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Review

Rehabilitation Strategies for Scapular Dyskinesia: A Systematic Review and Meta-Analysis of Physical Therapy Interventions

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Abstract: Work-related Musculoskeletal Disorders (WMSDs) are highly prevalent, affecting approximately 71.9% of the workforce. Among these, shoulder pain is one of the most frequently reported issues, often linked to Scapular Dyskinesia (SD), which contributes to shoulder dysfunction and impaired movement. This systematic review and meta-analysis aimed to evaluate the effectiveness of physical therapy interventions in improving scapular alignment, reducing pain, and enhancing functional outcomes in individuals with SD. A comprehensive search was conducted using the PIOD framework across major databases, including PubMed, Scopus, Cochrane, CINAHL, PEDrO, and Web of Science, covering studies from 2013 to 2024. Seventeen randomized controlled trials were included, and data were analyzed using MedCalc with both fixed- and random-effects models. Physical therapy interventions demonstrated a significant reduction in pain (SMD = -0.620; 95% CI: -0.966 to -0.273; $p < 0.001$) with moderate heterogeneity ($I^2 = 44.48\%$). However, improvements in functional disability (SPADI) and scapular deviation (LSST) were statistically insignificant. Overall, physical therapy is effective in alleviating SD-related pain and should be considered a first-line treatment, although individualized and multimodal approaches may be necessary to achieve optimal functional recovery.

Keywords: Scapular dyskinesia, exercise, rehabilitation, scapular winging, pain

1. Introduction

Work-related musculoskeletal disorders (WMSDs) have emerged as a major global health concern, with a prevalence rate as high as 71.9% among the working population [1]. Among these, shoulder pain is particularly common, affecting 67% of individuals at some point [2]. While multiple factors contribute to shoulder pain, scapular dyskinesia has been documented to play a significant role in shoulder-related pathologies [2]. International studies have reported a high prevalence (67%) of scapular dyskinesia with shoulder pathologies. A recent study in Thailand reported a 90% prevalence of SD, as confirmed by the scapular dyskinesia test [3]. Previous studies have documented prevalence rates of 22.38% in India, 41.9% in Turkey, and 25.7% in Pakistan, especially among individuals aged 25-60 years who spend 5-6 hours a day on computers [4-6]. A systematic review by Salamh et al. further highlighted that SD is present in 60% of symptomatic individuals and 48 % of asymptomatic individuals [7].

Scapular dyskinesis (SD) is classified into three distinct types based on the pattern of scapular movement. Type I, which occurs in approximately 10.6% of cases, is identified by the posterior displacement of the lower medial angle of the scapula away from the thoracic wall. Type II, the most prevalent form with a 63.6% occurrence rate, involves the entire medial border of the scapula moving backward from the ribcage. Type III, seen in about 4.5% of individuals, is characterized by abnormal scapular motion during arm elevation, such as early scapular elevation or excessive, uncoordinated upward rotation, commonly referred to as dysrhythmia [8]. A plethora of research has demonstrated a correlation between shoulder range of motion and shoulder dysfunction. Biomechanically linked movement of the scapula and humerus, known as the scapulohumeral rhythm, plays a crucial role. However, deviation in scapular kinematics disrupts this rhythm [9,]. Factors contributing to SD include shoulder joint instability, nerve damage, poor posture, and muscular imbalances [10]. For clinical evaluation, SD is assessed using a combination of visual and symptom alteration tests. Visual tests include the Scapular Dyskinesia Test (SDT) and the Lateral Scapular Slide Test (LSST). The symptom alteration tests include the Scapular Assistance Test (SAT) and the Scapular Retraction Test (SRT) [11]. Management of SD may include pharmacological and non-pharmacological options. Pharmacological treatment includes analgesics, NSAIDS, and muscle relaxants that alleviate pain and severity and would be used during an acute phase. However, typical side effects of analgesics include severe GI disturbance, sedation, and addiction [12]. Non-pharmacological intervention, particularly physical therapy, is considered a long-term rehabilitation approach. Rehabilitation protocols often focus on progressive exercises to strengthen the lower trapezius and serratus anterior while minimizing overactivity of the upper trapezius [13].

