NAPS 2016

NATIONAL ACUTE PAIN SYMPOSIUM

TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS) IN ACUTE PAIN

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www.electrotherapy.org

Electro Physical Agents and Pain Management










Electrical Stimulation Agents / Modalities	Thermal Agents / Modalities	Non Thermal Agents / Modalities
Transcutaneous Electrical Nerve Stimulation (TENS)	Infra Red Irradiation (IRR)	[Pulsed] Ultrasound
Neuromuscular Electrical Stimulation (NMES)	Shortwave Diathermy (SWD)	Low Intensity Pulsed Ultrasound (LIPUS)
Interferential Therapy (IFT)	Microwave Diathermy (MWD)	[Pulsed] Shortwave Therapy (PSWT)
Functional Electrical Stimulation (FES)	Other RF Therapies [Indiba, Tecar]	[Pulsed] Laser Therapy (LLLT / LILT)
Faradic Stimulation: Diadynamic Therapy	Hydrocollator Packs	[Pulsed] Microwave Therapy
Iontophoresis	Wax Therapy	Shockwave Therapy (Radial and Focused)
High Voltage Pulsed Galvanic Stimulation (HVPGS)	Balneotherapy (inc spa/whirlpool)	Low Intensity RF Applications [e.g. Indiba; Tecar]
Low Intensity Direct Current (LIDC) and Pulsed LIDC	Fluidotherapy	Pulsed Electromagnetic Fields (PEMF's)
Twin Peak Monophasic Stimulation	Therapeutic Ultrasound	MAGNETIC THERAPIES
H Wave Therapy®; Action Potential System (APS)	Laser Therapy	[Static Magnetic Therapy] [Pulsed Magnetic Therapy]
Russian Stimulation : Aussie Stim: Medium Frequency Stimulation (BMAC)		Vibration [Local and Whole Body]
Rebox Therapy; Scenar Therapy, NRN (InterX) based therapy	Cryotherapy / Cold Therapy / Ice / Immersion Therapy	
Microcurrent Therapy (MCT)	Contrast Baths	Microcurrent Therapy (MCT)

TENS Principles

- Aims to activate normal physiological mechanisms of pain management by means of the

PAIN GATE MECHANISM

- and/or the

ENDOGENOUS OPIOIDS

- Primarily works by means of

SENSORY NERVE ACTIVATION

- **Symptomatic management** rather than cure

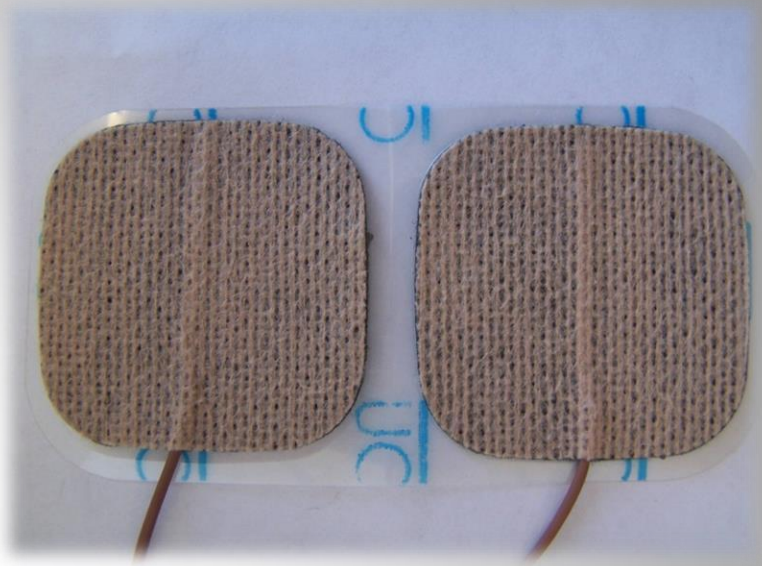
Acute vs Chronic Pain ?

- Clinically, TENS is most widely employed as a pain management tool for patients with **CHRONIC** pain
- Not a problem as it is evidenced as having significant effects for this patient group (outwith this presentation)
- BUT also has highly significant effects for patients who are experiencing **ACUTE** pain
- Will consider evidence

Non Invasive and Low Side Effect Incidence

- **Non invasive** treatment
- Very **few side effects** compared with drug therapy
- Small percentage experience **allergic reaction** (cited at ≈ 3%)
- Not to TENS but to electrodes, gel, tape etc

TENS Electrodes



- Most therapists and patients use pre-gelled, self adhesive electrodes
- Designed to be **SINGLE PATIENT** but **MULTI USE** electrodes

Range of garment electrodes available from multiple outlets and suppliers

Analogue TENS	Digital TENS	Maternity TENS

TENS vs Interferential (IFT)

- Several comparative studies
- Some lab based, some clinical
- E.g.
  - Shannahan et al (2006)
  - Bae and Lee (2014)
- On comparison :
- TENS produces ‘stronger’ pain relief / pain reduction
- Interferential considered to be more comfortable
- (certainly in induced pain studies with healthy participants who try both stimulations)

ELSEVIER

Physiotherapy

Physiotherapy 92 (2006) 247–253

Comparison of the analgesic efficacy of interferential therapy and transcutaneous electrical nerve stimulation

Christine Shanahan [a], Alex R. Ward [b,*], Val J. Robertson [c,d]

Original Article

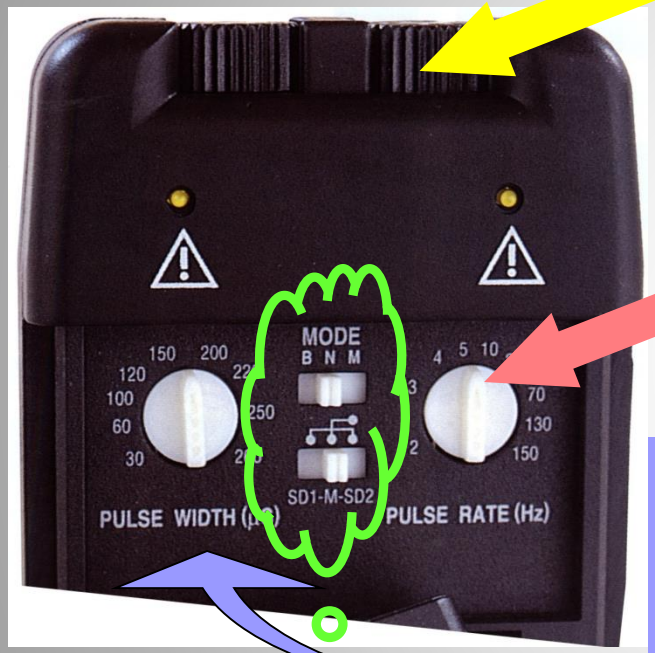
J. Phys. Ther. Sci.
26: 1945–1948, 2014

Analgesic Effects of Transcutaneous Electrical Nerve Stimulation and Interferential Current on Experimental Ischemic Pain Models: Frequencies of 50 Hz and 100 Hz

Young-hyeon Bae, PT, PhD[1, 2], Suk min Lee, PT, PhD[3]*

Variables on modern TENS machines

Variables on typical TENS machines



OUTPUT INTENSITY

0 - 80 mA typical

PULSE FREQUENCY

2 - 150 pps (Hz)

(some go higher)

PULSE WIDTH (DURATION)

50 - 250 µs

- Most machines also offer a **BURST** mode
  Deliver around 2 - 3 bursts per second
- Many machines also now offer a **MODULATED** output

Variables on typical Digital TENS machines

OUTPUT INTENSITY

0 - 80 mA typical

PULSE FREQUENCY

2 - 150 pps (Hz)

(some go higher)

- Most machines also offer a **BURST** mode
  Deliver around 2 - 3 bursts per second
- Many machines also now offer a **MODULATED** output

