Evidence of disease severity, cognitive and physical outcomes of dance interventions for persons with Parkinson's Disease: a systematic review and meta-analysis

Sophia Rasheeqa Ismail^{1*}, Shaun Wen Huey Lee², Dafna Merom³, Puteri Sofia Nadira Megat Kamaruddin¹, Min San Chong⁴, Terence Ong⁴, Nai Ming Lai^{2,5}

¹ Institute for Medical Research, National Institutes of Health, Ministry of Health, Malaysia

² School of Pharmacy, Monash University Malaysia, Malaysia

³ University of Western Sydney, Australia

⁴ University of Malaya Medical Centre, Malaysia.

⁵ School of Medicine, Faculty of Health and Medical Sciences, Taylor's University Malaysia

Additional File 8

Forest plots

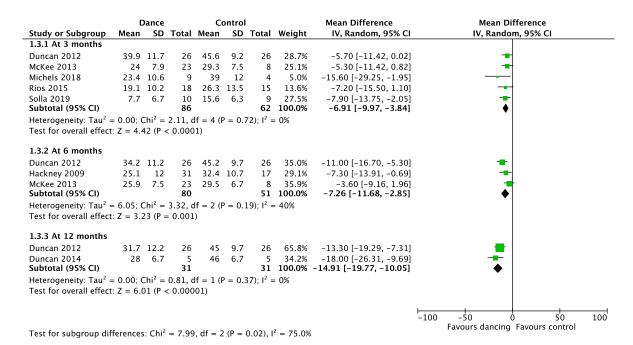
1. Comparison 1: Dance versus control

		ance		C	ontrol			Mean Difference		Mean	Differen	ice	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Ran	dom, 959	% CI	
Duncan 2014	5.8	4	5	14.8	5.8	5	66.5%	-9.00 [-15.18, -2.82]		1			
Michels 2018	37.7	15.9	9	30.3	16.8	4	33.5%	7.40 [-12.07, 26.87]			+-	-	
Total (95% CI)			14			9	100.0%	-3.50 [-18.68, 11.67]		•			
Heterogeneity: Tau ² = Test for overall effect					(P = 0)	.12); I ²	= 60%		-100	–50 Favours dan	0 ce Favoi	50 urs control	100

1.1 Disease severity: MDS-UPDRS 1 (non-motor experiences of daily living) (0-16, higher score worse)

	D	ance		Co	ntro	I		Mean Difference		Me	an Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, R	andom, 959	% CI	
Duncan 2014	11.5	7.8	5	17.2	7.6	5	33.1%	-5.70 [-15.25, 3.85]					
Michels 2018	10.7	6.5	9	11	5.3	4	66.9%	-0.30 [-7.01, 6.41]			-		
Total (95% CI)			14			9	100.0%	-2.09 [-7.57, 3.40]			•		
	otal (95% CI) $ 14 \\ \text{eterogeneity: } \text{Tau}^2 = 0.00; \text{Chi}^2 = 0.82, \text{ df} = 1 \text{ (P} = 0. \\ \text{est for overall effect: } Z = 0.74 \text{ (P} = 0.46) $								-100	-50 Favours d	0 ance Favou	50 irs control	100

1.2 Disease severity: MDS-UPDRS 2 (motor experiences of daily living) (0-56, higher score worse)



1.3 Disease severity: MDS-UPDRS 3 (Motor examination) (0-108, higher score worse)

	Ta	ango		Self-dire	cted exer	cise		Mean Difference		Mea	an Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, R	andom, 95	% CI	
Rios 2015	0.6	0.9	18	0.7	1.1	15	100.0%	-0.10 [-0.79, 0.59]					
Total (95% CI)			18			15	100.0%	-0.10 [-0.79, 0.59]					
Heterogeneity: Not a Test for overall effect			0.78)						-100	-50 Favours Ta	0 ngo Favo	50 urs exercise	100 e

