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EFFICACY OF MYOFUNCTIONAL THERAPY FOR OBSTRUCTIVE SLEEP APNEA: A SYSTEMATIC REVIEW AND NETWORK META-ANALYSIS

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ABSTRACT

Objectives

Myofunctional therapy (MT) has emerged as an adjunct treatment for obstructive sleep apnea (OSA). This systematic review and network meta-analysis of randomized controlled trials (RCTs) aims to evaluate the efficacy of MT in treating adult and pediatric OSA.

Methods

Four electronic databases were searched until April 30, 2024. Meta-analysis, subgroup, and network meta-analysis using multivariate random effects were performed to estimate pooled differences, focusing on objective and subjective indicators.

Results

A total of 15 RCTs involving 473 adults and 139 children were eligible, with 10 adult studies ($n = 380$) included in the network meta-analysis. Compared to the controls, MT yielded an improved decrease in Epworth sleepiness scale (ESS) of −3.54 (95%CI −5.96 to −1.13, $P = .004$) and Pittsburgh sleep quality index (PSQI) of −2.24 (95%CI −3.46 to −1.01, $P = .0003$), though no statistically significant change in apnea-hypopnea index (AHI) (−8.73/h, 95%CI −21.19 to 3.74/h, $P = 0.17$). Improvements in arousal index and snoring intensity were also noted in adults. Combining MT with continuous positive airway pressure (CPAP) could lead to a pronounced reduction in AHI but did not significantly increase CPAP efficacy. Limited evidence suggests MT may benefit AHI and average SpO2 in pediatric OSA, with high compliance being essential.

Conclusions

The network meta-analysis supports MT as a promising adjunct for improving subjective indicators in adults and suggests that when daily training exceeds 30 minutes, MT can significantly improve AHI. Additionally, MTSP and MT combined with myofascial release may offer further benefits in subjective outcomes.

INTRODUCTION

Obstructive sleep apnea (OSA) is a common breathing disorder affecting children and adults, characterized by recurrent episodes of complete (resulting in apnoea) or partial (resulting in hypopnoea) obstruction of the upper

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KEYWORDS
Sleep-disordered breathing, Myofunctional therapy, Treatment efficacy

SOURCE OF FUNDING

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CONFLICT OF INTEREST

The authors have no actual or potential conflicts of interest.

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respiratory tract during sleep .[1] The reported prevalence of OSA ranges from 1.2% to 5.8% in the general pediatric population [2,3] and from 9% to 38% in the overall adult population.[4] Pediatric OSA is linked to an elevated risk of cardiovascular diseases,[5] metabolic dysfunction,[6] and cognitive impairment,[7] and adult OSA is associated with morbidities such as hypertension, arrhythmia, and cerebrovascular diseases, highlighting OSA as a global serious health concern.[8]

Continuous positive airway pressure (CPAP) is the preferred treatment option for most adult patients with OSA.[9] However, the efficacy of CPAP has been limited by poor clinical acceptance and adherence, mainly due to mask discomfort and cutaneous allergies.[10] Meanwhile, the first-line treatment for pediatric OSA, adenotonsillectomy (AT), is unable to resolve the condition completely, and the incidence of residual OSA after AT continues to be a point of contention.[11,12] Adjuvant therapy options have therefore been investigated. Considering that OSA could arise from suboptimal functioning of upper airway dilator muscles,[13] myofunctional therapy (MT) stands out as a noninvasive and cost-effective option with no major risks, which usually involves a multi-component approach with various combinations of oropharyngeal exercises.[14] These combinations typically encompass both isotonic and isometric exercises targeting several muscles and areas of oral (lip, tongue) and oropharyngeal structures (soft palate, lateral pharyngeal wall),[15] to improve functions that are essential for maintaining pharyngeal patency,[16] as well as speaking, breathing, blowing, sucking, chewing and swallowing.[17]

Several reviews have been published on myofunctional therapy for OSA or snoring.[14,17-19] However, most of these reviews include results from observational studies, which are less dependable than randomized clinical trials (RCTs) in terms of evaluating the efficacy and safety of interventions. Given that MT is a complex intervention targeting multiple areas, with inconsistent patient inclusion criteria across the existing RCTs, varying training protocols, and diverse implementation approaches, including non-device methods and commercialized products, meta-analyses evaluating the efficacy of MT should explicitly exclude studies with potential conflicts of interest and ensure consistency in the inclusion criteria for adult patients. Therefore, this systematic review and network meta-analysis aims to provide a comprehensive and reliable summary of the available evidence from high-quality RCTs assessing the efficacy of myofunctional therapy on OSA, facilitating decision-making for clinicians and patients.

MATERIALS AND METHODS

This systematic review and meta-analysis is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement.[20] The PRISMA checklist for this review is reported in Supplementary Table 1. This review was registered at International Prospective Register of Systematic Reviews (number CRD42024557807).

Selection Criteria

According to the PICO (patient, intervention, comparison, and outcome) approach, the inclusion criteria were the following:

Population: patients diagnosed with OSA.

Intervention: myofunctional therapy.

Comparison: no treatment, waiting list, sham treatment or other therapies.

Outcome: apnea-hypopnea index (AHI) at baseline and a follow-up visit, and other measured subjective or objective parameters.

Study design: randomized controlled trials (RCTs).

Search Strategy

The systematic literature search was conducted in electronic databases on 30 April 2024 using prespecified search terms, including PubMed (MEDLINE), EMBASE, Web of Science, and Cochrane Library, with keywords such as (“breathing, sleep disordered” OR “obstructive sleep apnea”) and (“myofunctional therapy” OR “orofacial myotherapy” OR “myofascial reeducation” OR “oral myotherapy” OR “oropharyngeal exercises” OR “speech therapy” OR “upper airway exercises” OR “upper airway remodeling”). The detailed search strategy for each database is presented in Supplementary Table 2. We considered all potentially eligible studies for review, and we also did a manual search, using the reference lists of key articles published in English.

Study Selection and Data Extraction

Two reviewers (Y.X. and R.C.Y.) independently screened the titles and abstracts for potential eligibility. Any discrepancies were resolved by discussing with each other and consulting with a third reviewer (X.M.G.). In case of uncertainty, all potentially eligible studies with retrieved full texts were read thoroughly. Exclusion criteria were as follows: observational and retrospective studies; studies with no same outcomes as other RCTs; conference abstracts, reviews, personal opinions, books, and articles not written in English; research involving commercial or financial relationships that could be perceived as a potential conflict of interest.

The following data were collected from each included study: author and year of publication, country, sample characteristics (sample size, gender, age), description of intervention and control group, OSA severity, follow-up periods and examinations. Outcomes of both post- and pretreatment were recorded. Data extraction was performed independently by 2 reviewers (Y.X. and R·C.Y.) using a preformed, standardized spreadsheet that was developed and agreed upon by the review team. Residual disagreements were solved by a third reviewer (X·M.G.). If the mean (M) and standard deviation (SD) were not reported in the study, the estimated values were used in the meta-analysis.[21,22] The main outcome of interest was the change in apnea-hypopnea index (AHI), Epworth sleepiness scale (ESS) and Pittsburgh sleep quality index (PSQI). Secondary outcomes, including snoring intensity and frequency assessed using questions derived from Berlin questionnaire, other polysomnographic (PSG) outcomes such as arousal index, average or lowest oxygen saturation (SpO_2), total sleep time (TST) and sleep efficiency, tongue elevation strength, and anthropometric measures were also extracted.

Risk of Bias Assessment

Two authors (Y.X. and R·C.Y.) independently assessed the risk of bias in the RCTs using the Cochrane Collaboration "risk of bias" tool,[23] and any discrepancies were settled through discussion with a third reviewer (X·M.G.). Studies were rated on selection bias, detection bias, performance bias, attribution bias, and reporting bias with low, unclear, or high risk.

Data Synthesis

The data synthesis was performed using Review Manager 5.4 (The Cochrane Collaboration). The heterogeneity among studies was represented by the I^2 index and the χ^2 test. Meta-analysis was performed with the fixed-effects model if $I^2 < 50\%$, otherwise the random-effects model would be implemented. Quantitative data were computed as post-treatment minus pretreatment and different meta-analyses were performed according to different outcomes of interest. Studies with incomplete statistical reporting (e.g., absence of standard deviation values) or non-comparable assessments were excluded from the meta-analysis. To explore the possible sources of heterogeneity in studies of adults, subgroup analyses were performed based on different AHI severity according to the severity classification for adult OSA (moderate: AHI 15-30 events/h vs. severe: AHI $\geq$30 events/h), [24] body mass index (BMI, overweight: 25-29.9 kg/m^2 vs. obese: $\geq$30 kg/m^2 according to World Health Organization classification for general Western population [25]), and accumulated daily practice time (less than 30 minutes vs. 30 minutes or more). Meanwhile, to compare the effects of different treatment regimens among the included studies, a network meta-analysis was conducted using R 4.3.0, with meta package version 8.0.1 and netmeta package version 2.9.0. Random-effects models were implemented in the network meta-analysis to account for potential heterogeneity. The consistency was assessed using node-splitting method and potential publication bias for the primary outcomes was evaluated with a funnel plot,[26] both conducted using the statistical software package Stata 14.0.

