Appendix 1. Search strategy

Pubmed:

("Transcutaneous Electric Nerve Stimulation"[Mesh]) OR ("Electric Stimulation Therapy"[Mesh]) OR ("Electric Stimulation"[Mesh]) OR (TENS[Text Word]) OR (Transcutaneous electric* nerve stimulation[Text Word]) OR (transcutaneous nerve stimulation[Text Word]) OR (TNS[Text Word]) OR (TENMS[Text Word]) OR (Transcutaneous Electric* Stimulation[Text Word]) OR (Transcutaneous electric* neurostimulation[Text Word]) OR (Analgesic Cutaneous Electrostimulation[Text Word]) OR (Transcutaneous Electric* Nerve[Text Word] OR Muscle Stimulation[Text Word]) OR (Transcutaneous Muscle Stimulation[Text Word]) OR (Transdermal electric* stimulation[Text Word]) OR (Transcutaneous electrostimulation[Text Word]) OR (Transdermal Electrostimulation[Text Word]) OR (Percutaneous Electric* Nerve Stimulation[Text Word]) OR (Peripheral conditioning stimulation[Text Word]) OR (Percutaneous neural stimulation[Text Word]) OR (Microamperage electric* stimulation[Text Word]) OR (electroanalgesia[Text Word]) OR (electrotherapy[Text Word]) OR (electro therapy[Text Word]) OR (electro analgesia[Text Word]) OR (Micro amperage electric* stimulation[Text Word]) OR (Per cutaneous Electric* Nerve Stimulation[Text Word]) OR (Trans dermal Electrostimulation[Text Word]) OR (Transdermal Electro stimulation[Text Word]) OR (Trans dermal Electro stimulation[Text Word]) OR (Trans cutaneous electrostimulation[Text Word]) OR (Transcutaneous electro stimulation[Text Word]) OR (Trans cutaneous electro stimulation[Text Word]) OR (Trans dermal electric* stimulation[Text Word]) OR (Trans cutaneous Electric* Nerve[Text Word]) OR (Trans cutaneous Electric* Stimulation[Text Word]) OR (Trans cutaneous electric* nerve stimulation[Text Word]) OR (Trans-cutaneous Electric Nerve Stimulation[Text Word]) OR (Trans cutaneous Electric Nerve Stimulation[Text Word])

AND

(shoulder[Text Word]) OR ("Shoulder Joint"[Mesh]) OR ("Shoulder"[Mesh]) OR ("Rotator Cuff"[Mesh]) OR (rotator cuff[Text Word])

AND

(frozen[Text Word]) OR (tendinitis[Text Word]) OR (impinge*[Text Word]) OR (bursitis[Text Word]) OR (pain*[Text Word]) OR ("Tendinopathy"[Mesh]) OR "Pain"[Mesh]) OR ("Shoulder Impingement Syndrome"[Mesh]) OR ("Bursitis"[Mesh]) OR ("Shoulder Pain"[Mesh])

Scopus:

(TITLE-ABS-KEY ((frozen) OR (tendinitis) OR (impinge*) OR (bursitis) OR (pain*) OR (tendinopathy) OR ("Impingement Syndrome") OR (bursitis)) AND TITLE-ABS-KEY ((shoulder) OR ("Shoulder Joint") OR ("Rotator Cuff")) AND TITLE-ABS-KEY (("Transcutaneous Electric Nerve Stimulation") OR ("Electric Stimulation Therapy") OR ("Electric Stimulation") OR (tens) OR ("Transcutaneous electric* nerve stimulation") OR ("transcutaneous nerve stimulation") OR (tns) OR (tenms) OR ("Transcutaneous Electric* Stimulation") OR ("Transcutaneous electric* neurostimulation") OR ("Analgesic Cutaneous Electrostimulation") OR ("Transcutaneous Electric* Nerve") OR ("Muscle Stimulation") OR ("Transcutaneous Muscle Stimulation") OR ("Transdermal electric* stimulation") OR ("Transcutaneous electrostimulation") OR ("Transdermal Electrostimulation") OR ("Percutaneous Electric* Nerve Stimulation") OR ("Peripheral conditioning stimulation") OR ("Percutaneous neural stimulation") OR ("Microamperage electric* stimulation") OR (electroanalgesia) OR (electrotherapy) OR ("electro therapy") OR ("electro analgesia") OR ("Micro amperage electric* stimulation") OR ("Per cutaneous Electric* Nerve Stimulation") OR ("Trans dermal Electrostimulation") OR ("Transdermal Electro stimulation") OR ("Trans dermal Electro stimulation") OR ("Trans cutaneous electrostimulation") OR ("Transcutaneous electro stimulation") OR ("Trans cutaneous electro stimulation") OR ("Trans dermal electric* stimulation") OR ("Trans cutaneous Electric* Nerve") OR ("Trans cutaneous Electric* Stimulation") OR ("Trans cutaneous electric* nerve stimulation") OR ("Trans-cutaneous Electric Nerve Stimulation") OR ("Trans cutaneous Electric Nerve Stimulation")))