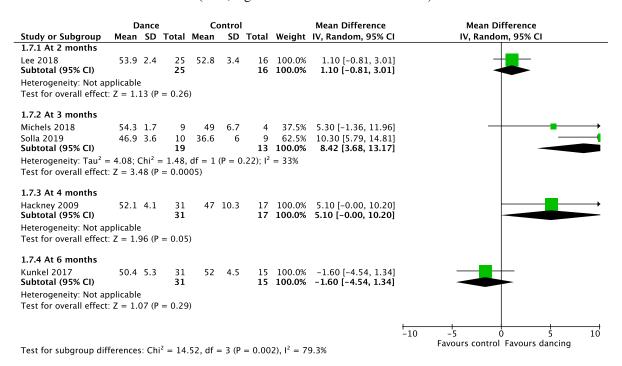
1.4 Disease severity: MDS-UPDRS 4 (dyskinesia) (0-13, higher score worse)

	T	ango		Self-dired	cted exer	cise		Mean Difference		Me	an Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, R	andom, 95	% CI	
Rios 2015	1.7	2.7	18	1.1	1.7	15	100.0%	0.60 [-0.92, 2.12]					
Total (95% CI)			18			15	100.0%	0.60 [-0.92, 2.12]			•		
Heterogeneity: Not ap Test for overall effect			0.44)						-100	-50 Favours Ta	0 Ingo Favo	50 urs exercise	100

1.5 Disease severity: MDS-UPDRS 4 (fluctuation) (0-10, higher score worse)

	Da	ance		Co	ontro	I		Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Duncan 2012	21.3	5.1	26	17.2	5.6	26	56.2%	4.10 [1.19, 7.01]	- -
Duncan 2014	21.5 2 36.3 3		5	16.7	7.6	5	10.0%	4.80 [-2.09, 11.69]	+-
Rios 2015	36.3	3	18	31.3	6.9	15	33.8%	5.00 [1.24, 8.76]	
Total (95% CI)			49			46	100.0%	4.47 [2.29, 6.66]	•
	Total (95% CI) 49 46 1 Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.15$, $df = 2$ ($P = 0.93$); $I^2 = 0$ % Test for overall effect: $Z = 4.02$ ($P < 0.0001$)								-20 -10 0 10 20 Favours control Favours dance

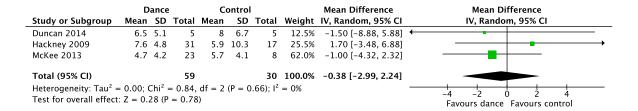
1.6 Balance: Mini-BEST Test (0-28, higher score indicates better balance)



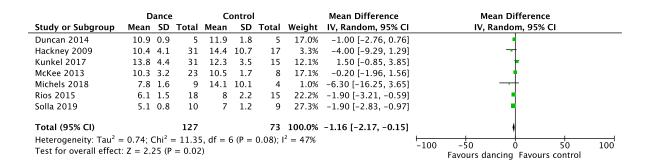
1.7 Balance: Berg Balance Scale (0-56, higher score indicates better balance)

	D	ance		C	ontrol			Mean Difference		Mea	an Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, R	andom, 95	% CI	
Kunkel 2017	75.6	17.6	31	75.4	22.4	15	100.0%	0.20 [-12.72, 13.12]			-		
Total (95% CI)			31			15	100.0%	0.20 [-12.72, 13.12]			*		
Heterogeneity: Not ap Test for overall effect:	•		0.98)						-100	-50 Favours dan	o cing Favo	50 urs control	100

1.8 Balance: Activity-specific balance confidence (0-100, higher score indicates better balance confidence)



1.9 Freezing of gait questionnaire (0-24, higher score indicates more severe condition)



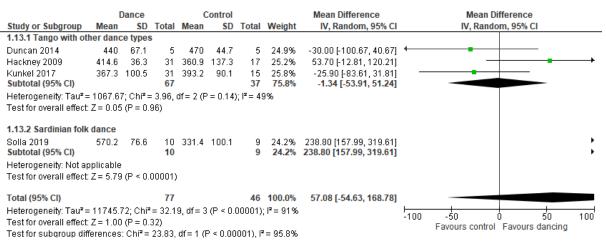
1.10 Timed Up and Go Test (TUG) (seconds)