RESULTS

Search and Study Selection

A total number of 678 records were identified, 82 in PubMed, 283 in Embase, 214 in Web of Science, 97 in Cochrane Library, and 2 by manual search. After removing duplications, 420 articles remained. Irrelevant articles were excluded after reading the title and abstract, leaving 21 articles for full text assessment. Two articles were excluded due to no full text. One trial was excluded due to the inclusion of poststroke patients. One article was excluded as it didn't report the same outcome parameters as other RCTs. One trial was excluded because its data had been updated in a more recent publication. One trial was excluded due to a conflict of interest involving a financial interest with the MT education medium (mobile health app).

As a result, a total of 15 articles (3 pediatric and 12 adult) were included in the systematic review. Due to the anatomical and clinical differences between adult and pediatric OSA, the limited number of pediatric RCTs, and the lack of common outcome measures, pediatric studies were excluded from the pooled analysis. Additionally, the standard deviation values from one adult study involving didgeridoo playing could not be retrieved for data synthesis .[27] Another RCT, which recruited patients from 3 subgroups including (1) treated with APAP, (2) previously failed or refused CPAP therapy, and (3) currently being treated with an oral appliance but still experiencing residual OSA, [28] was excluded since the treatment classification of the intervention group was unclear. Consequently, 10 adult studies were included in the network meta-analysis. PRISMA flow diagram illustrating the study identification, screening, eligibility, and inclusion phases is presented in Figure 1. The detailed characteristics of the 15 included studies are summarized in Table 1 . The treatment protocols of myofunctional therapy with supervision methods in each included study are shown in Supplementary Table 3. Among these articles, 14 reported positive effects of MT on OSA, while one study found no significant impact .[29] Additionally, the study by Erturk et al. was not included in the subgroup analysis of daily practice time as it did not specify the time of daily exercise.

The network graphs of the included studies with main outcome indicators are shown in Figure 2. A total of 10 adult studies were included in the network meta-analysis, which were performed separately for changes in AHI (6 studies),[29-34] ESS (9 studies) [29,31-38] and PSQI (7 studies).[29,33-38] Six studies compared MT with control, specifically, 1 study[29] evaluated AHI, ESS and PQSI, 3 studies[35-37] evaluated ESS and PSQI, 1 study [30] evaluated AHI, and one study[31] evalu-

Figure 1. The flowchart of the study selection process.

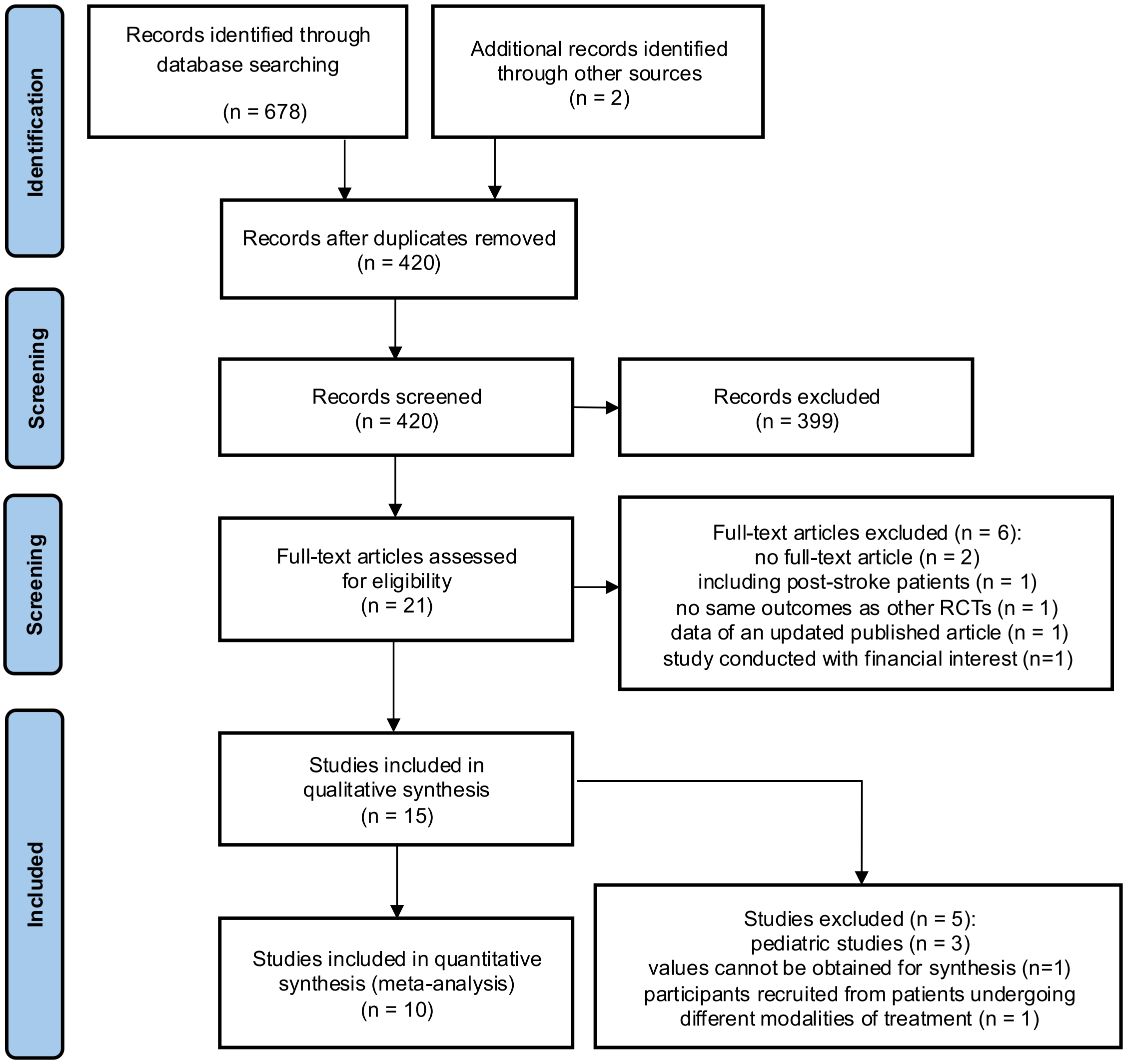

Figure 2. The network geometry for different main outcomes. (A) AHI; (B) ESS; (C) PSQI. AHI, apnea-hypopnea index; ESS, Epworth sleepiness scale; PSQI, Pittsburgh sleep quality index; CPAP, continuous positive airway pressure; MT, myofunctional therapy; MTSP, myofunctional therapy support program.

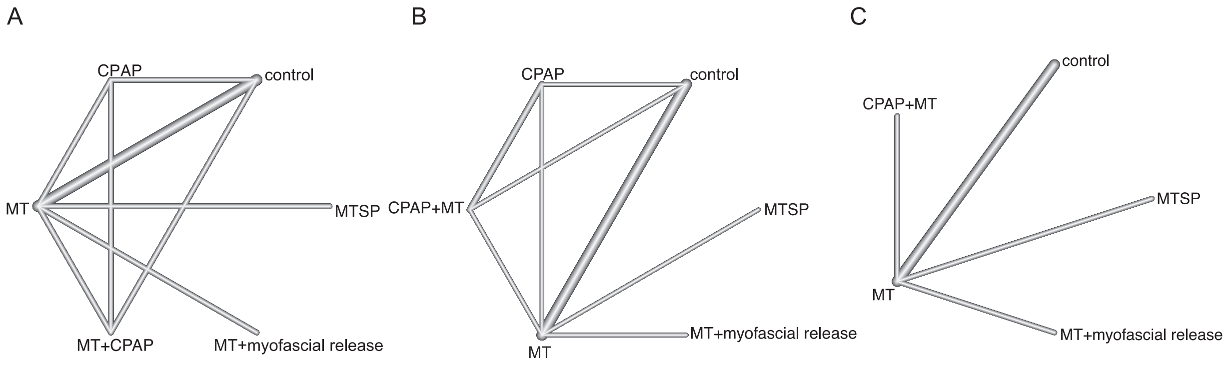

Table 1. Characteristics of included studies.

Study, year	Country /Area	Cases (M/F)		Age (years)	BMI (kg/m^2)	Severity	Interventions	Duration of interventions	Examinations (main outcomes of interest)
		Intervention	Control						
Puhan, 2005[27]	Switzerland	14 (12/2)	11 (9/2)	—	—	Average AHI 21	Didgeridoo playing vs. no treatment	4 months	PSG (AHI), questionnaire (ESS, PSQI)
Guimarães, 2009[35]	Brazil	16 (10/6)	15 (11/4)	49.66 ± 8.47	30.28 ± 3.37	AHI 22.4 ± 5.01	Oropharyngeal exercises vs. sham therapy	3 months	PSG, questionnaire (ESS, PSQI), physical examinations
Ieto, 2015[36]	Brazil	19 (11/8)	20 (11/9)	31.08 ± 21.37	28.2 ± 3.1	AHI 15.34 ± 9.28	Oropharyngeal exercises vs. sham therapy	3 months	PSG, questionnaire (ESS, PSQI)
Villa, 2015[40]	Italy	14	13	5.59 ± 1.35	Centile 67.52 ± 29.58	AHI 4.72 ± 3.03	Oropharyngeal exercises vs. sham therapy	2 months	PSG (AHI), questionnaire, morphofunctional evaluation
Villa, 2017[41]	Italy	36 (14/22)	18 (8/10)	7.1 ± 2.5	—	AHI 1.73 ± 0.5	Myofunctional therapy vs. sham therapy	2 months	PSG (AHI), questionnaire, morphofunctional evaluation, IOPI measurements
Diaféria, 2017[32]	Brazil	27 (27/0) 27 (27/0)[1] 22 (22/0)[2]	24 (24/0)	44.11 ± 11.83	26.69 ± 6.26	AHI 27.91 ± 21.39	Myofunctional therapy vs. sham therapy (vs. CPAP[1] vs. CPAP+MT[2])	3 months	PSG (AHI), questionnaire (ESS)
Huang, 2019[39]	Taiwan, China	10 (4/6)	48 (31/17)	7.82 ± 2.94	16.80 ± 2.90	AHI 5.39 ± 6.73	Myofunctional therapy vs. oral appliance	6 months	PSG (AHI), physical examinations, lateral cephalogram
Atilgan, 2019[37]	Turkey	15 (11/4)	15 (14/1)	51.33 ± 15.32	29.32 ± 4.56	AHI 29.34 ± 22.11	Oropharyngeal exercises vs. no treatment	3 months	PSG, questionnaire (ESS, PSQI), functional assessment