Cochrane:

#1 MeSH descriptor: [Shoulder] explode all trees

#2 MeSH descriptor: [Rotator Cuff] explode all trees

#3 MeSH descriptor: [Shoulder Impingement Syndrome] explode all trees

#4 MeSH descriptor: [Rotator Cuff Injuries] explode all trees

#5 MeSH descriptor: [Tendinopathy] explode all trees

#6 MeSH descriptor: [Bursitis] explode all trees

#7 MeSH descriptor: [Pain] explode all trees

#8 (frozen):ti,ab,kw OR (tendinitis):ti,ab,kw OR (impinge*):ti,ab,kw

#9 #1 OR #2

#10 #3 OR #4

#11 #5 OR #6 OR #7 OR #8

#12 #9 AND # 10

#13 #10 OR #12

#14 MeSH descriptor: [Transcutaneous Electric Nerve Stimulation] explode all trees

#15 MeSH descriptor: [Electric Stimulation Therapy] explode all trees

#16 MeSH descriptor: [Electric Stimulation] explode all trees

#17 #14 OR #15 OR #16

#18 #13 AND # 17

Web of Knowledge

(TENS):ti,ab,kw OR (TNS):ti,ab,kw OR (TENMS):ti,ab,kw OR (electroanalgesia):ti,ab,kw OR (electrotherapy):ti,ab,kw OR (Transcutaneous electric* nerve stimulation):ti,ab,kw OR (transcutaneous nerve stimulation):ti,ab,kw OR (Transcutaneous Electric* Stimulation):ti,ab,kw OR (Transcutaneous electric* neurostimulation):ti,ab,kw OR (Analgesic Cutaneous Electrostimulation):ti,ab,kw OR (Transcutaneous Electric* Nerve):ti,ab,kw OR (Muscle Stimulation):ti,ab,kw OR (Transcutaneous Muscle Stimulation):ti,ab,kw OR (Transdermal electric* stimulation):ti,ab,kw OR (Transcutaneous electrostimulation):ti,ab,kw OR (Transdermal Electrostimulation):ti,ab,kw OR (Percutaneous Electric* Nerve Stimulation):ti,ab,kw OR (Peripheral conditioning stimulation):ti,ab,kw OR (Percutaneous neural stimulation):ti,ab,kw OR (Microamperage electric* stimulation):ti,ab,kw PR ("electro-therapy"):ti,ab,kw OR ("electro-analgesia"):ti,ab,kw OR (Micro amperage electric* stimulation):ti,ab,kw OR (Per cutaneous Electric* Nerve Stimulation):ti,ab,kw OR (Trans dermal Electrostimulation):ti,ab,kw OR (Transdermal Electro stimulation):ti,ab,kw OR (Trans dermal Electro stimulation):ti,ab,kw OR (Trans cutaneous electrostimulation):ti,ab,kw OR (Transcutaneous electro stimulation):ti,ab,kw OR (Trans cutaneous electro stimulation):ti,ab,kw OR (Trans dermal electric* stimulation):ti,ab,kw OR (Trans cutaneous Electric* Nerve):ti,ab,kw OR (Trans cutaneous Electric* Stimulation):ti,ab,kw OR (Trans cutaneous electric* nerve stimulation):ti,ab,kw OR ("trans-cutaneous electric nerve stimulation"):ti,ab,kw

Appendix 2. To ensure consistency in GRADE judgments, the following assessment criteria were applied:

1. Risk of Bias: One level was downgraded if a single risk of bias (selection, performance, or detection bias) was identified, and two levels were downgraded if multiple risks of bias were detected.
2. Inconsistency: One level was downgraded if there was statistically significant heterogeneity with an I^2 statistic value exceeding 70%, or if the direction of effect was inconsistent. Two levels were downgraded if both statistically significant heterogeneity and inconsistent direction of effect were observed.
3. Indirectness: One level was downgraded if studies included co-interventions or if the etiology of shoulder pain varied. Two levels were downgraded if both the etiology of shoulder pain varied and co-interventions were present.
4. Imprecision: One level was downgraded if each study arm had fewer than 400 participants.
5. Publication Bias: One level was downgraded if there was direct evidence of publication bias.