Although several randomized controlled trials have investigated different physical therapy approaches, there remains a shortage of comprehensive evidence regarding their effectiveness in correcting scapular deviation and enhancing functional outcomes. This systematic review and meta-analysis seek to fill that gap by consolidating existing research on physical therapy interventions for scapular dyskinesis, with a particular emphasis on reducing scapular deviation, alleviating pain, and improving overall function.

2. Results

A total of 183 studies were identified through a database search. After removing 50 duplicate studies and 120 irrelevant studies lacking physical therapy interventions or full-text availability, seventeen full-text articles [18-30] were selected for inclusion in the systematic review, of which 14 were eligible for inclusion in the meta-analysis. (figure 1)

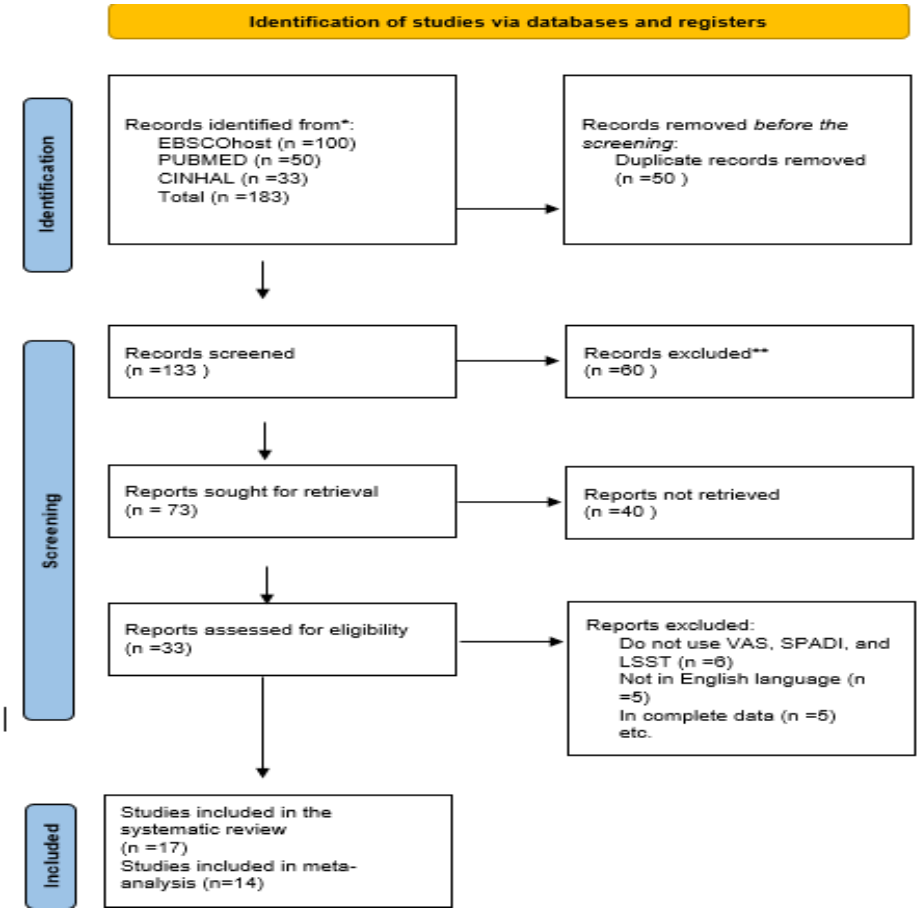


Figure 1: provides a comprehensive review of the trials along with participants' characteristics related to pain, scapular dyskinesia, and SPADI

2.1 PEDro Score:

The quality of methodology in the 17 selected studies using the (PEDro) Physiotherapy Evidence Database scale, ranging from 0 to 10, with an average score of 6, indicating moderate to good quality

