Dry Needling

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Dry needling is a treatment performed by skilled, trained physical therapists, certified in the procedure. A thin monofilament needle penetrates the skin and treats underlying muscular trigger points for the management of neuromusculoskeletal pain and movement impairments.

Keywords: dry needling, neck pain

1. Introduction

Neck pain is a musculoskeletal condition that often becomes chronic and can result in high levels of disability. The point prevalence is estimated to be 20%, whereas the lifetime prevalence can reach up to 70% in the general population ^[1]. The Global Burden of Disease Study identified neck pain as the fourth highest condition on number of years lived with disability ^[2]. Physical therapy is usually the first therapeutic option requested by individuals with neck pain. Several interventions, including cervical manual therapy ^[3], exercises ^[4], and education ^[5], have shown to be effective for the management of neck pain. Clinical practice guidelines for physical therapy management of these patients ^{[6][Z]}. Further, clinical practice guidelines do not recommend other treatments, such as dry needling, not because there is evidence against the particular intervention but, rather, there is a lack of studies examining its use.

The etiology of mechanical neck pain is under debate, and it seems to be multifactorial. Some authors proposed that myofascial trigger points (TrPs) can play a role in neck pain development ^[8]. Simons et al. ^[8] defined a TrP as "a hypersensitive spot located in a taut band of skeletal muscle which stimulation induces referred pain symptoms and motor phenomena". There is evidence showing that the referred pain elicited by active TrPs from neck musculature reproduces neck pain symptoms of insidious or traumatic origin ^[8]. Chiarotto et al. ^[9] found that TrPs in the upper trapezius is the most common finding in individuals suffering from neck pain.

Among the several approaches proposed for the treatment of TrPs, dry needling has received particular attention in the last decades [8][10]. Dry needling is defined as a "skilled intervention using a thin filiform needle to penetrate the skin that stimulates myofascial TrPs, muscles, and connective tissue for the treatment of musculoskeletal pain disorders" [11].

A few previous reviews have investigated the effectiveness of dry needling for inactivating TrPs associated with neck pain. Cagnie et al. concluded that dry needling can be recommended for upper trapezius muscle TrPs treatment; however, no quantitative analysis was conducted ^[12]. Liu et al. concluded that TrP dry needling could be recommended for the management of neck/shoulder pain of myofascial origin at short and mid-term follow-ups ^[13]. This meta-analysis only included pain intensity as the outcome and considered one month as a mid-term follow-up ^[13]. In addition, a greater number of randomized clinical trials investigating the effectiveness of dry needling in patients with TrPs associated to neck pain symptoms have been published after the Liu et al. meta-analysis ^[13].

2. Dry Needling and Neck Pain Intensity

Dry needling exhibited a small overall significant effect (MD -0.75, 95% CI -1.43 to -0.06; p = 0.03 Z = 2.14, N = 486, n = 11 trials) for reducing neck pain immediately after the intervention vs. a comparison group but with substantial heterogeneity (I² = 77%) between the trials (Figure 1). A significant effect (MD -1.53, 95% CI -2.29 to -0.76, p < 0.001) was found for the grouping analysis (p = 0.002) being significant comparing dry needling vs. sham/placebo/waiting list/other forms of dry needling (MD -1.53, 95% CI -2.29 to -0.76, p = 0.04). The funnel plot did not present potential publication bias.

Dry needling also showed a significant overall short-term effect (MD -0.65, 95% CI -1.09 to -0.22; p = 0.003, Z = 2.96, N = 1121, n = 24 trials) for reducing the intensity of neck pain as compared to a comparative group but, also, with considerable heterogeneity (I² = 87%) between the trials (Figure 2). Significant subgroup differences (p = 0.0004, I² =

87.2%) were observed when comparing dry needling with sham/placebo/waiting list/other forms of dry needling (MD –2.31, 95% CI –3.64 to –0.99, p < 0.001) and with manual therapy (MD –0.53, 95% CI –0.97 to –0.09, p = 0.02), but not when comparing with other physical therapy interventions (MD 0.10, 95% CI –0.21 to 0.41, p = 0.52). The funnel plot did not present a potential publication bias.

At mid-term, dry needling did not exhibit a significant overall effect (MD –0.27, 95% CI –0.73 to 0.18, p = 0.23, Z = 1.19, N = 225, n = 5 trials) for decreasing neck pain intensity when compared with a comparative group, with no significant heterogeneity ($I^2 = 28\%$) between the studies (Figure 3). No significant subgroup differences (p = 0.32, $I^2 = 0.5\%$) were observed. Table S1 summarizes the main results of the included studies.

	Dry	Need	ing	Con	nparat	ive		Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Sham / Placebo / Waiting list	/ Other fo	orm of	dry ne	edling					
Fernández-Carnero et al. 2017	2.88	1.83	63	3.33	2.45	21	9.5%	-0.45 [-1.59, 0.69]	
Martín-Rodríguez et al. 2019	2.5	2.16	16	3.9	2.45	15	7.4%	-1.40 [-3.03, 0.23]	
Mejuto-Vázquez et al. 2014	3.8	1.9	9	5.5	2.1	8	6.4%	-1.70 [-3.61, 0.21]	
Myburgh et al. 2012	3.41	2.13	17	4.6	2.09	20	8.5%	-1.19 [-2.56, 0.18]	
Pecos-Martín et al. 2015	2.6	1.8	36	5.3	1.6	36	11.0%	-2.70 [-3.49, -1.91]	
Tekin et al. 2013	4	1.6	22	5.4	1.6	17	10.0%	-1.40 [-2.41, -0.39]	
Subtotal (95% CI)			163			117	52.8%	-1.53 [-2.29, -0.76]	•
Heterogeneity: Tau ² = 0.50; Ch	i² = 11.82	df = 5	5 (P = 0	.04); l ² =	= 58%				
Test for overall effect: Z = 3.90	(P < 0.00	01)							
Manual Therapy									
Arias-Buria et al. 2020	4.7	2.1	15	5.1	1.9	15	8.2%	-0.40 [-1.83, 1.03]	
Campa-Morán et al. 2015	3.97	1.77	12	3.4	1.85	24	9.0%	0.57 [-0.68, 1.82]	
Ziaeifar et al. 2016	7.85	2.24	14	7.55	2.17	17	7.7%	0.30 [-1.26, 1.86]	
Subtotal (95% CI)			41			56	24.9%	0.19 [-0.61, 1.00]	+
Heterogeneity: Tau ² = 0.00; Ch	i² = 1.03,	df = 2	(P = 0.6)	i0); l² =	0%				
Test for overall effect: Z = 0.47	(P = 0.64)							
Other Physical Therapy Inter	ventions								
García-de-Miguel et al. 2020	2.28	1.58	22	2.04	1.69	22	10.2%	0.24 [-0.73, 1.21]	+
Luan et al. 2019	2.78	1.07	33	2.93	0.94	32	12.1%	-0.15 [-0.64, 0.34]	+
Subtotal (95% CI)			55			54	22.3%	-0.07 [-0.51, 0.37]	•
Heterogeneity: Tau ² = 0.00; Ch	² = 0.50,	df = 1	(P = 0.4)	8); I ² =	0%				
Test for overall effect: Z = 0.32	(P = 0.75)							
Total (95% CI)			259			227	100.0%	-0.75 [-1.43, -0.06]	•
Heterogeneity: Tau ² = 0.94; Ch	² = 43.32	df = '	0 (P <	0.00001	1); 12 =	77%		-	
Test for overall effect: Z = 2.14	(P = 0.03))							-10 -5 0 5 10
Test for subaroup differences: (Chi ² = 12	29 df	= 2 (P =	0.002)	12 = 8	3.7%			[biy recomg] [Comparative]

Figure 1. Mean differences (MD) comparing the immediate effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy interventions on pain intensity.

