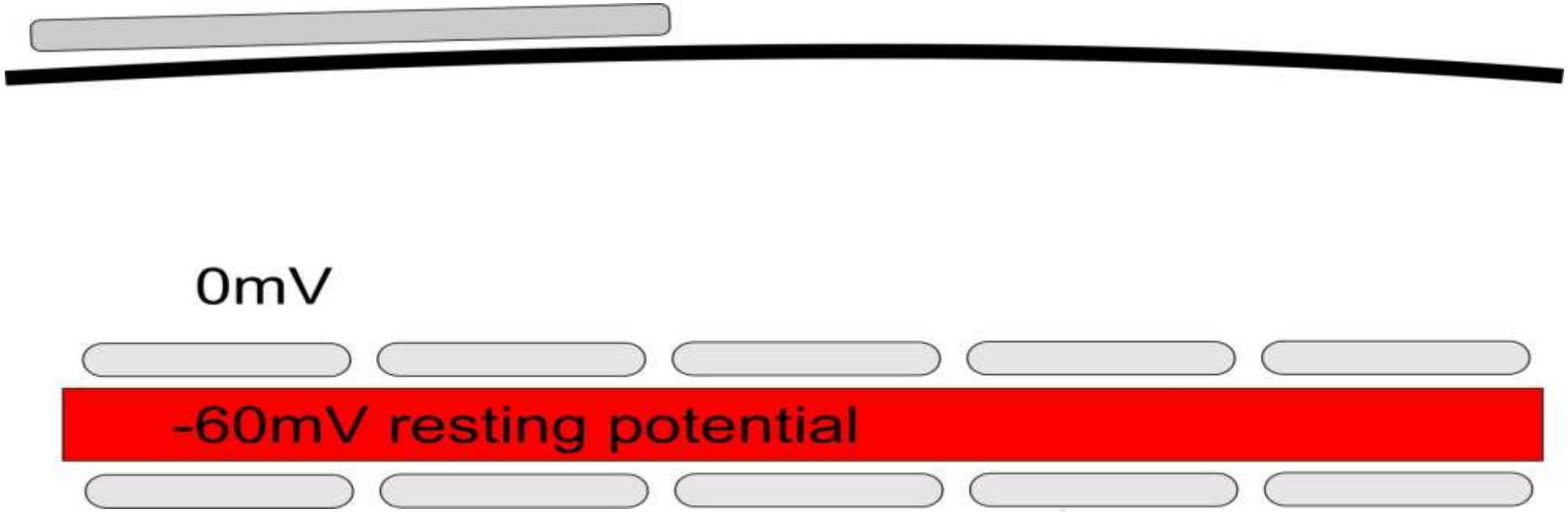
Every other pulse reversed polarity

SYM.	■
ASYM.	

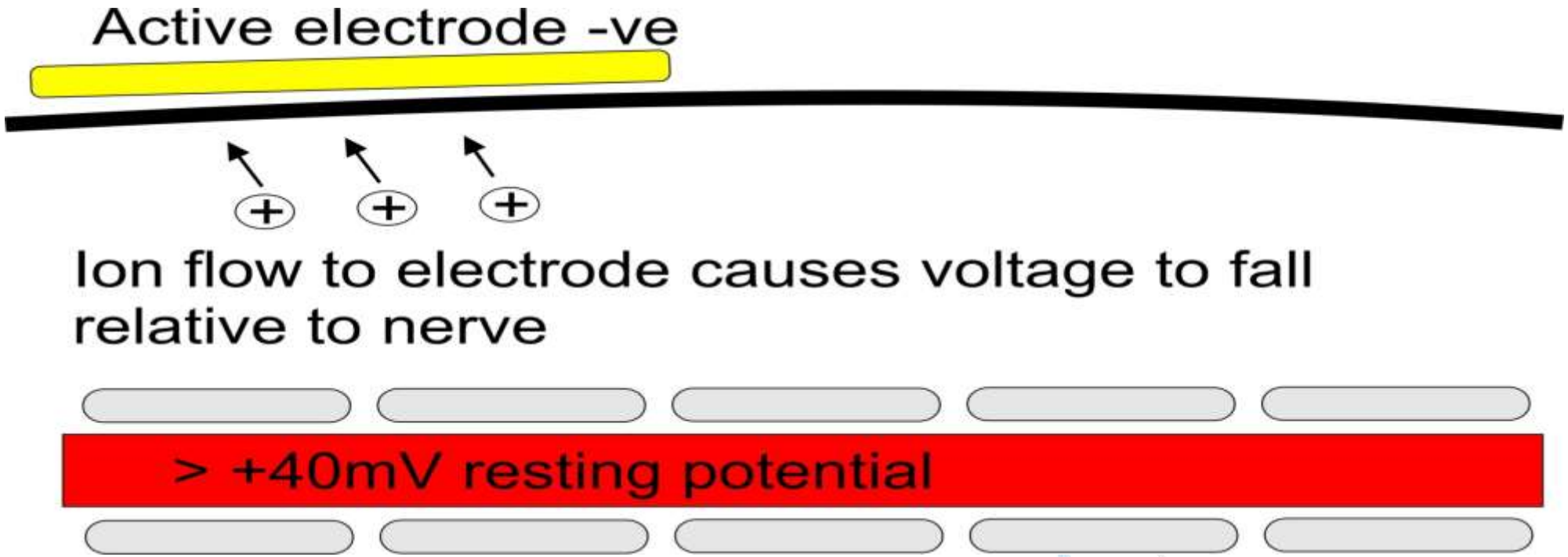
Same response under both electrodes
Less risk of skin reaction
Can be more comfortable
Can balance eversion and inversion

NB. The current will often need to be adjusted when changing between waveforms.

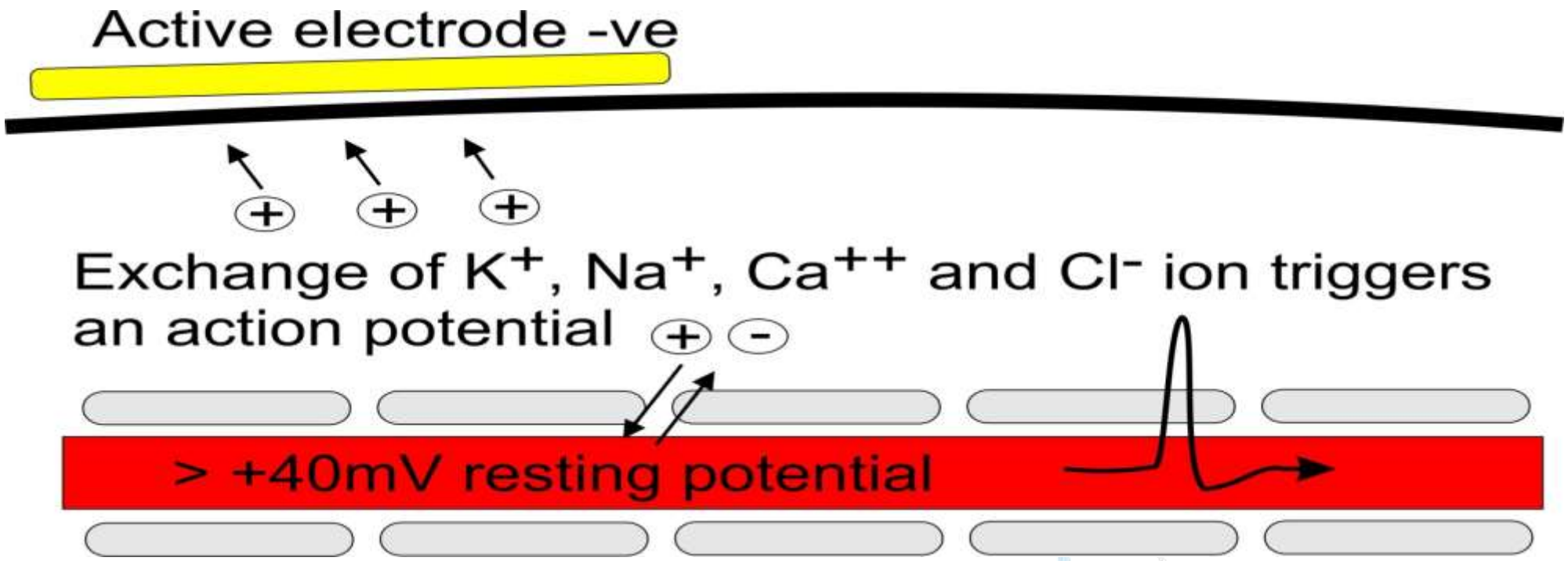
When not active the balance of positive and negative ions causes the inside of a nerve to be negative relative to its outside



Stimulation cause ions to flow towards the electrode. Positive ions move away from the nerve causing the area outside the nerve to become negative relative to the inside.

