Article:
Almutairi, N.A., Greenwood, D.C. and Sivan, M. (Accepted: 2026) The prevalence of dysautonomia in chronic musculoskeletal pain: A systematic review and meta-analysis. Rheumatology Advances in Practice. ISSN: 2514-1775 (In Press)

Supplementary Materials

Contents

Supplementary Tables

Supplementary Table 1. Search strategy

1. (Autonomic Dysfunction* OR Dysautonomia* OR Autonomic Dysregulation* OR Parasympathetic Activity* OR Sympathetic Activity*).tw.

2. (CASS* OR COMPASS* OR Tilt Table* OR Stabilometry* OR COMPASS 31* OR Autonomic Function Testing* OR Ewing's Battery of Tests* OR Valsalva Maneuver* OR Orthostatic Hypotension* OR Heart Rate Variability* OR Postural Tachycardia* OR Orthostatic Intolerance*).tw.

3. (Musculoskeletal* OR MSK* OR Musculoskeletal System* OR Osteoarthritis* OR Rheumatoid Arthritis* OR Rheumatism* OR LBP* OR Chronic Musculoskeletal Condition* OR Fibromyalgia*).tw.

4. 1 OR 2

5. 3 AND 4

6. exp Animals/ NOT (exp Humans/)

7. 5 NOT 6

8. 7 NOT ((exp child/ OR exp adolescent/) NOT exp adult/)

9. Limit 8 to English Language

10. Limit 9 to yr="1990 -Current"

Supplementary Table 2. List of studies excluded at full text screening stage with brief reason

Review

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Editorial

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Target population

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Not validated outcome

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Non-relevant outcome

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No prevalence estimation

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Potential sample overlap

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Supplementary Table 3. Adapted Newcastle - Ottawa Quality Assessment Scale

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and comparability categories. A maximum of two stars can be given for **Comprehensiveness of the used method**

Selection

1) Is the definition of the musculoskeletal condition adequate?

a) Yes, clinically approved. *

b) No, Self-diagnosed – not lab or clinically confirmed

2) Representativeness of the cases

a) Consecutive or obviously representative series of cases *

b) Potential for selection biases or not stated

3) Comparison with controls

a) yes *

b) no

Comparability

1) Comparability of cases and controls based on the design or analysis

a) Controls are comparable to cases in terms of setting, demographics, and other confounding variables. *

b) Controls are recruited from a different site or are not adequately matched to cases in terms of key variables.

c) No control group included.

Outcome

1) **Were all study participants tested for dysautonomia?**

a) Yes. *

b) No.

2) Validity of the method used to assess dysautonomia

a) Validated objective or subjective method *

b) Non-validated method

3) **Comprehensiveness of the method used to assess dysautonomia**

a) Assessment included a comprehensive battery of validated autonomic tests covering multiple domains *
b) Assessment used only a single validated test or a limited subset without full domain coverage

Risk of Bias Classification:

6–7 stars Low Risk

4–5 stars Moderate Risk

0–3 stars High Risk

Supplementary Table 4. Risk of Bias Assessment

Risk of bias ratings for included studies using the adapted Newcastle–Ottawa Quality Assessment Scale (maximum score: 7 stars).

Study	Diagnosis Adequacy	Sample Representativeness	Comparison with controls	Comparability	Were all study participants tested for dysautonomia?	Validity of Dysautonomia Assessment	Comprehensiveness of Assessment	**Total Score**
Visuri, et al. 1992	Diagnosis of FM confirmed by clinicians, using published criteria	n=17 FM n=20 controls	Yes	Controls similar mean age and same sex	The response rate is not mentioned or calculable	Active standing test. Validated questionnaire of dystonic symptoms.	Yes	5
	*		*	*		*	*	
Tang, et al. 2004	FM assessed using ACR criteria	n=76 with SLE (18 FM)	No	N/A No health controls	27.6% of participants withdrew before study completion - the withdrawal reasons were outlined and are unlikely to introduce bias.	NMH measured using validated tool (tilt-table test).	single validated test or a limited subset	4
	*			N/A	*	*	*	
Furlan, et al. 2005	FM diagnosis confirmed using ACR criteria and inclusion criteria	n= 16 Consecutive patients from a hospital-based rheumatology clinic.	Yes	Study controls for age and sex through matching.	Yes	Used structured HRV and autonomic testing protocols.	Yes	7
	*	*	*	*	*	*	*	
Naschitz, et al. 2006	FM used ACR criteria	n=70 FM n=50 controls	yes	Controls younger	Analysis includes data from all participants, no mention of	Validated tool (tilt-table test)	single validated test or a limited subset	5

					dropouts, missing data, or exclusions.			
	*		*		*	*	*	
Seidel, et al. 2007	Fibromyalgia diagnosis confirmed using ACR criteria and inclusion criteria clearly outlined.	n=72 patients from a rehabilitation center. Sampling strategy not stated. All females. Few descriptive statistics are provided to confirm representative.	Yes	Study controls for age and sex through matching.	Yes	Used ISAX—a validated tool for HRV and autonomic function measurements.	No	5
	*		*	*	*	*		
Stojanovich, et al. 2007	Diagnosis of chronic musculoskeletal autoimmune conditions (SLE, RA, etc.) made using ACR criteria—clear and validated.	n= 125 patients from a university medical center and 35 controls. Sampling strategy is not stated, but descriptive statistics confirm representative.	Yes	Control group formed to approximately frequency match the mean age. Sex ratio differed substantially. No individual-matching or statistical control for major confounders such as age, BMI, or comorbidities.	Yes	autonomic dysfunction assessed using gold-standard cardiovascular reflex tests Ewing's battery	Yes	6
	*	*	*		*	*	*	
Solano, et al. 2009	FM and RA used ACR criteria	n=30 FM n=30 RA n=30 controls	Yes	Controls younger	All patients completed the questionnaires. No indication of dropouts or incomplete participation	Validated questionnaire (COMPASS)	Yes	5