	Dry	Needli	ng	Con	nparati	ive		Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Sham / Placebo / Waiting list /	Other fo	orm of	dry ne	edling					
Fernández-Carnero et al. 2017	2.65	2.09	63	3.52	2.35	21	3.9%	-0.87 [-2.00, 0.26]	
Itoh et al. 2007	1.1	0.93	8	5.76	1.8	8	3.4%	-4.66 [-6.06, -3.26]	
Martin-Rodriguez et al. 2019	1.7	2.16	16	1.4	1.53	15	3.5%	0.30 [-1.01, 1.61]	
Mejuto-Vázquez et al. 2014	2	1.7	9	4.6	2.1	8	2.7%	-2.60 [-4.43, -0.77]	
Pecos-Martin et al. 2015	2.1	1.6	36	5.1	1.5	36	4.6%	-3.00 [-3.72, -2.28]	
Tekin et al. 2013	2.2	2	22	5.3	1.8	17	3.7%	-3.10 [-4.30, -1.90]	
Subtotal (95% CI)			154			105	21.8%	-2.31 [-3.64, -0.99]	-
Heterogeneity: Tau ² = 2.30; Chi Test for overall effect: Z = 3.43 (² = 37.33 (P = 0.00	, df = 5 06)	(P < 0.	00001)	; I² = 8	7%			
Manual Therapy									
Arias-Buria et al. 2020	3.4	2.2	15	4.8	2.1	15	3.2%	-1.40 [-2.94, 0.14]	
Campa-Morán et al. 2015	1.33	1.47	12	2.18	1.9	24	3.9%	-0.85 [-1.98, 0.28]	
Llamas-Ramos et al. 2014	0.9	0.8	45	1	1.1	46	5.0%	-0.10 [-0.49, 0.29]	+
Segura-Orti. et al. 2016	1.71	1.47	10	1.86	1.03	8	3.8%	-0.15 [-1.31, 1.01]	
Sobhani et al. 2017	3.92	2	7	3.38	1.26	13	3.0%	0.54 [-1.09, 2.17]	
Tabatabaiee et al. 2019	3.3	0.24	10	4	0.85	20	5.0%	-0.70 [-1.10, -0.30]	-
Ziaeifar et al. 2014	1.34	1.93	16	3.05	2.27	17	3.3%	-1.71 [-3.14, -0.28]	
Subtotal (95% CI)			115			143	27.2%	-0.53 [-0.97, -0.09]	•
Test for overall effect: Z = 2.37 (Other Physical Therapy Interv	P = 0.02)							
Aridici et al. 2016	4 5.9	1.05	21	4.2	2.05	20	4 194	0.381.060 1.361	
Dooso et al. 2019	1.07	1.60	10	1.60	2.00	23	3.0%	0.62 [-1.70, 0.46]	
García de Miguel et al. 2020	2.26	1.55	22	1.00	1 29	22	4 4%	0.55 [.0.29 1.39]	
Havta et al. 2016	5.5	12	28	57	12	27	4 7%	-0 20 [-0.83 0.43]	
Ibuldu et al. 2004	3.71	2 33	20	2.05	1 43	20	3 7%	1 66 [0.46, 2.86]	
Luan et al. 2019	1.91	1	32	1 73	0.91	30	4 9%	0.18 [-0.30, 0.66]	
Manafnezhad et al. 2019	3.79	22	35	3.89	2 16	35	4.1%	-0.10[-1.12_0.92]	
Onat et al. 2019	3.1	2.4	36	2.7	2.8	36	3.7%	0.40 [-0.80, 1.60]	
Ravegani et al. 2014	1.5	2.8	14	2.2	2.6	14	2.5%	-0.70 [-2.70, 1.30]	
Sobhani et al. 2017	3.92	2	6	3.69	1.49	13	2.8%	0.23 [-1.56, 2.02]	
Sukareechai et al. 2019	2.6	2.2	21	3.4	2.1	21	3.6%	-0.80 [-2.10, 0.50]	
Tabatabaiee et al. 2019	3.3	0.24	10	2.96	0.3	20	5.2%	0.34 [0.14, 0.54]	~
Valiente-Castrillo et al. 2020	2.38	1.85	20	3.85	2.38	19	3.5%	-1.47 [-2.81, -0.13]	
Subtotal (95% CI)	2.50		294			310	51.0%	0.10 [-0.21, 0.41]	•
Heterogeneity: Tau ² = 0.11; Chir Test for overall effect: Z = 0.65 (² = 21.32 P = 0.52	df = 1:	2 (P = (0.05); P	= 44%			a (6) 8	-
Total (95% CI)			563			558	100.0%	-0.65 [-1.09, -0.22]	•
Heterogeneity: Tau ² = 0.93; Chi ² Test for overall effect: Z = 2.96 (Test for subgroup differences: C	² = 193.7 (P = 0.00 Chi ² = 15.1	0, df = : 3) 67, df =	25 (P <	0.0000)1); ² =	87% 87.2%			-4 -2 0 2 4 [Dry Needling] [Comparative]

Figure 2. Mean differences (MD) comparing the short-term effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy. SD:standard deviation; CI: confidence interval.



Figure 3. Mean differences (MD) comparing the mid-term effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy. SD:standard deviation; CI: confidence interval.

3. Dry Needling and Pain-Related Disability

Dry needling had a significant overall small effect size (SMD -0.26, 95% CI -0.48 to -0.05, p = 0.001, Z = 2.44, N = 924, n = 20 trials) for improving pain-related disability at the short-term when compared with a comparative group but with moderate heterogeneity (I² = 58%) among trials (Figure 4A). Significant differences were found when comparing dry needing with sham/placebo/waiting list/other forms of dry needling (SMD -0.87, 95% CI -1.60 to -0.14, p = 0.003) but not when compared with manual therapy (SMD -0.20, 95% CI -0.49 to 0.10, p = 0.19) or other physical therapy interventions (SMD -0.07, 95% CI -0.27 to 0.13, p = 0.49). The funnel plot presented asymmetry and publication bias (Supplementary Figure S3).

At mid-term follow-up, dry needling did not exhibit a significant overall effect (SMD –0.33, 95% CI –0.70 to 0.05, p = 0.09, Z = 1.71, N = 226, n = 5 trials) for reducing pain related-disability as compared to a comparative group, with moderate heterogeneity (I² = 49%) among the trials (Figure 4B). No significant subgroup differences were found (p = 0.77, I² = 0%). Table S1 summarizes the main results of the included studies.



Figure 4. Standardized mean differences (SMD) comparing the effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy interventions on pain-related disability at the (**A**) short- and (**B**) mid-terms. SD:standard deviation; CI: confidence interval.

4. Dry Needling and Pressure Pain Sensitivity (Pressure Pain Thresholds)

Dry needling did not show a significant overall effect immediately after (MD 4.93 kPa, 95% CI -42.18 to 52.04, n = 415, Z = 0.21, p = 0.84, Figure 5A) and at short-term (MD 6.84 kPa, 95% CI -33.41 to 47.10, n = 780, Z = 0.33, p = 0.74, Figure 7B) for increasing the pressure pain thresholds vs. a comparative group. The funnel plot did not present a potential publication bias.