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Table 1 (*continued*)

Study, year	Country /Area	Cases (M/F)		Age (years)	BMI (kg/m²)	Severity	Interventions	Duration of interventions	Examinations (main outcomes of interest)
		Intervention	Control						
Erturk, 2020[31]	Turkey	14	12	50.73 ± 7.77	31.68 ± 3.71	AHI 40.8 ± 25.28	Oropharyngeal exercises vs. no treatment (vs. inspiratory muscle training)	3 months	PSG (AHI), questionnaire (ESS), physical examinations
Lin, 2020[30]	Taiwan, China	8 (5/3)	7 (5/2)	50.99 ± 7.67	26.11 ± 2.92	AHI 41.77 ± 18.84	Upper airway muscle and respiratory muscle strengthening vs. no treatment	3 months	PSG (AHI), physical examinations, IOPI measurements
Kim, 2020[33]	Korea	16 (10/6)	15 (13/2)	51.62 ± 18.74	25.57 ± 4.08	AHI 18.09 ± 9.59	MTSP vs. MT	3 months	PSG (AHI), questionnaire (ESS, PSQI)
Maghsoudipour, 2021[28,b]	USA	35 (26/9)	33 (17/16)	59.71 ± 11.71	30.44 ± 5.88	AHI 20.94 ± 19.67	Pharyngeal exercise device vs. sham therapy	3 months	HSAT (AHI), questionnaire (ESS, PSQI)
Çakmakcı, 2022[38]	Turkey	20 (11/9)	21 (17/4)	51.88 ± 7.40	32.81 ± 4.76	AHI 53.33 ± 27.37	Oropharyngeal exercises + CPAP vs. CPAP	3 months	Questionnaire (ESS, PSQI), physical examinations
Poncin, 2022[29]	Belgium	12 (8/4)	13 (6/7)	53.11 ± 9.44[a]	27.26 ± 7.63[a]	AHI 21.05 ± 20.19[a]	Tongue muscle training vs. sham therapy	1.5 months	PSG (AHI), questionnaire (ESS, PSQI), physical examinations, IOPI measurements
Paolucci, 2023[34]	Italy	28 (13/15)	14 (9/15)	60.98 ± 7.77	26.49 ± 2.90	AHI 9.76 ± 7.10[a]	oro-facial MT + myofascial release vs. oro-facial MT	2 months	PSG (AHI), questionnaire (ESS, PSQI)

BMI, body mass index; AHI, apnea-hypopnea index; PSG, polysomnography; IOPI, Iowa oral performance instrument; CPAP, continuous positive airway pressure; MT, myofunctional therapy; MTSP, myofunctional therapy support program; HSAT, home sleep apnea testing.

[a] Calculated from the original study.

[b] With treatment including automatic positive airway pressure or mandibular advancement splint.3.3 Main outcome indicators.

ated AHI and ESS; one study[32] compared MT with CPAP, CPAP+MT and control, and evaluated AHI and ESS; one [38] compared MT with CPAP+MT and evaluated ESS and PSQI; one [33] compared MT with myofunctional therapy support program (MTSP), and one (Paolucci et al.) compared MT with MT + myofascial release, [34] the latter 2 studies all evaluated AHI, ESS and PQSI.

Quality Assessment

Figure 3 shows the assessment of risk of bias in the trials. Three studies [27,30,37] in which the control group received no treatment rather than sham treatment were rated high risk in the blinding of participants. One study did not ensure blinding of investigators after randomization, and exhibited loss to follow-up, thus it was rated high risk in both the blinding of outcome assessment and incomplete outcome data.[38] Another study was also rated high risk in incomplete outcome data due to substantial sample attrition.[39] Four studies [33,34,38,39] that compared 2 treatments or compared MT with combined treatment, without including a control group, were thus rated high risk in other bias, and excluded in data synthesis. Other studies that lacked insufficient descriptions in allocation concealment, blinding of participants and personnel, and/or blinding of outcome measurement were rated unclear in the corresponding bias.

Main outcome indicators

AHI

A total of 4 adult studies evaluated the change of AHI before and after MT, of which 2 studies reported a significant reduction in AHI compared to baseline values,[30,32] while 2 found no significant change.[29,31] The synthesized result of the impact of each study on AHI is shown in Figure 4, demonstrating no significant effect in favor of MT in AHI, which decreased by −8.73/h (95% CI −21.19 to 3.74/h, $P = .17$, $I^2 = 59\%$). To explore the source of the heterogeneity, subgroup analyses were also conducted. The results showed that high heterogeneity of subgroup differences was observed for daily practice time ($I^2 = 80.8\%$, $P = .02$), which indicated that only training for no less than 30 minutes every day could yield a significant reduction in AHI. It is also worth noting that the training duration in the 2 studies with daily practice time exceeding 30 minutes was 3 months.[30,32] The change in AHI was consistent across these studies despite the heterogenous AHI severity and BMI.

For adult participants who received 4 months of upper airways training by didgeridoo playing, a significant effect on AHI was observed.[27] For pediatric studies, Villa et al. found children with residual OSA after adenotonsillectomy experienced a significant decrease in AHI in the MT group ($n = 14$) compared to the control group ($n = 13$).[40] Huang et al.[39] involved 23 pediatric OSA patients who underwent myofunctional therapy reported no significant changes in polysomnography data at the 6-month follow-up for the overall group. However, in the 10 children with good compliance, the AHI changed by −1.00 ± 1.18/h. Moreover, the comparison between MT and passive MT (using an oral appliance) revealed that passive MT, which required fewer parental involvements, resulted in a more significant decrease in AHI, indicating that good adherence is a crucial factor in achieving the therapeutic effects of MT in children.

Epworth Sleepiness Scale (ESS)

A total of six studies evaluated the change of ESS before and after MT, with 5 reporting a significant reduction compared to baseline values.[29,31,32,35-37] The synthesized result showed that there was a significant effect in favor of MT in ESS, which decreased by −3.54 (95% CI −5.96 to −1.13, $p = .004$, $I^2 = 60\%$). The results of subgroup analyses showed that the change of ESS was consistent across these studies, despite the severity of AHI ($I^2 = 42.6\%$, $p = .19$), BMI ($I^2 = 26.8\%$, $p = .24$), and daily practice time ($I^2 = 61.6\%$, $p = .11$) (Figure 5). Notably, it is also suggested that MT could be more effective in improving daytime sleepiness when the daily practice time is no less than 30 minutes or without obesity at the baseline.

Pittsburgh Sleep Quality Index (PSQI)

A total of 4 studies with moderate OSA patients at the baseline reported on the PSQI and the mean difference in change of PSQI for MT compared with control was −2.24 (95% CI −3.46 to −1.01, $p = .0003$, $I^2 = 0\%$) [29,35-37]. The results of subgroup analysis showed that no significant subgroup difference existed for BMI ($I^2 = 0\%$, $p = .98$), or daily practice time ($I^2 = 59.3\%$, $p = .39$) (Figure 6).