Table 1: Characteristics of included studies

Author (Year)	Study Design	Sample Size	Target Population	Age (Years)	Intervention Group	Control Group	Outcome Measures	Key Results
Miotto et al., 2013	RCT	EG=18, CG=18	Scapular dyskinesia with neck pain	18–65	Global postural reeducation once/week for 10 weeks (60 min/session)	Segmental stretching (30 sec, 3 sets)	VAS	Significant improvement in pain, function, and quality of life
Turgut et al., 2017	RCT	EG=18, CG=18	Subacromial impingement with SD	—	12-week kinetic chain and strengthening program	Strengthening & stretching	SPADI	Improved external rotation, posterior tilt, and SPADI
Nowotny et al., 2018	RCT	EG=15, CG=13	Scapular dyskinesia	30–35	6-week specific exercise program	Massage therapy	VAS, LSST	Both groups reduced pain effectively
Chang et al., 2020	RCT	EG=20, CG=20	Scapular dyskinesia	19–30	4-week kinetic chain training	Conventional shoulder exercise	VAS	KC training more effective for scapular control
Kheradmandi et al., 2020	RCT	EG=20, CG=20	Overhead athletes with SD	18–45	Dry needling + scapular mobilization	Same therapy without dry needling	NPRS, LSST	Both effective; combo improved SPADI
Goti et al., 2020	RCT	EG=20, CG=20	Proximal humerus post-reduction with SD	20–50	6-week scapular + spinal stabilization	Rest + isometrics	VAS	Program reduced SD risk during immobilization
Özdemir et al., 2021	Quasi-exp.	EG=13, CG=12	Chronic neck pain with SD	25–65	15 scapular stabilization + PT sessions	Home-based stabilization (3 weeks)	VAS	Added stabilization reduced pain, improved function
Alshami et al., 2023	RCT	EG=20, CG=20	Neck pain with SD	>20	Scapulothoracic MWM + exercises + tape	Same regimen without MWM	VAS	3-week program reduced pain significantly

Saeed et al., 2022	RCT	EG=10, CG=10	SD with adhesive capsulitis	35–55	PNF + heating (3×/week, 6 weeks)	Myofascial release + heating	NPRS, SPADI	Both effective; PNF superior
Naderifar et al., 2022	RCT	EG=27, CG=27	Scapular dyskinesia	18–25	3-phase sensory-motor + strengthening	—	LSST	Improved ROM and reduced SD
Karthikeyan et al., 2022	RCT	EG=20, CG=20	Scapular dyskinesia	—	Muscle energy technique (4 weeks)	Conventional therapy	SPADI	MET improved pain, ROM, and function
Altaf et al., 2023	RCT	EG=13, CG=13	Scapular dyskinesia	30–50	PNF + conventional therapy	Conventional therapy	VAS, SPADI	PNF showed greater improvement
Nabil et al., 2023	RCT	EG=15, CG=15	Chronic neck pain with SD	18–30	McConnell taping + scapular exercises	Scapular stabilization	VAS	Taping with exercise superior in reducing pain
Yuksel et al., 2024	RCT	EG=32, CG=32	Subacromial pain with SD	>18	8 scapular-focused exercises	Standard stabilization	NRS	Improved shoulder pain and function
Rehman et al., 2024	RCT	EG=23, CG=23	Stroke with unilateral SD	40–60	D1 flexion + hot-pack + stabilization	D2 flexion + hot-pack + stabilization	VAS, SPADI	Both improved ROM and pain; no significant difference
Tang et al., 2024	RCT	EG=41, CG=39	Shoulder pain with SD	20–60	Scapular stabilization (6 weeks)	Conventional therapy	NRS, LSST	Greater Constant-Murley improvement
Chaudhary et al., 2024	RCT	EG=20, CG=20	Scapular dyskinesia	20–50	Modified robbery + EMG biofeedback	Modified robbery + ergonomics	VAS	Biofeedback improved pain and function