Appendix 3. In preparing the data for meta-analysis, we followed the following procedures:

1. If the data was not explicitly provided in the text or tables, we extracted it from the plots and graphs (WebPlotDigitizer).
2. Available data such as standard errors (SE) or confidence intervals (CI) were used in cases where the mean or standard deviation was not reported. Additionally, data from studies that did not report normal data distribution or provided median and range values were calculated according to the methods recommended by the Cochrane Handbook, version 5.0.1, to ensure consistency in GRADE judgments.
3. When studies employed multiple units of pain measurement, we prioritized the visual analog scale (VAS) and used it for the meta-analysis.
4. Data were extracted at the immediate time point following the cessation of TENS. For studies that prescribed TENS as a treatment course, data from the final treatment session were considered to reflect the immediate effect.
5. In multi-arm studies, to prevent unit-of-analysis errors arising from multiple control groups, we pooled the control groups based on the Cochrane Handbook, version 5.0.1.

Appendix 4. Summary of the TENS details

Study ID	TENS mode	Frequency (Hz)	Pulse waveform	Pulse width (ms)	Intensity (mA)	Duration of session	Total of Sessions (follow-ups)	Electrodes location
Leandri et al, 1990	High-Intensity TENS Low-Intensity TENS	100 Hz	Square pulses	0.2 μs	3x sensory threshold 1x sensory threshold	-	12s/4w Immediate	-
Herrera-Lasso et al, 1993	TENS	50 Hz	-		Slow pricking or tickling sensation	-	1s Immediate	Anterior and posterior Shoulder areas
Pan et al, 2003	Conventional TENS	95Hz	constant square wave pulse	0.5ms	local contraction of the muscles with a mild pain intensity that was acceptable to the patient	20 minutes Daily	12s/4w Immediate	Skin at the sub-acromion painful area
Ozdincler 2005	Conventional TENS	80 Hz	-	140 μs	-	30 minutes Daily	15s/3w Immediate Mid term	Painful area
Baskurt et al, 2006	Conventional TENS	100 Hz	Symmetric biphasic wave form	0.1 ms	Tolerable intensity	20 minutes Daily	1s Immediate	-
Poeneru et al, 2008	Conventional TENS	80 Hz			Threshold intensity	20 minutes	15s/15d	Subscapularis muscle

			-			Daily	Immediate	
Bello et al, 2009	Conventional TENS	100 Hz	-	60 μs	Low intensity	30 minutes Daily	12s/6w Immediate	-
Eyigor et al, 2010	Conventional TENS	100 Hz	-	150 μs	15 mA	30 minutes Daily	15s/3w Short term Mid term Long term	Anterior and posterior aspects of the joint
Korkmaz et al, 2010	Conventional TENS	100 Hz	-	150 μs	15 mA	30 minutes Daily	20s/4w Short term Mid term Long term	Anterior and posterior aspects of the joint
Lin et al, 2015	Acupuncture Like TENS	2 Hz	-	-	-	15 minutes Daily	3s/1w Immediate	-
Ashtiani et al, 2016	Burst mode TENS	50-100 Hz	-	70 ms	-	20 minutes Daily	6s Immediate	Two sides of pain region
Tiwari et al, 2018	Acupuncture Like TENS	30 Hz	Biphasic Surge current	300 μs	-	30 minutes Daily	30s/ 6w Immediate	Muscles attachment area of supraspinatus, middle deltoid and posterior deltoid muscles
Ucurum et al, 2018	Conventional TENS	-	-	-	-	20 minutes Daily	12s/4w Immediate Short term Mid term	-