The analysis also revealed considerable heterogeneity ($I^2 > 95\%$) between the studies. Only the subgroup comparing dry needling with sham/placebo/waiting list/other forms of dry needling had a significant immediate effect (MD 55.48 kPa, 95% CI 27.03 to 83.93, p < 0.001, Figure 5B).

A) Immediate



Figure 5. Mean differences (MD) comparing the effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy interventions on the pressure pain thresholds (kPa) (**A**) immediately after and (**B**) at the short-term. SD:standard deviation; CI: confidence interval.

5. Dry Needling and Cervical Range of Motion

No significant overall effects of dry needling immediately after on the cervical range of motion when compared with a comparison group were observed: flexion (MD 1.93°, 95% CI –5.90° to 9.77°, n = 212, Z = 0.48, p = 0.63, Figure 6A), extension (MD 5.23°, 95% CI –1.05° to 11.51°, n = 212, Z = 1.63, p = 0.10, Figure 6A), rotation (MD 2.04°, 95% CI –4.08° to 8.15°, n = 176, Z = 0.65, p = 0.51, Figure 7A), and lateral-flexion (MD 2.65°, 95% CI –2.07° to 7.37°, n = 176, Z = 1.10, p = 0.27, Figure 7A). Similarly, no significant overall short-term effect of dry needling on cervical flexion (MD 1.26°, 95% CI –3.06° to 5.58°, n = 458, Z = 0.57, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°, 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°), 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°), 95% CI –3.02° to 3.70°, n = 454, Z = 0.20, p = 0.57, Figure 5B), extension (MD 0.34°), 95% CI –3.02° to 3.70°, n = 454, Z

= 0.84, Figure 8B), rotation (MD -0.23° , 95% CI -1.40° to 0.95°, n = 478, Z = 0.38, p = 0.71, Figure 8B), and lateral-flexion (MD 0.30° , 95% CI -1.00° to 1.61°, n = 520, Z = 0.45, p = 0.65, Figure 5B) was found. All group analyses showed substantial heterogeneity. Table 3 summarizes the main results of the included studies.

Cervical Flexion

A) Immediate

Study or Subgroup	Dry	Needli	ng	Cor	nparati	ve .		Mean Difference	Mean Difference
	Mean	SD	Total	Mean	SD	Total	Weight	nt IV, Random, 95% CI IV,	IV, Random, 95% CI
Sham / Placebo / Waiting list /	Other fo	rm of c	iry nee	dling				Second based	
Fernández-Camero et al. 2017	51,24	10.04	63	50.35	10.36	21	22.9%	0.89 [-4.19, 5.97]	
Martin-Rodriguez et al. 2019	51.9	11.41	16	49.4	9.97	15	20.5%	2.50 [-5.03, 10.03]	
Mejuto-Vázquez et al. 2014 Subtotal (95% CI)	68.3	13.4	9 88	46.2	9.5	8 44	17.0% 60.4%	22.10 [11.15, 33.05] 7.51 [-3.23, 18.25]	-
Heterogeneity: Tau ² = 73.62; Ch	i ² = 12.00	3. cf = 2	(P = 0	.002); P	= 83%				
Test for overall effect: Z = 1.37 (P=0.17)								
Manual Therapy									
Campa-Morán et al. 2015 Subtotal (95% CI)	39.48	16.07	12 12	45.91	17.73	24 24	16.4% 16.4%	-6.43 [-17.96, 5.10] -6.43 [-17.96, 5.10]	
Heterogeneity: Not applicable									
Test for overall effect: Z = 1.09 (P = 0.27)								
Other Physical Therapy Interv	entions								
Garcia-de-Miguel et al. 2020 Subtotal (95% CI)	48.36	9.31	22 22	54.73	6.39	22 22	23.2% 23.2%	-6.37 [-11.09, -1.65] -6.37 [-11.09, -1.65]	-
Heterogeneity: Not applicable Test for overall effect: Z = 2.65 (P = 0.000	3)							
Total (95% CI)			122			90	100.0%	1.93 [-5.90, 9.77]	-
Heterogeneity: Tau ² = 63.06: Ch	i ² = 24.2	l. dl = 4	(P < 0	0001):	FF = 835	6			
Test for overall effect: Z = 0.48 (P = 0.63					<u>.</u>			-20 -10 0 10 2
Test for subgroup differences: C	hi* = 5.5	1. df = 2	(P = 0	06), (*	= 63.7%				[combarative] [thy weeds

B) Short-term

	Dry	Needili	ng	Cor	nparati	ve		Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	50	Total	Weight	IV, Random, 95% CI	IV, Random, 95% Cl
Sham / Placebo / Waiting list	Other fe	orm of d	iry nee	dling	- 11				and second and second
Fernández-Camero et al. 2017	50.35	10.36	63	49.2	10.81	21	10.6%	1.15 [-4.13, 6.43]	
Martin-Rodriguez et al. 2019	54.2	14.57	16	52.8	14.57	15	7.4%	1.40 [-8.86, 11.66]	
Mejuto-Vázquez et al. 2014 Subtotal (95% CI)	67.7	5	9 88	50.6	7,7	8 44	10.0% 28.0%	17.10 [10.84, 23.36] 6.76 [-4.53, 18.06]	
Heterogeneity: Tau ² = 85.37; Cl	ni ² = 15.84	6, df = 2	(P = 0	(0004);	12 = 1871	6			
Test for overall effect: Z = 1.17	(P = 0.24))							
Manual Therapy									
Campa-Morán et al. 2015	44,78	7.88	12	47.22	13.97	24	9.4%	-2.44 [-9.59, 4.71]	
Llamas-Ramos et al. 2014	60.2	6.6	45	59.8	6	46	12.1%	0.40 [-2.19, 2.99]	+
Sobhani et al. 2017	55.1	7.6	7	52.7	10.8	13	8.7%	2.40 [-5.73, 10.53]	
Subtotal (95% CI)			64			83	30.3%	0.26 [-2.07, 2.60]	+
Heterogeneity: Tau ² = 0.00; Chi	*= 0.82. +	df = 2 (F	a 0.6	6); IP = 0	1%				~
Test for overall effect: Z = 0.22	(P = 0.83))							
Other Physical Therapy Interv	entions								
Garcia-de-Miguel et al. 2020	47.27	8.41	22	51.27	7.59	22	11.0%	-4.00 [-8.73. 0.73]	
Ibuldu et al. 2004	50.84	10.28	20	64.15	9.25	20	10.1%	-13.31 [-19.37, -7.25]	
Onat et al. 2019	69.1	3.7	36	63.3	8.6	36	11.9%	5.80 [2.74, 8.86]	
Sobhani et al. 2017	55.1	7.6	6	50.6	10.2	13	8.7%	4.50 [-3.73, 12.73]	
Subtotal (95% CI)			84			91	41.7%	-1.74 [-10.51, 7.03]	
Heterogeneity: Tau ² = 71.65; Cl	1i ² = 35.8	1, cf = 3	(P < 0	.00001)	$ 1^{2} = 92$	1%			
Test for overall effect: Z = 0.39	(P = 0.70))							
Total (95% CI)			236			218	100.0%	1.26 [-3.06, 5.58]	+
Heterogeneity: Tau ² = 38.31; Cl	ni ² = 62.03	3, ct = 9	(P<0	.00001)	; i# = 85	156		NEOGAN CENNIN	<u> </u>
Test for overall effect: Z = 0.57	(P = 0.57))	100000						-20 -10 0 10 20
Test for subnroun differences: ($bi^{p} = 1.40$	$R_{\rm eff} = 2$	iP = 0	483 81	10%				frombaranival (ruk waaqaud)

Figure 6. Mean differences (MD) comparing the effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy interventions on the cervical range of motion in flexion (**A**) immediately after and (**B**) at the short-term. SD: standard deviation; CI: confidence interval.