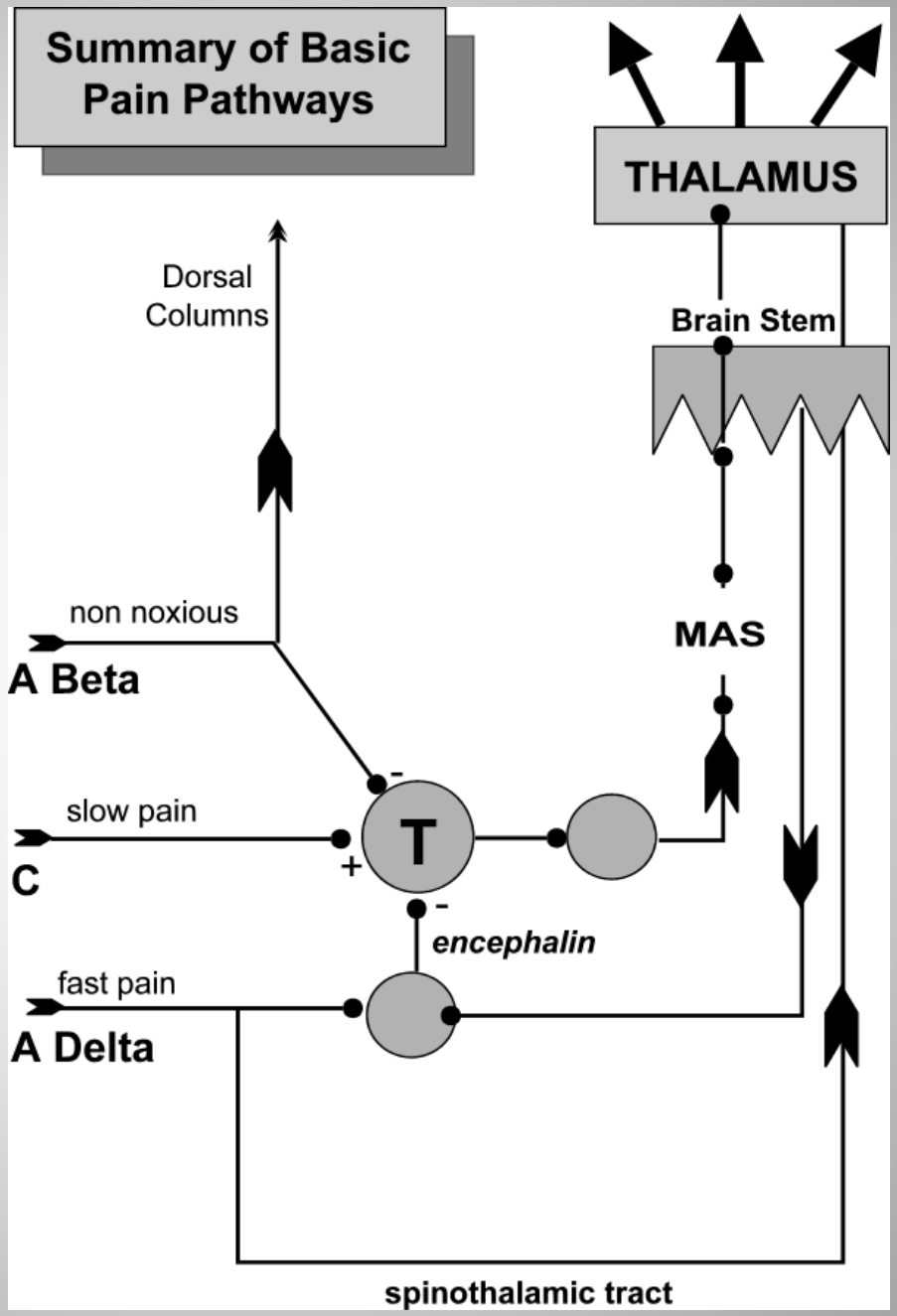
PULSE WIDTH (DURATION)

50 - 250 µs

Touch, pressure, vibration, warm, cold, proprioception, mechanoreception

Intensity, nature, quality, unpleasantness . .

Alert - pain awareness



Touch, pressure, vibration, warm, cold, proprioception, mechanoreception

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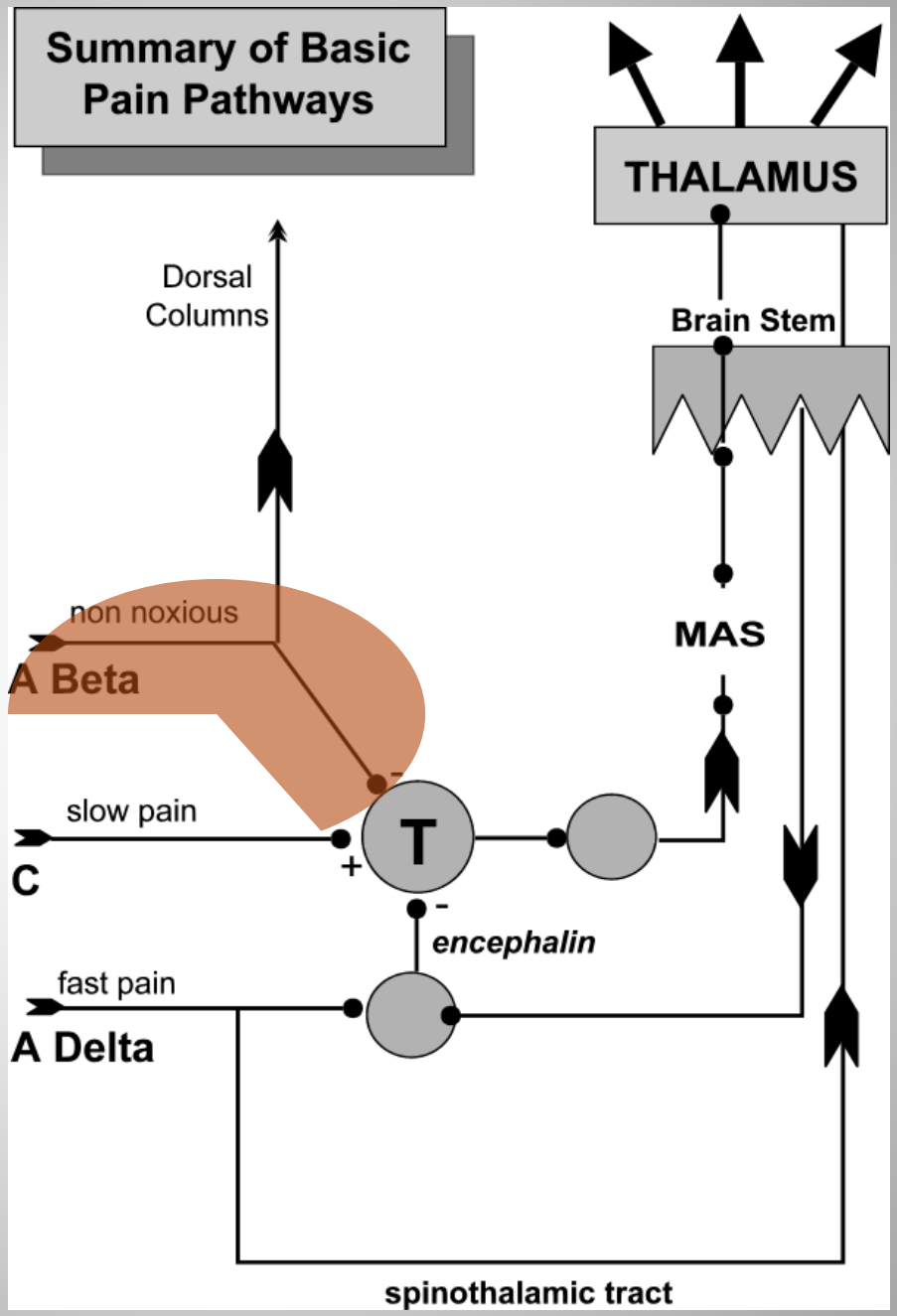
Alert - pain awareness



Stimulation Parameters

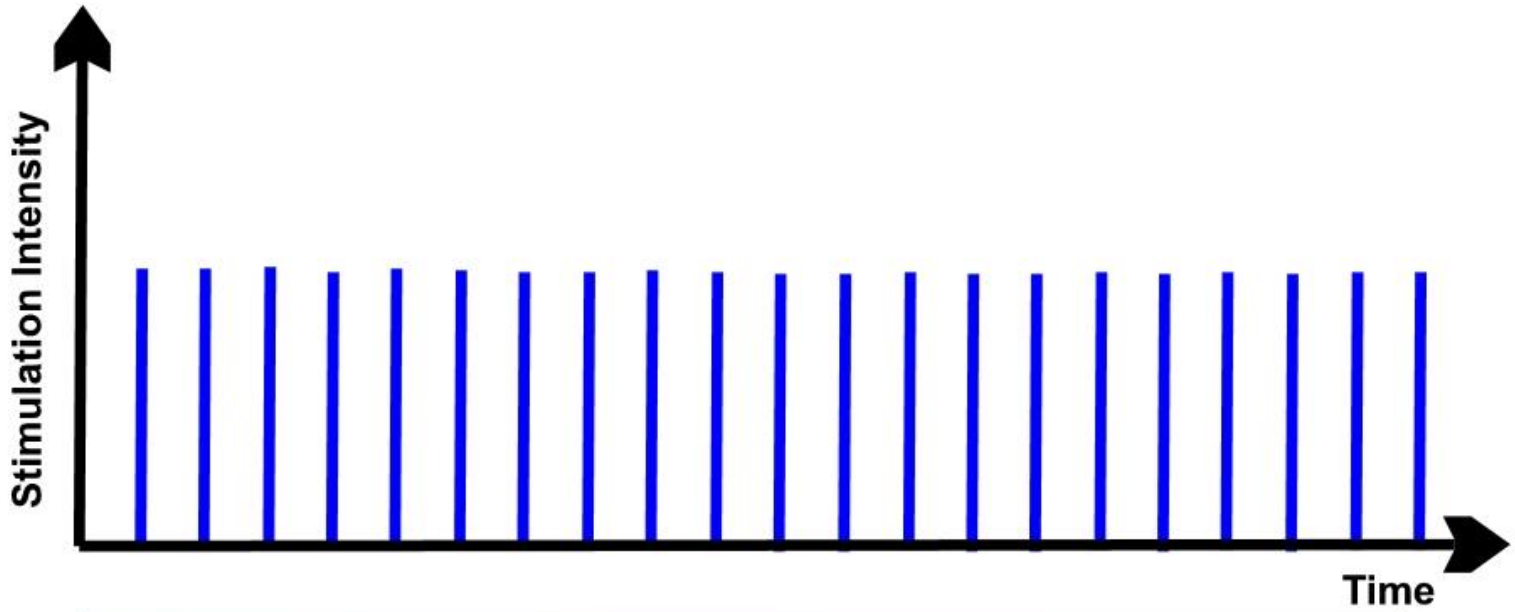
Aß fibres → Pain Gate activation → 80 - 130 Hz