	*		*		*	*	*	
El-Sawy, et al. 2012	FM used ACR criteria	n=25 FM n=15 controls	Yes	Controls similar mean age and sex ratio	The response rate is not mentioned or calculable	Objective measures: tilt table test and sympathetic skin response (SSR)	No	4
	*		*	*		*		
Oaklander, et al 2013	FM used ACR criteria	n=57 FM	Yes	Controls similar mean age and sex ratio.	64% response rate for FM subjects	autonomic-function testing (AFT)	Yes	5
	*		*	*		*	*	
De Wandele, et al. 2014a	Diagnosis of EDS-HT confirmed by clinicians	n=74 EDS-HT n=35 controls	Yes	Controls similar mean age and same sex	The response rate is not mentioned or calculable	Used Composite Autonomic Scoring Scale (CASS), a validated tool	Yes	5
	*		*	*		*	*	
De Wandele, et al. 2014b	Diagnosis of EDS-HT confirmed by clinicians	n=80 EDS-HT	No	N/A No healthy controls with prevalence of dysautonomia reported	99% response rate	Used Composite Autonomic Scoring Scale (CASS), validated tool	Yes	4
	*			N/A	*	*	*	
Vincent, et al. 2016	FM diagnosis documented by a health care provider in medical records	n=30 FM n=30 controls	Yes	Controls younger, with an unknown % recruited from outside the cohort	Incomplete DXA measures, but all other % out of n=30	CASS and COMPASS31	Yes	5
	*		*		*	*	*	
Lee, et al. 2018	FM used ACR criteria	n=35 FM n=25 controls	Yes	Controls said to be similar mean	The response rate is not	Ewing tests Standard	Yes	5

				age (data not presented). Controls same sex	mentioned or calculable	validated autonomic function tests		
	*		*	*		*	*	
Song, et al. 2020	Diagnosis of EDS and subtypes confirmed by clinicians	n=98 EDS	No	N/A No healthy controls	Analysis includes data from all participants, no mention of dropouts, missing data, or exclusions.	Presence of autonomic dysfunction confirmed by clinicians	Yes	4
	*			N/A	*	*	*	
Singh, et al. 2021	FM used ACR criteria	n=30 FM n=30 controls	Yes	Matched for age and gender	91% completion rate	Used Ewing's battery of validated tests	Yes	6
	*		*	*	*	*	*	
Mucci, et al. 2022	Diagnosis of FM confirmed by clinicians	n=277 FM n=80 controls	Yes	Controls similar gender, but younger	FM response rate not stated. Controls response rate 41%	Validated Dizziness Handicap Inventory (DHI) and Situational Vertigo Ques-tionnaire (SVQ)	No	4
	*	*	*			*		
Kulshreshtha, et al. 2022	Diagnosis of FM confirmed by clinicians	n=42 FM		N/A No healthy controls with prevalence of dysautonomia reported	The response rate is not mentioned or calculable	Used Ewing's battery of validated tests	Yes	3
	*			N/A		*	*	

Risk of Bias Classification:

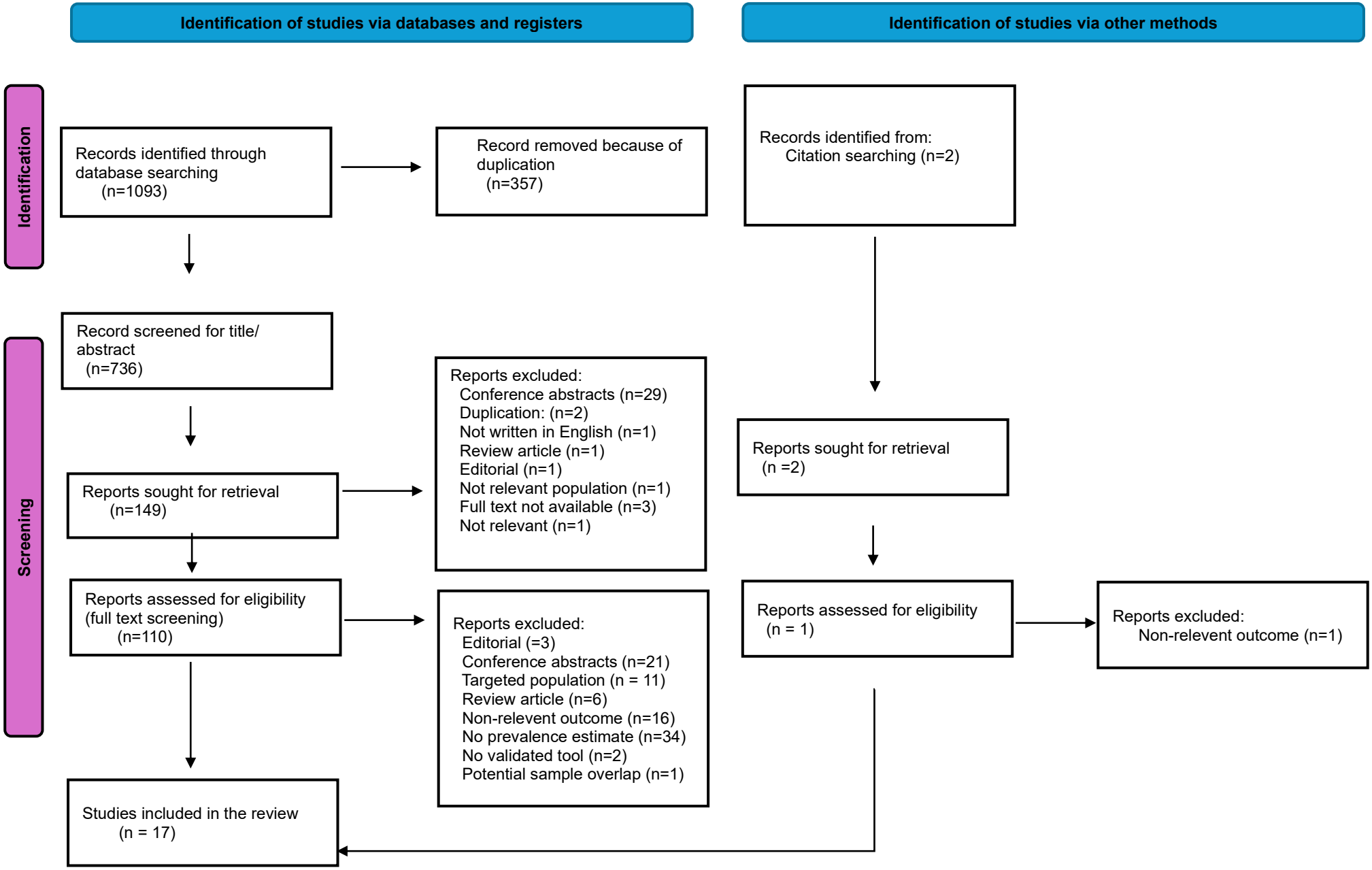
6–7 stars Low Risk = 3 studies

4–5 stars Moderate Risk = 13 studies

0–3 stars High Risk = 1 studies

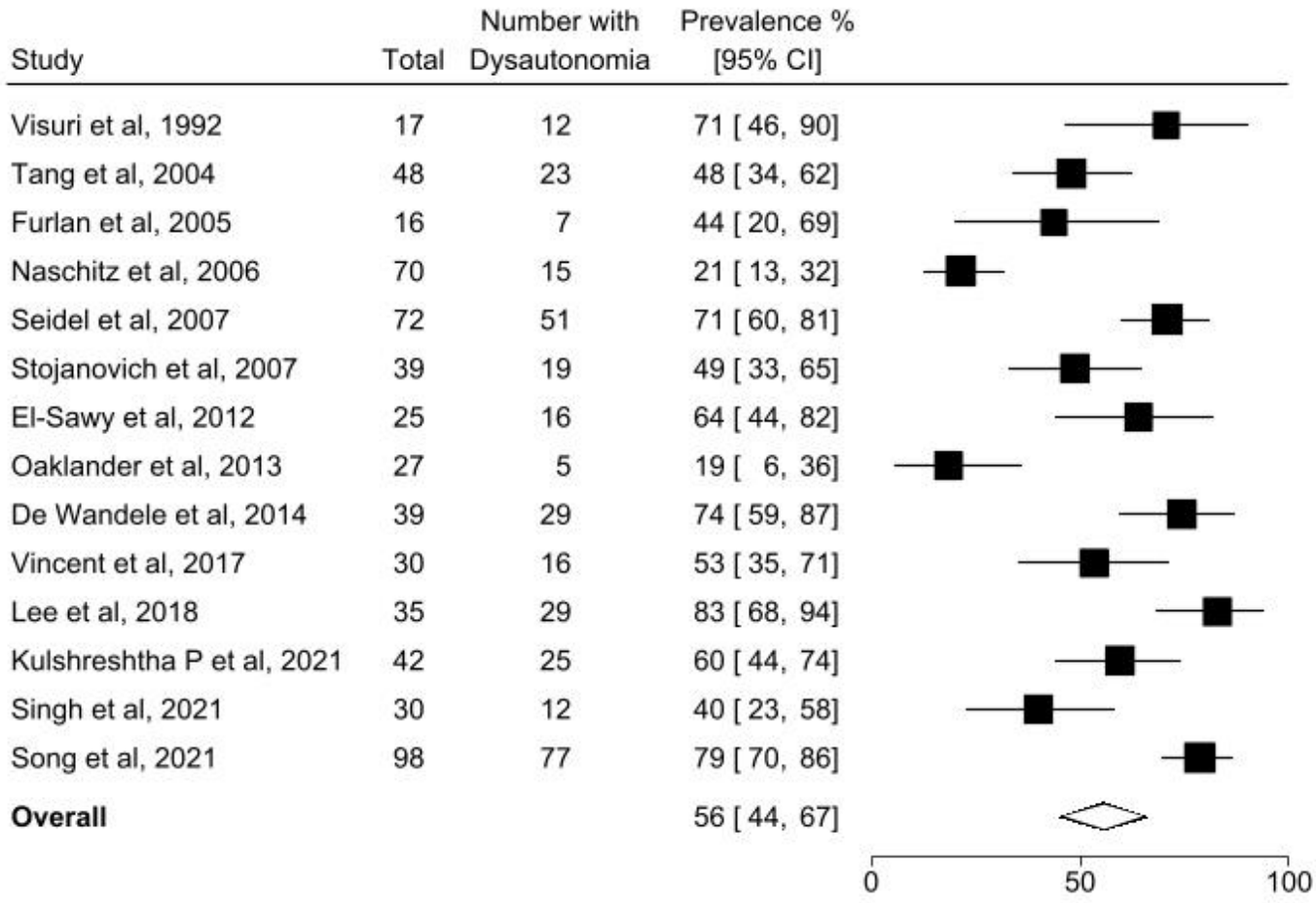
Supplementary Figures

Supplementary Figure 1. PRISMA flowchart demonstrates the article screening process.