Secondary Outcome Indicators

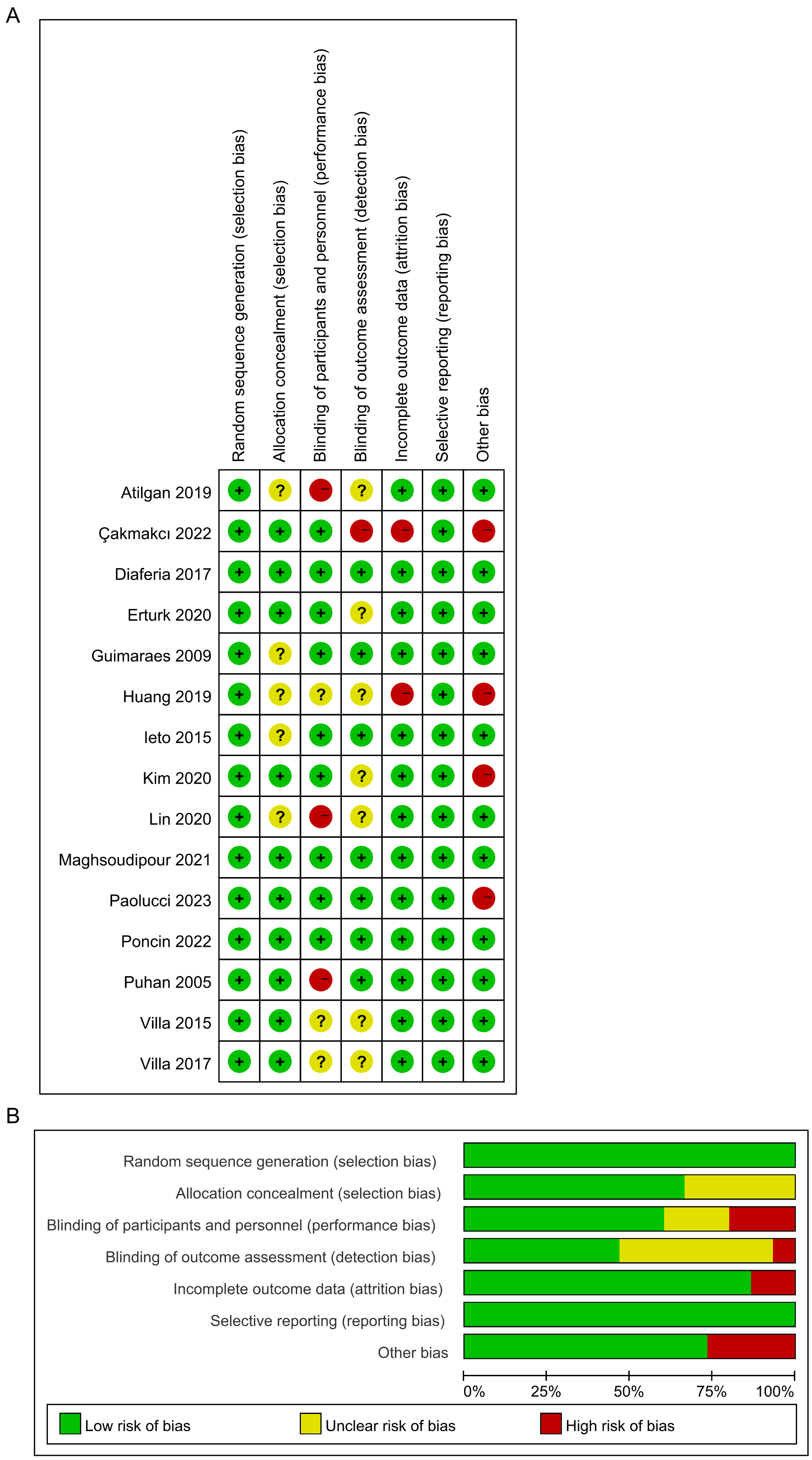
Snoring-Related Index

Three studies reported on snoring in patients evaluated with Berlin questionnaire.[31,35,36] Snoring intensity ranges from 1 (similar to breathing) to 3 (very loud) and frequency ranges from 0 (never) to 4 (every day). The synthesized results of the impact of each study on snoring intensity and frequency are shown in Figure 6. A significant reduction in snoring intensity was observed in favor of MT, with a decrease of −1.44 (95%CI −2.63 to −0.65, $P = .02$, $I^2 = 91\%$). However, no statistically significant changes were observed in snoring frequency (MD −1.52, 95%CI −3.23 to 0.19, $P = .08$) (Supplementary Figure 1).

Other PSG Outcomes

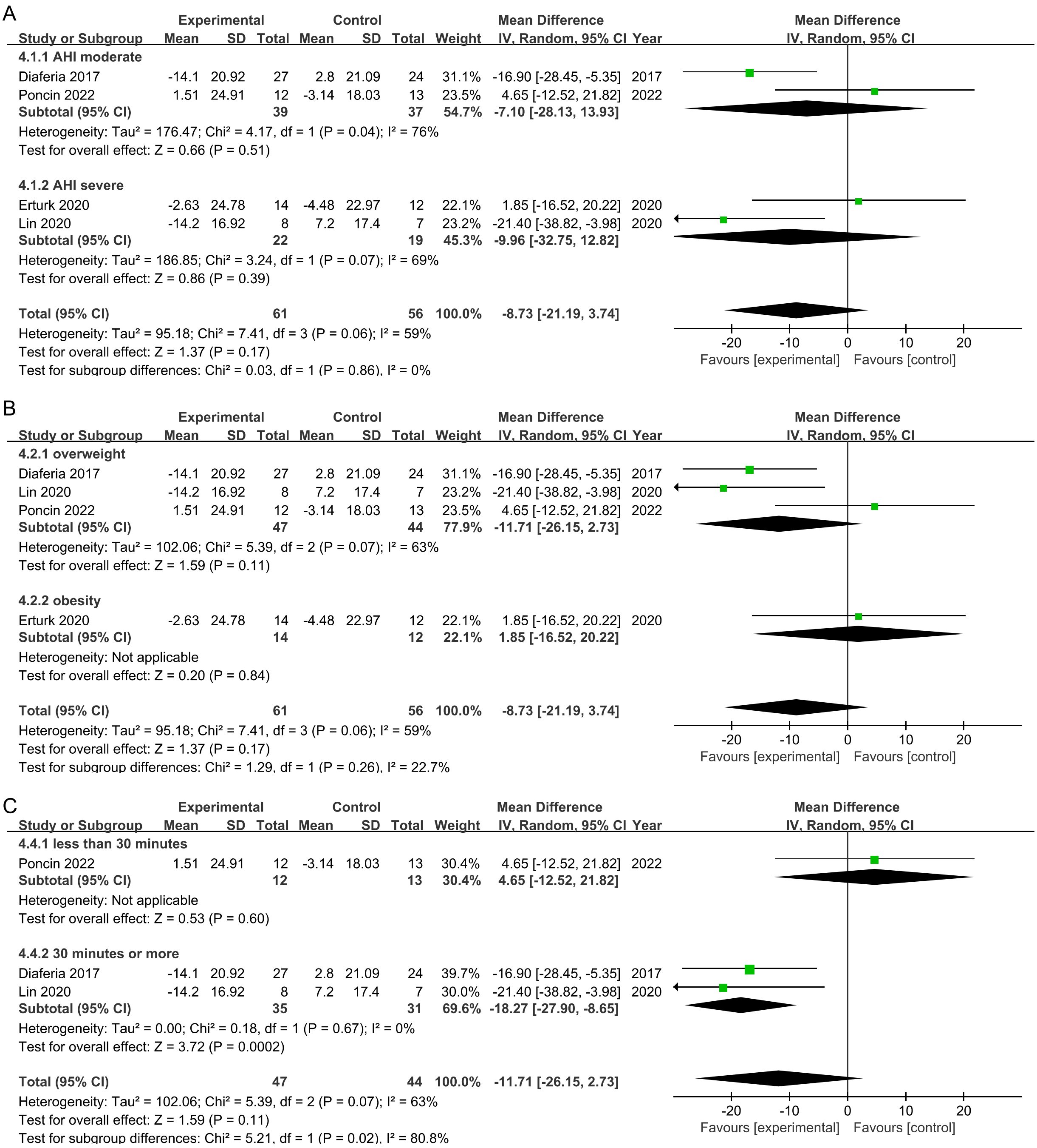
Other PSG outcomes include arousal index, average or lowest oxygen saturation (SpO_2), total sleep time (TST) and sleep efficiency. Two studies evaluated the change of arousal index before and after MT,[30,36] and the mean difference in change of arousal index for MT compared with control was −15.68 (95% CI −20.34 to −11.03, $P < .00001$, $I^2 = 0\%$). Two

Figure 3. The risk of bias summary (A) and risk of bias graph (B).



	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Atilgan 2019	+	?	−	?	+	+	+
Çakmakcı 2022	+	+	+	−	−	+	−
Diaferia 2017	+	+	+	+	+	+	+
Erturk 2020	+	+	+	?	+	+	+
Guimaraes 2009	+	?	+	+	+	+	+
Huang 2019	+	?	?	?	−	+	−
Ieto 2015	+	?	+	+	+	+	+
Kim 2020	+	+	+	?	+	+	−
Lin 2020	+	?	−	?	+	+	+
Maghsoudipour 2021	+	+	+	+	+	+	+
Paolucci 2023	+	+	+	+	+	+	−
Poncin 2022	+	+	+	+	+	+	+
Puhan 2005	+	+	−	+	+	+	+
Villa 2015	+	+	?	?	+	+	+
Villa 2017	+	+	?	?	+	+	+

Figure 4. Treatment effect for change in the apnea-hypopnea index (AHI). Subgroup analysis according to severity of AHI (A), BMI (B), and daily practice time (C). AHI, apnea-hypopnea index; BMI, body mass index.