Cervical Extension

A) Immediate

	Dry	Needh	ng	Cor	nparati	ve		Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Sham / Placebo / Waiting list /	Other fo	rm of c	fry nee	dling					
Fernández-Carnero et al. 2017	59.85	13.84	.63	60.22	13.97	21	24.2%	-0.37 [-7.25, 6.51]	
Martin-Rodriguez et al. 2019	66.8	12.11	16	57.1	9.35	15	22.8%	9.70 [2.11, 17.29]	
Mejuto-Vázquez et al. 2014 Subtotal (95% CI)	78.8	12.6	9 88	58.1	16	8 44	12.9% 59.9%	20.70 [6.89, 34.51] 8.70 [-1.94, 19.35]	-
Heterogeneity: Tau ² = 65.61; Ch	n ² = 8.55.	df = 21	P = 0.0	01); I* =	77%				2,853
Test for overall effect: Z = 1.60 (P = 0.11)	E.							
Manual Therapy									
Campa-Moràn et al. 2015 Subtotal (95% CI)	49.96	16.26	12 12	48.01	24.42	24 24	13.4% 13.4%	1.95 [-11.47, 15.37] 1.95 [-11.47, 15.37]	-
Heterogeneity: Not applicable									
Test for overall effect: Z = 0.28 (P = 0.78)								
Other Physical Therapy Interv	entions								
Garcia-de-Miguel et al. 2020 Subtotal (95% CI)	57.32	7.49	22 22	56.64	11.37	22 22	26.7% 26.7%	0.68 [-5.01, 6.37] 0.68 [-5.01, 6.37]	*
Heterogeneity: Not applicable Test for overall effect: Z = 0.23 (P = 0.81)								
Total (95% Ci)			122			90	100.0%	5.23 [-1.05, 11.51]	•
Heterogeneity: Tau# = 30.02; Ch	n# = 10.71	1. df = 4	(P = 0	.03); 1*	= 63%				<u>to to to to to</u>
Test for overall effect: Z = 1.63 (P = 0.10)	1							-20 -10 U 10 20
Test for subsenue differences C	1.0 - 1 70	1 48 - 2	dD = 0	425 12	- 094				teruburand, fruð naganniðt

B) Short-term

	Dry	Needli	ng	Cor	nparati	ve		Mean Difference	Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% Cl	
Sham / Placebo / Waiting list /	Other fo	orm of e	iry nee	dling						
Fernández-Carnero et al. 2017	62.66	13.54	63	60.08	14.97	21	9,6%	2.60 [-4.62, 9.82]		
Martin-Rodriguez et al. 2019	63.8	13.47	16	58.7	14.84	15	6.8%	5.10 [-4.90, 15.10]		
Mejuto-Vázquez et al. 2014 Subtotal (95% CI)	80.5	8.4	9 88	60.2	16,3	8 44	5.1% 21.5%	20.30 [7.74, 32.86] 8.26 [-1.36, 17.88]	-	
Heterogeneity: Tau ² = 47.04; Ct	n² = 5.83.	df = 2	P=0.	05); P =	66%					
Test for overall effect: Z = 1.68 (P = 0.09	1								
Manual Therapy										
Campa-Morán et al. 2015	50.62	15.34	12	54.53	7.6	24	7.5%	-3.91 [-13.11, 5.29]		
Llamas-Ramos et al. 2014	68	8.02	45	68.2	5.1	46	15.5%	-0.20 [-2.97, 2.57]	+	
Sobhani et al. 2017 Subtotal (95% CI)	53.1	7.6	64	51.1	8.4	13 83	9.6% 32.6%	2.00 [-5.25, 9.25] -0.21 [-2.70, 2.28]	•	
Heterogeneity: Tau ³ = 0.00; Chir	= 0.98, 4	# = 2 (F	= 0.6	t); P = 0	195				1000 C	
Test for overall effect: Z = 0.17 (P = 0.87	1								
Other Physical Therapy Interv	entions									
Garcia-de-Miguel et al. 2020	58.05	7.95	22	57.68	11.26	22	11,5%	0.37 [-5.39, 6.13]		
buldu et al. 2004	65.7	13.93	20	81.95	10.84	20	9.0%	-16.25 [-23.99, -8.51]		
Onat et al. 2019	59.7	2.91	36	57.8	5.4	36	16.3%	1.90 [-0.10, 3.90]		
Sobhani et al. 2017	53.1	7.6	6	53.5	8.8	13	9.0%	-0.40 [-8.14, 7.34]		
Subtotal (95% CI)			84			91	45.9%	-3.04 [-9.94, 3.87]	-	
Heterogeneity: Tau ² = 40.20; CR	n ² = 19.9	1, df = 3	(P=0	.0002);	12 = 857	6				
rescior overall effect: 2 = 0.861	P = 0.39									
Total (95% CI)			236			218	100.0%	0.34 [-3.02, 3.70]	+	
Heterogeneity: Tau ^a = 16.95; Ct	12 = 31.76	5, df = 9	(P=0	.0002);	12 = 729	6				
Test for overall effect: Z = 0.20 (P = 0.84	F							Comparative] [Dry Needling]	
Test for subgroup differences: C	thi ² = 3.6	t, df = 2	(P=0	.16), 14	44.5%				from demonstral [reck canon will	

Figure 7. Mean differences (MD) comparing the effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy interventions on the cervical range of motion in extension (**A**) immediately after and (**B**) at the short-term. SD: standard deviation; CI: confidence interval.