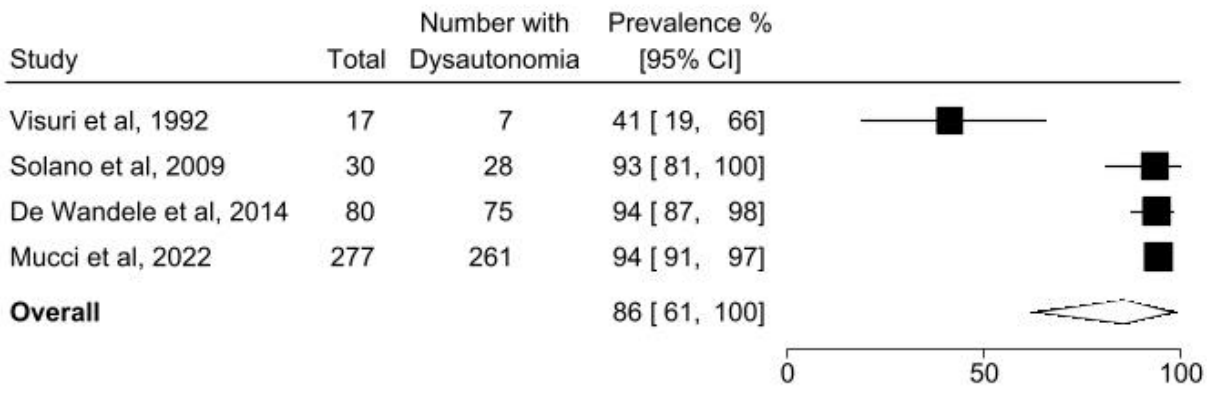


Forst plots

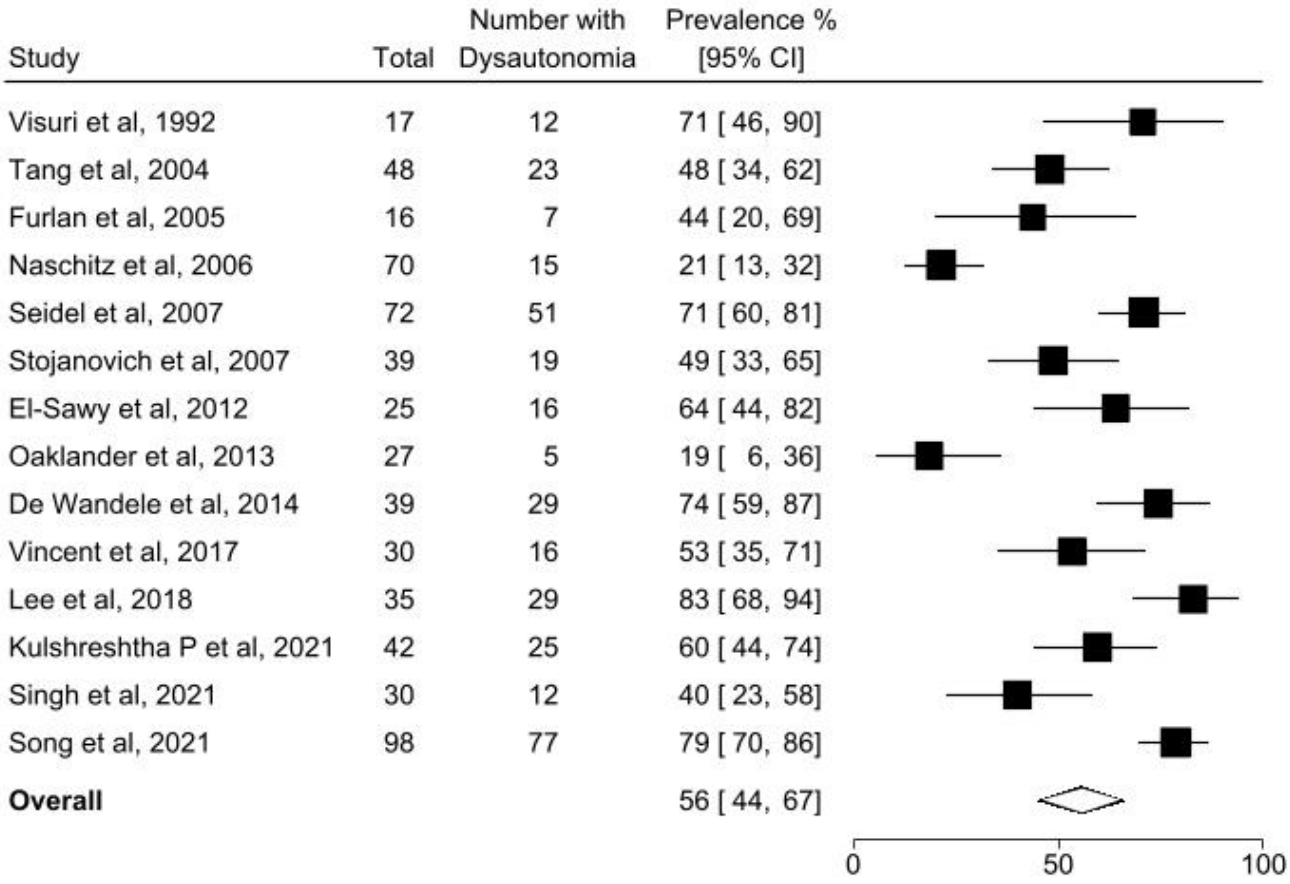
Supplementary Figure 2. Forest plot shows the overall pooled prevalence of dysautonomia across various musculoskeletal conditions, based on validated objective and subjective assessment methods.



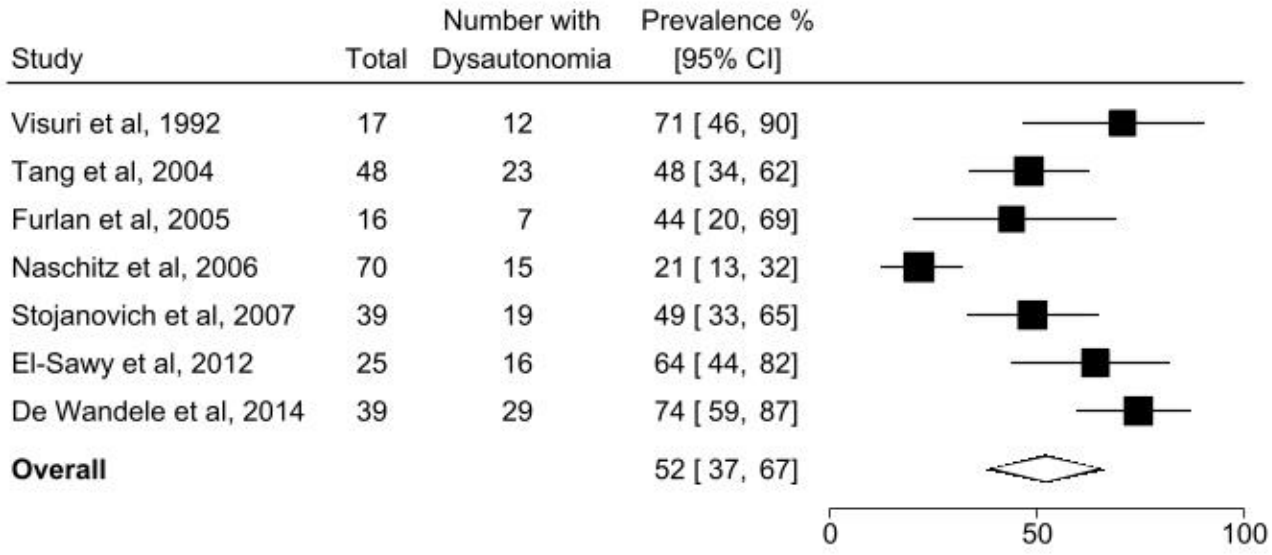
Supplementary Figure 3. *Forest plot shows overall pooled prevalence estimates of Dysautonomia across various musculoskeletal conditions using ONLY subjective methods*



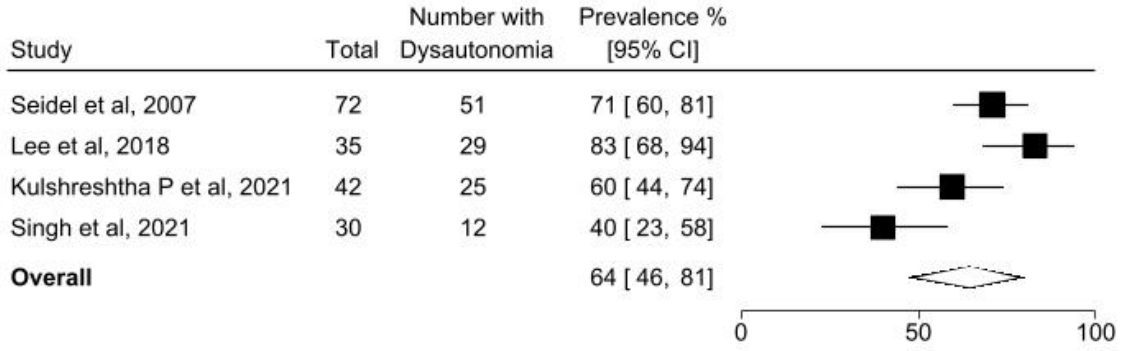
Supplementary Figure 4. Forest plot shows overall pooled prevalence estimates of Dysautonomia across various musculoskeletal conditions using ONLY objective methods



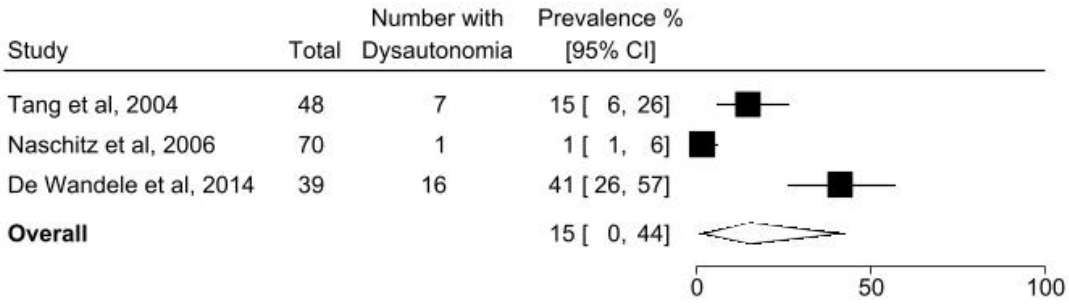
Supplementary Figure 5. Forest plot shows overall pooled prevalence estimates of Dysautonomia in all included musculoskeletal conditions using orthostatic intolerance domain.