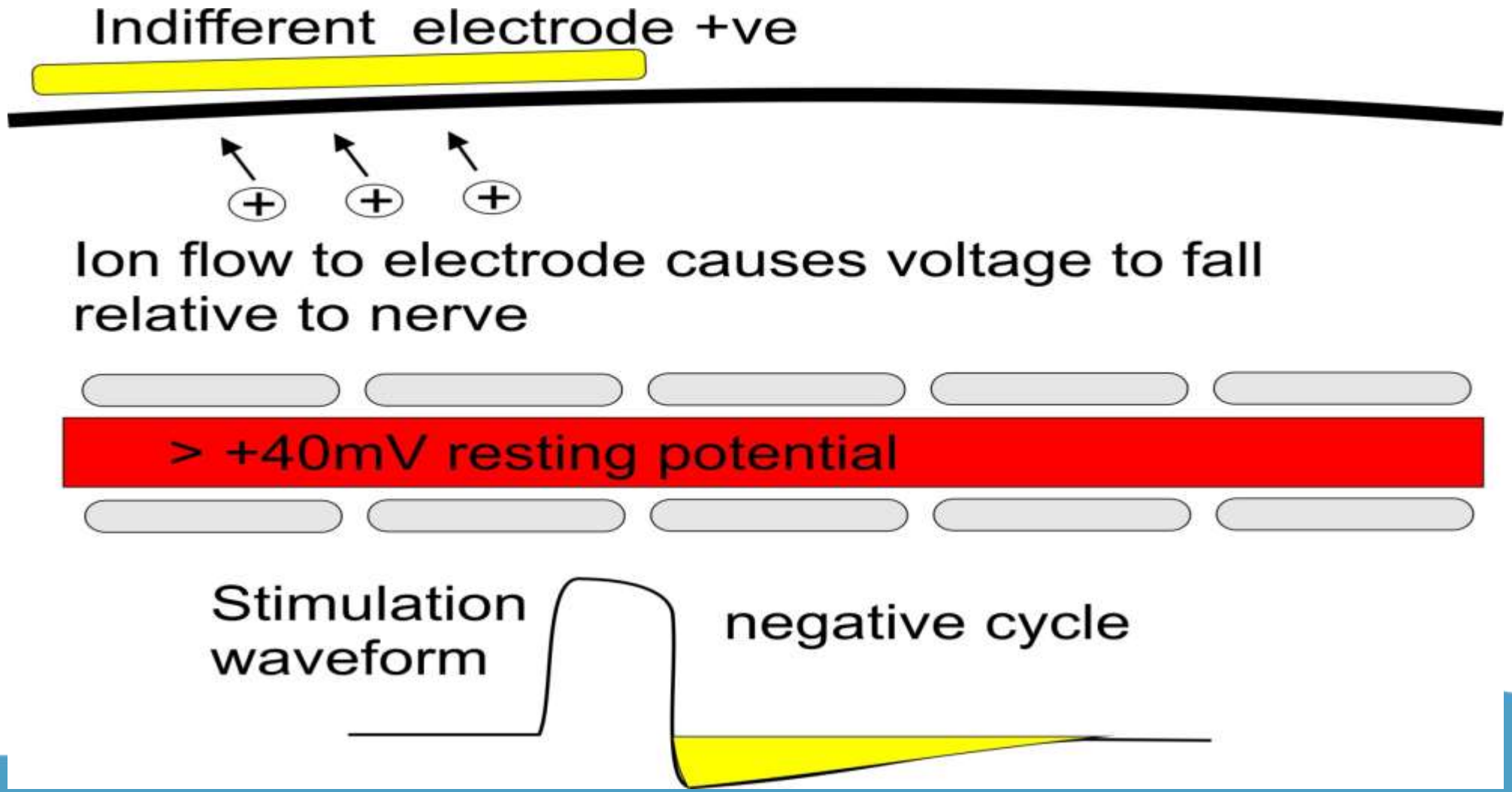


Once the voltage falls enough so the inside of the nerve becomes 40mV positive relative to the out side and the threshold is passed to open the ion channels. This causes an action potential.