2.2 Effect of Physical Therapy Exercise on Pain:

Six studies that evaluated pain level in individuals with scapular dyskinesia were included in the meta-analysis [18-27]. Pain in patients with scapular dyskinesia was measured using the Visual Analog Scale (VAS). The combined analysis showed a statistically significant decrease in pain levels following physical therapy interventions, as indicated by the pooled standardized mean difference (SMD -0.620 (95% CI -0.966 to -0.273), which further emphasizes the effectiveness of the interventions. The results demonstrated strong statistical significance with p-values of less than 0.001 for random effects models. Heterogeneity among the studies was evaluated, revealing a Q statistic of 9.0059 ($p < 0.0001$) and an I^2 statistic of 44.48%, which indicates moderate heterogeneity among the included studies. This level of heterogeneity implies that while there is some variation across study results, it is not excessive and does not substantially compromise the overall conclusions drawn from the meta-analysis.

Figure 2: : Illustration of forest plot for NRS/VAS

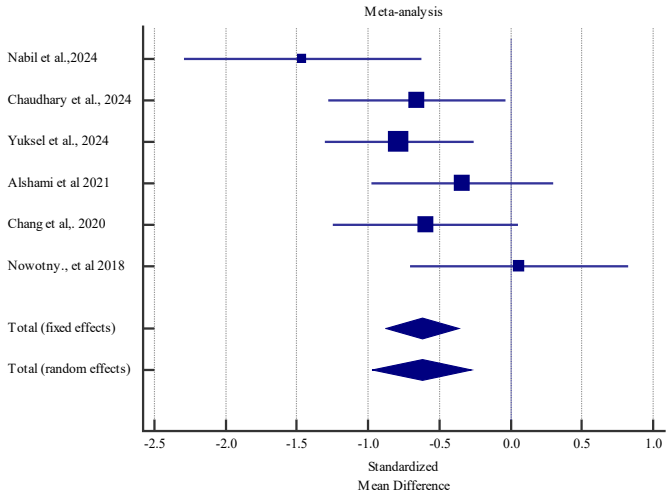


Table 2: Shows the SMD for the Pain using a random-effects model, with 95% CI and statistical heterogeneity

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (Fixed %)	Weight (Random %)
Nabil et al., 2024	15	15	30	-1.461	0.402	-2.285 to -0.637			10.34	12.72
Chaudhary et al., 2024	22	22	44	-0.661	0.304	-1.275 to -0.0468			18.06	17.76
Yuksel et al., 2024	32	32	64	-0.783	0.256	-1.296 to -0.270			25.44	20.99
Alshami et al., 2021	20	20	40	-0.341	0.312	-0.973 to 0.291			17.16	17.28
Chang et al., 2020	20	20	40	-0.597	0.317	-1.239 to 0.0444			16.64	16.99
Nowotny et al., 2018	15	13	28	0.0588	0.368	-0.698 to 0.815			12.36	14.26
Total (Fixed Effects)	124	122	246	-0.620	0.129	-0.875 to -0.366	-4.795	<0.001	100.00	100.00
Total (Random Effects)	124	122	246	-0.620	0.176	-0.966 to -0.273	-3.520	0.001	100.00	100.00
Test for Heterogeneity										
Q	9.0059			DF=5				P=0.1088		
I^2 (Inconsistency)	44.48%			95% CI for I^2 = 0.00 to 78.03						

2.2 Effect of Physical Therapy Exercise on the Shoulder Pain and Disability Index:

This meta-analysis included five studies that investigated shoulder pain and disability in patients with scapular dyskinesia [18,27,29-30] were analyzed using the SPADI score. The results show a significant effect of the interventions, with a standardized mean difference (pooled SMD of -0.291 (95% CI: -0.734 to 0.151) $I^2 = 57.42\%$ with a p-value of 0.195 indicating non-significance with moderate heterogeneity.