Appears to be more effective with ACUTE pains
Most effective DURING the stimulation period
Limited CARRY OVER period (minutes at most)

Can use for as long as needed – not time limited
MINIMUM useful clinical stim = 30 min

DESPITE commonly passed on clinical advice to only use for 20 mins at a time or 20 min a day etc

Normal / Traditional / High TENS

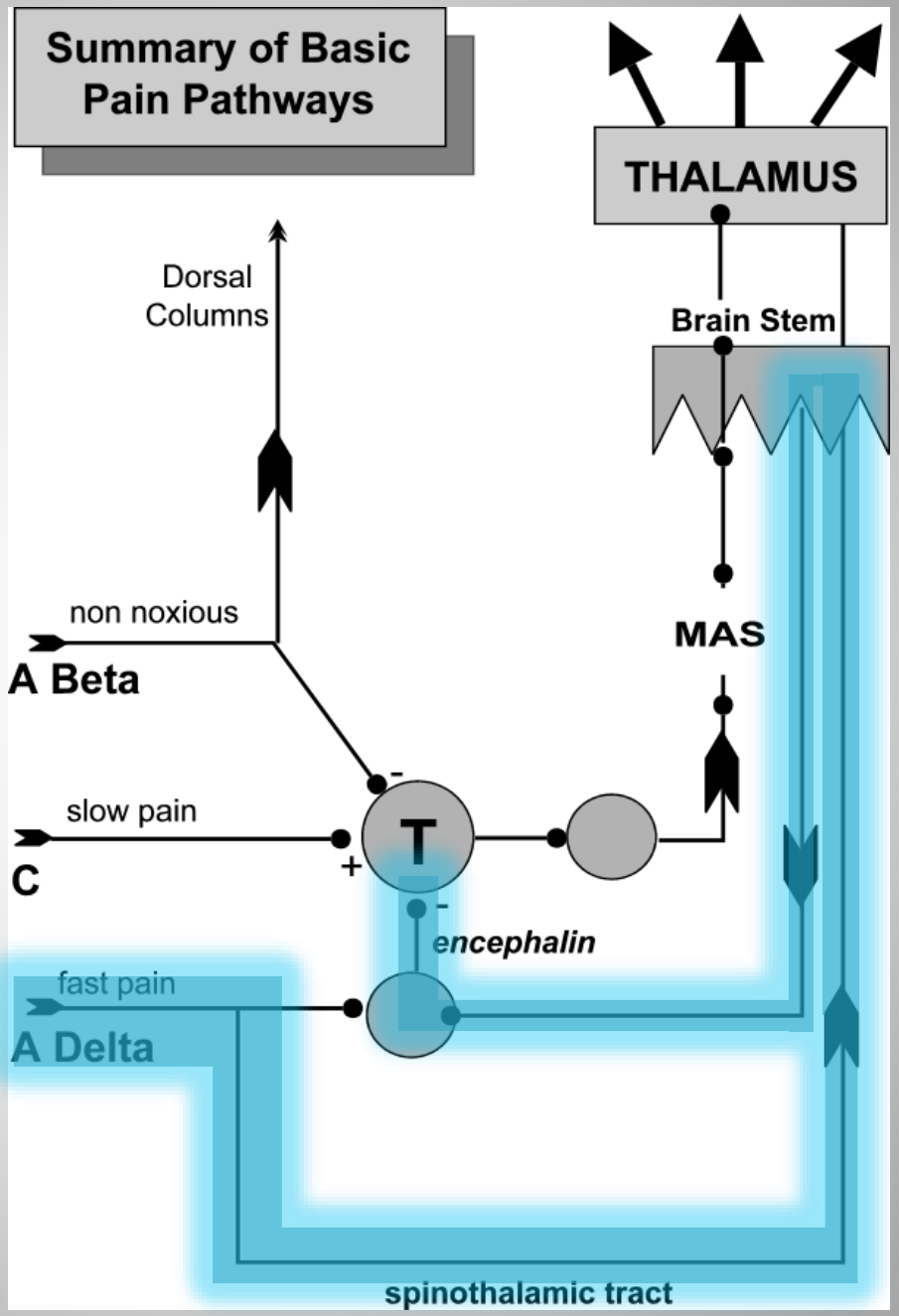


Normal (Traditional) TENS using stimulation at a 'high' frequency typically between 90 - 130 Hz (pps)

Touch, pressure, vibration, warm, cold, proprioception, mechanoreception

Intensity, nature, quality, unpleasantness . .