	Di	ance		Co	ontro	l		Mean Difference		Me	an Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, R	andom, 959	% CI	
Solla 2019	6.6	0.6	10	11.5	2.4	9	100.0%	-4.90 [-6.51, -3.29]					
Total (95% CI)			10			9	100.0%	-4.90 [-6.51, -3.29]			•		
Heterogeneity: Not ap Test for overall effect:			0.0000	01)					-100	-50 Favours da	0 ance Favou	50 urs control	100

1.11 Five Times Sit-to-Stand Test (seconds) (lower better)

	0	ance		Co	ntro	I		Mean Difference		Mean [)iffer	ence	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Rand	om,	95% CI	
Solla 2019	-1.3	11.1	10	-5.9	4.1	9	100.0%	4.60 [-2.78, 11.98]					
Total (95% CI)			10			9	100.0%	4.60 [-2.78, 11.98]			•		
Heterogeneity: Not ap Test for overall effect:			0.22)						-100	-50 Favours control	0 L Fa	50 vours dance	100

1.12 Sit-and-Reach Test (cm) (longer better)



1.13 Walking distance: six-minute walk test (meters) (longer better)

	D	ance		Co	ontro	I		Mean Difference		Mea	ın Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Ra	andom, 95	% CI	
Hackney 2009	1.2	0.2	31	1.1	0.4	17	100.0%	0.10 [-0.10, 0.30]					
Total (95% CI)			31			17	100.0%	0.10 [-0.10, 0.30]					
Heterogeneity: Not ap Test for overall effect:			0.33)						-100	-50 Favours con	0 Itrol Favo	50 urs dance	100

1.14 Forward velocity (meter/second)

	Di	ance		Co	ontro	I		Mean Difference		Mean	Differer	ice	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Ran	lom, 95	% CI	
Kunkel 2017	5.3	4.6	31	4	0.9	15	100.0%	1.30 [-0.38, 2.98]					
Total (95% CI)			31			15	100.0%	1.30 [-0.38, 2.98]			•		
Heterogeneity: Not ap Test for overall effect:			0.13)						-100	-50 Favours dancin	0 g Favo	50 ours control	100

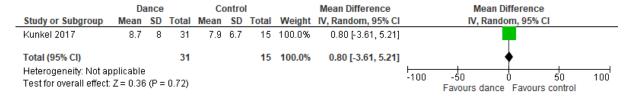
1.15 Standing start 180 degree turn test (number of steps)

	D	ance		Co	ontro	I		Mean Difference		Mean E)ifferenc	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Rand	om, 95%	6 CI	
Kunkel 2017	2.3	1.3	31	1.9	0.7	15	100.0%	0.40 [-0.18, 0.98]					
Total (95% CI)			31			15	100.0%	0.40 [-0.18, 0.98]					
Heterogeneity: Not ap Test for overall effect:			0.18)						-100	-50 Favours dancing	0 Favou	50 irs control	100

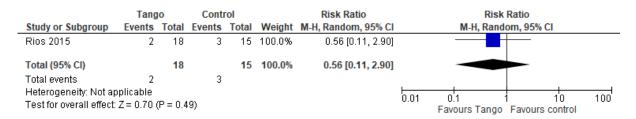
1.16 Standing start 180 degree turn test (time taken in seconds)

	D	ance		Co	ontro	I		Mean Difference		Mean Di	fferen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Rando	m, 95%	6 CI	
Solla 2019	-8.6	8.5	10	-13.9	9.7	9	100.0%	5.30 [-2.94, 13.54]					
Total (95% CI) Heterogeneity: Not as	nnlicable		10			9	100.0%	5.30 [-2.94, 13.54]			•		
Test for overall effect:			0.21)						-100	-50 Favours control	ΰ Favoι	50 urs dance	100