							Long term	
Zhou et al, 2018	Conventional TENS	100 Hz	-	100 µs	Minimal discomfort without any discernible Muscle contraction (20-50mA)	60 minutes Daily	20s/4w Short term Mid term Long term	Near the motor points of the supraspinatus and medial or posterior bundle of deltoids.
Vrouva et al, 2019	Conventional TENS	100 Hz	-	-	10-15 mA	20 minutes Daily	15s/3w Immediate Long term	Four electrodes on either side of the deltoid muscle on the front and back surfaces of the shoulder joint
Lin et al, 2019	Conventional TENS	150 Hz	Asymmetric triangular waveform	700 µs	-	15 minutes Daily	3 s Immediate short term Mid term Long term	Maximally tender area and inferior margin of the deltoid muscle
Badaru et al, 2020	-	80 Hz	-	60 µs	-	10 minutes for each of the 3 muscles	16s/8w Immediate	Subscapularis, posterior deltoid and supraspinatus muscles
Rani et al, 2020	Conventional TENS	100 Hz	-	120 µs	Low intensity (30- 40mA)	20 minutes Daily	5 s Immediate	-
Billek et al, 2021	Conventional TENS	100 Hz	Asymmetrical biphasic current	65 µs	Comfortable without causing pain and any Muscle twitch/contraction	30 minutes Daily	1 s Immediate	Crossing each other and surrounding the affected area

Appendix 5. Evaluation of the certainty of the pain evidence with the GRADE

Effect of TENS on Shoulder pain compared to control for Shoulder Pain

Certainty assessment							Summary of findings				
							Study event rates (%)			Anticipated absolute effects	
Participants (studies) Follow-up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	With placebo	With Immediate Effect of TENS on Shoulder pain	Relative effect (95% CI)	Risk with placebo	Risk difference with Immediate Effect of TENS on Shoulder pain
Immediate Effect of TENS on Shoulder pain											
978 (16 RCTs)	very serious[a]	serious[b]	very serious[c]	not serious	publication bias strongly suspected[d]	⨁◯◯◯ Very low	519	459	-	-	SMD **0.15 higher** (0.3 lower to 0.6 higher)
Effect of TENS on Shoulder pain - Long term effect											
122 (3 RCTs)	serious[e]	not serious	serious[f]	serious[g]	none	⨁◯◯◯ Very low	61	61	-	-	SMD **0.42 higher** (0.1 lower to 0.93 higher)

CI: confidence interval; **SMD:** standardised mean difference

Explanations

a. We downgraded 2 levels for serious Risk of bias (high risk of selection, performance, and detection bias).

b. We downgrade 1 level for serious unexplained inconsistency (substantial heterogeneity I2 = 91%),

c. We downgraded 2 levels for very serious indirectness (10 studies had co-intervention with TENS, the etiology of shoulder pain was different, and different types of control groups).

d. Publication bias detected due to Trim-&-Fill analysis showed five missing studies on the left side

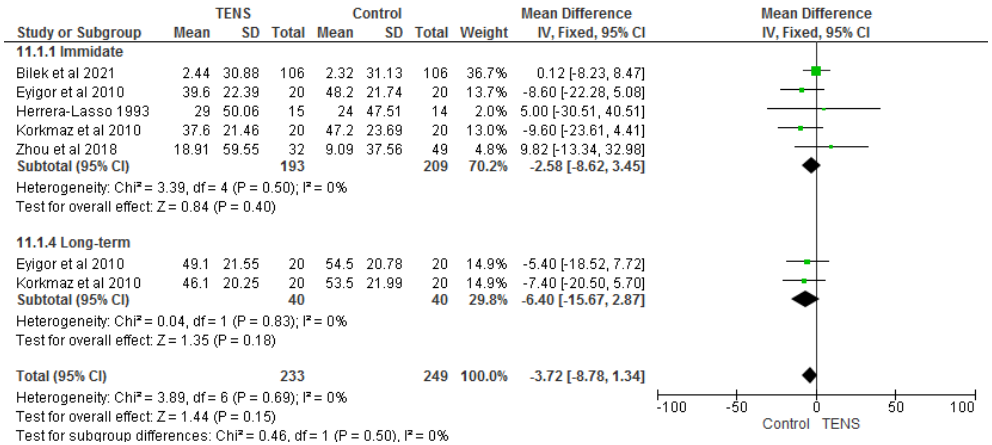
e. We downgraded 1 level for serious Risk of bias (high risk of detection bias).

f. We downgraded 1 level for serious indirectness (different control group)