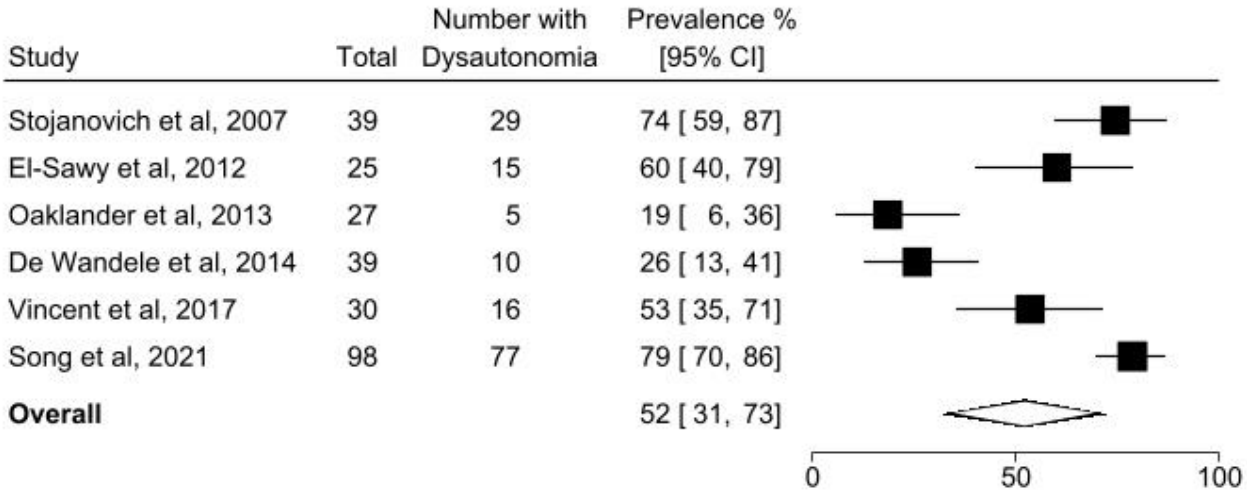
Supplementary Figure 6. Forest plot shows overall pooled prevalence estimates of Dysautonomia in all included musculoskeletal conditions using groups of autonomic tests, and only report a single cardiac-related outcome (cardiac autonomic dysfunction (CAD) or cardiac autonomic neuropathy (CAN)



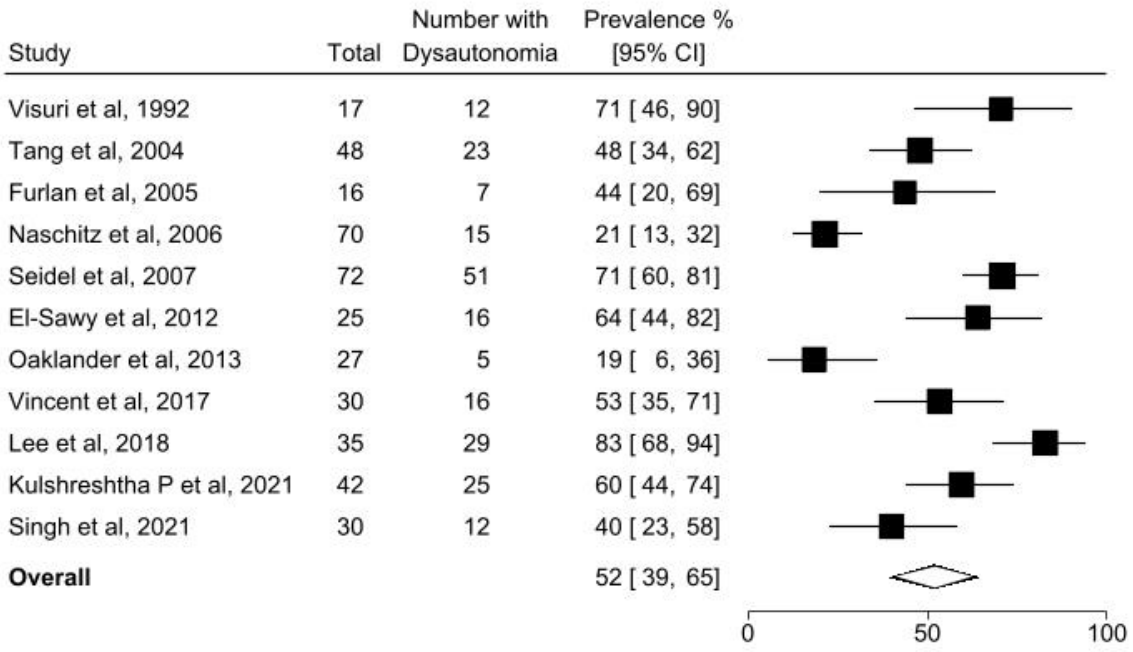
Supplementary Figure 7. Forest plot shows overall pooled prevalence estimates of POTS in all included musculoskeletal conditions using Tilt table test



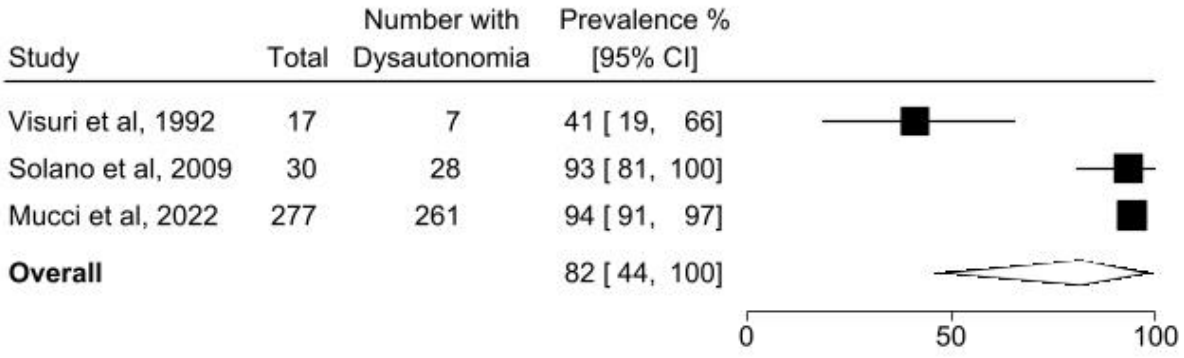
Supplementary Figure 8. Forest plot shows overall pooled prevalence estimates of Dysautonomia in all included musculoskeletal conditions using mixed clinical and subclinical testing approaches