1.17 Back-Scratch Test (cm) (longer better)



1.18 Spinal mouse inclination degree (higher worse)



1.19 Adverse events: falls during study

	Tar	ngo	Co	ontro	ıl		Mean Difference	Mean Difference
Study or Subgroup	Mean :	SD Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
McKee 2013	26.1	3.3 23	26.3	2.3	8	45.4%	-0.20 [-2.29, 1.89]	
Rios 2015	27.4 2	2.1 18	26.1	3.2	15	54.6%	1.30 [-0.59, 3.19]	
Total (95% CI)		41			23	100.0%	0.62 [-0.84, 2.08]	
Heterogeneity: Tau ² Test for overall effec				(P =	0.30);	$I^2 = 8\%$		-4 -2 0 2 4 Favours control Favours Tango

1.20 Cognitive function: Montreal Cognitive Assessment Scale (0-30, higher score better)

	D	ance		C	ontrol			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Foster 2013	54	30.6	26	46	10.2	26	100.0%	8.00 [-4.40, 20.40]	-
Total (95% CI)			26			26	100.0%	8.00 [-4.40, 20.40]	•
Heterogeneity: Not ap Test for overall effect	•		0.21)						-100 -50 0 50 100 Favours control Favours dance

1.21 Activity participation: Activity Card Sort score (0-100, higher score better)

	T.	ango	,	Co	ntro	d .		Mean Difference	Mean Difference				
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95%	CI			
Lee 2018	11.4	7.6	24	16	7.9	16	31.6%	-4.60 [-9.52, 0.32]					
Michels 2018	10.9	5.5	9	5.5	2.4	4	33.7%	5.40 [1.11, 9.69]	=				
Rios 2015	7.7	7.2	18	7.3	4.4	15	34.7%	0.40 [-3.60, 4.40]	†				
Total (95% CI)			51			35	100.0%	0.51 [-4.90, 5.91]	•				
Heterogeneity: Tau ² = Test for overall effect					2 (P =	= 0.01);	$I^2 = 78\%$		-100 -50 0 Favours Tango Favours		.00		

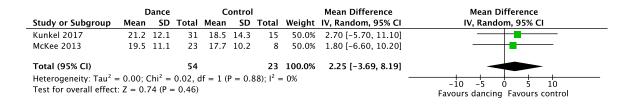
1.22Depressive symptoms: Beck Depression Inventory score (0-60, higher score worse)

	T	ango		Co	ontro	ı		Mean Difference		Mean	Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Ran	dom, 95%	6 CI	
Rios 2015	31.3	4.5	18	29.4	5.9	15	100.0%	1.90 [-1.74, 5.54]					
Total (95% CI) Heterogeneity: Not a	onlicable		18			15	100.0%	1.90 [-1.74, 5.54]			<u> </u>		
Test for overall effect			0.31)						-100	-50 Favours contr	0 ol Favou	50 Irs Tango	100

1.23 Apathy: Apathy Scale score (18-72, higher score better, less apathy)

	Т	ango		C	ontrol			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Michels 2018	34.2	14	9	27.5	14.7	4	30.8%	6.70 [-10.36, 23.76]	- •
Rios 2015	30.8	15.3	18	35.9	11.9	15	69.2%	-5.10 [-14.39, 4.19]	
Total (95% CI)			27			19	100.0%	-1.46 [-12.14, 9.22]	
Heterogeneity: Tau ² = Test for overall effect	,				(P = 0	.23); I ²	= 29%		-20 -10 0 10 20 Favours Tango Favours control

1.24Fatigue: Krupp Fatigue Severity Scale score (9-63, higher score worse)



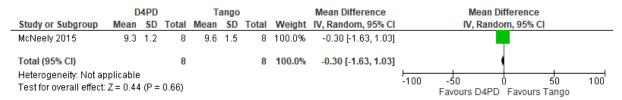
1.25 Quality of life: PDQ 39 score (0-100, higher score worse)

