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EFFECTIVENESS OF MUSCLE ENERGY TECHNIQUES ON GLENOHUMERAL INTERNAL ROTATION DEFICIT IN OVERHEAD ATHLETES: A SYSTEMATIC REVIEW

ORIGINAL ARTICLE

ABSTRACT

Purpose: Posterior shoulder tightness (PST) and Glenohumeral Internal Rotation Deficit (GIRD) are frequent biomechanical changes in overhead athletes. Evidence has shown that PST and the presence of GIRD increase subacromial pain syndrome. Posterior shoulder stretching exercises are used to improve posterior shoulder tightness. Muscle Energy Techniques (MET) are a long-established and effective approach, and the number of studies investigating the effects of MET on GIRD has been increasing in recent years. Despite the use of static stretching techniques in training, GIRD continues to be common in athletes performing overhead activities. Therefore, revealing the effects of MET on GIRD might be effective in determining the type of stretching most appropriate for preventing GIRD in athletes.

Methods: We performed a systematic literature review, assessing the relevance of studies for inclusion and selecting the studies from appropriate electronic databases (CINAHL, Cochrane Review, Pubmed (MEDLINE), Web of Science as well as Google Scholar©).

Results: The present systematic literature search generated 178 relevant citations and 8 articles were included in the final review. As an outcome measure, GIRD was assessed in all eight, whereas PST was assessed in four.

Conclusion: According to this systematic literature review, MET is effective in the improvement of GIRD and PST in overhead athletes. Future research should focus on symptomatic shoulders and investigate the long-term benefits of MET.

Keywords: Injuries, Mobility, Physical Therapy

BAŞ ÜSTÜ AKTİVİTE YAPAN SPORCULARDA KAS ENERJİ TEKNİKLERİNİN POSTERİOR OMUZ GERGİNLİĞİ VE GLENOHUMERAL İNTERNAL ROTASYON DEFİSİTİNDEKİ ETKİNLİĞİ: SİSTEMATİK DERLEME

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Posterior omuz gerginliği (POG) ve glenohumeral internal rotasyon defisiti (GİRD), baş üstü sporcularda sık görülen biyomekanik değişikliklerdir. Kanıtlar, POG ve GİRD varlığının subakromiyal ağrı sendromuyla ilişkili olduğunu göstermiştir. POG'u iyileştirmek için sıklıkla posterior omuz germe egzersizleri yapılır. Kas Enerjisi Teknikleri (KET) uzun süredir rehabilitasyonda etkin bir şekilde kullanılmakta ve son yıllarda KET'in GİRD üzerindeki etkilerini araştıran çalışmaların sayısı artmaktadır. Sporcular antrenmanda genelliklestatik germe tekniklerini kullanırlar, ancak GİRD, baş üstü aktivite yapan sporcularda yaygın bir şekilde görülmeye devam etmektedir. GİRD'de KET'in etkisinin ortaya çıkarılması, sporcularda GİRD oluşumunu etkin bir şekilde önleyebilecek germe egzersizinin belirlenmesinde faydalı olabilir.

Yöntem: Sistematik bir literatür taraması gerçekleştirdik. İlgili çalışmalar uygun elektronik veri tabanlarından (CINAHL, Cochrane Review, Pubmed (MEDLINE), Web of Science ve Google Scholar©) araştırıldı ve dahil edilmek üzere değerlendirildi.

Sonuçlar: Sistematik literatür araştırması 178 ilgili makale ile sonuçlandı ve derlemeye 8 makale dahil edildi. Sonuç ölçümü olarak GİRD'in dahil edilen tüm çalışmalarda değerlendirilirken, POG'un 4 çalışmada değerlendirildiği belirlendi.

Tartışma: Bu sistematik literatür derlemesine göre MET, baş üstü aktivite yapan sporcularda GİRD ve POG'un iyileştirilmesinde tavsiye edilmektedir. Gelecekteki araştırmalar semptomatik omuzlara odaklanmalı ve KET germelerinin uzun süreli etkilerini araştırmalıdır.