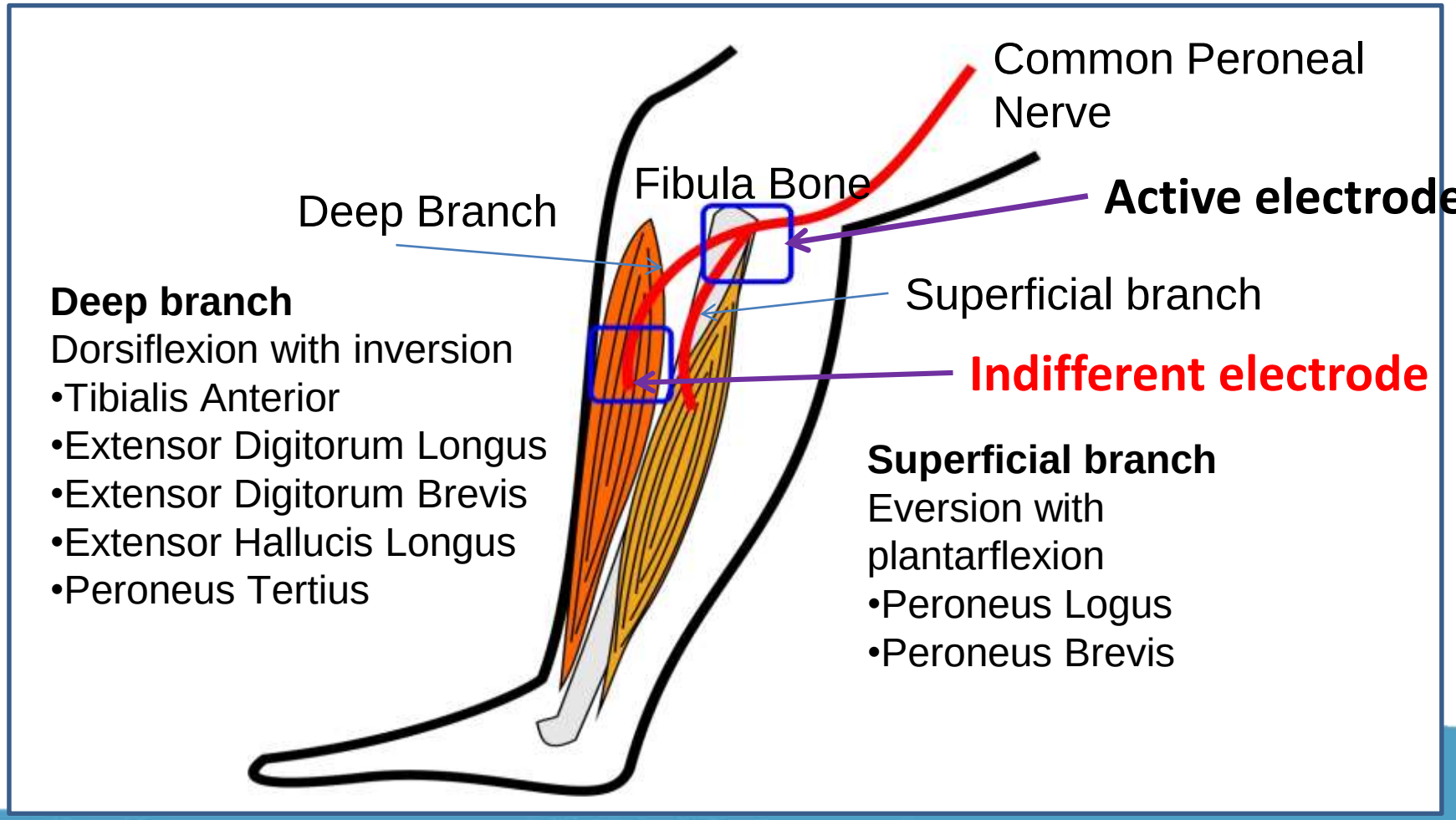


The action potential travels down the nerve to the muscle

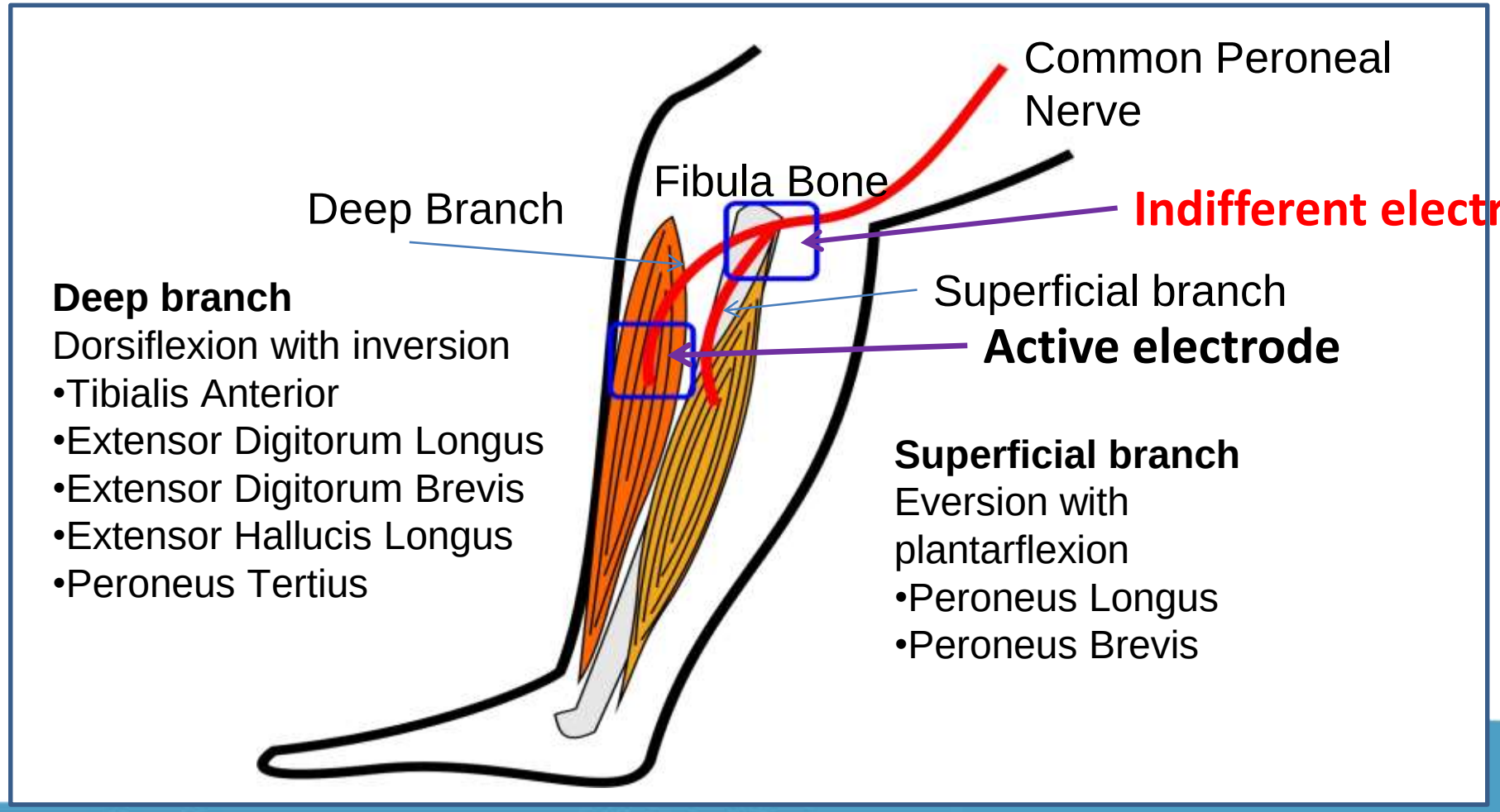
The indifferent electrode will also cause the nerve to become positive in the negative part of the cycle. This a smaller effect because it reaches a lower negative threshold.



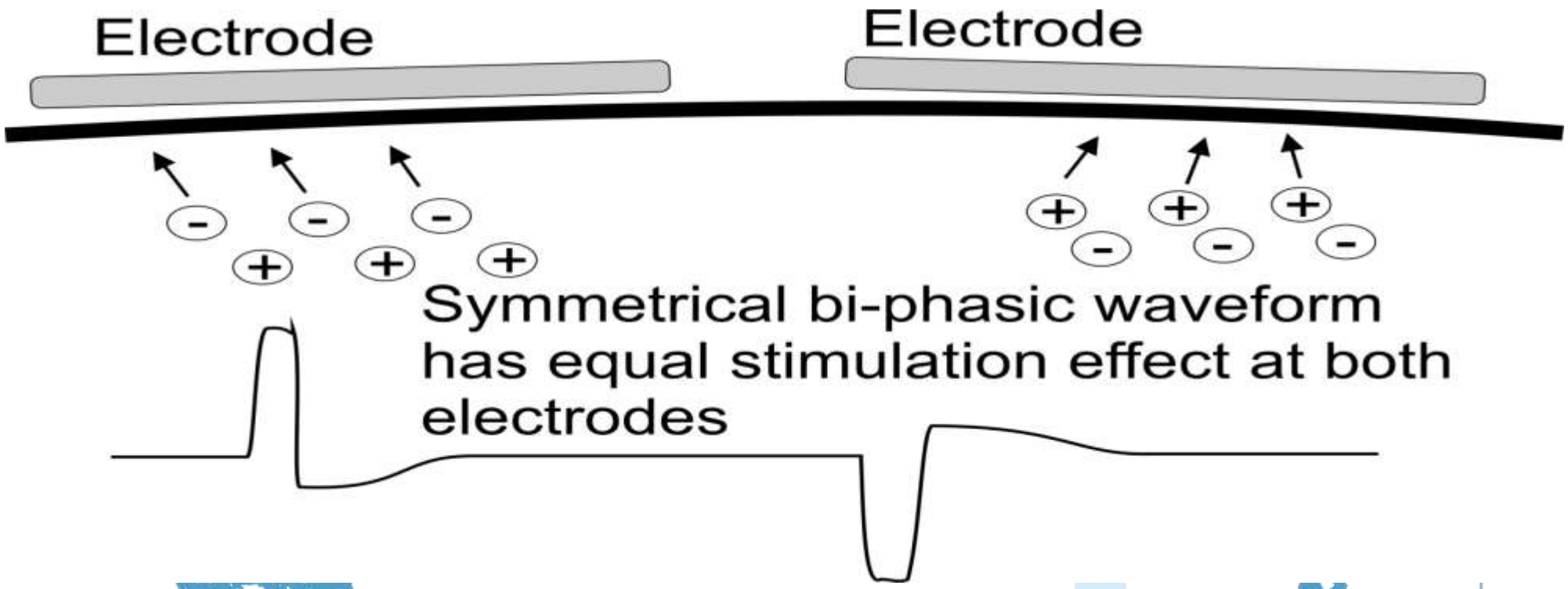
Standard electrode positions with ASYM waveform. The active electrode stimulates both strong dorsiflexion and eversion. The indifferent electrode stimulates less strong dorsiflexion and inversion.



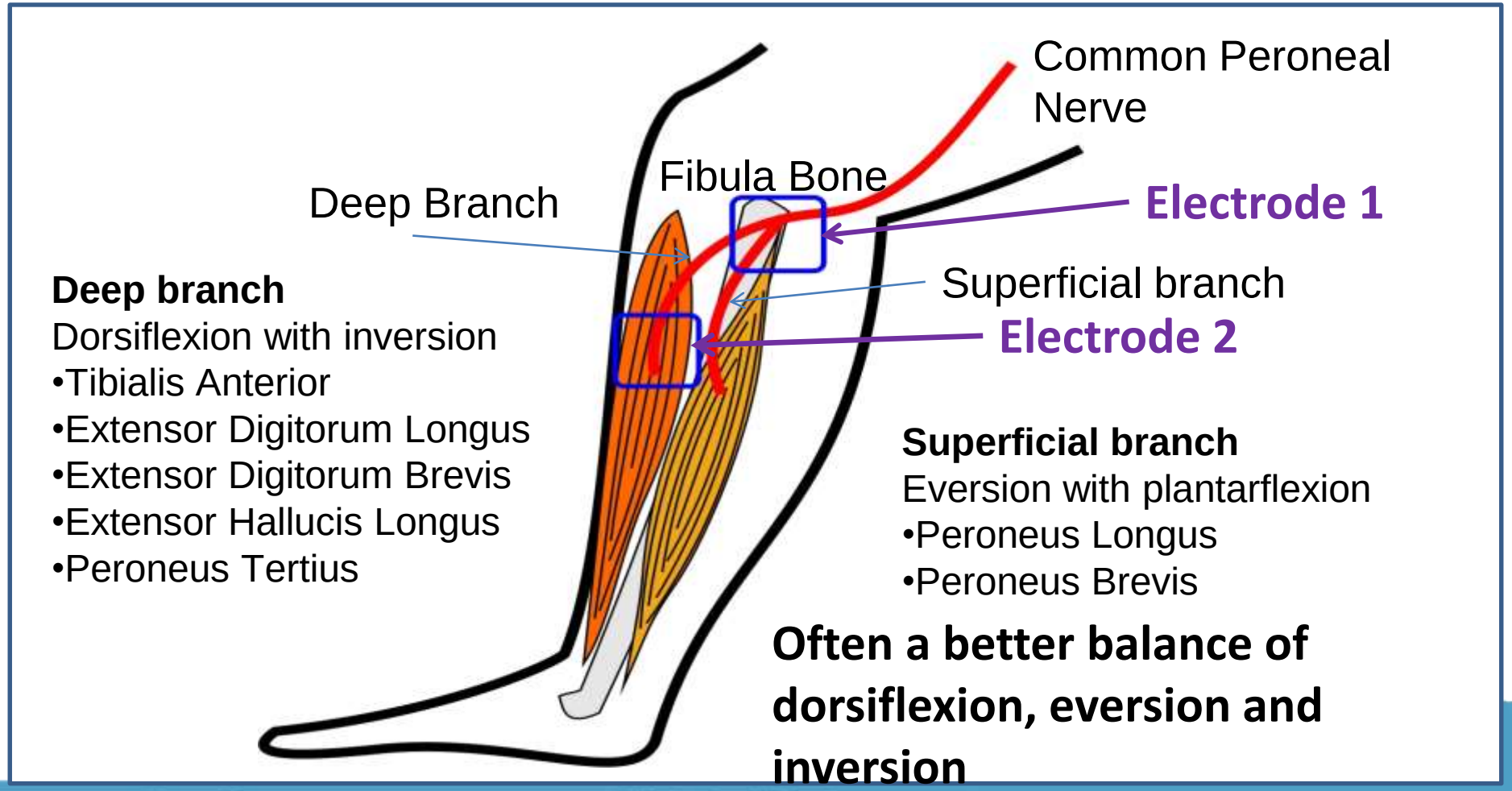
Reverse polarity electrode positions with ASYM waveform. The active electrode stimulates strong dorsiflexion and inversion. The indifferent electrode stimulates less strong dorsiflexion and eversion.