Alert - pain awareness



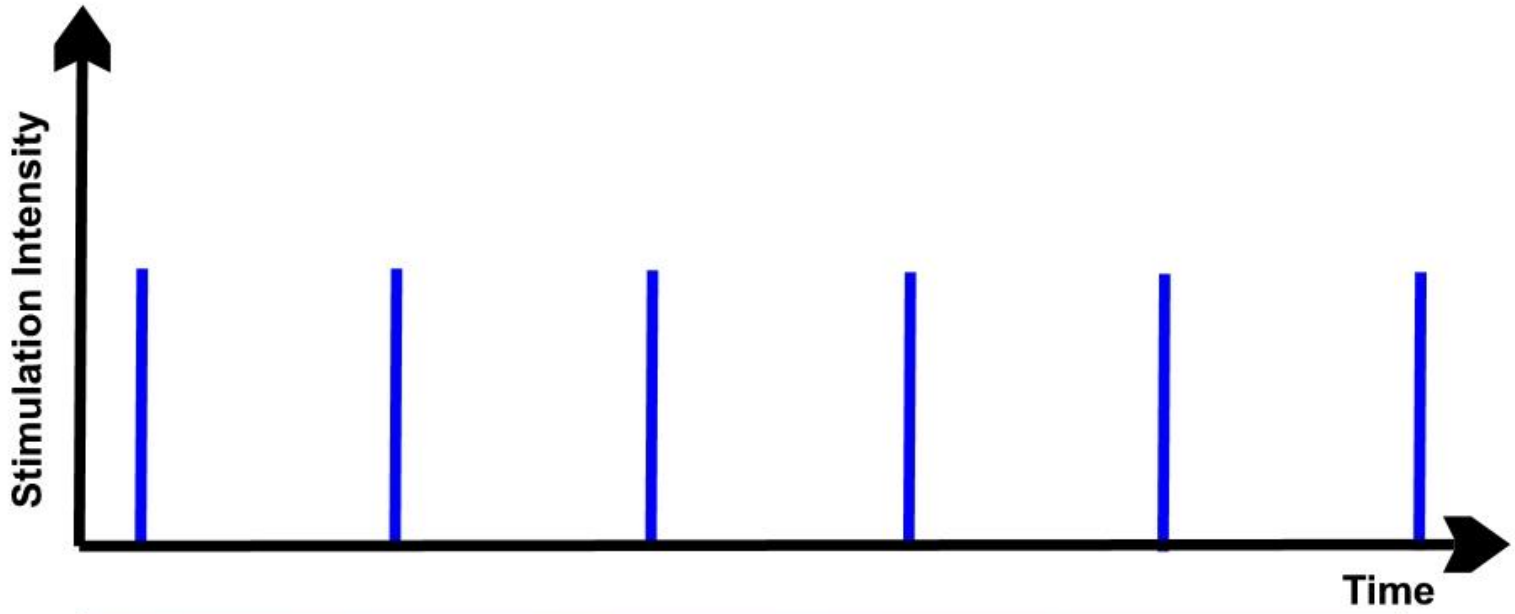
Stimulation Parameters

Aß fibres → Pain Gate activation → 80 - 130 Hz

Aδ fibres → Opioid system activation → 2 - 5 Hz

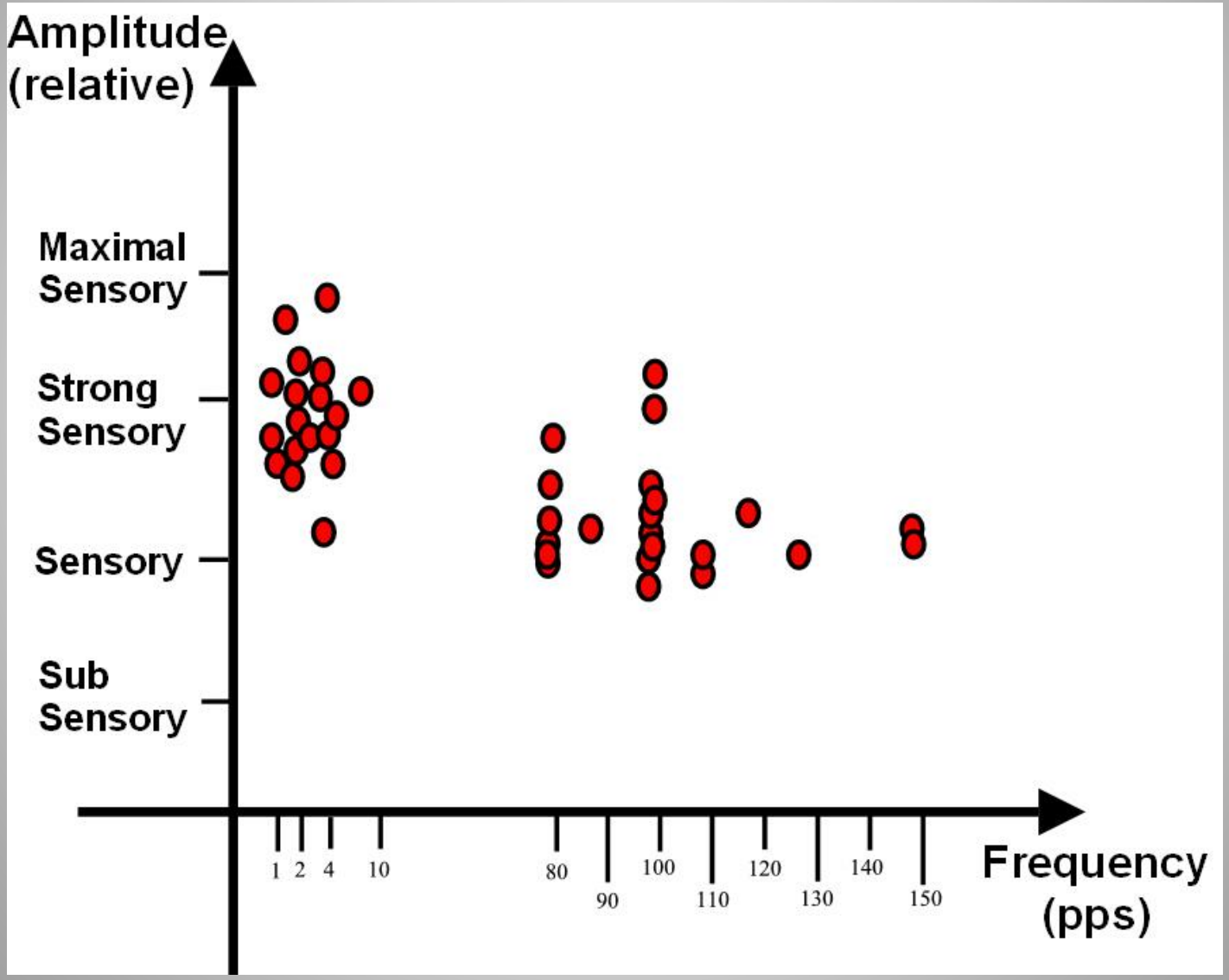
Appears to be more effective with CHRONIC pains
Effective DURING the stimulation period
But has a SIGNIFICANT CARRY OVER period
Can use for as long as needed – not time limited
Most commonly used in STIM/REST pattern
Typically 1-2 hrs ON followed by 1-2 hrs OFF

Low /Acupuncture / ACUTENS

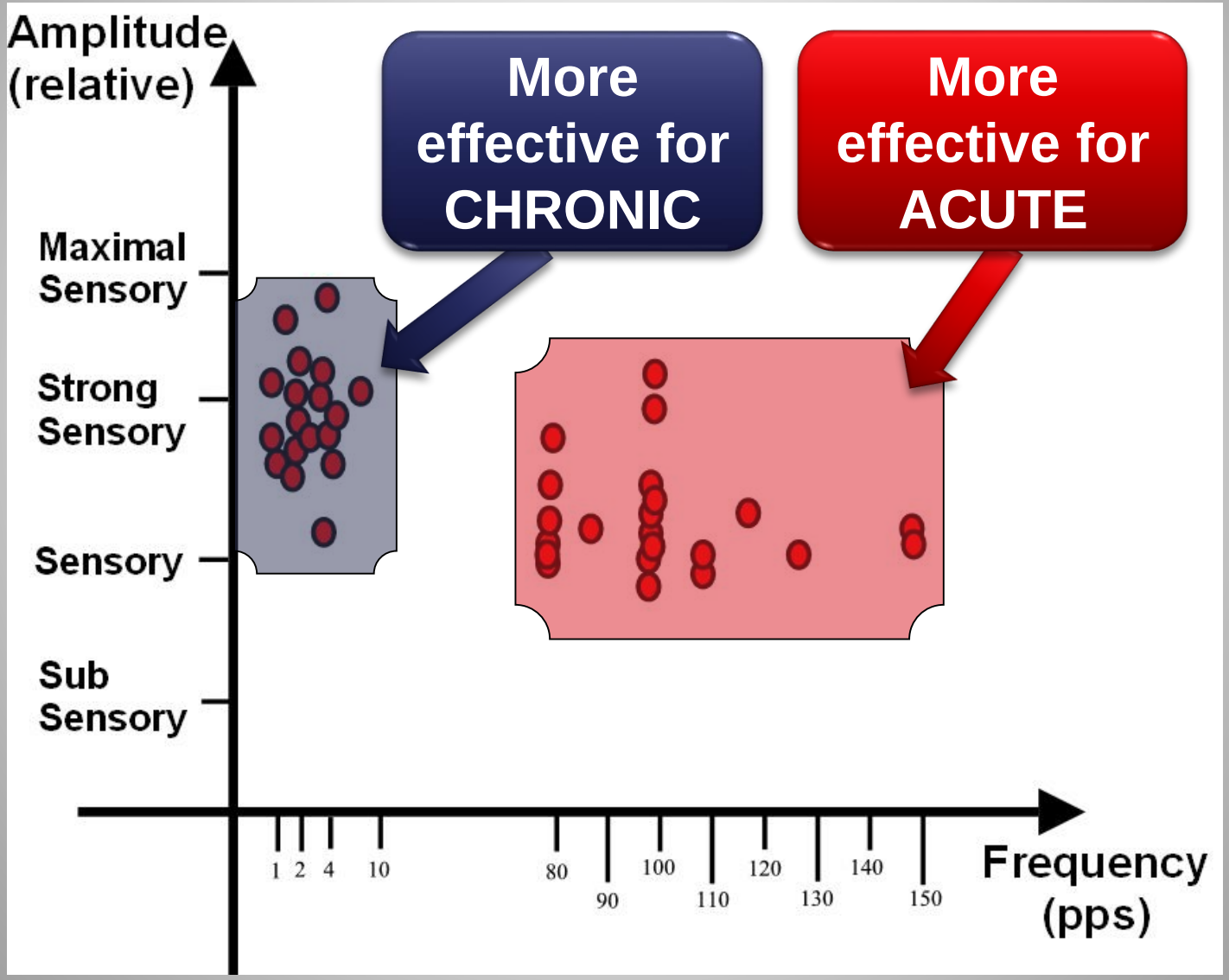


Acupuncture (Low frequency or ACUTENS) TENS using stimulation at a 'low' frequency typically between 2 - 5 Hz (pps)