Anahtar Kelimeler: Yaralanmalar, Mobilite, Fizik tedavi

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INTRODUCTION

Glenohumeral joint dysfunctions are common in overhead athletes. A study conducted on university athletes implemented that the incidence of shoulder injury in overhead athletes was 30% (1). Posterior shoulder tightness (PST) and Glenohumeral Internal Rotation Deficit (GIRD) are frequent biomechanical changes in overhead athletes (2). PST is described as the restriction of the posterior shoulder soft tissues, including contractile (infraspinatus, teres minor, and posterior deltoid muscles) and non-contractile structures (posterior glenohumeral capsule) (3). GIRD is characterized as concurrent deficits of the shoulder, and internal rotation (IR) of the dominant side compared to the non-dominant side (4). Evidence has shown that PST and the presence of GIRD results in an increase in athletes' subacromial pain syndrome (SPS) (1,5). A cross-sectional study by Tyler et al. demonstrated that PST and GIRD were correlated with impingement findings (6). Additionally, PST increases subacromial compression when the shoulder is in flexion (7). A prospective cohort study found that a reduction of SPS symptoms was associated with decreased capsular tension (8). In this context, maintaining the flexibility of the posterior shoulder structures is extremely important for the prevention of future SPS and other related shoulder injuries.

Considering that GIRD is associated with PST, posterior shoulder stretching exercises are frequently used in routine, especially in static form, in order to prevent and rehabilitate possible injuries, and to improve performance (8,9). Although stretching exercises can be performed in different positions (10–12), the most common are sleeper and cross-body stretching. Studies have reported that cross-body stretching exercise is more effective in increasing shoulder internal rotation (IR) (11–15). Furthermore, Wilk et al., suggested that performing cross-body stretching in the modified position may increase the stabilization of the scapula and humerus and reduce the symptoms of impingement, and they recommend that this exercise be performed in the modified position (16). A recent systematic review concluded that cross-body stretching can be effective to improve GIRD (17).

Muscle Energy Techniques (MET) covers soft tissue stretching methods that aim to mobilize joints with limited movement, strengthen weak muscles, stretch shortened muscles and fascia, increase regional circulation, stretch fibrous tissues, and reduce tissue edema and muscle spasm (18). MET is well-established and effective, and the number of studies investigating the effects of MET on GIRD has increased in recent years (11,19,20).

It has been reported that MET can reduce pain with the gate control theory, and stretching when the muscle is in a hypertonic state immediately after isometric contraction can help the muscle reach a new resting length (21). Studies comparing static and MET on individuals with neck pain have shown that MET is more effective than static stretching in reducing pain and disability and increasing range of motion (ROM) (22,23). MET exercises might be more beneficial than other types of exercises in adhesive capsulitis patients in regard to ROM and pain (24). Static stretching techniques are commonly used in athlete training, but GIRD continues to be common in athletes who do overhead activities. Therefore, revealing the effects of MET in GIRD may contribute to determining the type of stretching most appropriate for preventing the formation of GIRD in athletes.

Objective

The objective of this study was to identify and analyze available studies reporting on the effectiveness of MET interventions for PST and GIRD.

METHOD

Eligibility Criteria for Studies

A clinical question was developed according to the PICOS (P: participant, I: intervention, C: comparator, O: outcome, and S: study design) format for the present systematic review (Table 1). PICOS includes the population characteristics, treatments given, comparative treatments, primary and secondary outcomes, and data collection settings. Available studies investigating the effects of MET on GIRD or PST were included in this review. Eligible studies reported IR or horizontal abduction (HA); also included were studies with overhead athletes with symptomatic and asymptomatic shoulders. All MET methods were screened but the literature research

revealed only studies on Post Isometric Relaxation (PIR) method. No criteria were included for the timeframe of interventions or type of interventions compared.