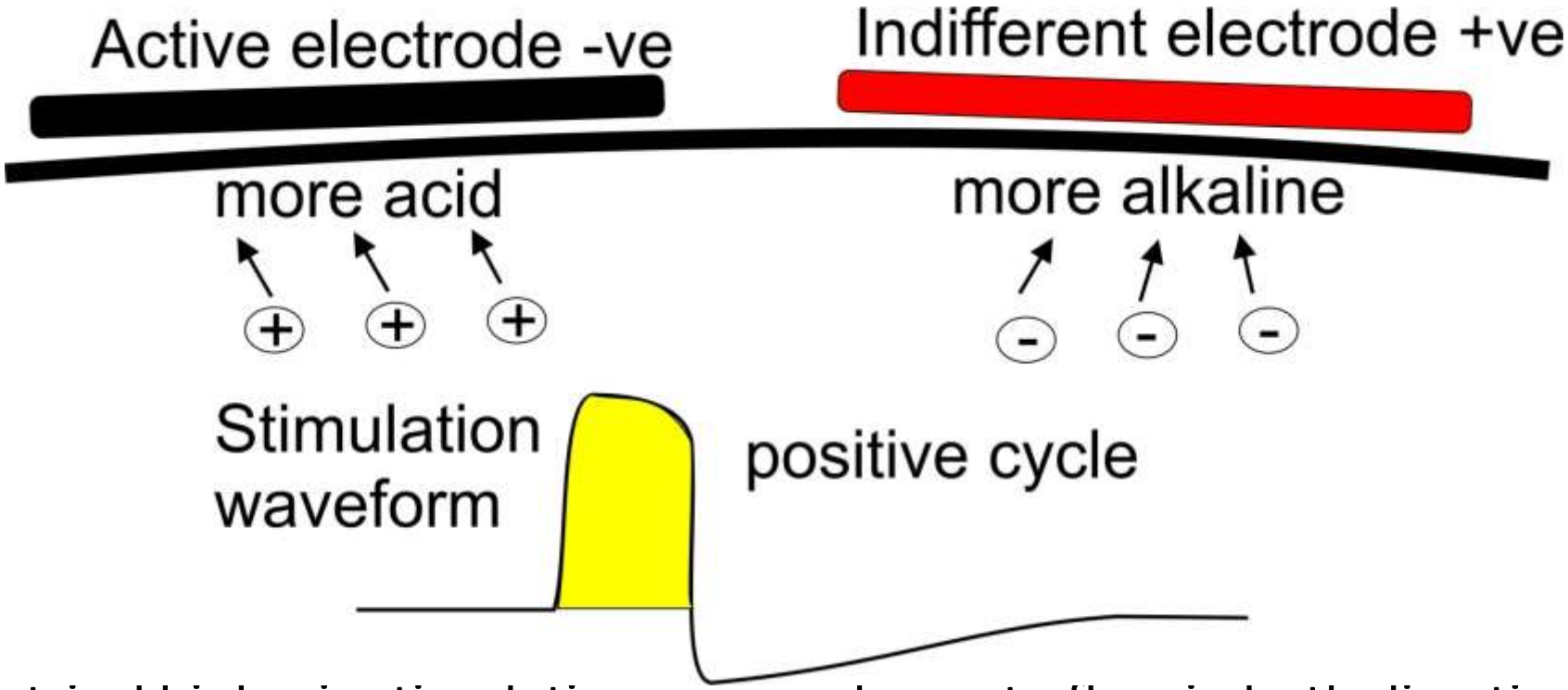
Symmetrical Biphasic wave form. Every other pulse has reveres polarity. There is no longer an active or indifferent electrode



Standard electrode position with SYMM waveform. Electrode 1 stimulates dorsiflexion and Eversion. Electrode 2 stimulated dorsiflexion and inversion.