2. Two different forms of dance interventions

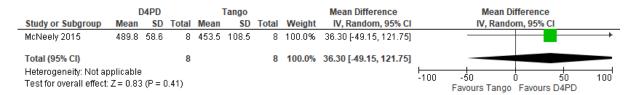
2.1. Dance for Parkinson's Disease (D4PD) versus Tango

	[)4PD		Ta	ango			Mean Difference		Me	ean Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, F	Random, 959	% CI	
McNeely 2015	29.4	18.6	8	23.3	5.9	8	100.0%	6.10 [-7.42, 19.62]			-		
Total (95% CI)			8			8	100.0%	6.10 [-7.42, 19.62]			•		
Heterogeneity: Not ap Test for overall effect:			0.38)						-100	-50 Favours D	0 0 0 0 04PD Favou	50 Jrs Tango	100

2.1.1. Disease severity: MDS-UPDRS 3 (motor examination) (0-108, higher score worse)



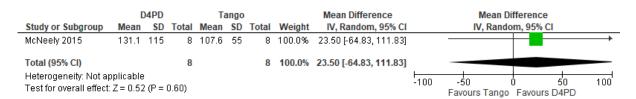
2.1.2. Agility: Timed Up and Go Test (seconds)



2.1.3. Walking distance: six-minute walk test (meters)

	[04PD		T	ango			Mean Difference		Me	an Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, F	Random, 95	% CI	
McNeely 2015	1.5	0.27	8	1.4	0.25	8	100.0%	0.10 [-0.15, 0.35]					
Total (95% CI)			8			8	100.0%	0.10 [-0.15, 0.35]					
Heterogeneity: Not ap Test for overall effect:			0.44)						-100	-50 Favours Ta	0 ango Favo	50 urs D4PD	100

2.1.4. Forward velocity (meter/second)

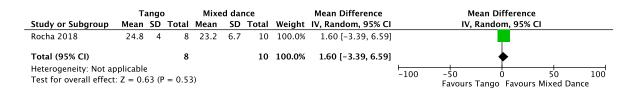


2.1.5. Quality of life: PDQ 39 score (0-100, higher score worse)

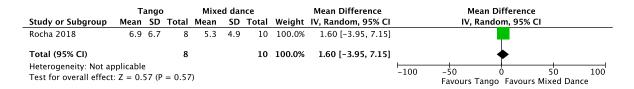
2.2. Tango versus Mixed dances

	т	ango)	Mixe	d dar	ıce		Mean Difference		Me	an Differenc	e	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, R	andom, 95%	CI	
Rocha 2018	8	1.4	8	9.6	3.1	10	100.0%	-1.60 [-3.75, 0.55]					
Total (95% CI)			8			10	100.0%	-1.60 [-3.75, 0.55]			•		
Heterogeneity: Not ap Test for overall effect	•		= 0.15)					-100	–50 Favours T	0 ango Favour	50 s Mixed Da	100

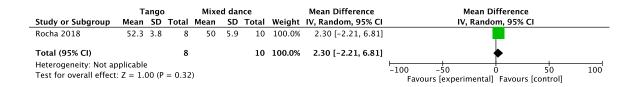
2.2.1. Time Up and Go test (TUG)



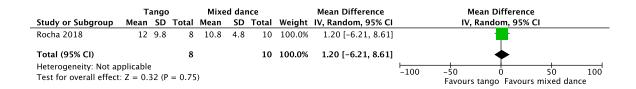
2.2.2. Functional Gait Assessment



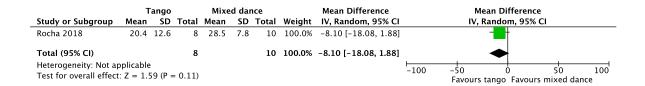
2.2.3. Freezing gait questionnaire (0- 24, lower score better)