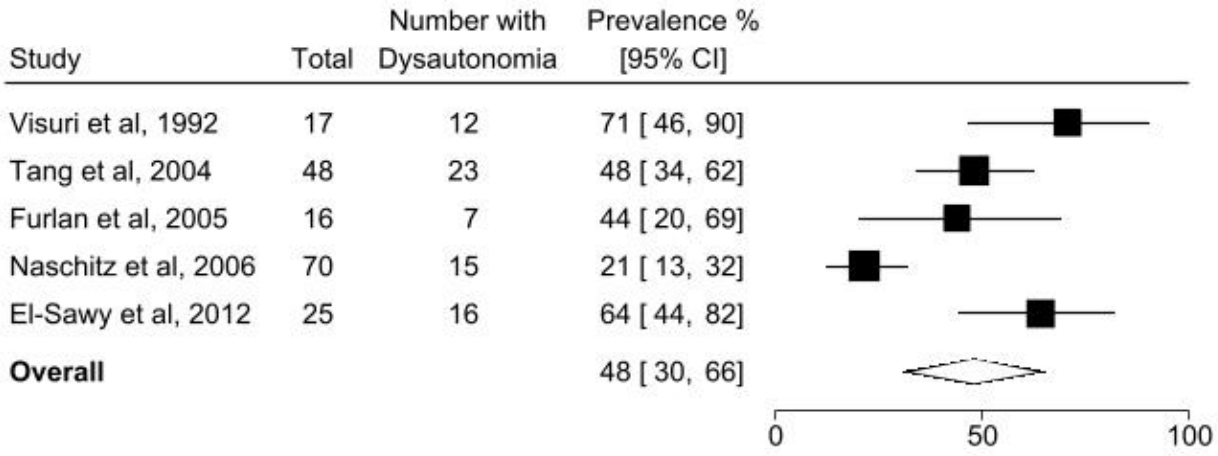
Supplementary Figure 9. *Forest plot shows the overall pooled prevalence of dysautonomia in fibromyalgia, based on validated objective assessment methods.*



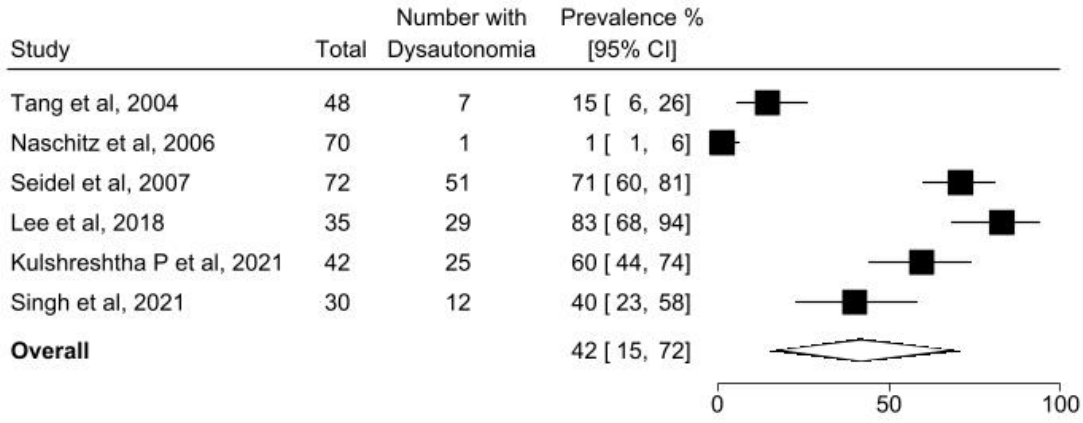
Supplementary Figure 10. Forest plot shows the overall pooled prevalence of dysautonomia in fibromyalgia, using self-report methods.



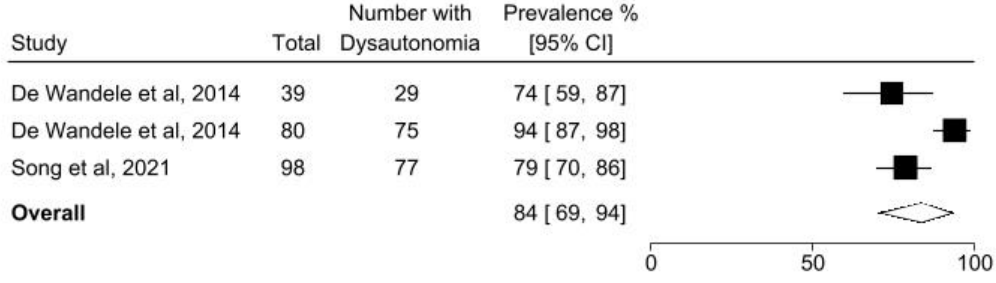
Supplementary Figure 11. *Forest plot shows overall pooled prevalence estimates of Dysautonomia in fibromyalgia using orthostatic intolerance domain.*



Supplementary Figure 12. Forest plot shows overall pooled prevalence estimates of Dysautonomia in fibromyalgia using mixed autonomic function test.

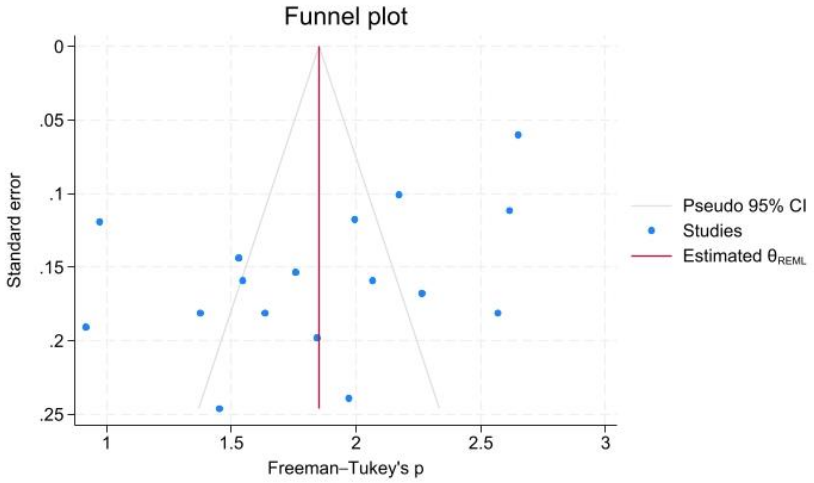


Supplementary Figure 13. Forest plot shows the overall pooled prevalence of dysautonomia in Ehlers-Danlos syndrome, based on validated objective and subjective assessment methods.