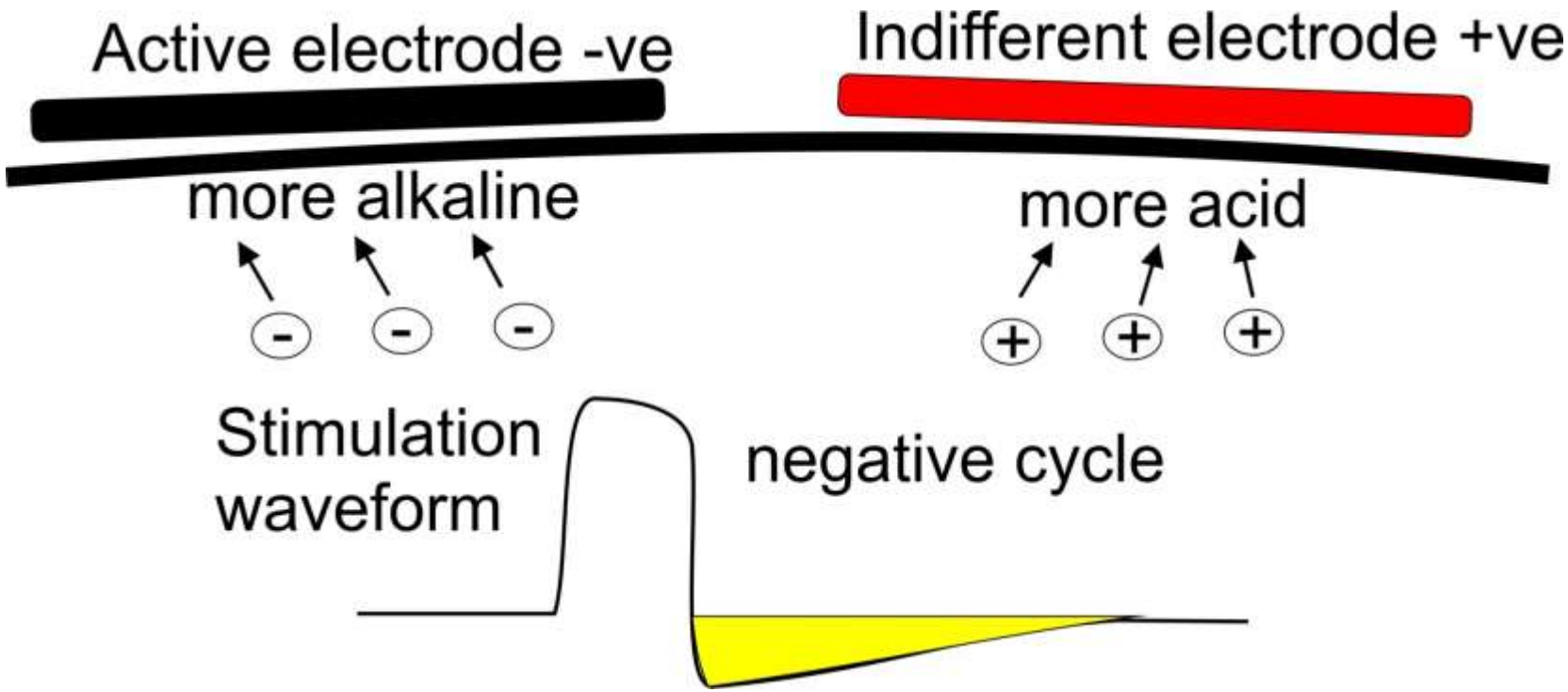


The effect of waveform on skin irritation



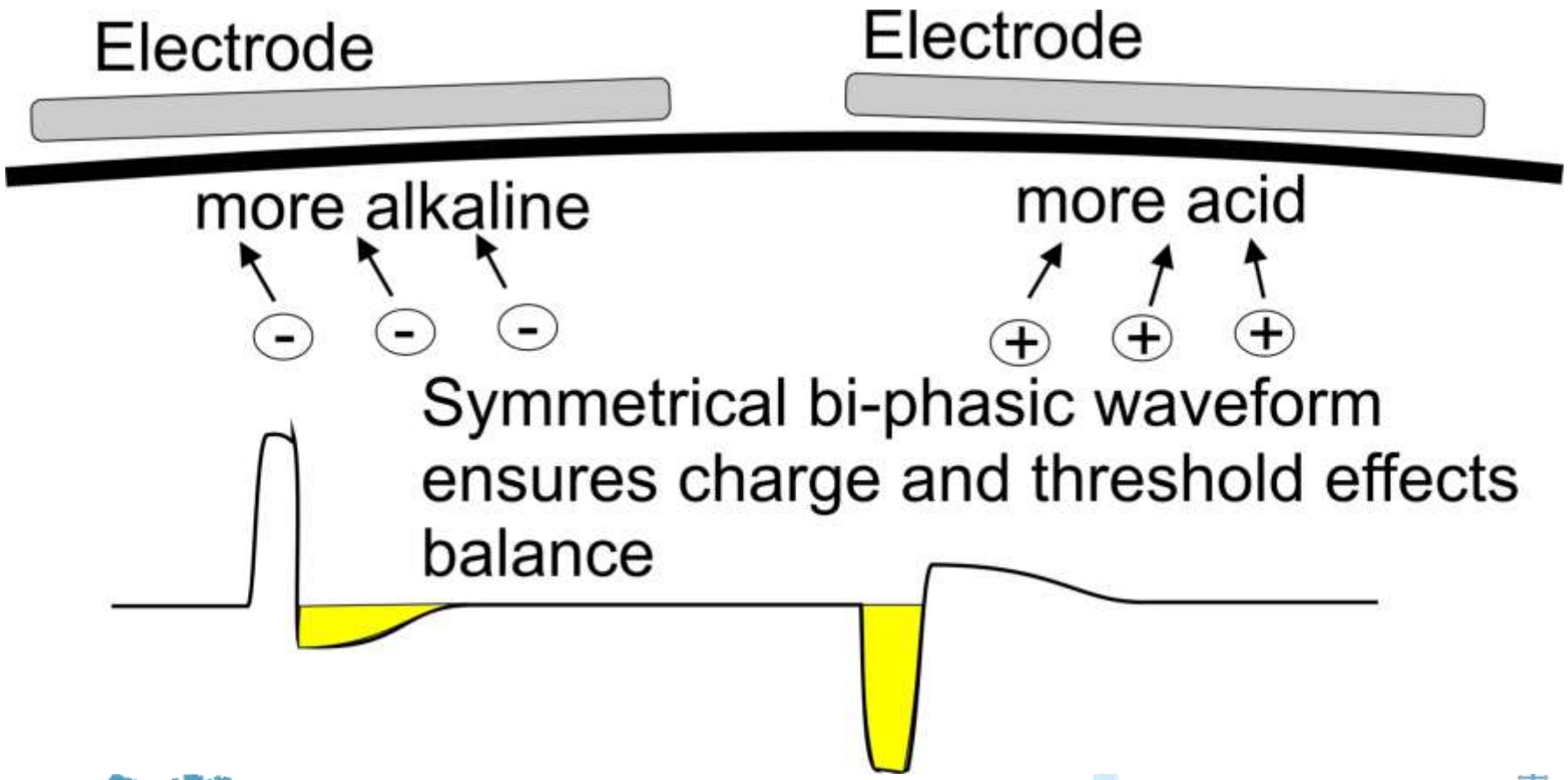
Asymmetrical biphasic stimulation causes charge to flow in both directions.
Momentary charge imbalance causes acidity and alkalinity under the electrodes

The negative cycle returns the charge that flowed in the positive cycle.

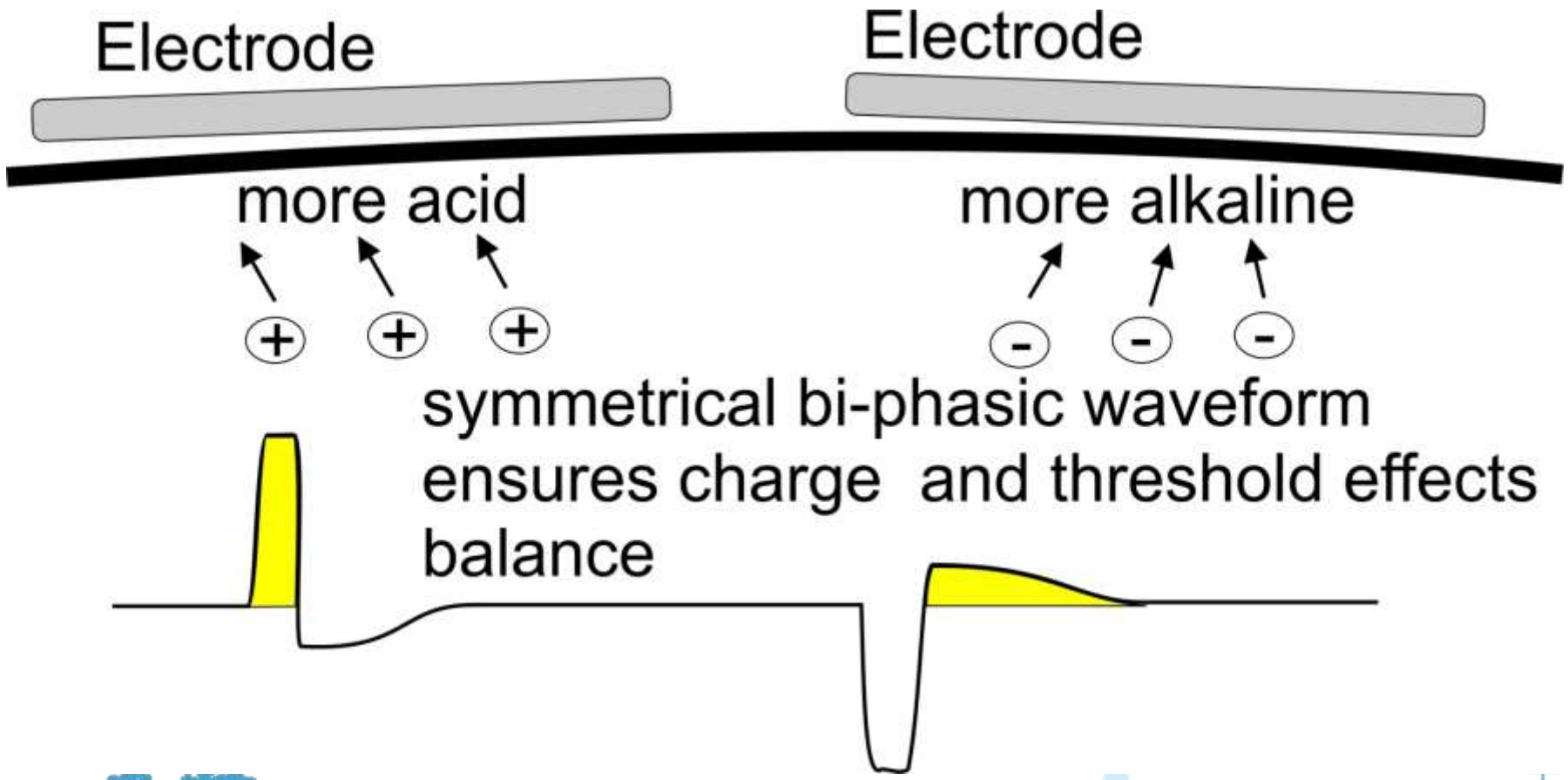


Over the whole stimulation cycle the ion flow is balanced and hence the balance of acidity and alkalinity is also balanced. However, threshold effects may prevent perfect balanced charge.