A

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Year
4.1.1 AHI moderate									
Diaferia 2017	-14.1	20.92	27	2.8	21.09	24	31.1%	-16.90 [-28.45, -5.35]	2017
Poncin 2022	1.51	24.91	12	-3.14	18.03	13	23.5%	4.65 [-12.52, 21.82]	2022
Subtotal (95% CI)			**39**			**37**	**54.7%**	**-7.10 [-28.13, 13.93]**	
Heterogeneity: Tau² = 176.47; Chi² = 4.17, df = 1 (P = 0.04); I² = 76%									
Test for overall effect: Z = 0.66 (P = 0.51)									
4.1.2 AHI severe									
Erturk 2020	-2.63	24.78	14	-4.48	22.97	12	22.1%	1.85 [-16.52, 20.22]	2020
Lin 2020	-14.2	16.92	8	7.2	17.4	7	23.2%	-21.40 [-38.82, -3.98]	2020
Subtotal (95% CI)			**22**			**19**	**45.3%**	**-9.96 [-32.75, 12.82]**	
Heterogeneity: Tau² = 186.85; Chi² = 3.24, df = 1 (P = 0.07); I² = 69%									
Test for overall effect: Z = 0.86 (P = 0.39)									
Total (95% CI)			**61**			**56**	**100.0%**	**-8.73 [-21.19, 3.74]**	
Heterogeneity: Tau² = 95.18; Chi² = 7.41, df = 3 (P = 0.06); I² = 59%									
Test for overall effect: Z = 1.37 (P = 0.17)									
Test for subgroup differences: Chi² = 0.03, df = 1 (P = 0.86), I² = 0%									

B

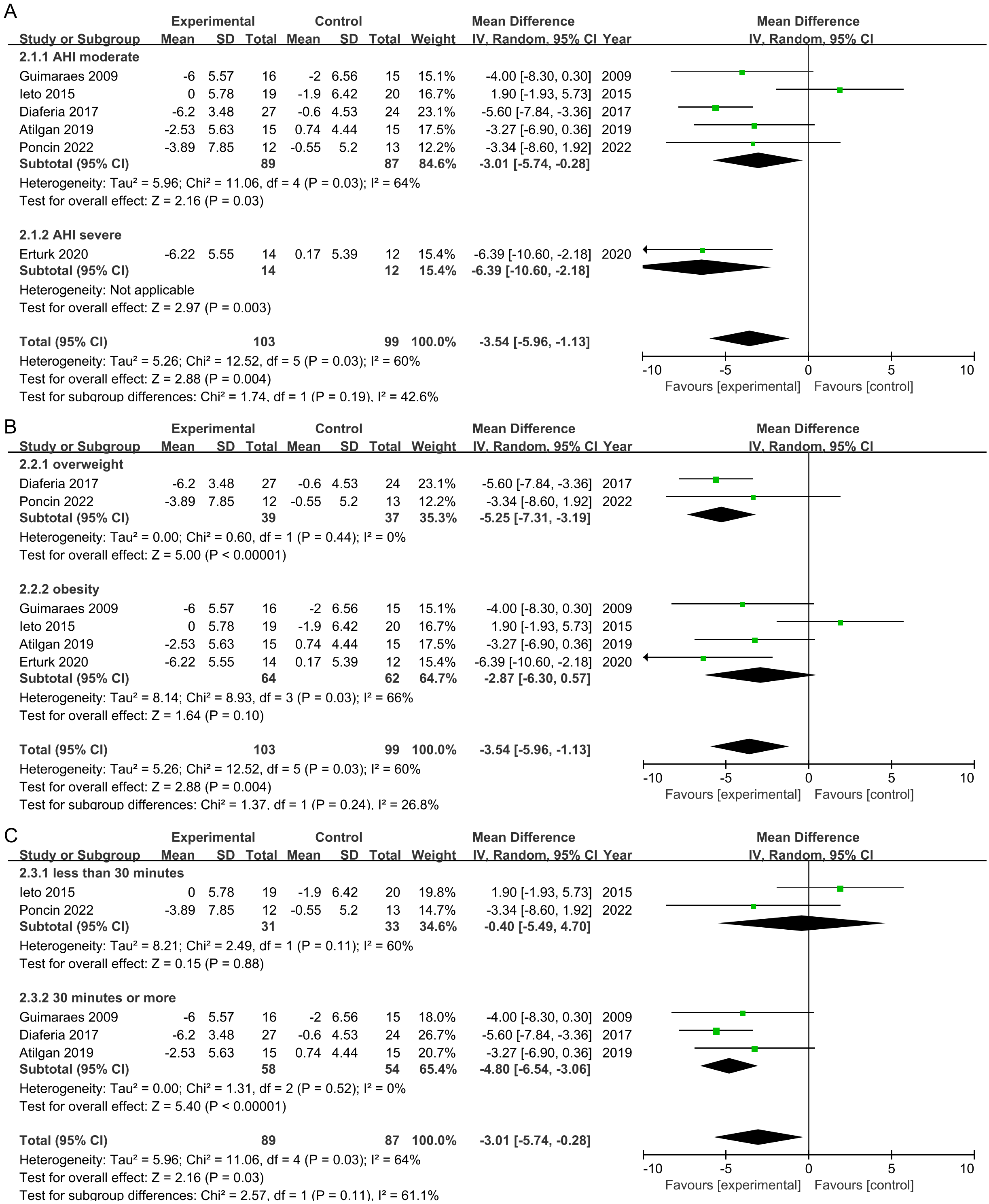
Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Year
4.2.1 overweight									
Diaferia 2017	-14.1	20.92	27	2.8	21.09	24	31.1%	-16.90 [-28.45, -5.35]	2017
Lin 2020	-14.2	16.92	8	7.2	17.4	7	23.2%	-21.40 [-38.82, -3.98]	2020
Poncin 2022	1.51	24.91	12	-3.14	18.03	13	23.5%	4.65 [-12.52, 21.82]	2022
Subtotal (95% CI)			**47**			**44**	**77.9%**	**-11.71 [-26.15, 2.73]**	
Heterogeneity: Tau² = 102.06; Chi² = 5.39, df = 2 (P = 0.07); I² = 63%									
Test for overall effect: Z = 1.59 (P = 0.11)									
4.2.2 obesity									
Erturk 2020	-2.63	24.78	14	-4.48	22.97	12	22.1%	1.85 [-16.52, 20.22]	2020
Subtotal (95% CI)			**14**			**12**	**22.1%**	**1.85 [-16.52, 20.22]**	
Heterogeneity: Not applicable									
Test for overall effect: Z = 0.20 (P = 0.84)									
Total (95% CI)			**61**			**56**	**100.0%**	**-8.73 [-21.19, 3.74]**	
Heterogeneity: Tau² = 95.18; Chi² = 7.41, df = 3 (P = 0.06); I² = 59%									
Test for overall effect: Z = 1.37 (P = 0.17)									
Test for subgroup differences: Chi² = 1.29, df = 1 (P = 0.26), I² = 22.7%									

C

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Year
4.4.1 less than 30 minutes									
Poncin 2022	1.51	24.91	12	-3.14	18.03	13	30.4%	4.65 [-12.52, 21.82]	2022
Subtotal (95% CI)			**12**			**13**	**30.4%**	**4.65 [-12.52, 21.82]**	
Heterogeneity: Not applicable									
Test for overall effect: Z = 0.53 (P = 0.60)									
4.4.2 30 minutes or more									
Diaferia 2017	-14.1	20.92	27	2.8	21.09	24	39.7%	-16.90 [-28.45, -5.35]	2017
Lin 2020	-14.2	16.92	8	7.2	17.4	7	30.0%	-21.40 [-38.82, -3.98]	2020
Subtotal (95% CI)			**35**			**31**	**69.6%**	**-18.27 [-27.90, -8.65]**	
Heterogeneity: Tau² = 0.00; Chi² = 0.18, df = 1 (P = 0.67); I² = 0%									
Test for overall effect: Z = 3.72 (P = 0.0002)									
Total (95% CI)			**47**			**44**	**100.0%**	**-11.71 [-26.15, 2.73]**	
Heterogeneity: Tau² = 102.06; Chi² = 5.39, df = 2 (P = 0.07); I² = 63%									
Test for overall effect: Z = 1.59 (P = 0.11)									
Test for subgroup differences: Chi² = 5.21, df = 1 (P = 0.02), I² = 80.8%									

studies reported that the average SpO_2 increased more in MT group than in control group,[30,32] while 3 studies evaluated the lowest SpO_2.[29,32,36] with one study reporting on significant increase in lowest SpO_2. However, the synthesized results showed that there was no significant effect in favor of MT in average SpO_2 or lowest SpO_2, and no significant changes were found in TST or sleep efficiency (Supplementary Figure 2). Additionally, Villa et al. [41] observed that MT

Figure 5. Treatment effect for change in the Epworth Sleepiness Scale (ESS). Subgroup analysis according to severity of AHI (A), BMI (B), and daily practice time (C). AHI, apnea-hypopnea index; BMI, body mass index.



A

	Experimental			Control				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year
2.1.1 AHI moderate									
Guimaraes 2009	-6	5.57	16	-2	6.56	15	15.1%	-4.00 [-8.30, 0.30]	2009
Ieto 2015	0	5.78	19	-1.9	6.42	20	16.7%	1.90 [-1.93, 5.73]	2015
Diaferia 2017	-6.2	3.48	27	-0.6	4.53	24	23.1%	-5.60 [-7.84, -3.36]	2017
Atilgan 2019	-2.53	5.63	15	0.74	4.44	15	17.5%	-3.27 [-6.90, 0.36]	2019
Poncin 2022	-3.89	7.85	12	-0.55	5.2	13	12.2%	-3.34 [-8.60, 1.92]	2022
Subtotal (95% CI)			**89**			**87**	**84.6%**	**-3.01 [-5.74, -0.28]**	
Heterogeneity: Tau² = 5.96; Chi² = 11.06, df = 4 (P = 0.03); I² = 64%									
Test for overall effect: Z = 2.16 (P = 0.03)									
2.1.2 AHI severe									
Erturk 2020	-6.22	5.55	14	0.17	5.39	12	15.4%	-6.39 [-10.60, -2.18]	2020
Subtotal (95% CI)			**14**			**12**	**15.4%**	**-6.39 [-10.60, -2.18]**	
Heterogeneity: Not applicable									
Test for overall effect: Z = 2.97 (P = 0.003)									
Total (95% CI)			**103**			**99**	**100.0%**	**-3.54 [-5.96, -1.13]**	
Heterogeneity: Tau² = 5.26; Chi² = 12.52, df = 5 (P = 0.03); I² = 60%									
Test for overall effect: Z = 2.88 (P = 0.004)									
Test for subgroup differences: Chi² = 1.74, df = 1 (P = 0.19), I² = 42.6%									