Data Sources and Literature Search Strategy

According to the PRISMA statement, English databases (CINAHL, Cochrane Review, Pubmed (MEDLINE), and Web of Science), as well as Google Scholar©, were systematically searched to identify peer-reviewed articles about the effectiveness of MET on GIRD and PST (25). The following keywords were used to identify eligible studies: Muscle energy techniques, Glenohumeral internal rotation deficit, posterior shoulder tightness, posterior shoulder stretching, and posterior shoulder stretch. After a scan of abstracts of the eligible studies, the full texts were investigated to determine eligible studies. Databases were searched from inception (1995) to March 2022. Additionally, the reference lists of included articles were manually scanned. The effect size was assessed for data extraction and synthesis as follows; small (0.20 to 0.49), moderate (0.50 to 0.79), and large (0.80 or greater) (26).

Assessment of Risk of Bias

To assess the risk of bias in included studies, the PEDro scale was used. This is reported to be valid tool for assessing randomized controlled trials (RTC) (27). The total scores indicated the quality of each study as "high" (≥7/10), "moderate" (5/10, 6/10), or "poor" (≤4/10). Total PEDro scores are presented in Table 2 Table 2 (Table 2).

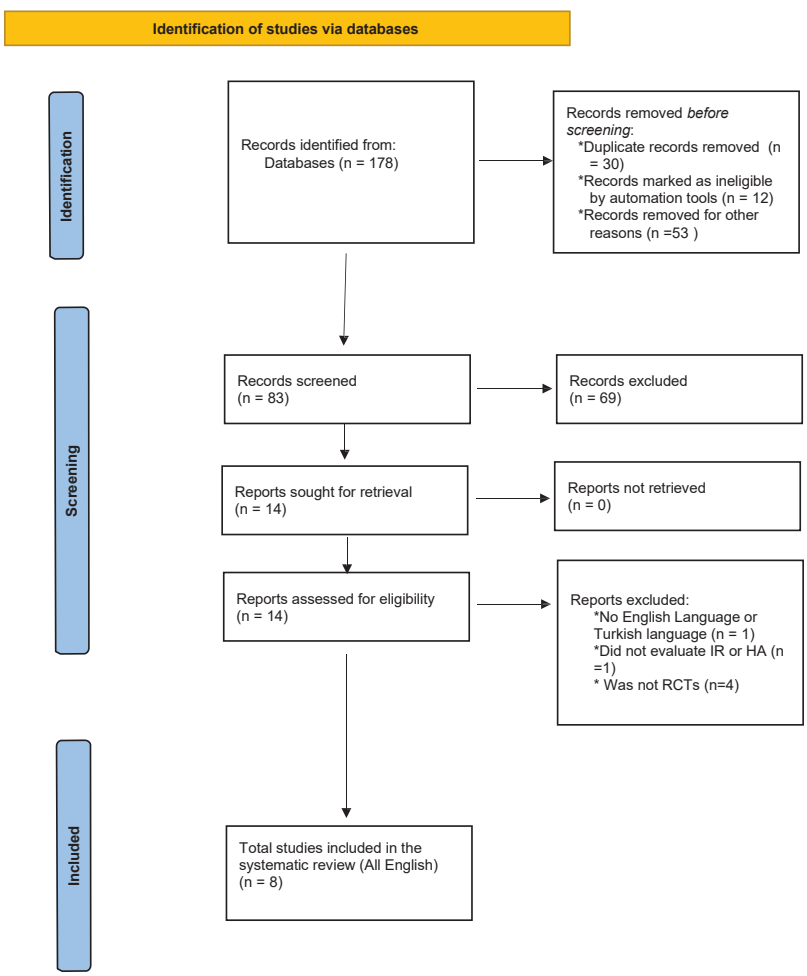

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Diagram of the Literature Search Used.

Study Selection

The initial literature search revealed 178 papers. After removing the duplicates and irrelevant studies, 14 articles underwent a full-text review. 8 studies met the inclusion criteria for this systematic review (Figure 1).