Cervical Rotation

	Dry	Needlin	9	Cor	nparativ	0		Mean Difference	Mean Difference
study or Subgroup	Mean	SD	SD Total Mean SD			Total	Weight	IV, Random, 95% Cl	IV, Random, 95% CI
Sham / Placebo / Waiting list /	Other fo	rm of dr	y nee	dling					
emández-Camero et al. 2017	62.73	8.03	63	57.25	12.08	21	32.6%	5,48 [-0.05, 11.01]	-
fartin-Rodriguez et al. 2019	63.9	13.26	16	64.25	10.77	15	24.0%	-0.35 [-8.83, 8.13]	
fejuto-Vázquez et al. 2014	67,45	15.5	9	54.4	16.6	8	11.7%	13.06 [-2.28, 28.38]	
ubtotal (95% CI)			88			44	68.3%	4.51 [-0.96, 9.98]	-
leterogeneity: Tau ² = 5.81; Chi est for overall effect: Z = 1.61 (P = 0.11	df = 2 (P)	= 0.2	3); 17 = 2	2%				
ther Physical Therapy Interv	entions								1200
larcia-de-Miguel et al. 2020	67.18	11	22	70.95	8.52	22	31.7%	-3.77 [-9.58, 2.04]	
ubtotal (95% CI)			22			22	31.7%	-3.77 [-9.58, 2.04]	-
leterogeneity: Not applicable									1.1.1.1
est for overall effect: Z = 1.27 (P = 0.20)							
atal (95% CD			110			66	100.0%	2.047-4.08 8.151	
eteroceneity: Taul = 21 88- Ch		1 - 3 -	2 = 0.4	WD IF -	60%	40	.00.078	*'nd [.d.00' m.13]	
entrogeneity: $100 = 21.00$; Gr	P=0.51	0 = 3 ()	= 0/	<i>M</i>), F #	0.776				-20 -10 0 10 20
ost for subgroup differences: C	hi? = 4 1	3. df = 17	P = 0	04) (2)	75.8%				[Comparative] [Dry Needling]
Short-term									
		Montling	m	Con	on a rabic	100		Mean Difference	Mean Difference
udy or Subaroup	Mean	Needlin SD	g Totel	Con	nparativ SD	Total	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV. Random, 95% Cl
tudy or Subgroup ham / Placebo / Waiting list /	Mean Other fo	SD rm of dr	g Total y nee	Mean dling	sD	e Total	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham / Placebo / Waiting list / mandez-Camero et al. 2017	Mean Other fo	SD rm of dr 8.66	g Total y nee 63	Mean dling 58.58	sD	Total	Weight	Mean Difference IV, Random, 95% Cl	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham / Placebo / Waiting list / amández-Camero et al. 2017 artin-Rodríguez et al. 2019	Mean Other fo 62.76 67.25	Needlin SD rm of dr 8.66 9.51	g Total y nee 63 16	Mean dling 58.58 66.3	11.61 8.78	21	Weight 3.9%	Mean Difference IV, Random, 95% Cl 4.18 (-1.23, 9.59) 0.95 (-5.49, 7.39)	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham / Placebo / Walting list / emández-Camero et al, 2017 artin-Rodriguez et al, 2019 euto-Vázquez et al, 2014	0ther fo 62.76 67.25 73.55	Needlin SD rm of dr 8.66 9.51 11.05	g Total y nee 63 16 9	Con Mean dling 58.58 66.3 58.1	11.61 8.78 7.45	21 15 8	Weight 3.9% 2.9% 1.6%	Mean Difference IV, Random, 95% Cl 4.18 (-1.23, 9.59) 0.95 (-5.49, 7.39) 15.45 (6.57, 24.33)	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham / Placebo / Waiting list / emändez-Camero et al. 2017 artin-Rodriguez et al. 2019 lejuto-Vázquez et al. 2014 ubtotal (95% CI)	Mean Other fo 62.76 67.25 73.55	8.66 9.51 11.05	g <u>Total</u> y nee 63 16 9 88	Con Mean dling 58.58 66.3 58.1	5D 11.61 8.78 7.45	21 21 15 8 44	Weight 3.9% 2.9% 1.6% 8.5%	Mean Difference IV, Random, 95% CI 4.18 [-1.23, 9.59] 0.95 [-5.49, 7.39] 15.45 [6.57, 24.33] 6.20 [-1.06, 13.46]	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham / Placebo / Waiting list / emández-Camero et al. 2017 artin-Rodriguez et al. 2019 lejuto-Vázquez et al. 2014 ubtota (95% CI) eterogeneity: Tau ² = 29.12; Ch est for overall effect: Z = 1.67 (Mean Other fo 62.76 67.25 73.55 n ² = 6.93, P = 0.10)	Needlin SD m of dr 8.66 9.51 11.05 df = 2 (P	g Total y nee 63 16 9 88 9 88	Con Mean dling 58.58 66.3 58.1 (3); 1 ² =	11.61 8.78 7.45	21 21 15 8 44	Weight 3.9% 2.9% 1.6% 8.5%	Mean Difference IV, Random, 95% Cl 4.18 [-1.23, 9.59] 0.95 [-5.49, 7.39] 15.45 [6.57, 24.33] 6.20 [-1.08, 13.48]	Mean Difference IV, Random, 95% Cl
tudy of Subgroup ham / Placebo / Waiting list / emández-Camero et al, 2017 artín-Rodríguez et al. 2019 lejuto-Vázquoz et al. 2014 ubtotal (95% GI) estrogoneity: Tau' = 29.12; Ch est for overall effect: Z = 1.67 (lanual Therapy	019 Mean Other fo 62.76 67.25 73.55 a ^p = 6.93. P = 0.10)	Needlin SD rm of dr 9.51 11.05 df = 2 (P	g <u>Total</u> 9 63 16 9 88 *= 0.0	Con Mean dling 58.58 66.3 58.1 (3); I ² =	nparativ 5D 11.61 8.78 7.45 71%	21 21 15 8 44	Weight 3.9% 2.9% 1.6% 8.5%	Mean Difference IV, Random, 95% C1 4.18 [-1.23, 0.59] 0.95 [-5.49, 7.39] 15.45 [6.57, 24.33] 6.20 [-1.08, 13.48]	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham / Placebo / Waiting list / amin-Rodriguez et al. 2019 artin-Rodriguez et al. 2019 ubtotal (95% CI) eterogeneity: Tau'r = 2014 ubtotal (95% CI) eterogeneity: Tau'r = 2014 ubtotal (95% CI) anual Therapy amas-Ramos et al. 2014	Mean Other fo 62.76 67.25 73.55 al ² = 6.93, P = 0.10) 70.25	Needlin SD 7 rm of dr 8.66 9.51 11.05 df = 2 (P	9 <u>Total</u> 9 63 16 9 88 9 = 0.0	Con Mean dling 58.58 66.3 58.1 (3); 1 ² = 69.8	11.61 8.78 7.45 71%	46	Weight 3.9% 2.9% 1.6% 8.5%	Mean Difference IV, Random, 95% C1 4.18 [-1.23, 0.59] 0.95 [-5.49, 7.39] 15.45 [657, 24.33] 6.20 [-1.08, 13.48] 0.45 [-0.65, 1.55]	Mean Difference IV, Random, 95% CI
tudy or Subgroup ham / Placebo / Waiting list / mindez-Camero et al. 2019 eleito-Vizquez et al. 2019 eleito-Vizquez et al. 2014 ubtotal (95% CI) eleropeneity: Tarl= 20.12; Chi anual Therapy amas-famos et al. 2014 obhani et al. 2017	Mean Other fo 62.76 67.25 73.55 el ⁴ = 6.93, P = 0.10) 70.25 77.65	Needlin, <u>SD</u> rm of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7	g <u>Total</u> 9 63 16 9 88 9 = 0.0 45 7	Con Mean dling 58.58 66.3 58.1 (3); I ² = 69.8 82.8	2.95 7.7	46 13 15 15 15 15 15 15 15 15 15 15 15 15 15	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.9%	Mean Difference IV, Random, 95% C1 4.18 (-1.23, 0.59) 15.45 (6.87, 24.33) 6.20 (-1.08, 13.48) 0.45 (-0.05, 1.55) -5.15 (-11.64, 1.34)	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham / Placebo / Waiting list / amin-Rodriguez et al. 2019 eijuto-Vázquez et al. 2014 ubtotal (95% CI) eterogeneity: Tau' = 29.12; Ch est for overall effect: Z = 1.67 (anual Therapy amas-Ramos et al. 2014 obhani et al. 2019 solatabaise et al. 2019	Mean Other fo 62.76 67.25 73.55 if = 6.93, P = 0.10) 70.25 77.65 74.05	Needlin, <u>SD</u> rm of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68	g Total y nee 63 16 9 88 *= 0.0 45 7 10	Con Mean dling 58.58 66.3 58.1 (3); I ² = 69.8 82.8 74.97	2.95 7.7 0.72	46 13 21 15 8 44	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.9% 23.3%	Mean Difference IV, Rendom, 95% C1 4.18 [-123, 0.59] 0.05 [5.40, 7.39] 15.45 [6.57, 24.33] 6.20 [-1.08, 13.48] 0.45 [-0.65, 1.55] -5.15 [-11.84, 1.34] 0.92 [-1.45, -0.39]	Mean Difference IV, Random, 95% CI