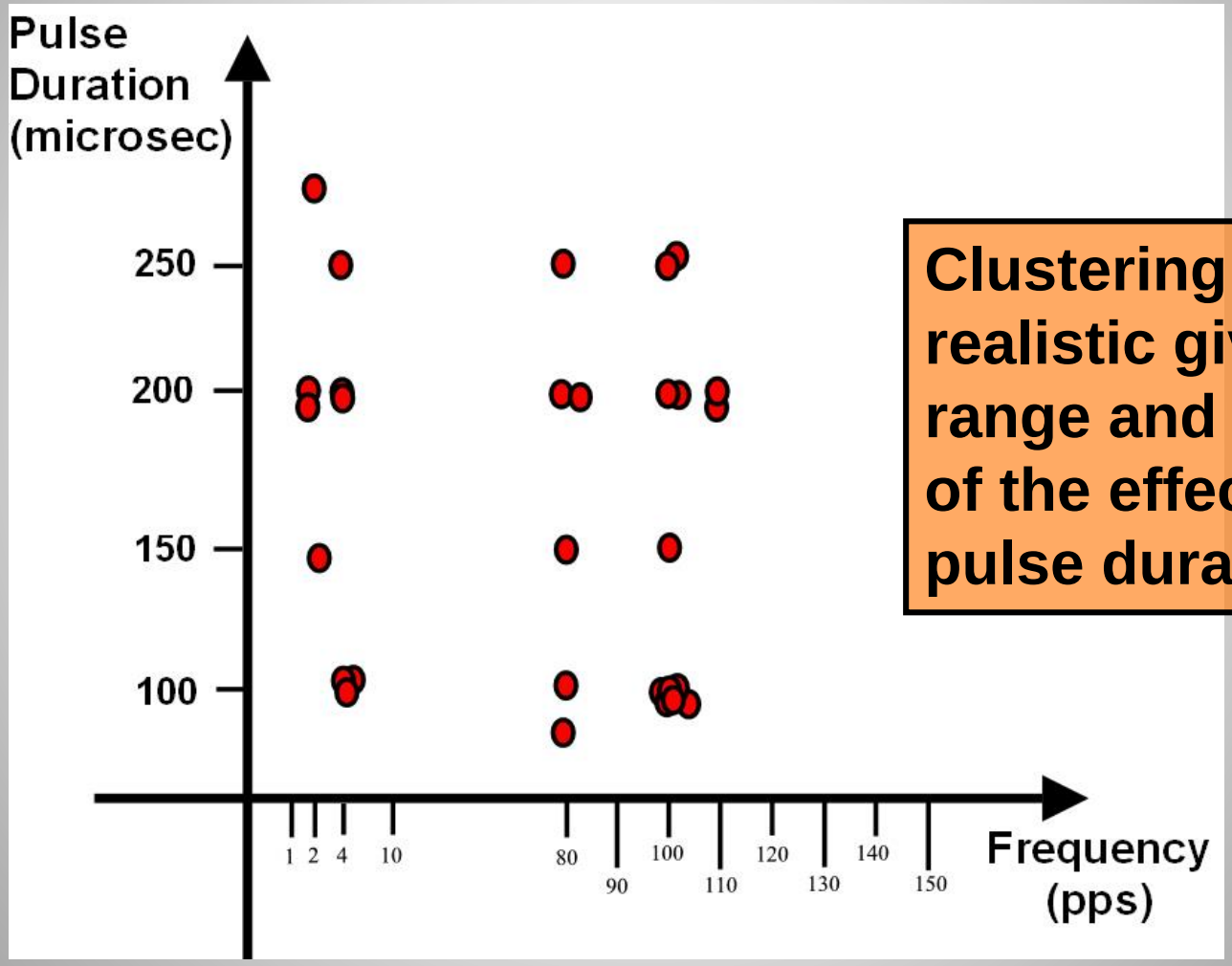
Looking at Pulse Frequency



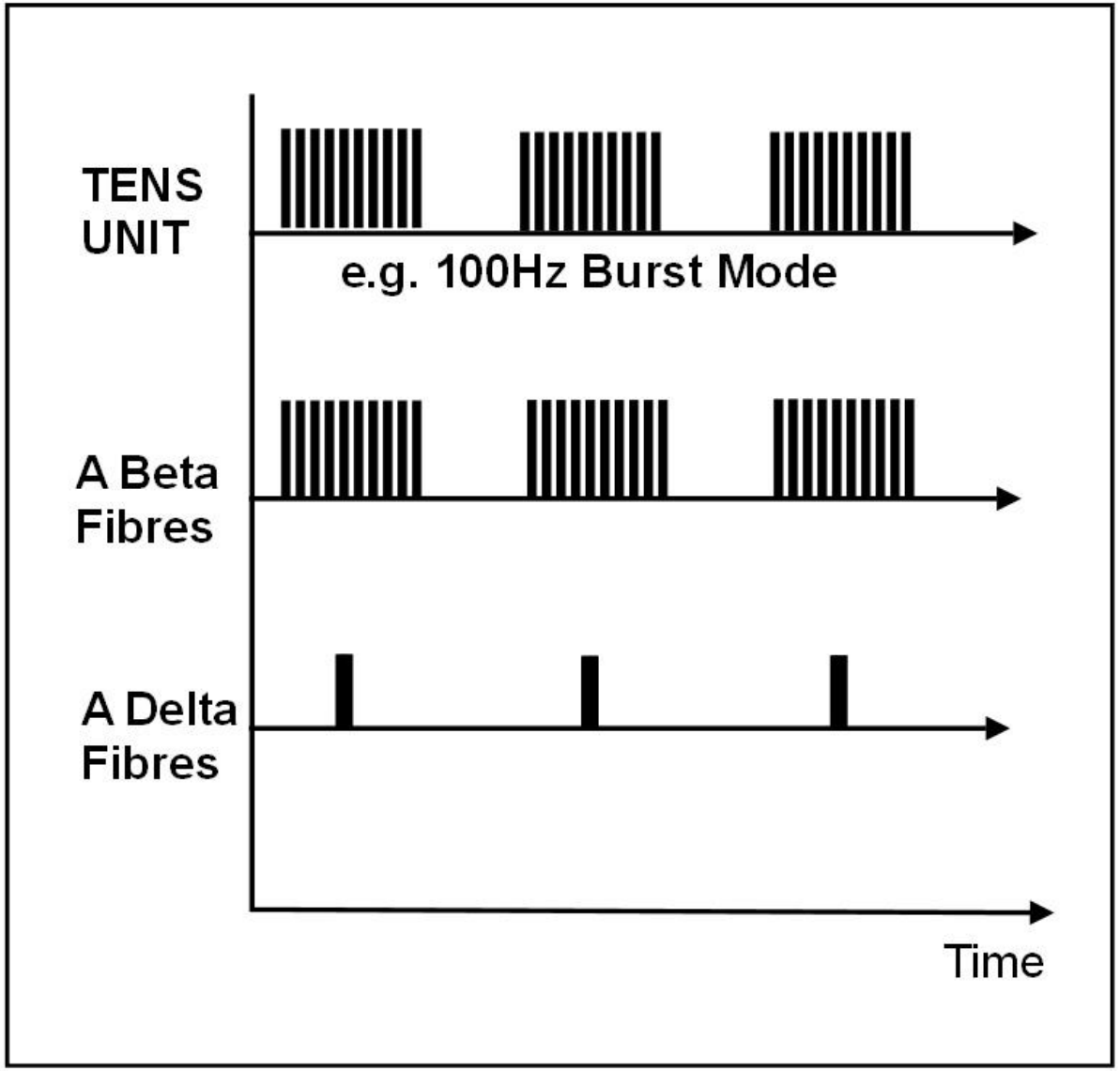
Pulse Frequency Clusters



Looking at Pulse Frequency combined with Pulse Duration



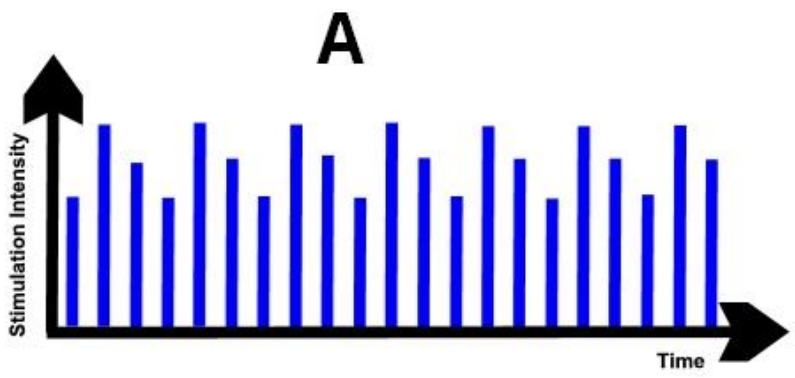
Clustering is not realistic given the range and spread of the effective pulse durations

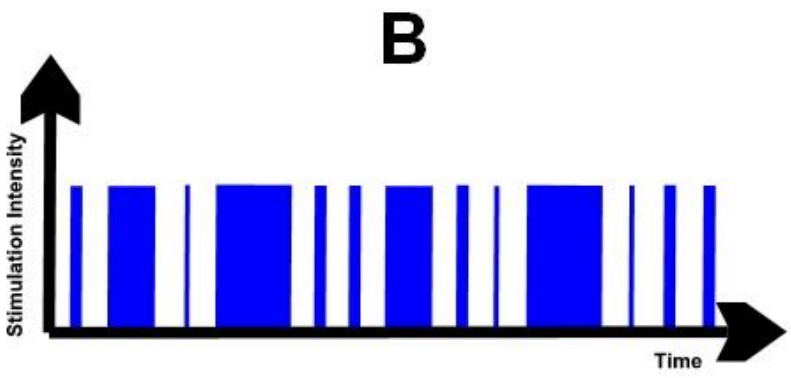


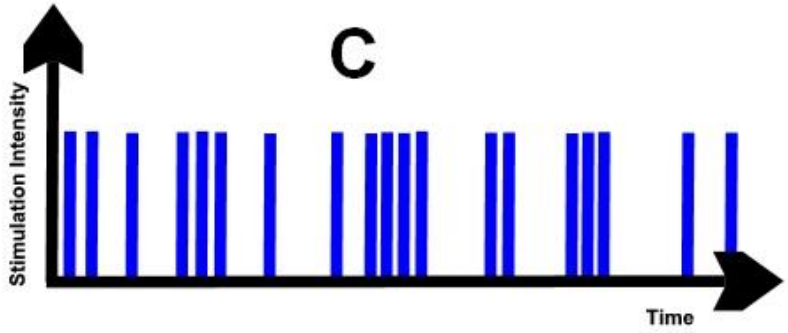
Burst Mode TENS

Stimulation (at around 100Hz) delivered in BURST mode (at 2-3Hz) such that both the A Beta fibres (due to 100Hz) and A Delta fibres (due to 2-3Hz) are stimulated.