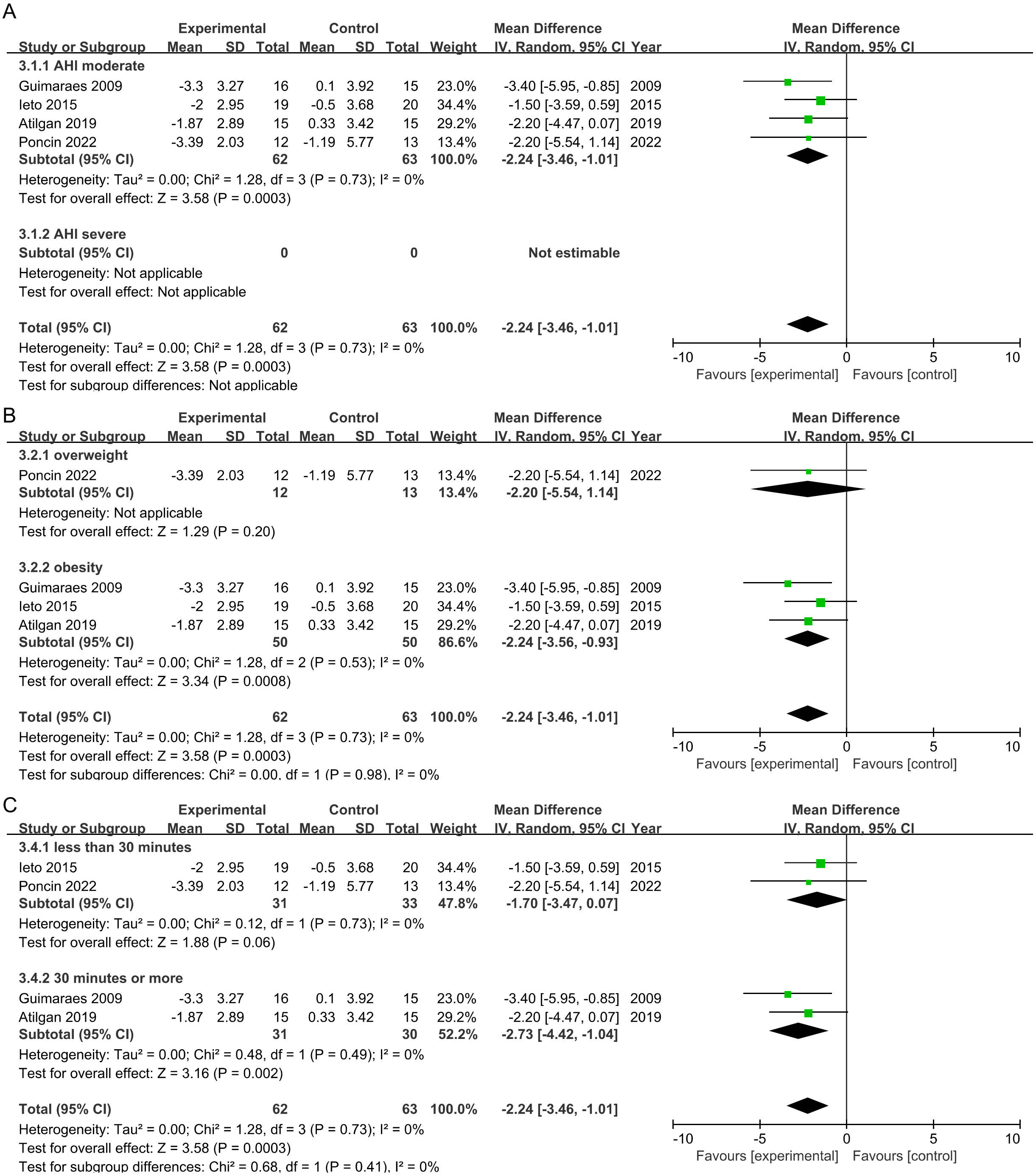
B

	Experimental			Control				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year
2.2.1 overweight									
Diaferia 2017	-6.2	3.48	27	-0.6	4.53	24	23.1%	-5.60 [-7.84, -3.36]	2017
Poncin 2022	-3.89	7.85	12	-0.55	5.2	13	12.2%	-3.34 [-8.60, 1.92]	2022
Subtotal (95% CI)			**39**			**37**	**35.3%**	**-5.25 [-7.31, -3.19]**	
Heterogeneity: Tau² = 0.00; Chi² = 0.60, df = 1 (P = 0.44); I² = 0%									
Test for overall effect: Z = 5.00 (P < 0.00001)									
2.2.2 obesity									
Guimaraes 2009	-6	5.57	16	-2	6.56	15	15.1%	-4.00 [-8.30, 0.30]	2009
Ieto 2015	0	5.78	19	-1.9	6.42	20	16.7%	1.90 [-1.93, 5.73]	2015
Atilgan 2019	-2.53	5.63	15	0.74	4.44	15	17.5%	-3.27 [-6.90, 0.36]	2019
Erturk 2020	-6.22	5.55	14	0.17	5.39	12	15.4%	-6.39 [-10.60, -2.18]	2020
Subtotal (95% CI)			**64**			**62**	**64.7%**	**-2.87 [-6.30, 0.57]**	
Heterogeneity: Tau² = 8.14; Chi² = 8.93, df = 3 (P = 0.03); I² = 66%									
Test for overall effect: Z = 1.64 (P = 0.10)									
Total (95% CI)			**103**			**99**	**100.0%**	**-3.54 [-5.96, -1.13]**	
Heterogeneity: Tau² = 5.26; Chi² = 12.52, df = 5 (P = 0.03); I² = 60%									
Test for overall effect: Z = 2.88 (P = 0.004)									
Test for subgroup differences: Chi² = 1.37, df = 1 (P = 0.24), I² = 26.8%									

C

	Experimental			Control				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year
2.3.1 less than 30 minutes									
Ieto 2015	0	5.78	19	-1.9	6.42	20	19.8%	1.90 [-1.93, 5.73]	2015
Poncin 2022	-3.89	7.85	12	-0.55	5.2	13	14.7%	-3.34 [-8.60, 1.92]	2022
Subtotal (95% CI)			**31**			**33**	**34.6%**	**-0.40 [-5.49, 4.70]**	
Heterogeneity: Tau² = 8.21; Chi² = 2.49, df = 1 (P = 0.11); I² = 60%									
Test for overall effect: Z = 0.15 (P = 0.88)									
2.3.2 30 minutes or more									
Guimaraes 2009	-6	5.57	16	-2	6.56	15	18.0%	-4.00 [-8.30, 0.30]	2009
Diaferia 2017	-6.2	3.48	27	-0.6	4.53	24	26.7%	-5.60 [-7.84, -3.36]	2017
Atilgan 2019	-2.53	5.63	15	0.74	4.44	15	20.7%	-3.27 [-6.90, 0.36]	2019
Subtotal (95% CI)			**58**			**54**	**65.4%**	**-4.80 [-6.54, -3.06]**	
Heterogeneity: Tau² = 0.00; Chi² = 1.31, df = 2 (P = 0.52); I² = 0%									
Test for overall effect: Z = 5.40 (P < 0.00001)									
Total (95% CI)			**89**			**87**	**100.0%**	**-3.01 [-5.74, -0.28]**	
Heterogeneity: Tau² = 5.96; Chi² = 11.06, df = 4 (P = 0.03); I² = 64%									
Test for overall effect: Z = 2.16 (P = 0.03)									
Test for subgroup differences: Chi² = 2.57, df = 1 (P = 0.11), I² = 61.1%									

Figure 6. Treatment effect for change in the Pittsburgh Sleep Quality Index (PSQI). Subgroup analysis according to severity of AHI (A), BMI (B), and daily practice time (C). AHI, apnea-hypopnea index; BMI, body mass index.



A

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Year
3.1.1 AHI moderate									
Guimaraes 2009	-3.3	3.27	16	0.1	3.92	15	23.0%	-3.40 [-5.95, -0.85]	2009
Ieto 2015	-2	2.95	19	-0.5	3.68	20	34.4%	-1.50 [-3.59, 0.59]	2015
Atilgan 2019	-1.87	2.89	15	0.33	3.42	15	29.2%	-2.20 [-4.47, 0.07]	2019
Poncin 2022	-3.39	2.03	12	-1.19	5.77	13	13.4%	-2.20 [-5.54, 1.14]	2022
Subtotal (95% CI)			**62**			**63**	**100.0%**	**-2.24 [-3.46, -1.01]**	
Heterogeneity: Tau² = 0.00; Chi² = 1.28, df = 3 (P = 0.73); I² = 0%									
Test for overall effect: Z = 3.58 (P = 0.0003)									
3.1.2 AHI severe									
Subtotal (95% CI)			**0**			**0**		**Not estimable**	
Heterogeneity: Not applicable									
Test for overall effect: Not applicable									
Total (95% CI)			**62**			**63**	**100.0%**	**-2.24 [-3.46, -1.01]**	
Heterogeneity: Tau² = 0.00; Chi² = 1.28, df = 3 (P = 0.73); I² = 0%									
Test for overall effect: Z = 3.58 (P = 0.0003)									
Test for subgroup differences: Not applicable									