Figure 2: Illustration of forest plot for Shoulder Pain and Disability Index (SPADI) Score

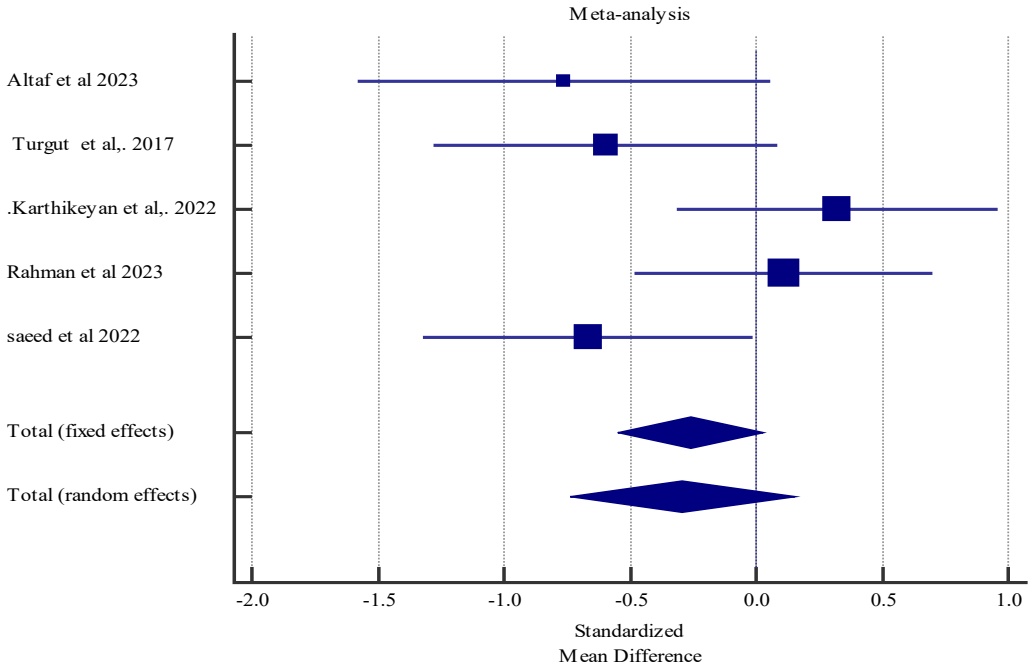


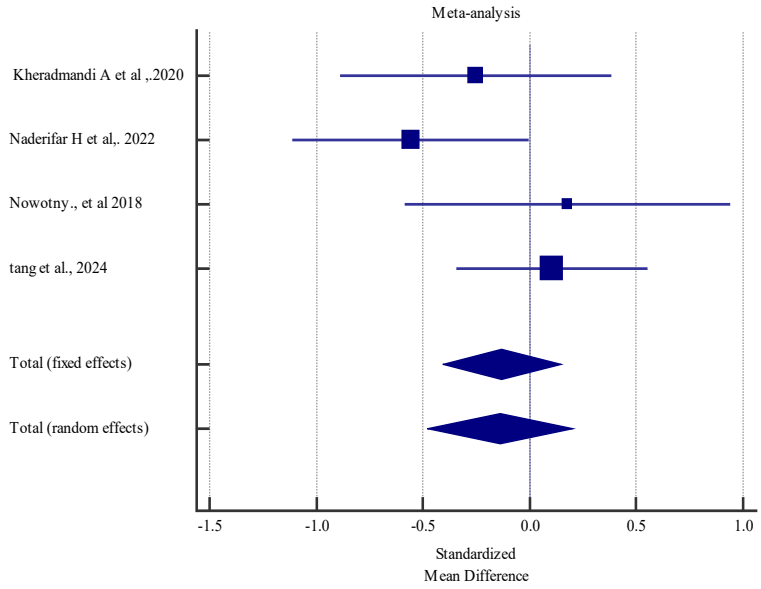
Table 3: Shows the SMD for the SPADI using a random-effects model, with 95% CI and statistical heterogeneity