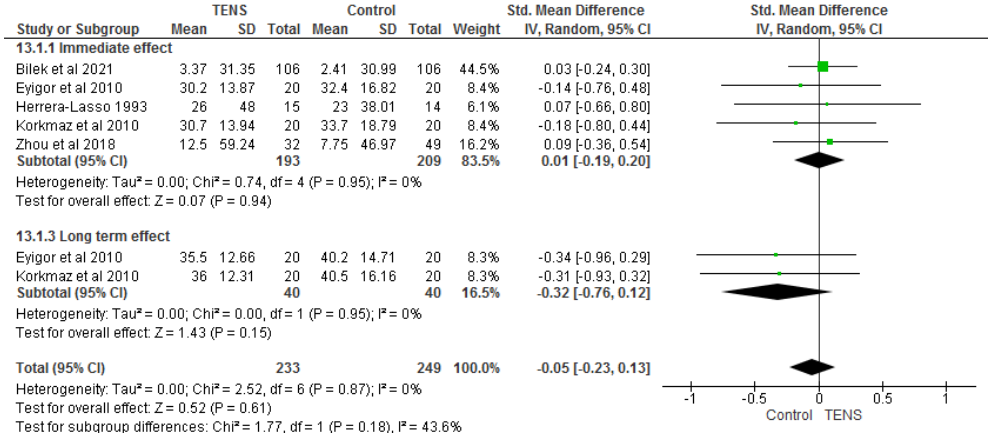
g. We downgraded 1 level for serious imprecision (All studies sample size was low (<100 participants), and the number of participants in each arm was fewer than 400)

Appendix 6. Effect of TENS on active range of motion. Abduction (A), Flexion (B), External rotation (C), and Internal rotation (D)

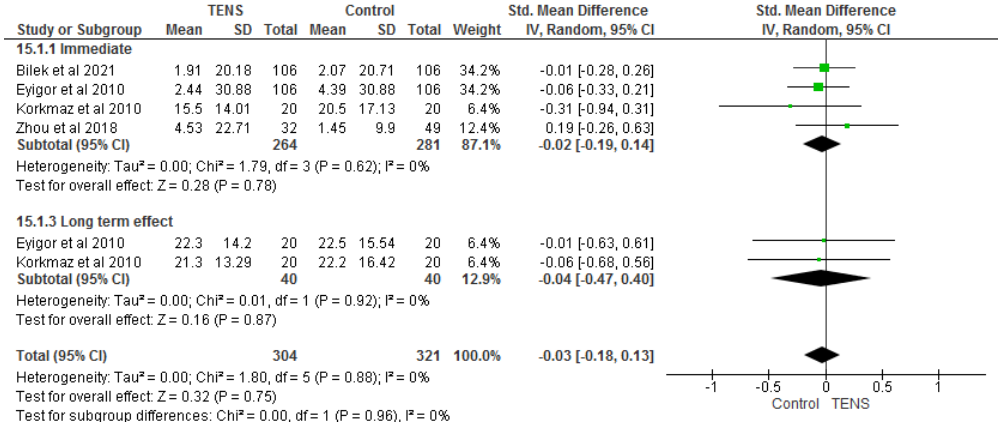
A



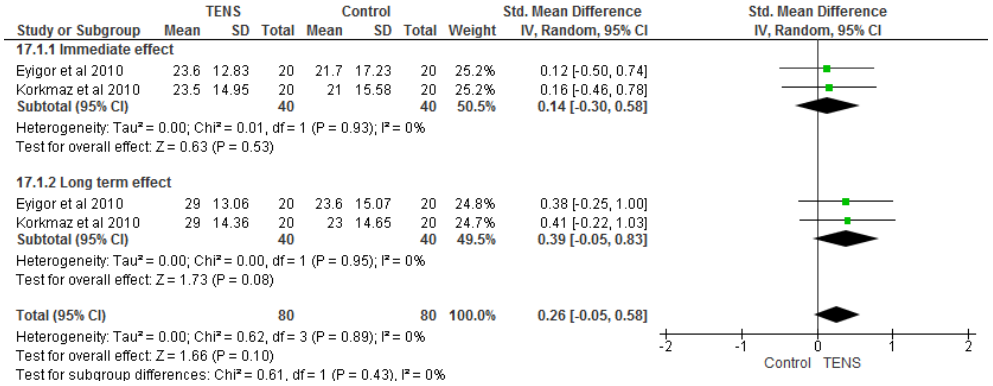
B



C



D



Appendix 7. Evaluation of the certainty of the Range of motion evidence with the GRADE