B

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Year
3.2.1 overweight									
Poncin 2022	-3.39	2.03	12	-1.19	5.77	13	13.4%	-2.20 [-5.54, 1.14]	2022
Subtotal (95% CI)			**12**			**13**	**13.4%**	**-2.20 [-5.54, 1.14]**	
Heterogeneity: Not applicable									
Test for overall effect: Z = 1.29 (P = 0.20)									
3.2.2 obesity									
Guimaraes 2009	-3.3	3.27	16	0.1	3.92	15	23.0%	-3.40 [-5.95, -0.85]	2009
Ieto 2015	-2	2.95	19	-0.5	3.68	20	34.4%	-1.50 [-3.59, 0.59]	2015
Atilgan 2019	-1.87	2.89	15	0.33	3.42	15	29.2%	-2.20 [-4.47, 0.07]	2019
Subtotal (95% CI)			**50**			**50**	**86.6%**	**-2.24 [-3.56, -0.93]**	
Heterogeneity: Tau² = 0.00; Chi² = 1.28, df = 2 (P = 0.53); I² = 0%									
Test for overall effect: Z = 3.34 (P = 0.0008)									
Total (95% CI)			**62**			**63**	**100.0%**	**-2.24 [-3.46, -1.01]**	
Heterogeneity: Tau² = 0.00; Chi² = 1.28, df = 3 (P = 0.73); I² = 0%									
Test for overall effect: Z = 3.58 (P = 0.0003)									
Test for subgroup differences: Chi² = 0.00, df = 1 (P = 0.98), I² = 0%									

C

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Year
3.4.1 less than 30 minutes									
Ieto 2015	-2	2.95	19	-0.5	3.68	20	34.4%	-1.50 [-3.59, 0.59]	2015
Poncin 2022	-3.39	2.03	12	-1.19	5.77	13	13.4%	-2.20 [-5.54, 1.14]	2022
Subtotal (95% CI)			**31**			**33**	**47.8%**	**-1.70 [-3.47, 0.07]**	
Heterogeneity: Tau² = 0.00; Chi² = 0.12, df = 1 (P = 0.73); I² = 0%									
Test for overall effect: Z = 1.88 (P = 0.06)									
3.4.2 30 minutes or more									
Guimaraes 2009	-3.3	3.27	16	0.1	3.92	15	23.0%	-3.40 [-5.95, -0.85]	2009
Atilgan 2019	-1.87	2.89	15	0.33	3.42	15	29.2%	-2.20 [-4.47, 0.07]	2019
Subtotal (95% CI)			**31**			**30**	**52.2%**	**-2.73 [-4.42, -1.04]**	
Heterogeneity: Tau² = 0.00; Chi² = 0.48, df = 1 (P = 0.49); I² = 0%									
Test for overall effect: Z = 3.16 (P = 0.002)									
Total (95% CI)			**62**			**63**	**100.0%**	**-2.24 [-3.46, -1.01]**	
Heterogeneity: Tau² = 0.00; Chi² = 1.28, df = 3 (P = 0.73); I² = 0%									
Test for overall effect: Z = 3.58 (P = 0.0003)									
Test for subgroup differences: Chi² = 0.68, df = 1 (P = 0.41), I² = 0%									

effectively increased children's average SpO_2 after 2 months of treatment but no significant change in lowest SpO_2.

Tongue Elevation

Two studies used Iowa Oral Performance Instrument (IOPI) device to measure tongue strength by obtaining maximal tongue elevation pressures.[29,30] Poncin et al.[30] witnessed significant improvements in tongue muscle function. The synthesized result of the impact of each study on tongue elevation is shown in Supplementary Figure 3, but there is no significant effect in favor of MT, which increased by 3.41 kPa (95% CI −4.22 to 11.04 kPa, $P = .38$, $I^2 = 0\%$). In children, Villa et al .[41] demonstrated that MT had a positive effect on enhancing tongue strength.

Anthropometric measures

Anthropometric measures include BMI,[29,32,35,36] neck circumference,[29,31,32,35,36] and abdominal circumference.[29,31,35,36] The synthesized results showed that there was no significant effect in favor of MT in these 3 anthropometric measures (Supplementary Figure 4).

Network Meta-Analysis

For the treatment effect of AHI as shown in Figure 7A, the most effective intervention was CPAP (MD −28.78, 95%CI −48.96 to −8.52, $P = .0053$), based on data from only one RCT, [32] followed by the combination of MT and CPAP (MD −25.64, 95%CI −45.85 to −5.44, $P = .0127$). No significant improvements in AHI were observed with the other interventions. Additionally, according to the forest plot and rankograms for each intervention (Supplementary Figure 5A), CPAP had the highest probability of ranking first in reducing AHI, either alone or in combination with MT.

The results for other subjective main outcomes varied. As for ESS, MTSP had the highest probability of ranking first in improving daytime sleepiness (MD −5.36, 95% CI −10.22 to −0.50, $P = .0306$, followed by MT alone (MD −3.58, 95% CI −5.74 to −1.43, $P = .0011$) based on the forest plot (Figure 7B) and rankograms (Supplementary Figure 5B). As for PSQI, the study including CPAP group by Guimarães et al. did not report on the change in PSQI, and comparisons were made only between MT and each other interventions, without direct comparisons among the other treatments. CPAP plus MT and MT alone are associated with statistically significant improvement of PSQI, which decreased by −4.04 (95% CI −6.53 to 1.54, $P = .0015$) and −2.24 (95% CI −3.46 to −1.01, $P = .0003$), respectively. According to the forest plot (Figure 7C) and rankograms (Supplementary Figure 5C), CPAP plus MT appears to have the highest probability of ranking first for improvements in quality of life, with MT plus myofascial release ranking second.

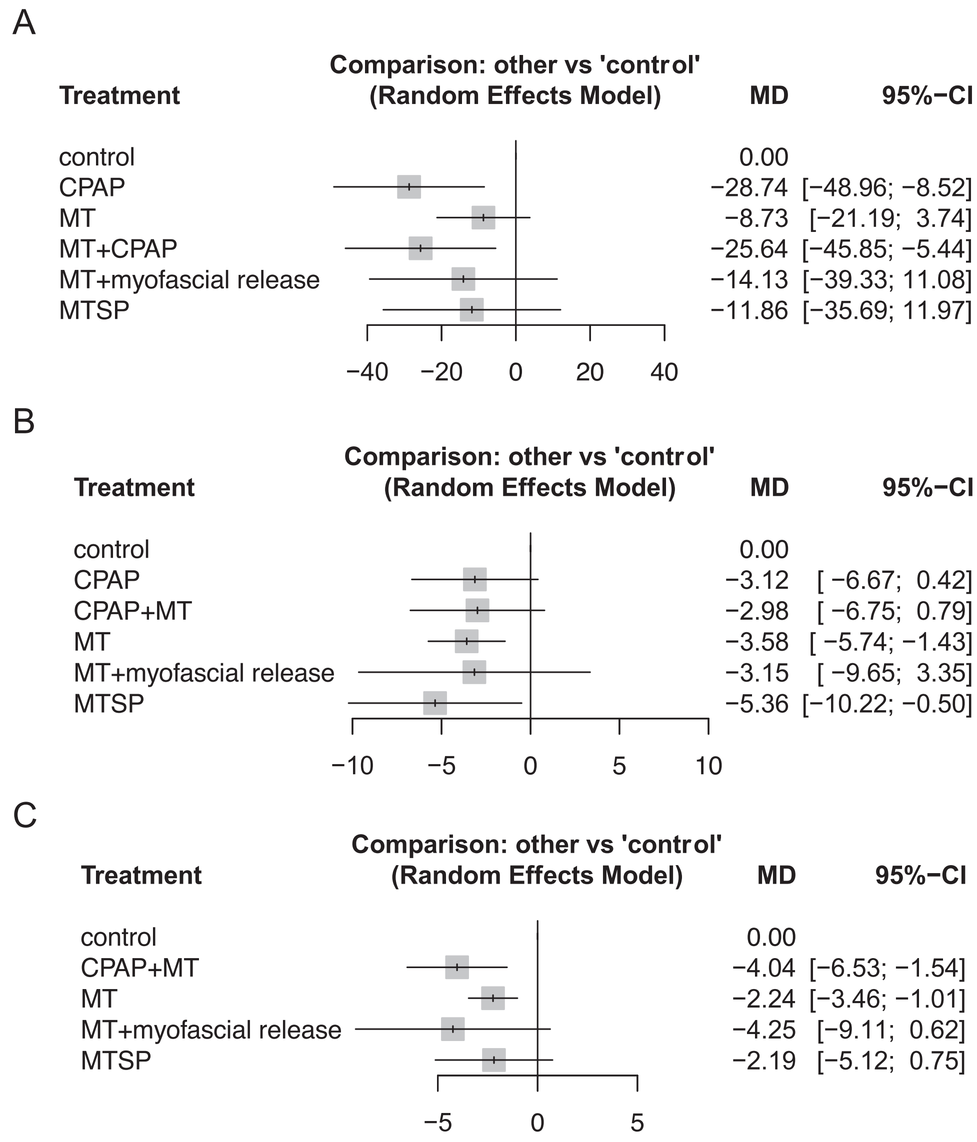
In addition, no inconsistency between evidence derived from direct and indirect comparisons was observed for the primary outcomes (Supplementary Figure 6). Visual inspection of the funnel plot revealed that most points were evenly distributed on both sides of the funnel and the distribution was generally symmetrical (Supplementary Figure 7), indicating no apparent publication bias. However, it is widely recognized that studies with significant or positive results are more likely to be published, which represents a common source of publication bias.[42]

DISCUSSION

In this network meta-analysis, we evaluated the efficacy of myofunctional therapy as a treatment for obstructive sleep apnea in comparison with other treatment regimens. We included 15 studies that randomized a total of 612 participants, with data analysis conducted on 380 of them derived from 10 adult RCTs. Our results indicate that myofunctional therapy is not associated with significant improvement of AHI, one of the primary metrics of OSA, in adult studies, while pediatric studies lack sufficient evidence. Improvements in daytime sleepiness as evaluated by ESS, quality of life assessed by PSQI, snoring intensity and arousal index can be observed in adults. These effects are particularly pronounced in patients who practiced for at least 30 minutes daily, without obesity and with high adherence to the therapy. Notably, when the daily practice time exceeds 30 minutes, MT also showed potential for significant improvement in AHI. Limited evidence of direct and indirect comparisons showed that while MT cannot replace CPAP in reducing AHI, both MTSP and MT alone significantly improve ESS. Furthermore, MT combined with myofascial release may yield further effects for PSQI compared to MT alone.