Study	N1	N 2	Tota l	SMD	SE	95% CI	t	P	Weigh t (Fixed %)	Weight (Rando m %)
Altaf et al., 2023	13	13	26	- 0.76 3	0.39 4	-1.576 to 0.051 2			13.56	16.81
Turgut et al., 2017	18	18	36	- 0.59 7	0.33 3	-1.275 to 0.080 2			18.97	19.74
Karthikeyan et al., 2022	20	20	40	0.32 2	0.31 2	-0.310 to 0.954			21.66	20.87
Rahman et al., 2023	23	23	46	0.11 0	0.29 0	-0.474 to 0.695			25.06	22.08
Saeed et al., 2022	20	20	40	- 0.66 7	0.31 9	-1.313 to - 0.022 0			20.75	20.50
Total (Fixed Effects)	94	94	188	- 0.25 8	0.14 5	-0.544 to 0.028 7	- 1.77 5	0.07 8	100.00	100.00
Total (Random Effects)	94	94	188	- 0.29 1	0.22 4	-0.734 to 0.151	- 1.30 0	0.19 5	100.00	100.00
Test for Heterogeneity										
Q	9.3935									
DF	4									
Significance level	P = 0.0520									
I^2 (Inconsistency)	57.42 %									
95% CI for I^2	0.00 to 84.19									

2.3 Effect of physical therapy exercise on the scapular dyskinesia test

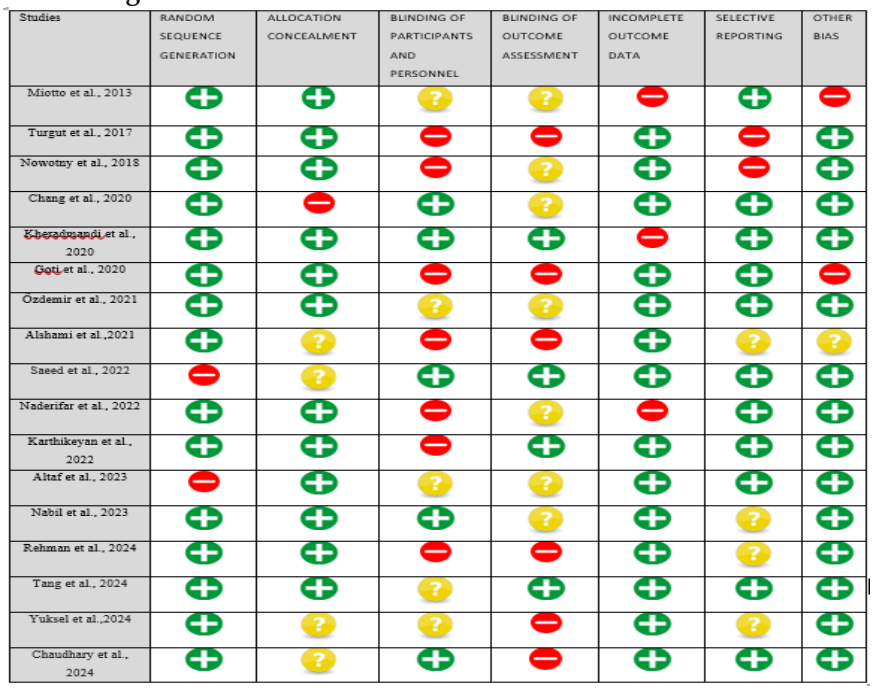
Four studies specifically assessed the scapular dyskinesia test or lateral scapular slide test [22,25,26,28]. The pooled analysis reported a standardized mean difference (SMD) of -0.137 (95% CI- 0.478 to 0.203), indicating a small statistically nonsignificant effect. However, heterogeneity was moderate, I^2 31.625%. Suggesting small variability in study design.