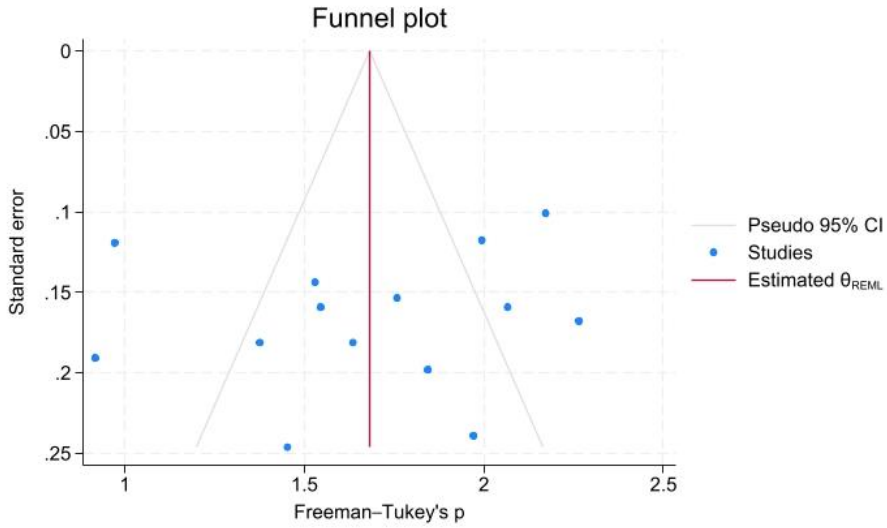


Funnel plots

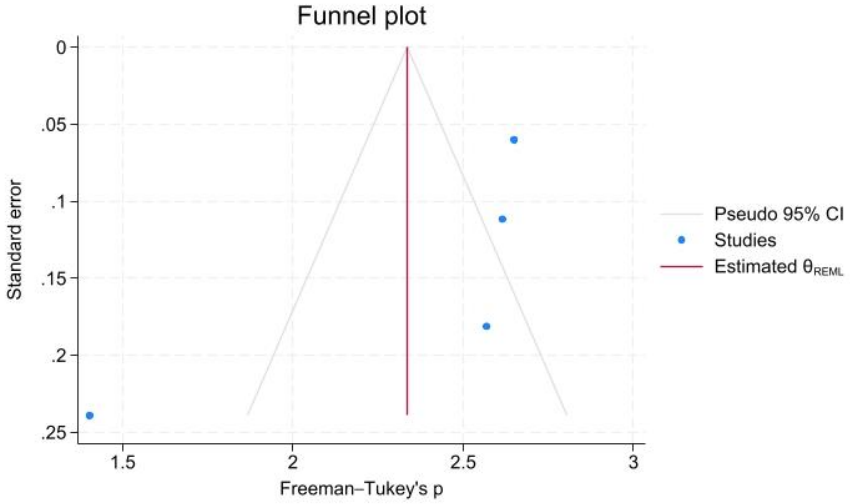
Supplementary Figure 14. *Funnel plot of dysautonomia prevalence estimates across all included studies and assessment methods.*



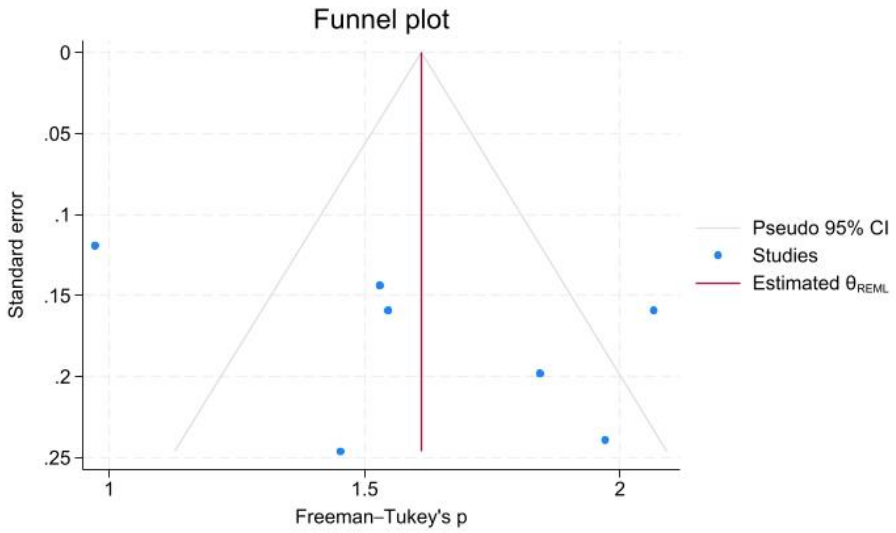
Supplementary Figure 15. Funnel plot of dysautonomia prevalence estimates across all included studies using objective assessment methods



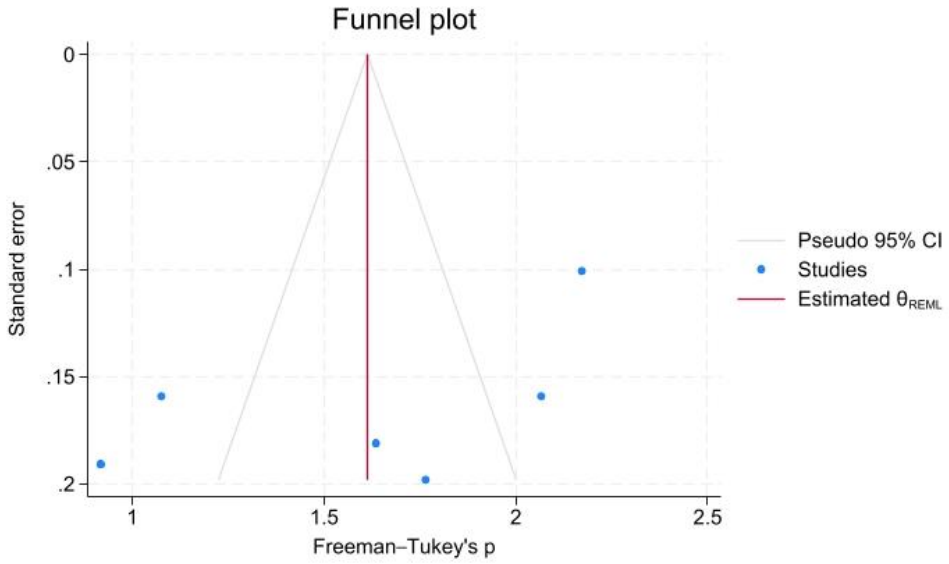
Supplementary Figure16. *Funnel plot of dysautonomia prevalence estimates across all included studies using subjective assessment methods*