Modulated Mode TENS

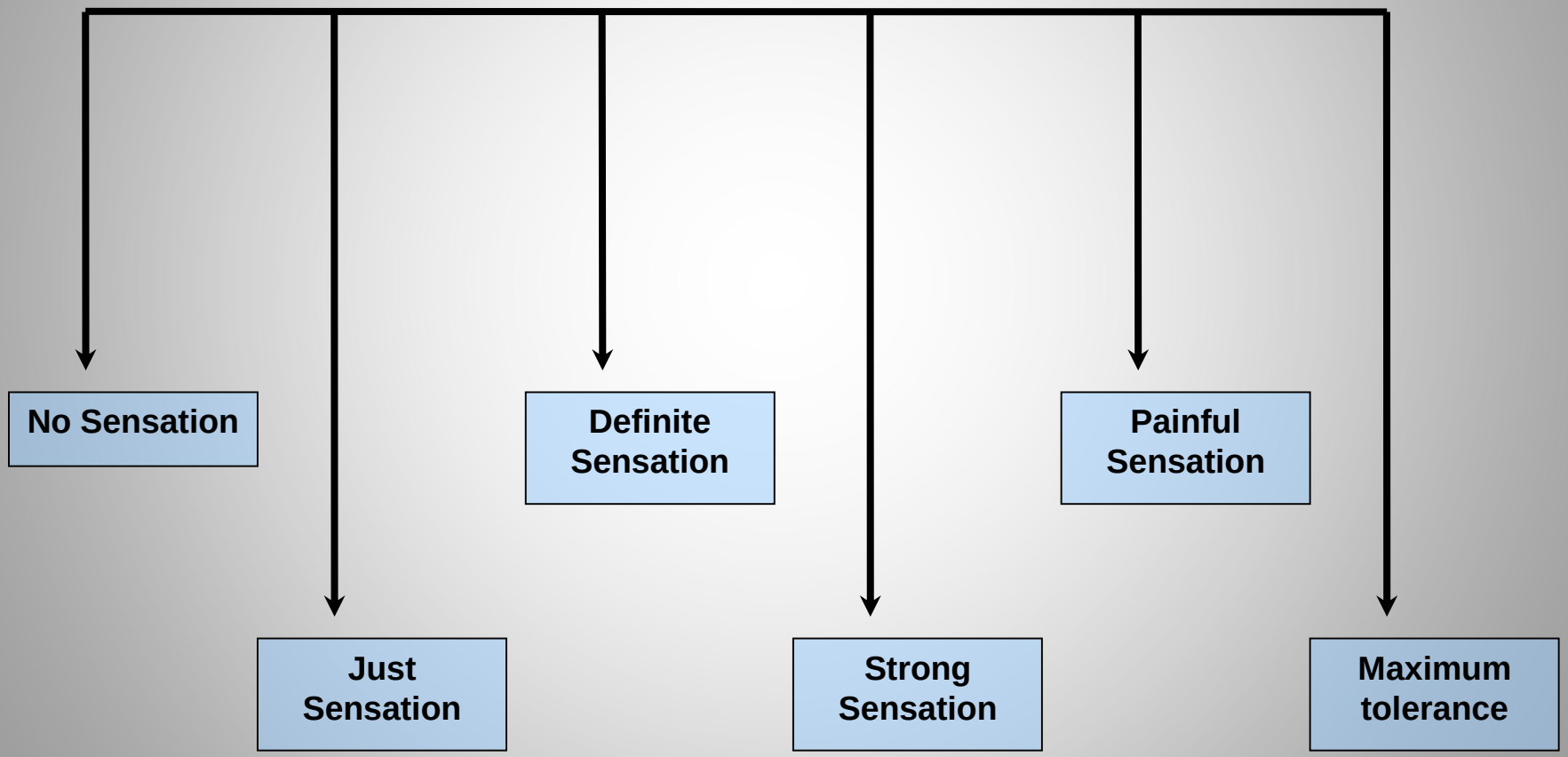




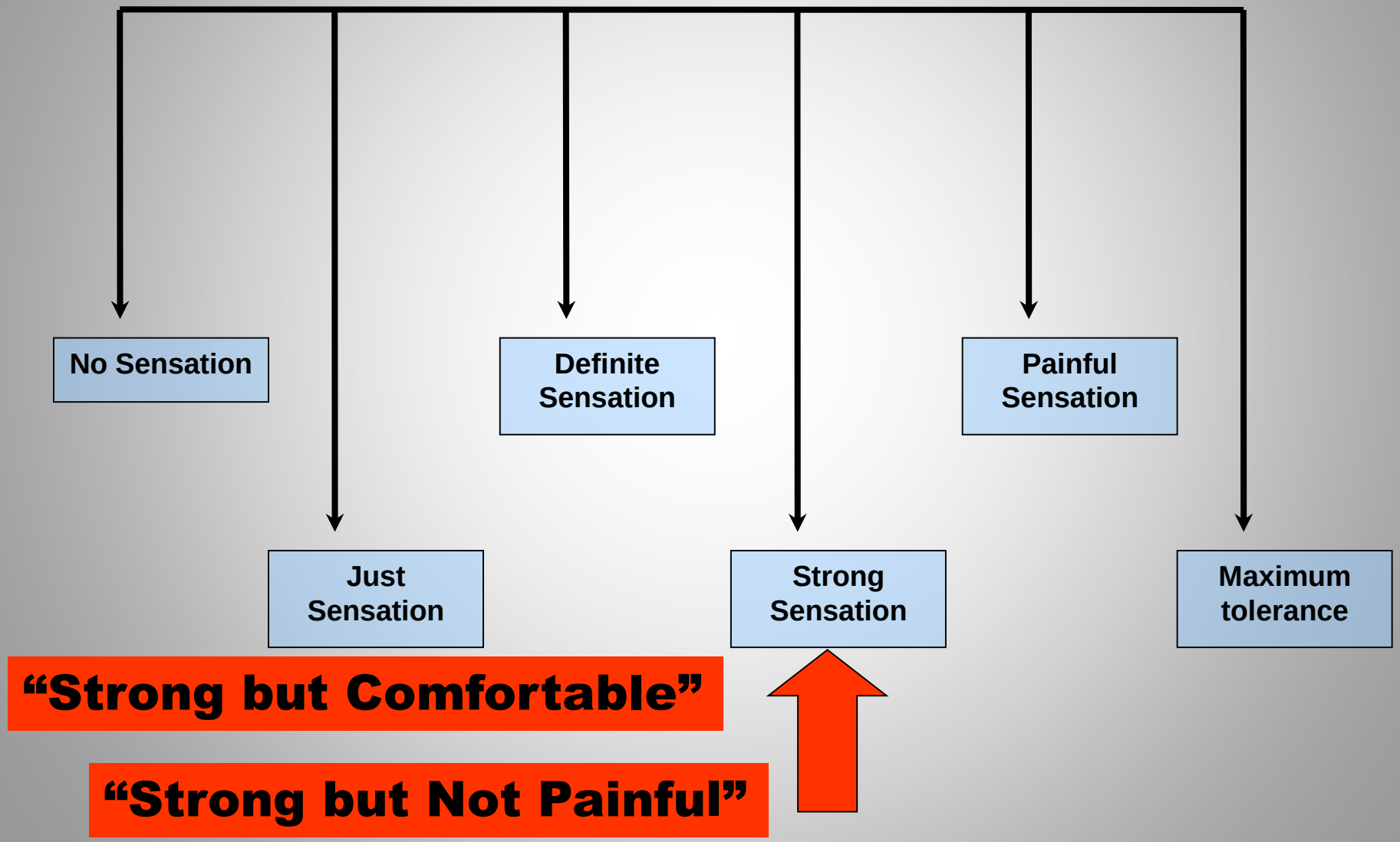


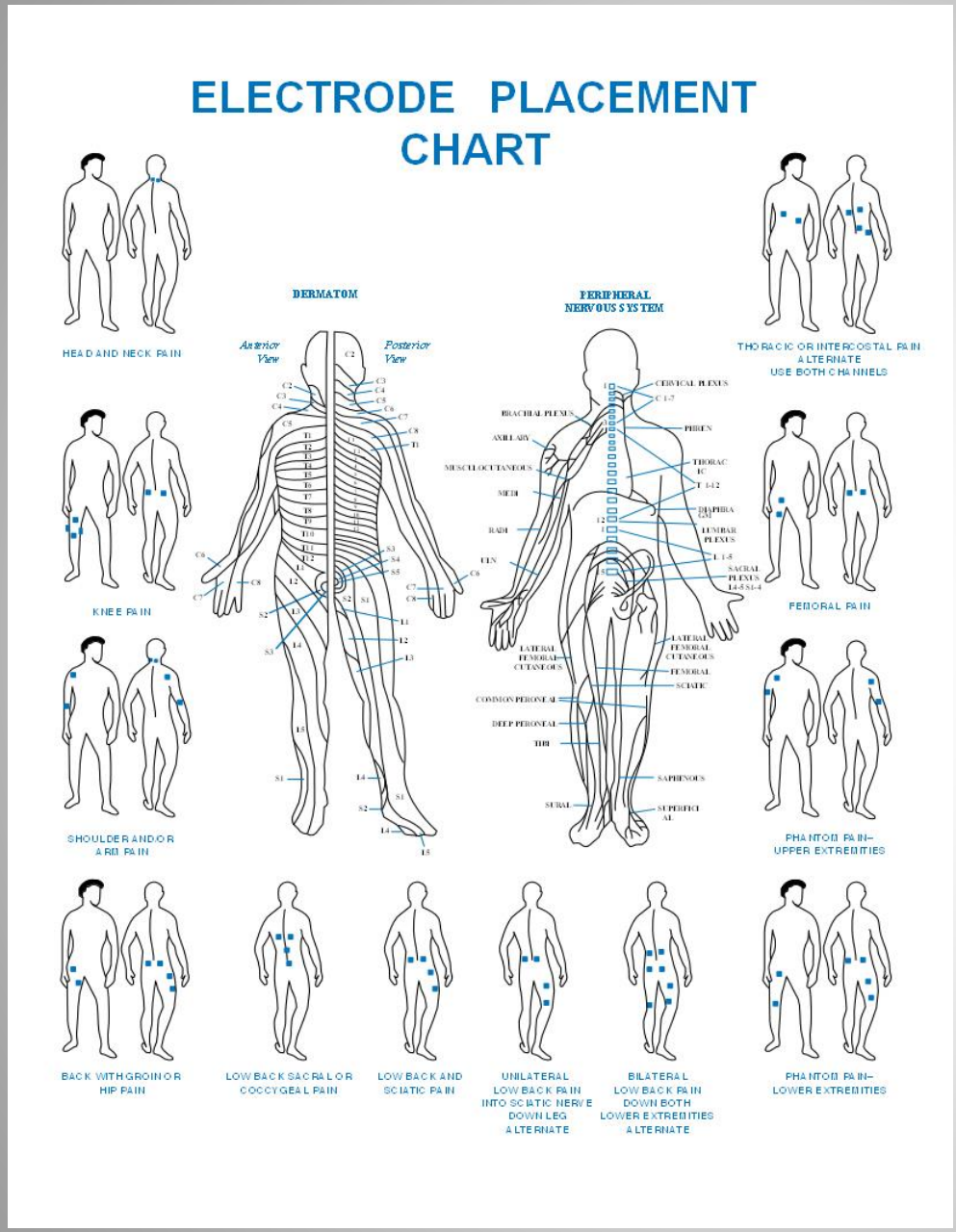
Modulation Mode TENS in which the stimulation pattern is varied in order to reduce nerve accommodation. Different modulation methods include
(A) INTENSITY
(B) PULSE DURATION
(C) FREQUENCY