Effect of TENS on Shoulder Range of Motion compared to control group

Certainty assessment							Summary of findings				
							Study event rates (%)			Anticipated absolute effects	
Participants (studies) Follow-up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	With placebo	With Effect of TENS on Shoulder Active Abduction	Relative effect (95% CI)	Risk with placebo	Risk difference with Effect of TENS on Shoulder Active Abduction
Effect of TENS on Shoulder Active Abduction											
563 (5 RCTs)	serious[a]	not serious	very serious[b]	serious[c]	none	⨁◯◯◯ Very low	298	265	-	-	SMD **0.05 lower** (0.22 lower to 0.11 higher)
Effect of TENS on Shoulder Passive Abduction											
271 (4 RCTs)	serious[a]	not serious	very serious[b]	serious[c]	none	⨁◯◯◯ Very low	139	132	-	-	SMD **0.11 lower** (0.45 lower to 0.24 higher)
Effect of TENS on Shoulder Active Flexion											

Effect of TENS on Shoulder Range of Motion compared to control group

Certainty assessment							Summary of findings				
482 (5 RCTs)	serious[a]	not serious	very serious[b]	serious[c]	none	⨁◯◯◯ Very low	249	233	-	-	SMD **0.05 lower** (0.23 lower to 0.13 higher)

Effect of TENS on Shoulder Passive Flexion

281 (4 RCTs)	serious[a]	not serious	very serious[b]	serious[c]	none	⨁◯◯◯ Very low	149	132	-	-	SMD **0.05 lower** (0.29 lower to 0.18 higher)

Effect of TENS on Shoulder Active External Rotation

625 (4 RCTs)	serious[a]	not serious	very serious[b]	serious[c]	none	⨁◯◯◯ Very low	321	304	-	-	SMD **0.03 lower** (0.18 lower to 0.13 higher)

Effect of TENS on Shoulder Passive External Rotation

281 (4 RCTs)	serious[a]	not serious	very serious[b]	serious[c]	none	⨁◯◯◯ Very low	149	132	-	-	SMD **0.09 lower** (0.42 lower to 0.24 higher)

Effect of TENS on Shoulder Active Internal Rotation

Effect of TENS on Shoulder Range of Motion compared to control group

Certainty assessment							Summary of findings				
160 (2 RCTs)	serious[a]	not serious	serious[d]	serious[c]	none	⨁◯◯◯ Very low	80	80	-	-	SMD **0.26 higher** (0.05 lower to 0.58 higher)

Effect of TENS on Shoulder Passive Internal Rotation

160 (2 RCTs)	serious[a]	not serious	serious[d]	serious[c]	none	⨁◯◯◯ Very low	80	80	-	-	SMD **0.04 higher** (0.27 lower to 0.35 higher)

CI: confidence interval; **SMD:** standardised mean difference

Explanations

a. We downgraded 1 level for serious Risk of bias (high risk of detection bias).

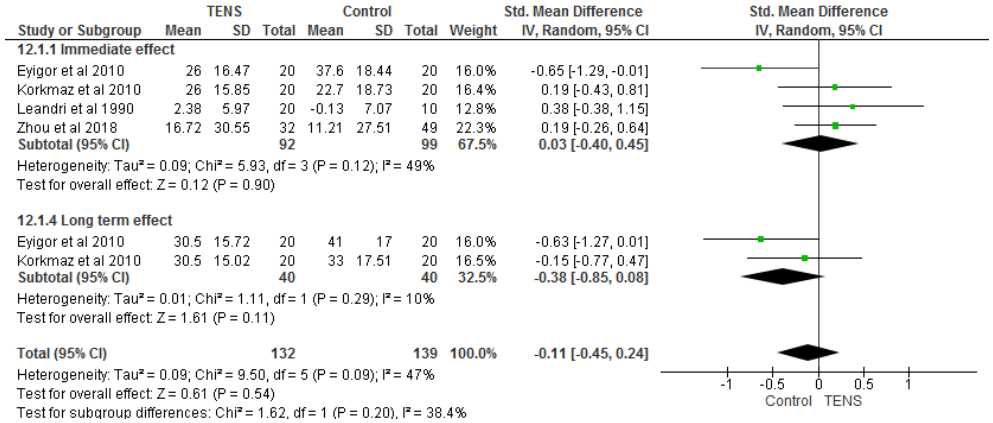
b. We downgraded 2 levels for very serious indirectness (Co-intervention with TENS, different etiologies of shoulder pain, and various types of control groups were considered).

c. We downgraded 1 level for serious imprecision (All studies sample size was low (<100 participants), and the number of participants in each arm was fewer than 400)