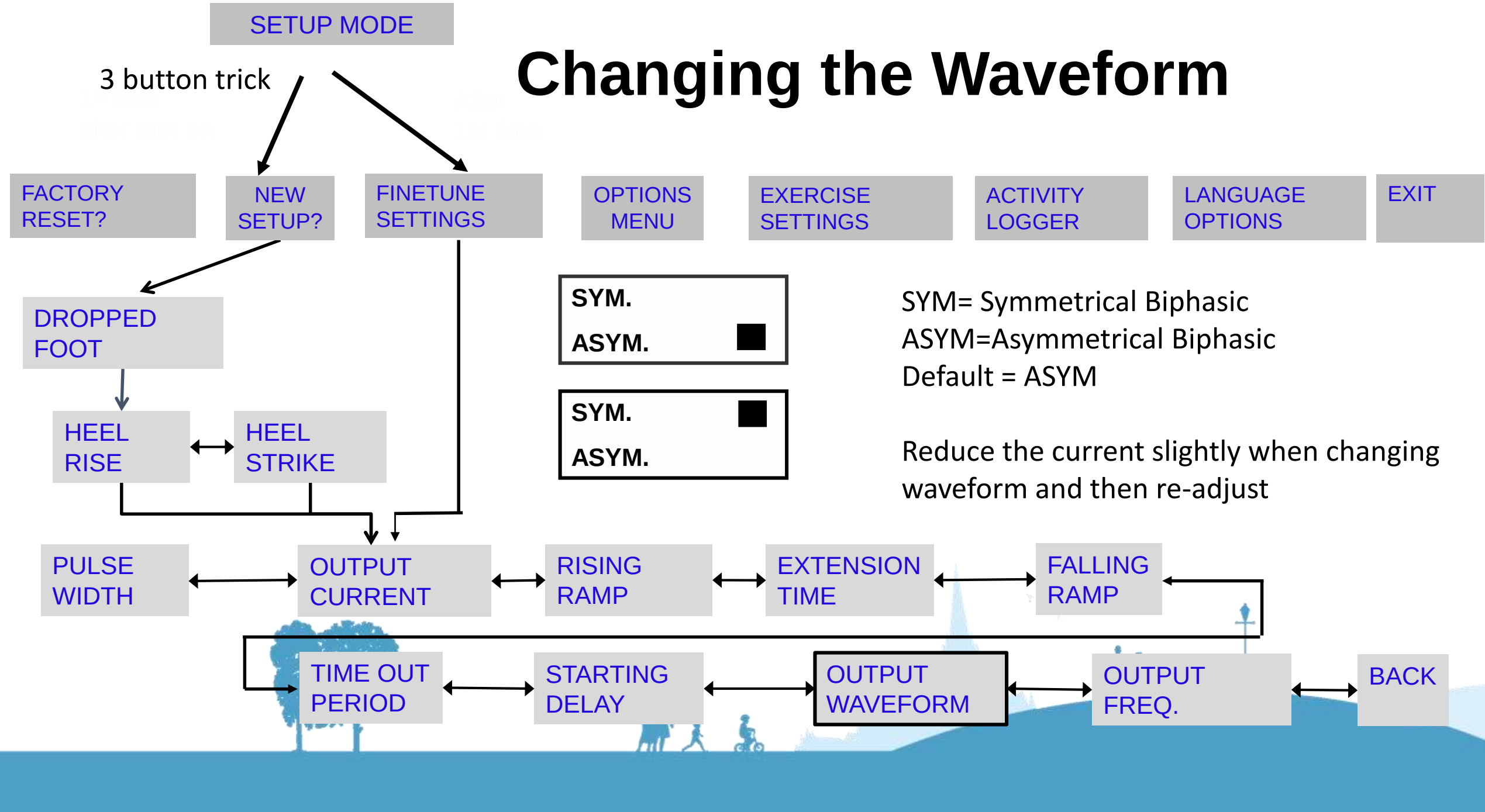
A symmetrical biphasic waveform balances both charge and current intensity



Symmetrical biphasic waveform may be less irritating to the skin



Changing the Waveform



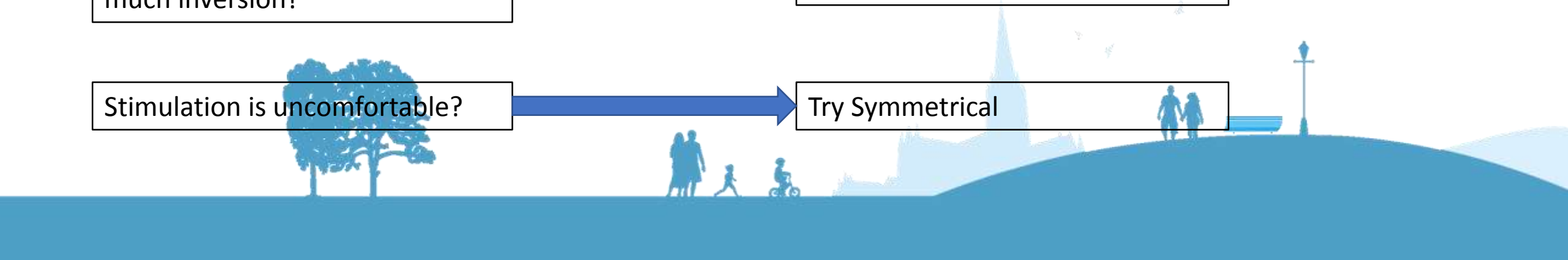
SYM= Symmetrical Biphasic
ASYM=Asymmetrical Biphasic
Default = ASYM

Reduce the current slightly when changing waveform and then re-adjust

Deciding which wave form to use? (Old thinking)

Use ASYM unless:

Is there poor skin condition or an increase risk of skin irritation?	Use Symmetrical
Standard position produces excessive eversion?	Use reverse polarity
Reverse polarity caused too much inversion?	Use Symmetrical
Stimulation is uncomfortable?	Try Symmetrical



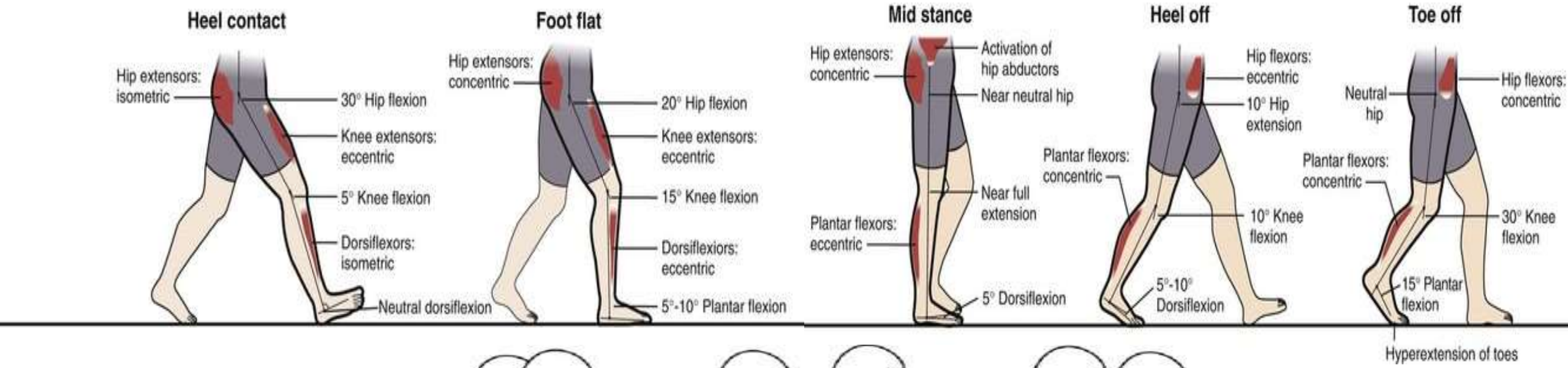
Deciding which wave form to use? (My clinical practice)

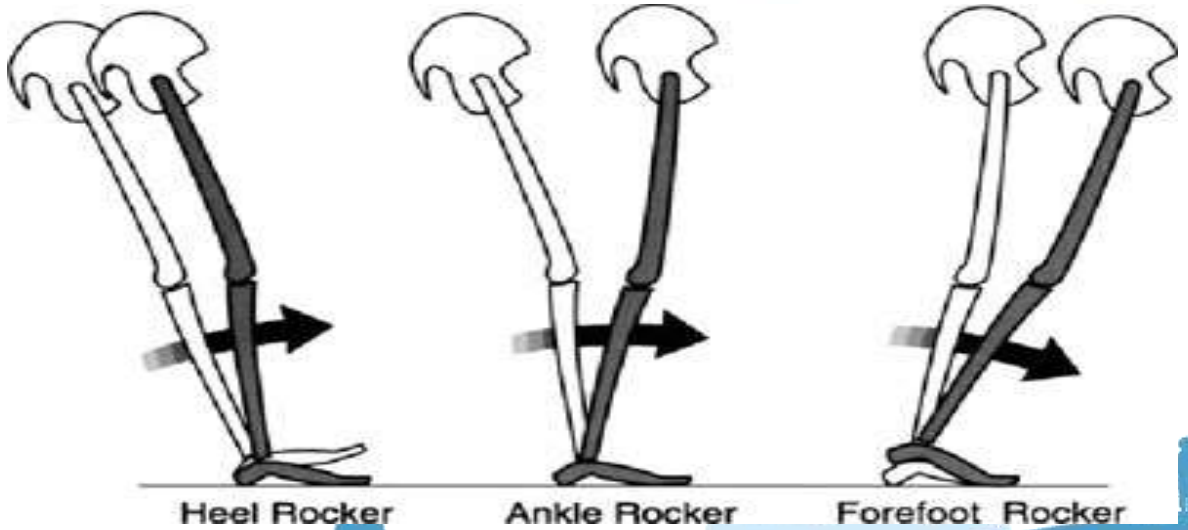
Use SYMM unless:

Need more eversion or a stronger response?	Use standard or pop fos position with ASYM or pop fos position with SYM or
Need less eversion?	Try motor point of Tib Ant electrode position or reverse polarity with ASYM
Stimulation is uncomfortable?	Try ASYM

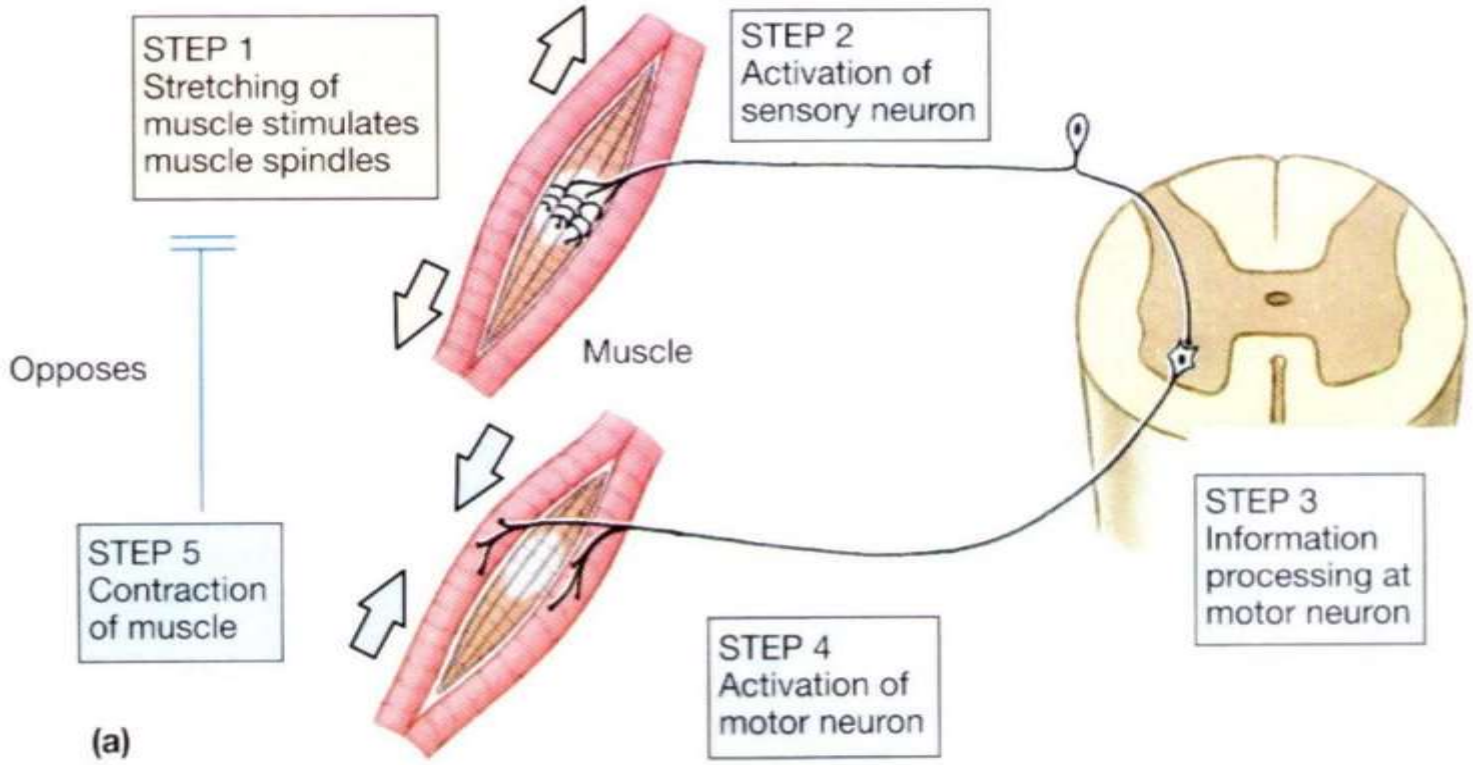
Use of Ramps and Clinical Reasoning

Biomechanics of lower leg in gait

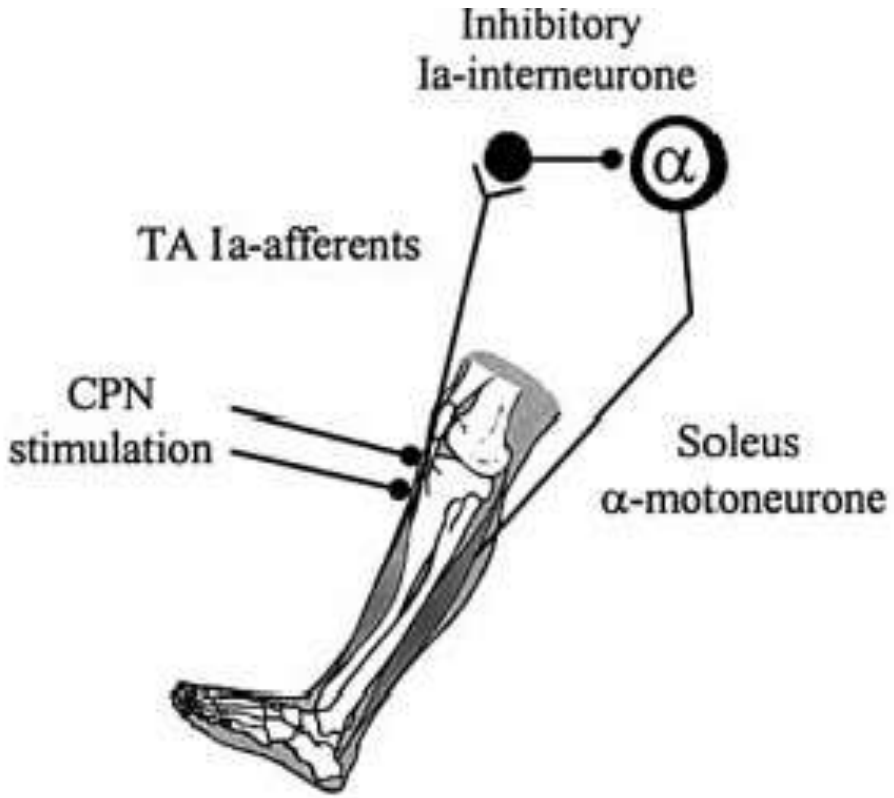




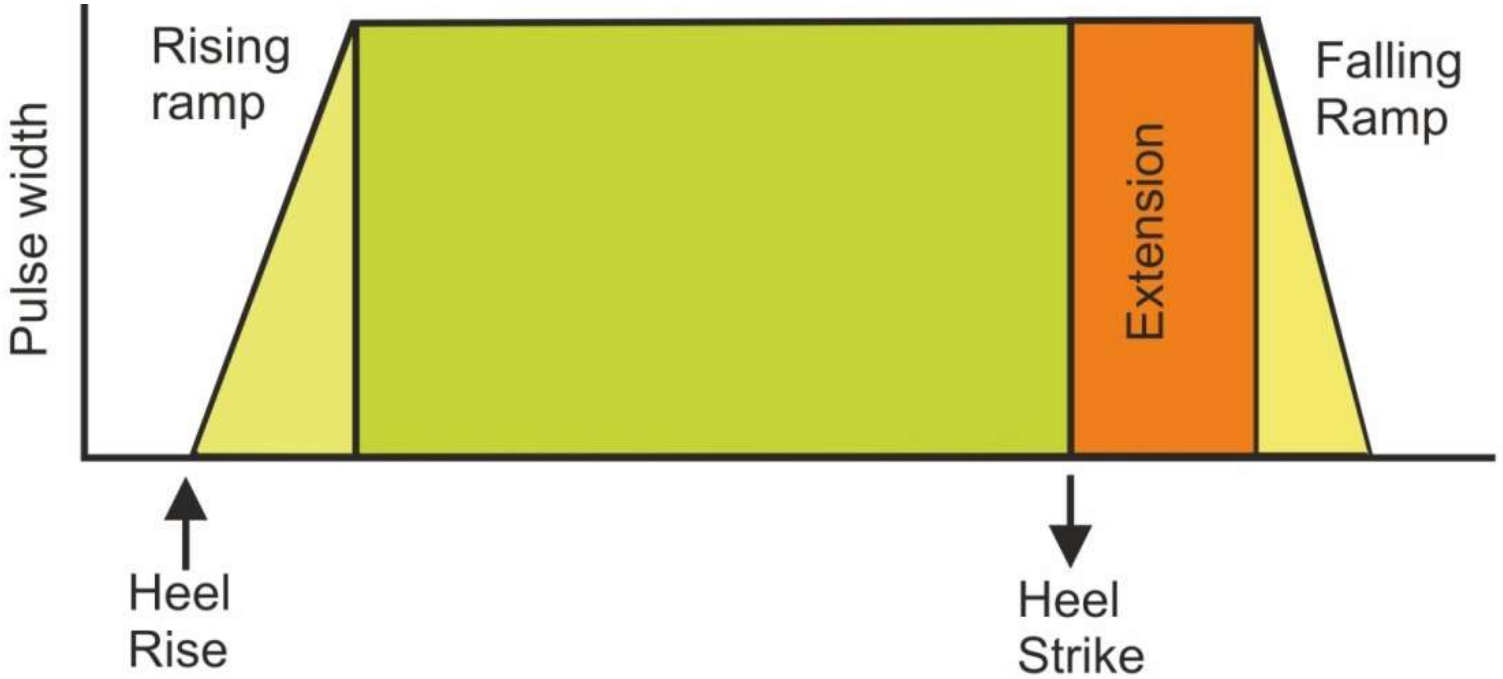
Stretch Reflex



Reciprocal Inhibition



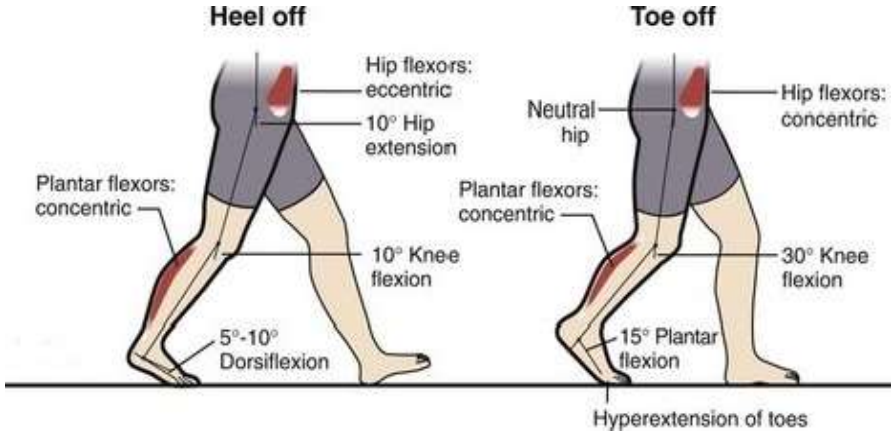
Simulation Envelope

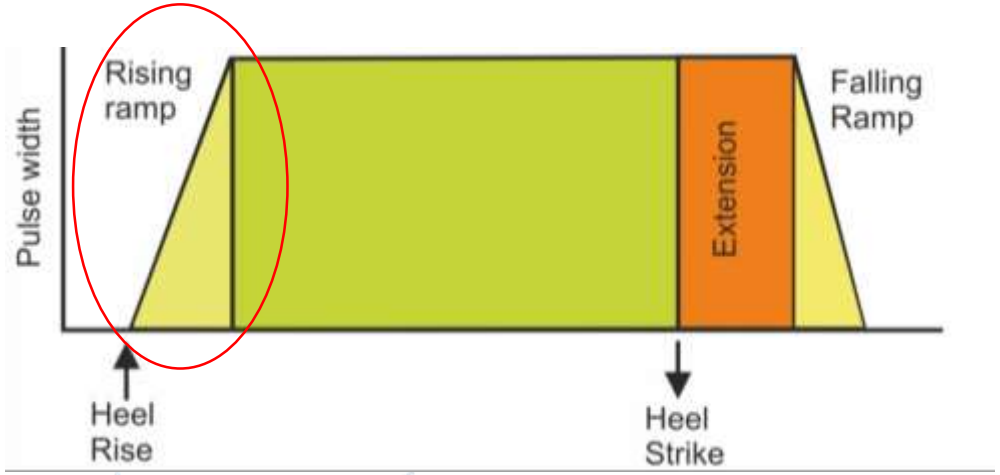


Rising Ramp

- Starts at heel rise depending on placement of footswitch (assuming f/switch is under the affected leg)

- The timing of the rising ramp can impact on:
  - Speed of foot lift
  - Spasticity
  - Push off



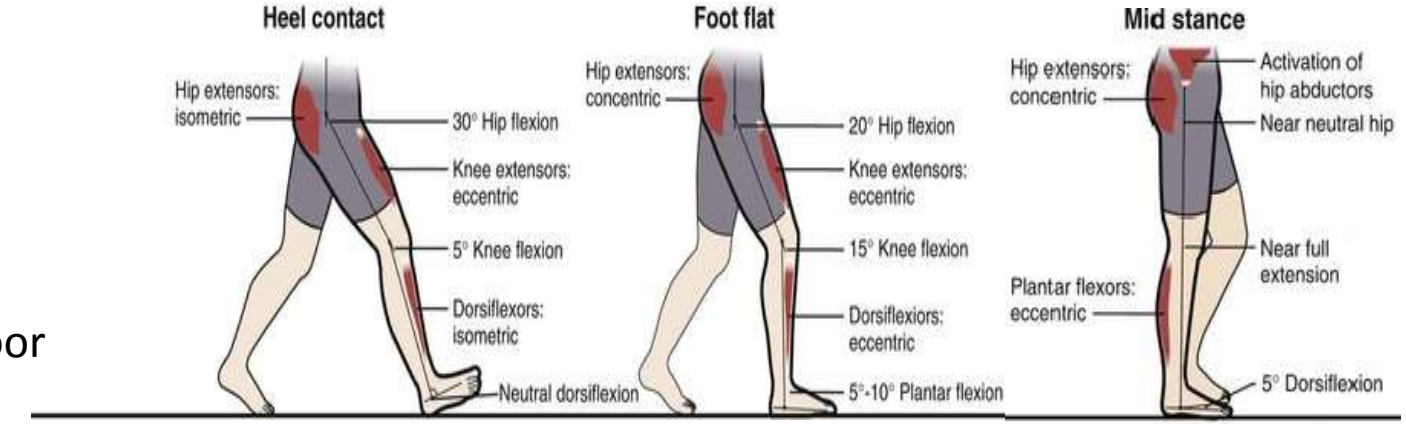


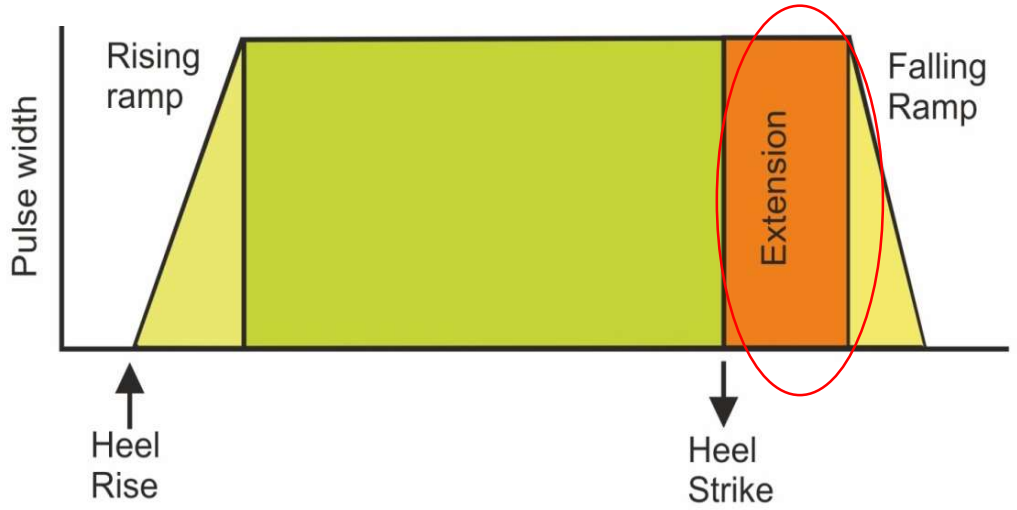
Long Rising Ramp	Short Rising Ramp
Allow push off	Increase speed of foot lift
Reduce stretch reflex	Aid withdrawal reflex
Aid sensory response	

Extension Phase

- Starts at heel strike and maintains stimulation for a given period in order to:
  - help control the lowering of the foot to the floor and translation of the tibia forward, thereby reducing foot slap
  - Aid ankle stability if you activate peronei (consider electrode position)

- Clinically need to consider the following:
  - Tibialis Anterior works eccentrically so need to ensure a strong enough level of stimulation
  - Weakness in the Plantarflexors can result in lack of knee extension in mid to terminal stance and at mid stance dorsiflexors are inactive





Falling Ramp

- Starts at the end of extension and controls the rate at which stimulation decreases
- Mainly adjusted for comfort
- Often we use very short falling ramps (50ms) but there are times where this appears more effective at controlling the lower limb and foot
- Worth experimenting with……