2.2.4. Berg Balance Scale



2.2.5. Motor experiences of daily living: MDS-UPDRS 2

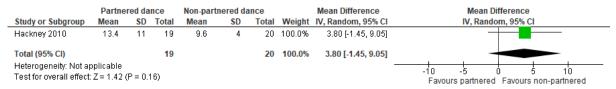


2.2.6. Quality of life: PDQ39

2.3. Partnered versus non-partnered dance

	Partne	red da	nce	Non-part	nered da	ance		Mean Difference		Me	an Differen	ce	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, R	andom, 95%	6 CI	
Hackney 2010	48.2	7.8	19	49	6.5	20	100.0%	-0.80 [-5.32, 3.72]			-		
Total (95% CI)			19			20	100.0%	-0.80 [-5.32, 3.72]			•		
Heterogeneity: Not ap Test for overall effect	•	(P = 0.7	73)						-50 Favo	-25 urs non-partn	0 ered Favou	25 urs partnere	50 ed

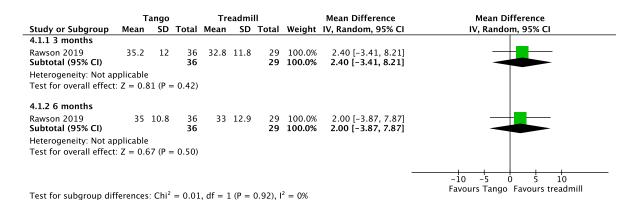
2.3.1. Balance: Berg Balance Scale (0-56, higher score indicates better balance)



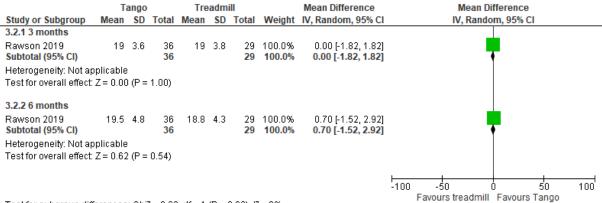
2.3.2. Agility: Timed Up and Go Test (seconds)

3. Dance versus different exercises

3.1. Tango versus treadmill

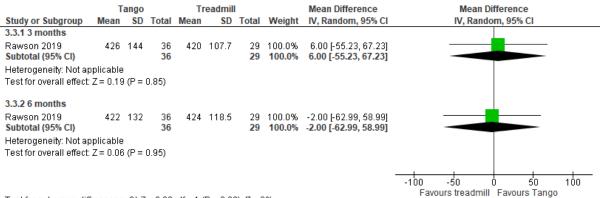


3.1.1. Disease severity: MDS-UPDRS 3 (motor examination) (0-108, higher score worse)



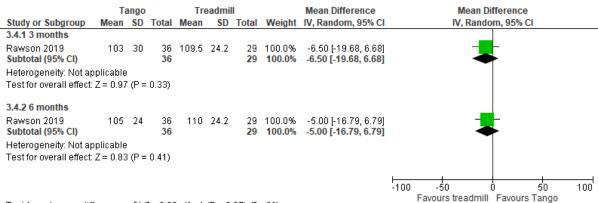
Test for subgroup differences: $Chi^2 = 0.23$, df = 1 (P = 0.63), $I^2 = 0\%$

3.1.2. Balance: Mini-BEST Test (0-28, higher score indicates better balance)



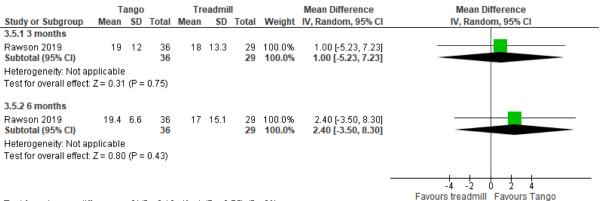
Test for subaroup differences: $Chi^2 = 0.03$ df = 1 (P = 0.86) $I^2 = 0\%$