tudy or Subgroup ham / Placebo / Waiting list / amin-Rodriguez et al. 2019 artin-Rodriguez et al. 2019 ubtotal (95% CI) eterogeneity: Tau' = 2014 ubtotal (95% CI) anual Therapy amas-Ramos et al. 2014 abatabase et al. 2019 ubtotal (95% CI)	Mean Other fo 62.76 67.25 73.55 il ^a = 6.93, P = 0.10) 70.25 77.65 74.05	Needlin, SD rm of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68	9 Total 9 63 16 9 88 *= 0.0 45 7 10 62	Con Mean dling 58.58 66.3 58.1 13); 1 ² = 69.8 82.8 74.97	nparativ SD 11.61 8.78 7.45 7.1% 2.95 7.7 0.72	46 13 20 79	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.9% 23.3% 46.3%	Mean Difference IV, Random, 95% C1 4.18 [-1.23, 9.59] 0.95 [5.44, 7.39] 15.45 [6.57, 24.33] 6.20 [-1.06, 13.48] 0.45 [-0.05, 1.55] -5.15 [-11.84, 1.34] -0.32 [-1.41, 0.87]	Mean Difference IV, Random, 95% CI
tudy of Subgroup ham / Placebo / Waiting list / emindez-Carnero et al. 2019 lejuto-Vázquoz et al. 2019 utototal (95% CI) eterogeneity: Tau ² = 20.12; Ch east for overall effect: Z = 1.67 (lanual Therapy lanual Therapy batababaice et al. 2014 obhani et al. 2019 outotal (95% CI) leterogeneity: Tau ² = 0.88; Ch ² eterogeneity: Tau ² = 0.88; Ch ²	Mean Other fo 62.76 67.25 73.55 it = 6.93, P = 0.10) 70.25 77.65 74.05 t = 6.64, cf P = 0.47)	Needlin, sp m of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68 ff = 2 (P	9 7 63 16 9 88 8 8 8 8 8 0 0 0 45 7 10 62 62 62 0.04	Con <u>Mean</u> dling 58.58 66.3 58.1 (3); I ² = 69.8 82.8 74.97 (); I ² = 7	nparativ SD 11,61 8.78 7.45 71% 2.95 7.7 0.72 0%	46 13 21 15 8 44 46 13 20 79	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.9% 23.3% 46.3%	Mean Difference IV, Rendom, 95% C1 4.18 [-1.23, 9.59] 0.95 [5-44, 7.39] 15.45 [6.57, 24.33] 6.20 [-1.06, 13.48] 0.45 [-0.65, 1.55] -5.15 [-11.84, 1.34] -0.92 [-1.45, -0.39] -0.52 [-1.91, 0.87]	Mean Difference IV, Random, 95% CI
tudy or Subgroup ham / Placebo / Waiting list / emindez-Camero et al. 2019 lejuto-Vázquoz et al. 2019 ubtotal (95% CI) eterogeneity: Tau' = 29.12; Ch est for overall effect: 2 = 1.67 (anual Therapy amas-Ramos et al. 2014 obhani et al. 2019 ubtotal (95% CI) eterogeneity: Tau' = 0.88; Chil statobase et al. 2019 ubtotal (95% CI) eterogeneity: Tau' = 0.88; Chil stof or overall effect: Z = 0.73 (ther Physical Therapy Interv	Mean Other fo 62.76 67.25 73.55 at = 6.93, P = 0.10) 70.25 77.65 74.05 r = 6.64, c P = 0.47) entions	Needlin, sp rm of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68 ff = 2 (P	9 <u>Total</u> y nee 63 16 9 88 * = 0.0 45 7 10 62 = 0.04	Con <u>Mean</u> diling 58.58 66.3 58.1 (3); 1 ² = 69.8 82.8 74.97 (); 1 ² = 7	nparativ SD 11.61 8.78 7.45 7.1% 2.95 7.7 0.72 0%	21 15 8 44 46 13 20 79	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.3% 46.3%	Mean Difference IV, Random, 95% C1 4.18 [-1.23, 9.59] 0.95 [5-44, 7.39] 15.45 [6 57, 24.33] 6.20 [-1.06, 13.48] 0.45 [-0.65, 1.55] -5.15 [-11.84, 1.34] -0.92 [-1.45, -0.39] -0.52 [-1.91, 0.87]	Mean Difference IV, Random, 95% CI
tudy or Subgroup ham / Placebo / Waiting list / mindez-Camero et al. 2017 artin-Rodriguez et al. 2019 ejuto-Vizquez et al. 2014 ubtotal (95% CI) eterogeneity: Tat ² = 29.12; Ch eterogeneity: Tat ² = 29.12; Ch eterogeneity: Tat ² = 20.12; Ch anual Therapy amas-Ramos et al. 2014 obhani et al. 2017 ubtotal (95% CI) eterogeneity: Tat ² = 0.88; Ch ³ est for overall effect Z = 0.73 (ther Physical Therapy Interv arcia-de-Muguet et al. 2020	Mean Other fo 62.76 67.25 73.55 at = 6.93, P = 0.10) 70.25 77.65 74.05 r = 6.64, c P = 0.47) entions 66.32	Needin, rm of dr, 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68 ff = 2 (P 9.81	9 Total y nee 63 16 9 88 * = 0.0 45 7 10 62 = 0.0 422	Con <u>Mean</u> dling 58,58,58,58,58,58,58,58,58,58,58,58,58,5	nparativ <u>SD</u> 11.61 8.78 7.45 7.1% 2.95 7.7 0.72 0% 8.42	70 Total 21 15 8 44 46 13 20 79 22	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.9% 23.3% 46.3%	Mean Difference IV, Random, 95% C1 4.18 [-1.23, 0.59] 10.45 [64, 7.39] 15.45 [6.67, 24.33] 6.20 [-1.08, 13.48] 0.45 [-0.65, 1.56] -5.16 [-11.84, 1.34] -0.92 [-1.45, -0.39] -0.52 [-1.91, 0.87] -3.79 [-9.19, 1.61]	Mean Difference IV, Random, 95% Cl
tudy or Subgroup ham (Placebo (Watting list / mindez-Camero et al. 2017) artin-Rodriguez et al. 2019 ejub-Vizzuez et al. 2014 ubtotal (95% CI) oterogeneity: Tau ² = 29.12; Ch est for overall effect: Z = 1.67 (anual Therapy amas-Ramos et al. 2019 sistababies et al. 2019 sistababies et al. 2019 ubtotal (95% CI) eterogeneity: Tau ² = 0.88; ChP est for overall effect: Z = 0.73 (ther Physical Therapy Interv arcia-de-Miguel et al. 2020 uddo et al. 2020	Mean Other fo 62.76 67.25 73.55 # = 6.93, P = 0.10) 70.25 77.65 74.05 * = 6.64, c P = 0.47) entions 66.32 78.21	Needlin, m of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68 ff = 2 (P 9.81 9.94	9 Total y nee 63 16 9 88 * = 0.0 45 7 10 62 = 0.0 42 22 20	Con <u>Mean</u> dling 58.58 66.3 58.1 13); I ² = 69.8 82.8 74.97 1); I ² = 7 70.111 79.92	sp 11.61 8.78 7.45 71% 2.95 7.7 0.72 0% 8.42 11.58	re Total 21 15 8 44 46 13 20 79 22 20	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.9% 46.3% 3.9% 2.7%	Mean Difference IV, Rendom, 95% C1 4.18 [-123, 9.59] 0.95 [5-44, 7.39] 15.45 [6.67, 24.33] 6.20 [-1.06, 13.48] 0.45 [-0.65, 1.55] -5.15 [-11.64, 1.34] 0.92 [-1.45, -0.39] -0.52 [-1.91, 0.87] -3.79 [-9.19, 1.61] -1.71 [-8.40, 4.98]	Mean Difference IV, Random, 95% CI