Figure and table 3: Illustration of forest plot for Scapular Dyskinesis Test (SDT) / Lateral Scapular Slide Test (LSST)



Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (Fixed %)	Weight (Random %)
Kheradmandi A et al., 2020	20	20	40	-0.252	0.311	-0.882 to 0.378			20.09	22.12
Naderifar H et al., 2022	27	27	54	-0.557	0.274	-1.106 to -0.00808			26.00	26.46
Nowotny et al., 2018	15	13	28	0.178	0.369	-0.580 to 0.936			14.32	17.15
Tang et al., 2024	41	39	80	0.102	0.222	-0.339 to 0.544			39.59	34.27
Total (Fixed Effects)	103	99	202	-0.129	0.139	-0.404 to 0.146	-0.928	0.355	100.00	100.00
Total (Random Effects)	103	99	202	-0.137	0.173	-0.478 to 0.203	-0.797	0.427	100.00	100.00
Test for Heterogeneity										
Q	4.3872									
DF	3									
Significance level	P = 0.2226									
I^2 (Inconsistency)	31.62 %									
95% CI for I^2	0.00 to 75.49									

Figure 4: Risk of bias



4. DISCUSSION

This in-depth systematic review and meta-analysis explored the effectiveness of physical therapy interventions across multiple outcome measures, including improvement in scapular positioning, shoulder pain reduction, enhanced ROM, and overall functional recovery in individuals with scapular dyskinesia. The study involved a meticulous review of 183 studies, culminating in the inclusion of 17 pertinent studies after

eliminating duplicates and irrelevant research [18-30]. This analysis demonstrated statistically significant decrease in pain as reflected by the calculated standard mean difference (SMD) of -0.620 (95% CI-0.966 to -0.273), indicating the efficacy of physical therapy intervention in alleviating pain among patients with scapular dyskinesia this finding is particularly relevant given the high prevalence of shoulder pain in population suggesting targeted intervention can lead to meaningful improvement in pain management. [18-27]

In contrast, the outcome related to the shoulder pain and disability index and scapular dyskinesia test showed a more modest effect size with SMD values of -0.291 (95% CI: -0.734 to 0.151), respectively, and a lack of statistical significance. The observed inconsistency may suggest that although physical therapy interventions effectively reduce pain, they may not equally translate into improved scapular positioning.

The aforementioned findings align with the results of Khodaverdizadeh et al study, indicating that the exercise therapy protocol was effective in significantly decreasing pain and enhancing shoulder function. However, it was observed that exercise therapy did not have a significant impact on scapular positioning at any angle [31]. Moreover, the inclusion of diverse physical therapy techniques such as myofascial release, dry needling, and virtual reality exergaming may contribute to variability in results. This underscores the need for tailored approaches to address excessive scapular deviation, shoulder pain, and impairment in individuals with scapular dyskinesia.

The study was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. The quality of the trials was evaluated based on their potential for bias. Most of the trials had a greater likelihood of bias in participant blinding, while some studies had a higher risk of bias in outcome assessment blinding.

The following are the limitations of this meta-analysis is the high degree of heterogeneity observed among the included studies, particularly in the outcome measures related to shoulder pain and disability index and scapular dyskinesia test. The substantial variability in study design, intervention protocol, and participant characteristics may limit the generalizability of the findings. Furthermore, the reliance on subjective outcome measures for pain and disability could introduce subjective bias; an individual's perception of pain and functional limitation may vary widely. Lastly, the short duration of follow-up in many studies raises concern about the long-term sustainability of the observed effect, suggesting a need for further research to assess the enduring impact of physical therapy intervention on scapular dyskinesia. The advantage of this

4. Materials and Methods

Protocol Registration:

The preferred reporting item for Systematic Review and Meta-analysis (PRISMA) 2020 guidelines [14]. The review protocol was registered with the International Prospective Register of Systematic Reviews PROSPERO under registration no CRD42024592830

Eligibility criteria:

Inclusion criteria:

The inclusion criteria were structured based on the PIOD framework work, which considers the Population, Intervention, Outcome, and study Design[15].