3.1.3. Walking distance: Six-minute walk test (meters)



Test for subgroup differences: $Chi^2 = 0.03$, df = 1 (P = 0.87), $I^2 = 0\%$

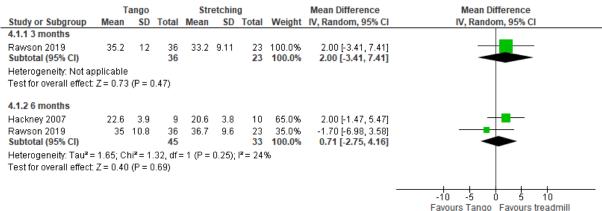
3.1.4. Forward velocity (meter/second)



Test for subgroup differences: Chi² = 0.10, df = 1 (P = 0.75), I² = 0%

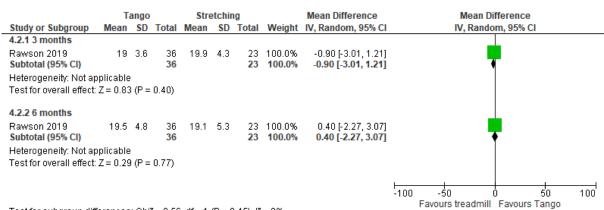
3.1.5. Quality of life: PDQ 39 score (0-100, higher score worse)

3.2. Tango versus stretching or flexibility exercises



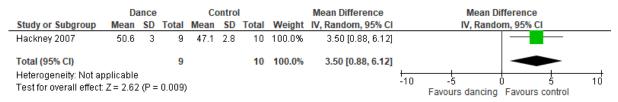
Test for subgroup differences: $Chi^2 = 0.16$, df = 1 (P = 0.69), $I^2 = 0\%$

3.2.1. Disease severity: MDS-UPDRS 3 (motor examination) (0-108, higher score worse)

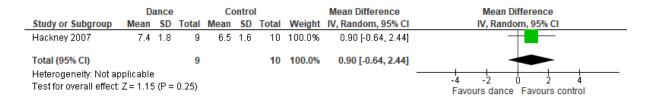


Test for subgroup differences: Chi² = 0.56, df = 1 (P = 0.45), l² = 0%

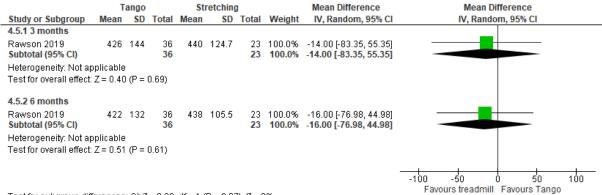
3.2.2. Balance: Mini-BEST Test (0-28, higher score indicates better balance)



3.2.3. Balance: Berg Balance Scale (0-56, higher score indicates better balance)



3.2.4. Freezing of gait questionnaire (0-24, higher score indicates more severe condition)

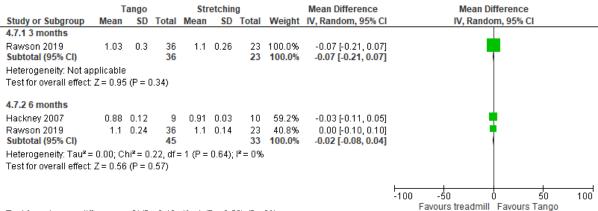


Test for subgroup differences: $Chi^2 = 0.00$, df = 1 (P = 0.97), $I^2 = 0\%$

3.2.5. Walking distance: Six-minute walk test (meters)

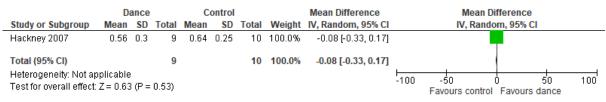
	Di	ance		Co	ontro	I		Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Hackney 2007	9.8	1.2	9	11.8	1.3	10	100.0%	-2.00 [-3.12, -0.88]	•
Total (95% CI)			9			10	100.0%	-2.00 [-3.12, -0.88]	
Heterogeneity: Not ap Test for overall effect:			0.0006	5)					-100 -50 0 50 100 Favours dancing Favours control