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tudy or Subgroup ham / Placebo / Waiting list / minidez-Camero et al. 2019 ejulo-Vizquez et al. 2019 ejulo-Vizquez et al. 2014 ubtotal (95% CI) eterogeneity: Tau ² = 20.12; Ch anual Therapy amas-Ramos et al. 2014 obhani et al. 2017 abatabase et al. 2019 ubtotal (95% CI) eterogeneity: Tau ² = 0.88; Ch ² est for overall effect: Z = 0.73 (ther Physical Therapy Interv arcia-do-Migue Herapy Interv arcia-do-Jago Herapy	0 ory Mean Other fo 62.76 67.25 73.55 at = 6.93, P = 0.10) 70.25 77.85 74.05 P = 0.47) entions 66.32 78.21 79 77.45 74.05 74.05 74.05 74.05 74.05 74.05 74.05 74.05 74.05 74.05 74.05 75.55 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 74.05 76.25 77.85 77.85 74.05 76.25 77.85 74.05 76.25 77.85 77.85 77.85 77.85 76.25 77.85 77.85 74.05 76.25 77.85 77.85 77.85 77.85 76.25 77.85 76.25 77.85 77.85 77.85 77.85 77.85 77.85 76.25 77.85 77.85 76.25 77.85 76.25 77.85 76.25 77.85 77.85 77.85 77.85 77.85 77.85 77.85 77.85 77.85 77.85 77.85 77.85 77.85 76.25 77.85 77.85 77.85 77.85 77.85 77.85 76.25 77.85 76.25 77.85 76.25 77.85 76.25 77.85 76.25 77.85 76.25 77.85 76.25 77.85 76.25 77.85 76.25 77.85 76.75 77.85 76.75 77.85 76.75 77.85 77	Needing SD rm of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68 ff = 2 (P 9.81 9.94 4.15 0.68 ff = 4.00 ff = 4.00	9 Total 9 88 9 = 0.0 45 7 10 62 = 0.0 62 20 36 6 10 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 9 9 8 8 8 9 9 8 8 9 9 8 8 9 9 8 8 8 9 9 8 8 8 9 9 8 8 8 9 9 8 8 8 9 9 8 8 8 9 9 8 8 8 9 9 8 8 8 9 9 8 8 9 9 8 8 8 9 9 9 8 8 8 9 9 9 8 8 9 9 9 8 8 9 9 9 9 9 9 9 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9	Con <u>Mean</u> <u>Mean</u> <u>58.58</u> <u>66.3</u> <u>58.58</u> <u>66.3</u> <u>58.58</u> <u>74.97</u> <u>70.11</u> <u>79.92</u> <u>70.11</u> <u>79.92</u> <u>70.11</u> <u>74.45</u> <u>75.83</u> <u>74.45</u> <u>75.83</u>	nparativ SD 11.61 8.78 7.45 7.1% 2.95 7.7 0.72 0% 8.42 11.58 6.15 0.78 0.78	e Total 21 15 8 44 46 13 20 79 22 20 20 36 13 20 111	Weight 3.9% 2.9% 1.6% 8.5% 20.1% 2.9% 23.3% 46.3% 3.9% 2.7% 12.0% 3.3% 23.3% 45.2%	Mean Difference IV, Random, 95% C1 4.18 [-1.23, 0.59] 0.05 [5.44, 7.39] 15.45 [6.67, 7.43] 6.20 [-1.06, 13.48] 0.45 [-0.65, 1.55] -5.15 [-11.84, 1.34] -0.52 [-1.81, 0.87] -3.79 [-0.19, 1.61] 1.77 [-8.40, 4.98] 0.90 [-155, 3.31] 3.20 [-2.62, 9.22] -1.78 [-2.2, -1.24] -0.82 [-2.73, 1.09]	Mean Difference IV, Random, 95% CI
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Itady or Subgroup Itam / Placebo / Waiting list / emandez-Camero et al. 2019 tepto-Vizequez et al. 2019 tepto-Vizequez et al. 2014 iustotal (95% CI) teerogeneity: Tau' = 29.12; Ch est for overall effect. Z = 1.67 (tanual Therapy tamas-Ramos et al. 2014 iobhani et al. 2017 substabilize et al. 2019 uibtotal (95% CI) teerogeneity: Tau' = 0.88; Chi ² est for overall effect: Z = 0.73 (Dther Physical Therapy Interv arcia-de-Miguel et al. 2020 oubdu et al. 2017 abatabales et al. 2019 uibtotal (95% CI) teerogeneity: Tau' = 1.93; Chi ² est for overall effect: Z = 0.84 (otal (95% CI)	Mean Mean Other fo 62.76 67.25 73.55 73.55 73.55 74.65 77.65 77.65 77.65 74.05 66.32 76.21 79.25 77.65 74.05 74.05 77.65 74.05 77.65 74.05 74.05 74.05	Needlin, SD 1 rm of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68 ff = 2 (P 9.81 9.94 6.7 0.66 ff = 2 (P 11.05 ff = 2 (P) ff	9 Total y nee 63 16 9 88 8 8 8 8 0 0 45 7 10 62 2 20 36 6 10 9 8 8 8 8 8 8 8 8 8 8 8 8 8	Con <u>Mean</u> <u>Mean</u> <u>58,58</u> 66,3 58,1 (3); l ² = 69,8 82,8 74,97 (1); l ² = 7 70,11 79,92 78,1 74,45 75,83 (2); l ² = 4 (2); l ² = 4 (2)	sparativ sparativ sparativ sparatic spa	re <u>Total</u> 21 15 8 44 46 13 20 79 22 20 36 13 20 79 22 20 36 13 20 79 22 20 36 13 20 79 22 20 23 24 21 20 21 20 20 20 20 20 20 20 20 20 20	Weight 3.9% 2.9% 8.5% 20.1% 2.0.1% 2.9% 46.3% 46.3% 3.9% 2.7% 12.0% 3.3% 45.2%	Mean Difference IV, Rendom, 95% C1 4.18 [-123, 9.59] 10.95 [5-44, 7.39] 15.45 [6.67, 24.33] 6.20 [-1.06, 13.48] 0.45 [-0.65, 1.55] -5.15 [-11.84, 1.34] 0.92 [-1.45, -0.39] -0.52 [-1.91, 0.87] -3.79 [-9.19, 1.61] -1.71 [-8.40, 4.98] 0.00 [-1.51, 3.31] 0.02 [-2.82, 9.22] -1.78 [-2.22, -1.24] -0.82 [-2.73, 1.09] -0.23 [-1.40, 0.95]	Mean Difference IV, Random, 95% CI
Itudy or Subgroup Itudy or Subgroup Itam / Placebo / Waiting list / emandez-Camero et al. 2019 teptor-Vizquez et al. 2019 teptor-Vizquez et al. 2014 iubtotal (95% CI) teterogeneity: Taz ² = 20.12; CF anual Therapy Jamas-Ramos et al. 2014 Jobhani et al. 2017 iabatbaike et al. 2019 Libbani et al. 2014 Libbani et al. 2014 Libbani et al. 2015 Libbani et al. 2014 Libbani et al. 2015 Libbani et al. 2015 Libbani et al. 2015 Libbani	Mean Mean Other fo 62.76 67.25 73.55 77.65 77.65 77.65 77.65 77.65 77.65 77.65 77.65 77.65 77.65 77.65 77.65 77.65 77.55 77.65 77.75	Needlin, 5D 1 SD 1 rm of dr 8.66 9.51 11.05 df = 2 (P 2.4 6.7 0.68 df = 2 (P 9.81 9.94 4.15 6.7 0.68 df = 4 (P df = 10 (9 Total y nee 63 16 9 88 8 8 8 8 8 8 8 8 8 8 8 8	Con Mean Miang 58,58 66,3 58,1 13); I ² = 69,8 82,8 74,97 70,11 74,97 70,11 74,45 75,83 75,83 (); I ² = 4 (); I ² = 4 (sparativ sparativ sparativ sparatic spa	re <u>Total</u> 21 15 8 44 46 13 20 79 22 20 36 13 20 111 234	Weight 3.9% 2.9% 8.5% 20.1% 23.3% 46.3% 3.9% 46.3% 12.0% 3.3% 45.2%	Mean Difference IV, Random, 95% C1 4.18 [-123, 0.59] 0.95 [544, 7.39] 15.45 [6 57, 24 33] 6.20 [-1.06, 13.48] 0.45 [-0.65, 1.55] -5.15 [-11.64, 1.34] -0.92 [-1.45, -0.39] -0.52 [-1.91, 0.87] -3.79 [-9.19, 1.61] -1.71 [-8.40, 4.98] 0.90 [-151, 331] 3.20 [-2.02, 9.22] -1.78 [-2.2, 1.24] -0.82 [-2.73, 1.09] -0.23 [-1.40, 0.95]	Mean Difference IV, Random, 95% CI