Stimulation Intensity



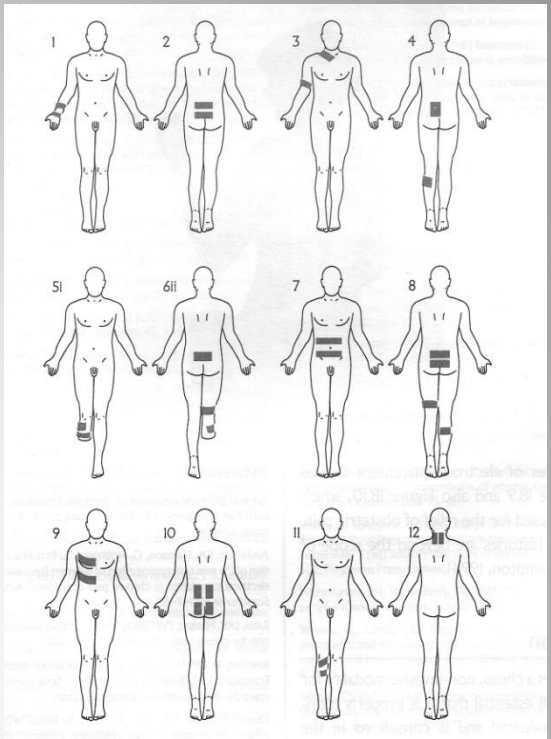
Stimulation Intensity



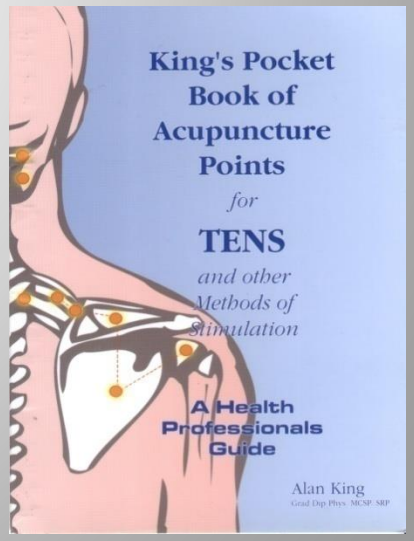


TENS Electrode Positioning

Electrode Placement



- √ Target stimulus at appropriate spinal level
- √ Either side of lesion
- √ Over nerve roots
- √ Over peripheral nerve
- √ At motor points
- √ At trigger/acupuncture points
- √ Dermatome, Myotome, Sclerotome
- √ If vague or extensive, can try 2 channel



TENS in Acute Pain Management

- Almost 15,000 paper on TENS (one sort or another) in database
- Almost 1200 specifically relate to TENS and ACUTE PAIN MANAGEMENT

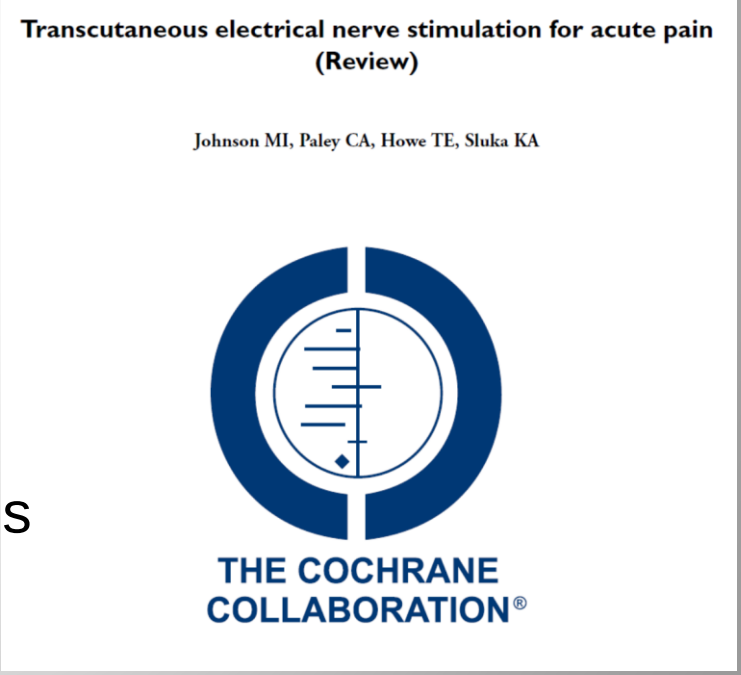
Author	Year	Title	pdf
Goncalves, T. C.; Londe, A...	2014	Cannabidiol and endogenous opioid peptide-mediated mechanisms modulate antinociception induced by transcutaneous electrostimul...	goncalves et al 2014
Ngee-Ming, G.; Tamsin, D...	2014	Complementary approaches to decreasing discomfort during shockwave lithotripsy (SWL)	-
Oo, W. M.	2014	Efficacy of addition of transcutaneous electrical nerve stimulation to standardized physical therapy in subacute spinal spasticity: a rand...	oo 2014
Silva, Julio Guilherme; Sa...	2014	Electrocortical Analysis of Patients with Intercostobrachial Pain Treated with TENS after Breast Cancer Surgery	silva et al 2014 b
Simpson, P. M.; Fouche, P....	2014	Transcutaneous electrical nerve stimulation for relieving acute pain in the prehospital setting: a systematic review and meta-analysis o...	simpson et al 2014
da Silva, M. L.; Chiappa, G...	2015	Effect of transcutaneous electrical nerve stimulation on peripheral to central blood pressure ratio in healthy subjects	
Diaz-Arribas, M. J.; Kovac...	2015	Effectiveness of the Godelieve Denys-Struyf (GDS) method in people with low back pain: cluster randomized controlled trial	diaz arribas et al 2015
Gross, A.; Langevin, P.; Bu...	2015	Manipulation and mobilisation for neck pain contrasted against an inactive control or another active treatment	gross et al 2015
Johnson, M. I.; Paley, C. A...	2015	Transcutaneous electrical nerve stimulation for acute pain	johnson et al 2015 b
Karakoyun, A.; Boyraz, I.; ...	2015	Electrophysiological and clinical evaluation of the effects of transcutaneous electrical nerve stimulation on the spasticity in the hemiple...	karakoyun et al 2015
Karakoyun, Ahmet; Boyra...	2015	Electrophysiological and clinical evaluation of the effects of transcutaneous electrical nerve stimulation on the spasticity in the hemiple...	karakoyun et al 2015
Lee, B.; Hong, S. H.; Kim, ...	2015	Efficacy of the device combining high-frequency transcutaneous electrical nerve stimulation and thermotherapy for relieving primary ...	lee et al 2015 b
Lee, C. H.; Lee, T. Y.; Her, J...	2015	Single-Blinded, Randomized Preliminary Study Evaluating the Effect of Transcutaneous Electrical Nerve Stimulation on Postoperative P...	lee et al 2015 c
Moeller Joensson, I.; Hag...	2015	Transcutaneous Electrical Nerve Stimulation Increases Rectal Activity in Children	-
Pak, Sok Cheon; Micalos, ...	2015	Nonpharmacological Interventions for Pain Management in Paramedicine and the Emergency Setting: A Review of the Literature	pak et al 2015
Pietrosimone, B.; Blackbu...	2015	Clinical strategies for addressing muscle weakness following knee injury	pietrosimone et al 20
Stepanovic, A.; Kolsek, M....	2015	Prevention of post-herpetic neuralgia using transcutaneous electrical nerve stimulation	-
Straube, A.; Ellrich, J.; Ere...	2015	Treatment of chronic migraine with transcutaneous stimulation of the auricular branch of the vagal nerve (auricular t-VNS): a randomi...	straube et al 2015 b
Gross, T.; Schneider, M. P.;...	2016	Transcutaneous Electrical Nerve Stimulation for Treating Neurogenic Lower Urinary Tract Dysfunction: A Systematic Review	gross et al 2016
Lamas, K.; Hager, C.; Lind...	2016	Does touch massage facilitate recovery after stroke? A study protocol of a randomized controlled trial	lamas et al 2015
Machado, A. F.; Liebano, R. ...	2016	Effect of High- and Low-Frequency Transcutaneous Electrical Nerve Stimulation on Angiogenesis and Myofibroblast Proliferation in Acute Excis...	machado et al 2016 c
Oncu, E.; Zincir, H.	2016	The Effect of Transcutaneous Electrical Nerve Stimulation in Patients with Acute Exacerbation of Chronic Obstructive Pulmonary Disease: Rando...	oncu and zincir 2016
Samuel, S. R.; Maiya, A. G.; V...	2016	Effectiveness of transcutaneous electrical nerve stimulation as a supplement to multimodal analgesia for acute post-operative pain following a...	samuel et al 2016
Tonuk, S. B.; Serin, E.; Ayhan,...	2016	The effects of physical therapeutic agents on serum levels of stress hormones in patients with osteoarthritis	tinuk et al 2016

Cochrane + Systematic Reviews

- We are all aware of the general ‘issues’ with Cochrane reviews
- Several publication (in EPA/therapy area) which highlight the issue of DOSE (stim parameters) which DO NOT routinely get included in the analysis
- e.g. Bjordal et al. (2005) Can Cochrane Reviews in controversial areas be biased? A sensitivity analysis based on the protocol of a Systematic Cochrane Review on low-level laser therapy in osteoarthritis. Photomed Laser Surg **23**(5): 453-458.