3.2.6. Agility: Timed Up and Go Test (seconds)

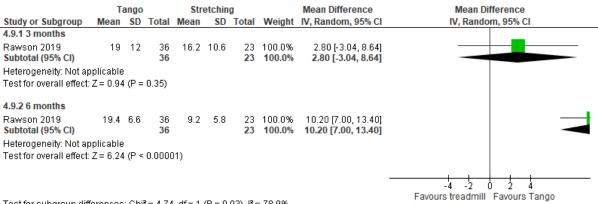


Test for subgroup differences: $Chi^2 = 0.42$, df = 1 (P = 0.52), $I^2 = 0\%$

3.2.7. Forward velocity (meter/second)



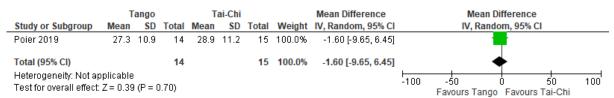
3.2.8. Dual-task walking velocity (meter/second)



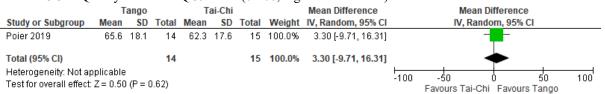
Test for subaroup differences: $Chi^2 = 4.74$. df = 1 (P = 0.03). $I^2 = 78.9\%$

3.2.9. Quality of life: PDQ 39 score (0-100, higher score worse)

3.3. Tango versus Tai-Chi



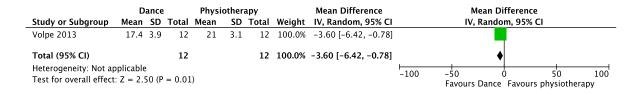
3.3.1. Quality of life: PDQ 39 score (0-100, higher score worse)



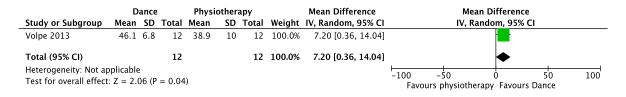
3.3.2. Brief Multidimensional Life Satisfaction Scale (BMLSS) (0-100, higher score better)

4. Dance versus physiotherapy

4.1. Irish Dance versus physiotherapy



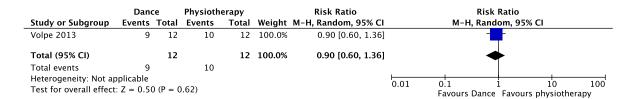
4.1.1. Disease severity: MDS-UPDRS 3 (motor examination) (0-108, higher score worse)



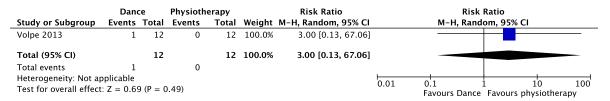
4.1.2. Balance: Berg Balance Scale (0-56, higher score indicates better balance)

	D	ance	!	Physi	other	ару		Mean Difference		Me	an Differen	e	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, F	andom, 95%	CI	
Volpe 2013	4.9	2.1	12	10.2	4.5	12	100.0%	-5.30 [-8.11, -2.49]					
Total (95% CI)			12			12	100.0%	-5.30 [-8.11, -2.49]			•		
Heterogeneity: Not ap Test for overall effect	•		= 0.00	002)					-100	-50 Favours D	0 Dance Favou	50 rphysiothera	100 apy

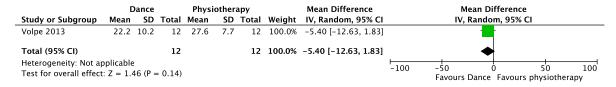
4.1.3. Freezing of gait questionnaire (0-24, higher score indicates more severe condition)



4.1.4. Adverse events: falls (any cause) during study period



4.1.5. Adverse events: falls during the time of intervention (dancing or physiotherapy)



4.1.6. Quality of life: PDQ 39 score (0-100, higher score worse)