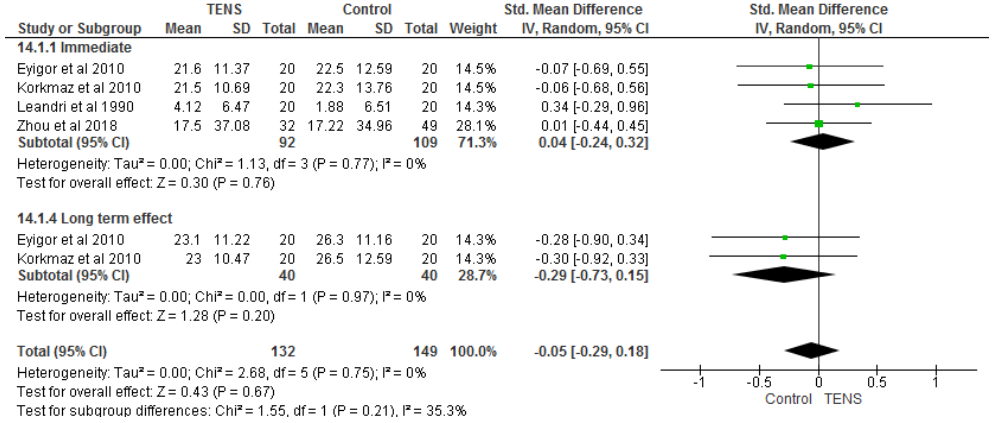
d. We downgraded 1 level for serious indirectness (different control group)

Appendix 8. Effect of TENS on passive range of motion. Abduction (A), Flexion (B), External rotation (C), and Internal rotation (D)