Johnson et al. (2015) Transcutaneous electrical nerve stimulation for acute pain Cochrane Database Syst Rev 6: CD006142.

- 2nd update from original (2009) (2011)
- Literature up to Dec 2014
- RCTs, adults with acute pain (< 12 weeks)
- TENS given as a sole treatment
- Assessed pain with subjective pain scales.
- Trials were eligible if they compared TENS to placebo TENS, no treatment controls, pharmacological interventions or non-pharmacological interventions.



Johnson et al (2015) Cochrane

- 12 trials in the original review (2009)
- None added for 2011 revision
- Additional 7 new trials met the inclusion criteria in 2015 update
- In total included **19 RCTs** involving **1346 patients**
- Most excluded trials because TENS was given in combination with another treatment as part of the formal study design or TENS was not delivered using appropriate TENS technique

Included Pain Studies

- Types of acute pain included
  - procedural pain, e.g. cervical laser treatment, venepuncture, screening flexible sigmoidoscopy
  - non-procedural pain, e.g. postpartum uterine contractions and rib fractures.

- Compare TENS with placebo
- Data pooled 6 trials. Substantial heterogeneity
- Mean difference with 95% confidence intervals on VAS (100 mm) was -24.62 mm (95% CI -31.79 to -17.46) in favour of TENS

- Proportion of participants achieving >/= 50% reduction in pain pooled 4 trials
- Relative risk was 3.91 (95% CI 2.42 to 6.32) in favour of TENS over placebo.

- Pooled data for pain intensity from 5 trials
- Considerable heterogeneity
- Mean Difference was -19.05 mm (95% CI -27.30 to -10.79) in favour of TENS (random-effects model)

Cochrane (2015) Conclusions

- “ . . . . This Cochrane Review update includes seven new trials, in addition to the 12 trials reviewed in the first update in 2011.
- The analysis provides tentative evidence that TENS reduces pain intensity over and above that seen with placebo (no current) TENS when administered as a stand-alone treatment for acute pain in adults.
- The high risk of bias associated with inadequate sample sizes in treatment arms and unsuccessful blinding of treatment interventions makes definitive conclusions impossible.
- There was incomplete reporting of treatment in many reports making replication of trials impossible.

Analysis 1.1. Comparison 1 TENS versus placebo TENS, Outcome 1 Pain intensity (100 mm VAS).

Review: Transcutaneous electrical nerve stimulation for acute pain

Comparison: 1 TENS versus placebo TENS

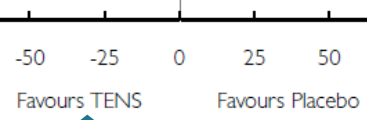
Outcome: 1 Pain intensity (100 mm VAS)

Study or subgroup	TENS N	Mean(SD)	Placebo N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Cheing 2005 (1)	10	17 (17)	9	46 (20)		10.2 %	-29.00 [-45.79, -12.21]
Ordog 1987 (2)	25	30.4 (26)	25	54.8 (25)		12.1 %	-24.40 [-38.54, -10.26]
Amer-Cuenca 2011 (3)	30	24.6 (24.6)	30	57.3 (27.9)		12.8 %	-32.70 [-46.01, -19.39]
Amer-Cuenca 2011 (4)	30	26.5 (24.7)	30	61.9 (23.2)		13.9 %	-35.40 [-47.53, -23.27]
Hruby 2006 (5)	48	35 (28.8)	49	43.7 (30.6)		14.1 %	-8.70 [-20.52, 3.12]
Oncel 2002 (6)	25	24 (13)	25	39 (20)		16.5 %	-15.00 [-24.35, -5.65]
Kim 2012 (7)	50	19 (12)	50	48 (15)		20.4 %	-29.00 [-34.32, -23.68]
Total (95% CI)	**218**		**218**			**100.0 %**	**-24.62 [-31.79, -17.46]**

Heterogeneity: $Tau^2 = 58.21$; $Chi^2 = 18.13$, df = 6 (P = 0.01); $I^2 = 67\%$

Test for overall effect: Z = 6.73 (P < 0.00001)

Test for subgroup differences: Not applicable



TENS Acute Pain Research Examples

- Unterrainer et al (2010). "Postoperative and preincisional electrical nerve stimulation TENS reduce postoperative opioid requirement after major spinal surgery." J Neurosurg Anesthesiol 22(1): 1-5. **SIGNIFICANTLY EFFECTIVE**

- Desantana et al (2009). "High and low frequency TENS reduce postoperative pain intensity after laparoscopic tubal ligation: a randomized controlled trial." Clin J Pain 25(1): 12-19. **SIGNIFICANTLY EFFECTIVE**

- Solak et al (2007). "Transcutaneous electric nerve stimulation for the treatment of postthoracotomy pain: a randomized prospective study." Thorac Cardiovasc Surg 55(3): 182-185. **SIGNIFICANTLY EFFECTIVE**

- Silva et al (2012). "Analgesic effect of transcutaneous electrical nerve stimulation after laparoscopic cholecystectomy." Am J Phys Med Rehabil 91(8): 652-657. **SIGNIFICANTLY EFFECTIVE**

TENS In Acute Pain Examples (contd)

- Samuel et al. (2016) "Effectiveness of transcutaneous electrical nerve stimulation as a supplement to multimodal analgesia for acute post-operative pain following abdominal surgery." Indian J Anaesth **60**(2): 151-152. SIGNIFICANTLY EFFECTIVE WITHOUT HAEMODYNAMIC COMPLICATIONS WHICH PATIENT WAS EXPERIENCING ON (OPIOID) MEDICATION
- Stepanovic et al. (2015) "Prevention of post-herpetic neuralgia using transcutaneous electrical nerve stimulation." Wien Klin Wochenschr **127**(9-10): 369-374. TENS SIG EFFECT LIMITING NUMBER OF ACUTE PROGRESSING TO CHRONIC/ESTABLISHED PHN
- Pak et al. (2015) "Nonpharmacological Interventions for Pain Management in Paramedicine and the Emergency Setting: A Review of the Literature." Evidence-Based Complementary and Alternative Medicine **2015**: 1-8
- Simpson et al. (2014) "Transcutaneous electrical nerve stimulation for relieving acute pain in the prehospital setting: a systematic review and meta-analysis of randomized-controlled trials." Eur J Emerg Med **21**(1): 10-17
- TENS as OPTION in EMERGENCY TRANSPORT PAIN MANAGEMENT (LINK UH CURRENT RESEARCH)
- Ozturk et al. (2016). "Comparison of Transcutaneous Electrical Nerve Stimulation and Parasternal Block for Postoperative Pain Management after Cardiac Surgery." Pain Res Manag **2016**: 4261949 TENS SIG EFFECT REDUCING POST OP OPIOID REQUIREMENTS THUS FASTER RECOVERY / FEWER SIDE EFFECTS

Significant Work on Stim Parameters and TIME

- e.g. Vance and colleagues in the USA
- Clearly demonstrating that [CLINICALLY], TENS at HIGH FREQ setting (for ACUTE pain) is MOST EFFECTIVE DURING APPLICATION
- Limited carry over / residual pain relief
- Research and clinical measures (e.g. VAS) should be taken DURING the TENS to get real reflection of effectiveness

[e.g. Vance et al (2014). Using TENS for pain control: the state of the evidence. Pain Manag 4(3): 197-209]

Under-dose of Home Based TENS?

- Many patients are told / instructed to use TENS say 1 x daily for 20 min
- Then compare pain relief effectiveness compared with a.n.other intervention or with placebo
- Not surprising that 1 x 20 min a day is not clinically effective, especially when employing conventional (high freq) TENS
- Especially when outcomes are taken a week or a month (or more) post end Rx

TENS under-dose trial example

Treatment of knee osteoarthritis with platelet-rich plasma in comparison with transcutaneous electrical nerve stimulation plus exercise: a randomized clinical trial

Hooman Angoorani[1], Ali Mazaherinezhad*[2], Omid Marjomaki[3], Shima Younespour[4]

- Angoorani et al. (2015) Med J Islam Repub Iran **29**: 223
- Compared 2 x PRP injections vs TENS + Ex's
- TENS was for 30 min 2 x weekly over 5 weeks
- Conclude that PRP has sig effect on knee symptom score (KOOS) but TENS does not!