Population:

Individuals between 18 to 65 years of age who have been diagnosed with scapular dyskinesia, characterized by increased scapular deviation, shoulder pain, and elevated SPADI score

Intervention:

Physical therapy intervention includes Proprioceptive Neuromuscular Facilitation (PNF), Scapular Stabilizing exercises, Scapular Position-Motion Maintenance exercises,

global postural reeducation exercises, segmental exercises, myofascial release techniques, dry needling, manual therapy, conventional therapies, muscle energy technique, and virtual reality exergaming was examined.

Outcome:

Measures included scapular deviation via Lateral Scapular Slide Test (LSST) or Scapular Dyskinesis Test (SDT). Pain using NPRS – Numeric Pain Rating Scale (NPRS) or Visual Analog Scale (VAS) and functional disability SPADI

Design:

The study exclusively included randomized controlled trials to ensure the highest level of incidence.

Exclusion criteria:

Studies without control groups, those utilizing non-physical therapy rehabilitation, studies not published in English or lacking English translation, and studies published before 2013 were excluded.

Data extraction and search strategy:

The researcher conducted a comprehensive search across multiple databases, including EBSCOhost, and PubMed. Scopus, Cochrane Central Register of Controlled Trials, Cumulative Index of Nursing and Allied Health Literature, PEDrO, and Web of Science between February 2024 and August 2024. The search aimed to identify publications from 2013 to 2024. The researcher used specific search strategies, combining keywords (MeSH) with the Boolean operator (AND. OR, NOT) in the following combination:" Physical therapy" OR "physiotherapy exercise" OR "treatment approaches" AND" Scapular Dyskinesia "OR "SD" AND "Range of motion" AND "Scapular deviation" OR "Scapular dyskinesia test "OR" scapular assistance test" AND "shoulder pain and disability index." OR "SPADI". Articles were screened for relevance according to predefined inclusion and exclusion criteria.

Risk of bias of assessment:

The risk of bias in each study was evaluated across multiple key areas, including selection bias (such as how participants were randomized and whether allocation was concealed), performance bias (related to blinding procedures), attrition bias (due to incomplete or missing outcome data), and reporting bias (such as selective outcome reporting), among other potential sources of bias.[16]

Data analysis:

Statistical analysis was conducted using MedCalc Statistical Software version 18.11.3. Both fixed-effect and random-effect models were utilized to interpret the data accurately and account for variability within and between studies, to estimate the pooled effect sizes of physical therapy interventions on pain, SPADI and scapular dyskinesis Heterogenicity were assessed using I^2 Where, 0-40% indicated low heterogeneity, 30-60% reflected a moderate heterogeneity, 50-90% suggested substantial heterogeneity, and 75- 100% were considered indicative of considerable heterogeneity [16]. A fixed model was used in cases of mild to moderate heterogeneity, while a random effect model was used in cases of moderate to high heterogeneity. The effect sizes were categorized as small (0.2 to 00.49), moderate (0.5 to 0.79), and large (0.8 or above). The Statistical significance was kept at $p<0.05$[17].

5. Conclusions

In conclusion, this meta-analysis offers strong evidence supporting the effectiveness of physical therapy interventions in reducing pain linked to scapular dyskinesia. The study demonstrates a significant impact on pain; however, it also highlights limitations in the effectiveness of these interventions on functional disability, as assessed by the

shoulder pain and disability index (SPADI). It underscores the need for continual research to improve functional outcomes. Subsequent studies should focus on refining intervention strategies and evaluating long-term effects to comprehensively address the needs of individuals with scapular dyskinesia. This research not only adds to the existing knowledge base but also provides valuable insights for clinicians looking to implement evidence-based practices in managing this condition.

Conflict of interest:
The author declares that there is no conflict of interest related to this stud.
Ethical approval:
Ethical approval was not required for this study, as it did not involve direct participation of human subjects.
Funding resource:
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