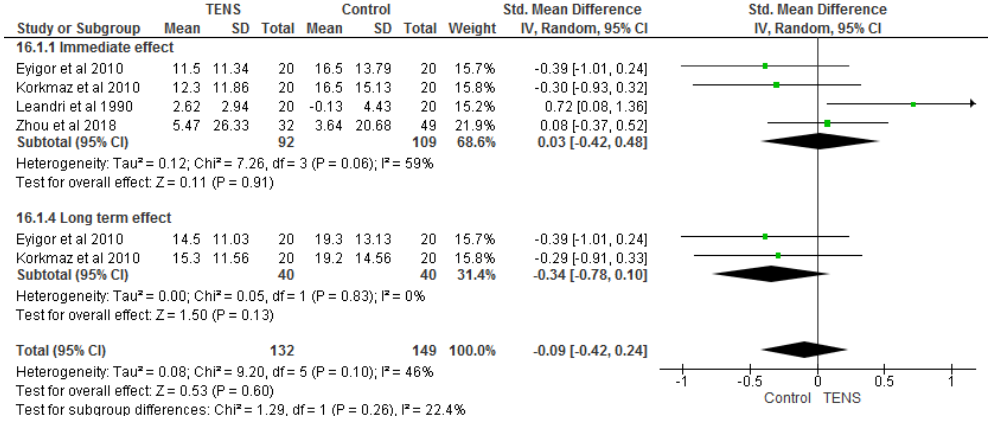
A



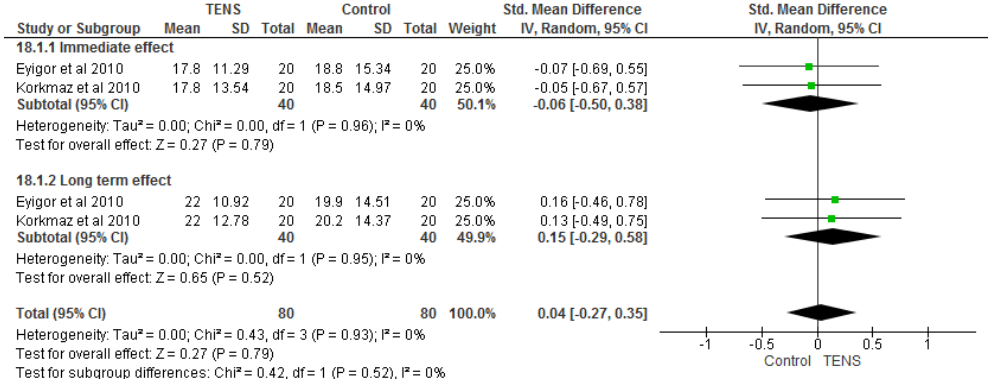
B



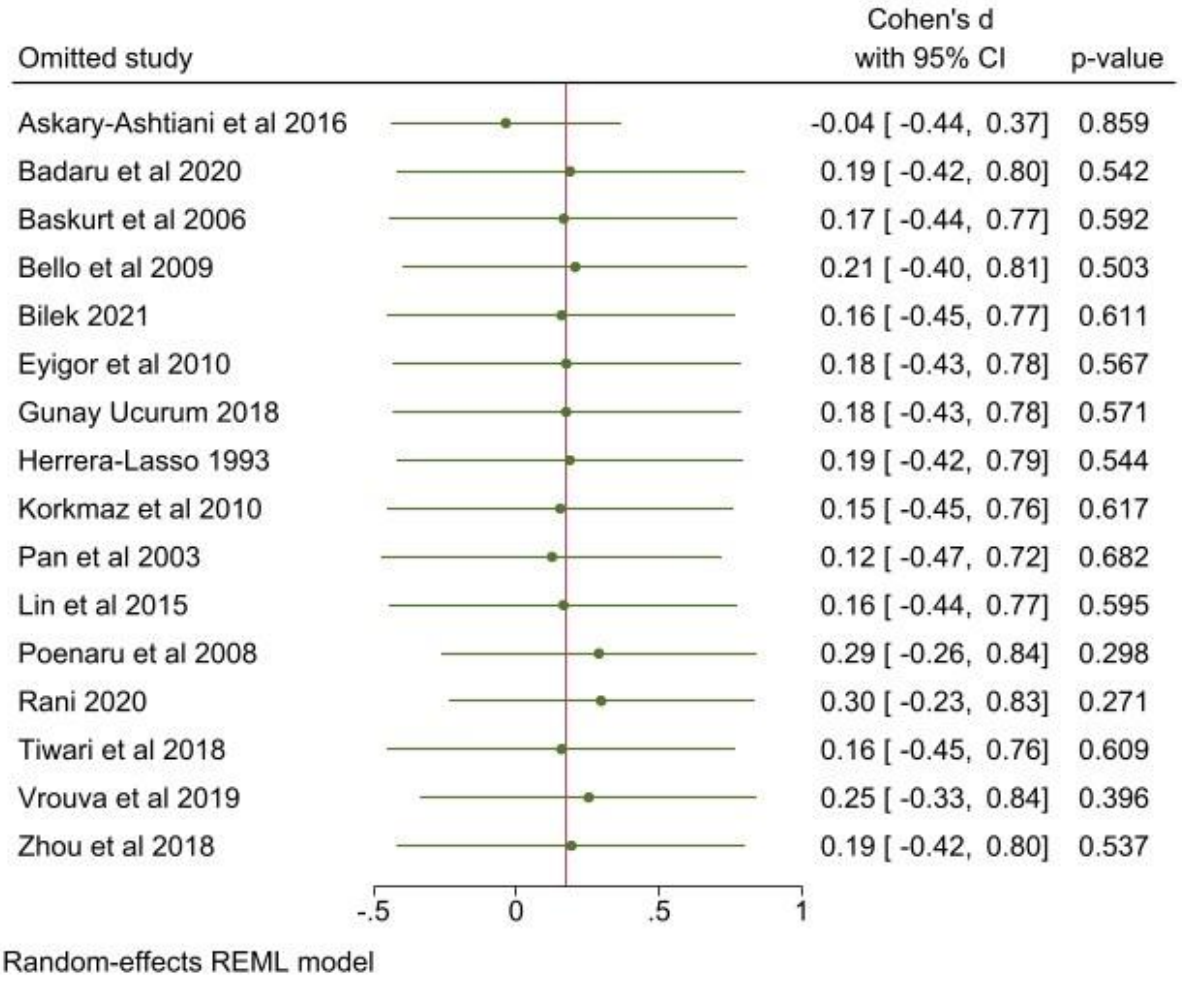
C



D



Appendix 9. Leave-one-out analysis in studies examining the immediate effect of TENS vs. control



Appendix 10. Sensitivity analysis based on risk of bias

Risk of Bias	**Availability**	**SMD (95%CI)**	**I^2**	***P*-value**
Performance Bias	With	-0.01 (-0.51, 0.50)	88%	0.98
	Without	0.44 (0.23, 0.65)	**0%**	**<0.001**
Detection Bias	With	0.12 (-0.42, 0.66)	84%	0.66
	Without	-0.02 (-0.68, 0.64)	91%	0.95
Allocation concealment	With	0.00 (-0.55, 0.55)	89%	0.99
	Without	0.22 (-0.60, 1.03)	92%	0.60
Sample size	> 30	-0.43 (-1.36, 0.49)	96%	0.36
	< 30	0.32 (011, 0.53)	**0%**	**0.003**