Figure 8. Mean differences (MD) comparing the effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy interventions on the cervical range of motion in rotation (A) immediately after and (B) at the short-term. SD: standard deviation; CI: confidence interval.

Cervical Lateral Flexion

A) Immediate

	Dry	Needli	ng	Con	parat	ive		Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV. Random, 95% CI	IV, Random, 95% CI
Sham / Placebo / Waiting list /	Other fo	rm of d	try nee	dling					
Femández-Carnero et al. 2017	43.94	9.45	63	39.58	9.45	21	28.7%	4.36 [-0.31, 9.03]	
Martin-Rodriguez et al. 2019	39.75	10.91	16	40.4	8.35	15	21.8%	-0.65 [-7.46, 6.16]	
Mejuto-Vázquez et al. 2014 Subtotal (95% CI)	49.95	7.95	9 88	37.8	11.4	8 44	15.3% 65.8%	12.15 [2.70, 21.60] 4.54 [-1.41, 10.48]	-
telerogeneity: Tau* = 15.64; Ch	/ = 4.66,	df = 2	P=0.1	10); 1* =	57%				
Test for overall effect: Z = 1.50 (P = 0.13)								
Other Physical Therapy Interv	entions								
Garcia-de-Miguel et al. 2020 Subtotal (95% CI)	40.09	5.3	22 22	41.04	5.08	22 22	34.2% 34.2%	-0.95 [-4.02, 2.12] -0.95 [-4.02, 2.12]	-
Heterogeneity: Not applicable Test for overall effect: Z = 0.61 (P = 0.54)								
Total (95% CI)			110			66	100.0%	2.65 [-2.07. 7.37]	-
Heterogeneity: Tau ² = 14.50; Ch	i ² = 9.08,	df = 3	P=0.0	(3); 2 =	67%			6.00019.00030.00030.0	
Test for overall effect: Z = 1.10 ()	P = 0.27)								-20 -10 0 10 20
Test for subgroup differences: C	hi ^a = 2.56	, df = 1	(P = 0	11), P +	61.3	5			[comparative] [bity ineeding]

B) Short-term

	Dry	Needli	ing	Cor	nparati	ve		Mean Difference	Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI	
Sham / Placebo / Waiting list	Other fo	rm of	dry nee	dling						
Femández-Camero et al. 2017	40.46	6.69	63	40.17	9.48	21	5.8%	0.29 [-4.09, 4.67]		
Martin-Rodriguez et al. 2019	40.2	7.66	16	39.4	7.87	15	4.3%	0.80 [-4.67, 6.27]		
Mejuto-Vázquez et al. 2014 Subtotal (95% CI)	51.9	5.45	9 88	41.85	8.5	8 44	3.0% 13.1%	10.05 [3.17, 16.93] 3.21 [-2.28, 8.70]	-	
Heterogeneity: Tau* = 15.52; Cl	sF = 5.97.	df = 2	(P = 0.1	15); 12 =	66%					
Test for overall effect: Z = 1.15	(P = 0.25)	1								
Manual Therapy										
Llamas-Ramos et al. 2014	44.3	3.7	45	44.9	4.7	46	13.1%	-0.60 [-2.34, 1.14]		
Sobhani et al. 2017	40.85	5.9	7	38.35	6.3	13	4.2%	2.50 [-3.05, 8.05]		
Tabatabaiee et al. 2019 Subtotal (95% CI)	43.17	0.48	10 62	41.11	0.8	20 79	16.6% 33.9%	2.06 [1.60, 2.52] 1.09 [-1.11, 3.28]	÷	
Heterogeneity: Tau ^a = 2.48; Chi Test for overall effect: Z = 0.97	* = 8.48, ((P = 0.33)	#=24	P = 0.0	1); I* = 7	16%					
Other Physical Therapy Interv	entions									
Dogan et al. 2019	45.8	5.39	19	46.7	6.01	23	7.8%	-0.90 [-4.35, 2.55]		
Garcia-de-Miguel et al. 2020	40.7	4.68	22	41.38	5.58	22	8.8%	-0.68 [-3.72, 2.36]		
Ibuldu et al. 2004	45.35	10.67	20	53.27	11.29	20	3.0%	-7.92 [-14.73, -1.11]		
Onat et al. 2019	45	0.01	36	45.9	5.6	36	12.7%	-0.90 [-2.73, 0.93]		
Sobhani et al. 2017	40.85	5.9	6	37.75	5.9	13	4.0%	3.10 [-2.61, 8.81]		
Tabatabaice et al. 2019 Subtotal (95% CI)	43.17	0.48	10 113	43.5	0.62	20 134	16.7% 53.1%	-0.33 [-0.73, 0.07] -0.58 [-1.59, 0.42]	4	
Heterogeneity: Tau ² = 0.41; Chi	*= 6.63. (#=5(1	P = 0.2	5); P = 2	25%					
Test for overall effect: Z = 1.13	(P = 0.26)									
Total (95% CI)			263			257	100.0%	0.30 [-1.00, 1.61]	+	
Heterogeneity: Tau ² = 2.61; Chi	= 79.48,	df = 1*	(P < 0	00001)	; I ² = 86	%		-		
Test for overall effect: Z = 0.45	(P = 0.65)	1000							-10 -5 0 5 10	
Test for subgroup differences: C	hi? = 3.3	5. cf = 2	2(P = 0)	(19); P	= 40.4%	8			fourthmannel for hundride	

Figure 9. Mean differences (MD) comparing the effects of dry needling alone against sham/placebo/waiting list/other forms of dry needling or manual therapy or other physical therapy interventions on the cervical range of motion in lateral-flexion (**A**) immediately after and (**B**) at the short-term. SD: standard deviation; CI: confidence interval.

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