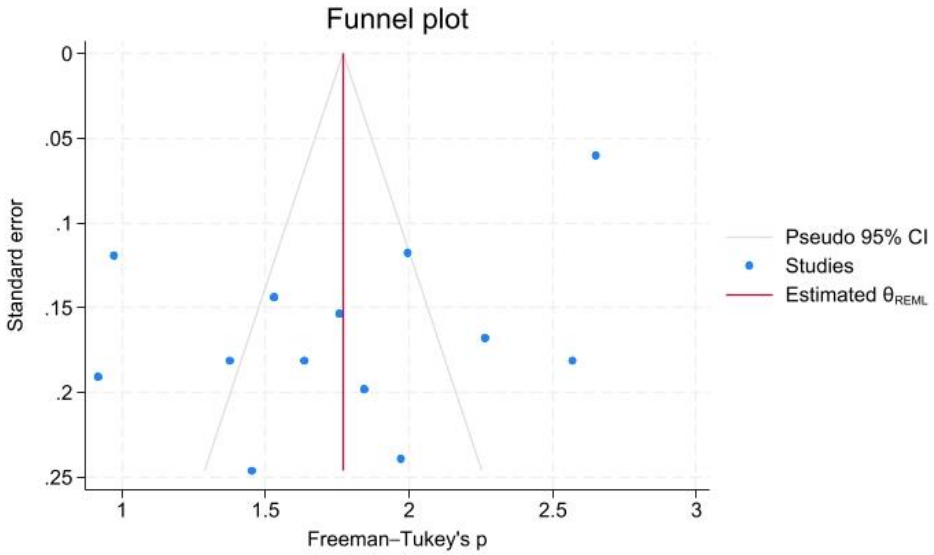
Supplementary Figure 17. *Funnel plot of dysautonomia prevalence estimates across all included studies based on orthostatic domain assessment*



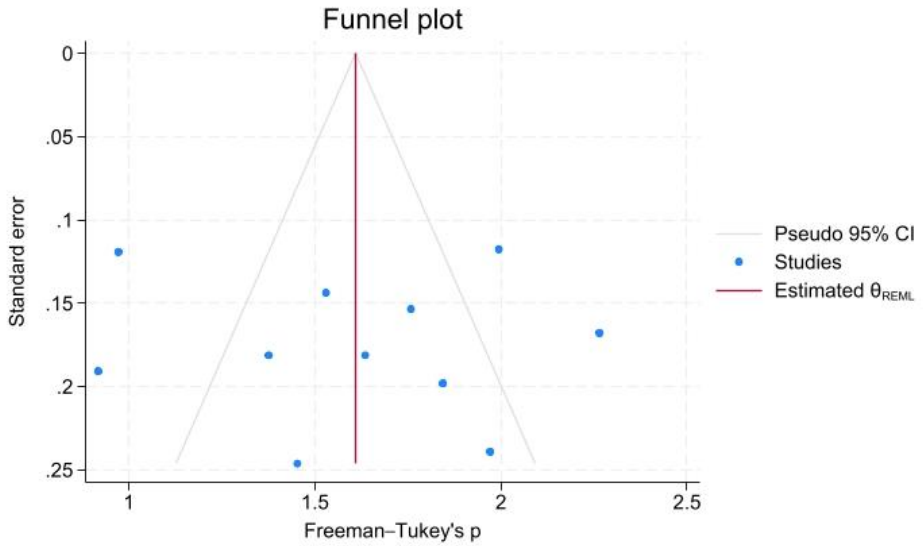
Supplementary Figure 18. *Funnel plot of dysautonomia prevalence estimates across all included studies based on mixed clinical and subclinical testing approaches.*



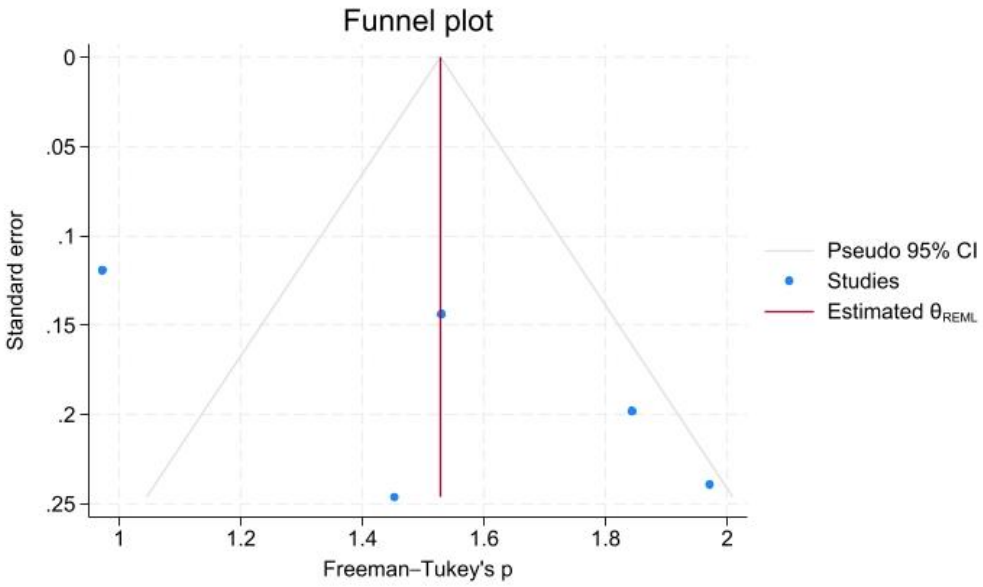
Supplementary Figure 19. Funnel plot of dysautonomia prevalence estimates in fibromyalgia using various assessment methods.



Supplementary Figure 20**.** Funnel plot of dysautonomia prevalence estimates in fibromyalgia using objective assessment methods



Supplementary Figure 21. Funnel plot of dysautonomia prevalence estimates in fibromyalgia based on orthostatic domain assessment


Funnel plot
Standard error
0
.05
.1
.15
.2
.25
1
1.2
1.4
1.6
1.8
2
Freeman–Tukey's p
Pseudo 95% CI
Studies
Estimated θREML