OSA is a prevalent clinical condition with a complex pathogenesis, involving anatomical and physiological factors.[43] The upper airway dilator muscles, particularly the genioglossus, which is the largest one and constitutes the bulk of the tongue, play a vital role in maintaining pharyngeal patency and the dysfunction may contribute to the development of OSA.[44] As early as 1918, Rogers described the correct positioning of the tongue within the oral cavity to enhance mandibular growth, nasal breathing, and facial appearance.[45] Guimarães later proposed oropharyngeal myofunctional therapy, originated from speech therapy, as a treatment for OSA aimed at improving the function of the upper airway dilators.[46] Subsequent research by Puhan et al.[27] then demonstrated that 4 months of upper airway muscle training through didgeridoo playing significantly reduced the severity of OSA. Since then, numerous studies, in the form of case studies, case series, and randomized controlled trials, have validated the effectiveness of myofunctional therapy both in children and adults, demonstrating subjective and objective improvements across various sleep parameters.[15,17,47-49]

Figure 7. The forest plot of network meta-analysis for the treatment effect of AHI (A), ESS (B) and PSQI (C). AHI, apnea-hypopnea index; ESS, Epworth sleepiness scale; PSQI, Pittsburgh sleep quality index; CPAP, continuous positive airway pressure; MT, myofunctional therapy; MTSP, myofunctional therapy support program.



Myofunctional therapy has since been recognized as a viable treatment option for OSA. It is generally believed that the plasticity of children is strong, and the efficacy of MT could be better, but their compliance is poor, while the plasticity of adults is relatively worse, but it can be used as an adjunct therapy for CPAP. Previous meta-analyses have evaluated the effects of MT on patients of OSA, but most included observational studies.[50-52] The strength of evidence from such meta-analyses is weaker than those based solely on RCTs, which are regarded as the gold standard for evaluating the efficacy and effectiveness of drugs, treatments, and interventions.[53] A more recent meta-analysis conducted by Saba et al.[54] focused exclusively on RCTs but included a trial for poststroke patients[55] and another trial with declared financial interest in the myofunctional therapy app used.[56] In our analysis, we excluded these studies not only to ensure the absence of systemic diseases in the study population, maintaining general consistency in patient inclusion criteria across the RCTs, but also to strictly ensure that the trial results are not influenced by potential conflicts of interest. Be-sides, we also supplemented one RCT by Lin et al. for AHI evaluation.[30]

Over the past decade, previous reviews have generally lent support to MT as a therapeutic strategy that could enhance the management of adult OSA, especially in reducing AHI.[17,19,50-52,54] However, in our study, the direct comparison between the MT group and the sham/no treatment group did not observe a statistically significant decrease of AHI with −8.73/h (95% CI −21.19 to 3.74/h, $P = .17$). Interestingly, the magnitude of reduction we observed is similar to Saba et al., who reported a statistically significant improvement by −8.29/h (95% CI −14.01 to −2.57/h, $P = .005$).[54] Although the pooled reduction in AHI of our study exceeded the minimum clinically important difference (MCID) threshold of 5 points, [57] the result lacked adequate statistical power to confirm the significance in our study. Subgroup analyses, however, provided further insights, revealing that only daily practice time of more than 30 minutes and consistently performed over a period of 3 months, resulted in a statistically significant reduction in AHI compared to the shorter sessions.

Beyond AHI, our findings indicate that MT significantly improved daytime sleepiness assessed by ESS (MD −3.54, 95% CI −5.96 to −1.13, $P = .004$). This improvement surpasses the MCID threshold of 3 points,[58,59] which aligns with the findings of Rueda et al., who also reported a reduction of −4.52 (95% CI −6.67 to −2.36) [17]. On the other hand, while our results for PSQI (MD −2.24, 95% CI −3.46 to −1.01, $P = .0003$) supported a statistically significant improvement in sleep quality, the observed change did not reach the MCID threshold of 3 points .[60] Moreover, a meta-analysis on observational studies concluded that oro-facial MT could improve ESS in patients with mild and moderate OSA.[51] In our subgroup analysis, MT is also found to be beneficial to patients with severe OSA in improving ESS. Notably, extending daily training time to 30 minutes or more appeared to amplify these benefits on ESS and PSQI, underscoring the importance of sufficient practice time in optimizing subjective outcomes. Based on the limited number of included studies with heterogeneity in study designs, our network meta-analysis also suggests a positive effect of MTSP on ESS, but this evidence is limited with only indirect comparisons and requires validation in future trials. Additionally, MT is believed to improve adherence to CPAP treatment.[32] While the precise mechanisms through which these exercises alleviate OSA remain unclear, it is hypothesized that these exercises could enhance the tone of the oral and/or oropharyngeal muscles and potentially reduce fat deposition in the tongue.[44]

However, some limitations should be noted. First, various methods of MT have been developed for treating OSA, though a unified standard has yet to be established. The training regimen developed by Guimarães et al.,[35] which incorporates repeated isometric and isotonic contractions along with exercises targeting the soft palate, tongue, and buccal muscles, has gained widespread recognition and applied in some of the included RCTs.[31,32,37,38,56] Building on this foundation, Ieto et al. simplified the training methods.[36] Poncin et al.[29] suggested that the current methods consist of a series of exercises and emphasized the need to identify the most effective components of MT, thus focusing the training on tongue elevation. Similarly, Paolucci et al.[34] regarded the tongue as the primary anatomical target of myofunctional therapy. Lin et al.,[30] combined respiratory resistance muscle strengthening with general endurance training to enhance upper airway muscles. Two studies used oral appliance for muscle training which engaged the genioglossus muscle and then the lateral pharyngeal muscles.[39,61] The methods used in pediatric studies are also inconsistent with those used in adults. Thus, the modality, frequency, and duration of MT exercises in the studies included in this analysis varied significantly. Additionally, since MT may involve a variety of exercises, current research has not yet been able to identify which specific exercises are effective.

Second, the long-term efficacy and durability of MT remain unclear, as most of the included trials lasted around 3 months, with only one pediatric RCT reporting follow-up data at 6 months[39] and one adult RCT evaluating the effect after 3 weeks of washout.[32]

Third, there are few high-quality RCTs in children to date, with only 2 studies using sham treatment as a control group but lacking common outcome measures. Therefore, we did not perform a pooled analysis of the data on children. The effectiveness of MT in treating pediatric OSA requires further research and non-RCT studies might be included for future meta-analysis.

Our findings of network meta-analysis also provide important implications for clinical practice. While MT may not yield statistically significant reduction in AHI, it could improve subjective indicators including ESS, PSQI and snoring intensity in adult OSA patients, particularly when the cumulative daily practice time is 30 minutes or more. Additionally, combining myofunctional therapy with CPAP could lead to a significant reduction in AHI, potentially increasing patient tolerance and adherence to CPAP. But the efficacy of CPAP for OSA remains superior to that of MT, and the combination does not significantly improve the efficacy of CPAP itself. Face-to-face education and supervision of MT by practitioners, such as MTSP, may facilitate higher MT adherence and enhance subjective and objective OSA measurements. Moreover, initial evidence suggests that MT might be associated with benefits in AHI and average SpO_2 in pediatric OSA with an emphasis on the importance of compliance, however, further studies are needed to confirm these promising results.

From a research perspective, more high-quality randomized controlled trials, both in adults and children, with larger sample sizes and extended follow-up periods, are needed to confirm the effectiveness and assess the sustainability of the treatment. Since MT comprises a series of exercises targeting various oropharyngeal structures, further research could consider exploring the specific roles of each exercise and the underlying mechanisms. Furthermore, future studies may require recording the actual daily practice time to objectively reflect patient adherence and the impact on outcomes. Products or devices help to increase compliance of patients or assist in supervision are worth developing.

CONCLUSION

This systematic review and meta-analysis indicate that MT is not associated with statistically significant reduction of AHI in OSA patients. However, significant improvements in AHI may occur when daily practice exceeds 30 minutes and the training duration reaches 3 months. MT has also demonstrated benefits in improving daytime sleepiness, quality of life and snoring intensity in adults. Limited evidence suggests that MTSP and MT combined with myofascial release may provide additional benefits in subjective symptoms. Further high-quality studies with longer follow-up are needed to assess the lasting effects of MT on OSA.

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Ying Xu: Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. **Ruicong Yang:** Visualization, Formal analysis, Data curation. **Min Yu:** Writing – review & editing, Visualization, Methodology. **Xuemei Gao:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebdp.2025.102137.

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