Study Characteristics

Table 3 shows the summaries of the studies and detailed information on the MET procedures.

Study Designs: Five RCTs used parallel designs (11,19,28–30), whereas one RCT used a cross- over design (20). Two studies conducted a quasi-randomized study (31,32).

Participants: MET were performed in overhead athletes, including players of baseball, softball, volleyball, and cricket (bowlers) (11,19,20,28–32). Sample sizes ages ranged 16 to 30. The total sample size for the present review was 315 subjects [197 male and 12 female, no given information related to sex in 106 subjects (11,29,30)]. Of the athletes included in the studies, 85 were baseball players (11,19), 78 were volleyball players (20,31), and 18 were softball players (11), 64 were cricket bowlers (29,32) and two studies reported no specific sport for the 70 overhead athletes that they included (28,30). Six studies cited the presence of GIRD as an inclusion criteria (20,28–32). GIRD definition varied among studies; two studies identified it as >10° restriction in IR ROM at 90° shoulder abduction in the dominant side compared to the non-dominant side (29,31), while Avci et al. (20) and Akula et al. (28) specified 18° and 20° decrease in IR ROM respectively. Kini et al. made no specification, (32) and Sehgal et al.'s definition was 18° to 20° of IR ROM restriction (30).

Interventions: All studies used the PIR technique among the MET (11,19,20,28–32). PIR was used in crossbody stretching in supine position in 5 studies (11,19,20,28,29). One study by Kumar et al. performed MET in IR, external rotation (ER), flexion, extension and HA of the glenohumeral joint (31), and three studies applied MET for external rotators in supine position while shoulder and elbow flexed 90° (19,30,32). MET methods differed among studies. Six studies used 25% of maximal voluntary contraction (MVC) during isometric contraction (11,19,20,29,30,32), Kumar et al. reported the isometric contraction as a forceful contraction (31) and the other study did not report the amount of force (28). Five studies applied 30-s of active assistive stretch after 3-7 seconds of isometric contraction (19,20,29,30,32), one study applied 3 seconds of active assistive stretching (11), and two others applied no stretching (28,31). Other interventions exploited in the included studies were static crossbody stretch in supine position (29), traditional sleeper stretch (30,31), a self-stretching method similar to sleeper stretch in standing position (28), joint mobilization (JM) (11), mulligan mobilization (32) and a sham MET procedure (20). Control groups with no stretching intervention were used in two studies (11,19). Additionally, the dosage of interventions as weekly frequencies were as follows: twice (28), three times (30), four times (29), five times (31) and six times (32).

Outcome Measures: All studies included in the present review measured IR ROM at 90° abduction (11,19,20,28–32), and four studies measured HA ROM (11,19,29,31).

RESULTS

Immediate Effects of MET on PST and GIRD

There were three studies that investigated the immediate effects of MET on PST and GIRD (11,19,20). Moore et al. found that a single session of MET for horizontal abductors (Habd) resulted in greater IR ROM than both no intervention and MET for ER. Furthermore, MET for Habd group had significantly more HA ROM than the no intervention group, but the benefit compared to MET for ER group was not significant. On the other hand, MET for ER group's improvement was not better than no intervention in any outcome (19). Reed et al. performed a single session of MET for Habd and compared it with a single session of JM and no intervention. Results show that shoulders treated with MET had significantly more passive HA ROM post-treatment compared with the no intervention group. There were no significant differences between either JM and MET or JM, and no intervention for post-intervention HA ROM. There was no significant between-group difference in IR ROM post-intervention. An analysis of the results of measurements collected 15 minutes post-intervention showed no significance between

Table 1. PICOS Format and Search Keywords

	Definition	Search Key Words
Participants	Overhead Athletes	Not set
Intervention	Any form of MET	Muscle Energy Technique, AND Shoulder stretching
Comparison	Any interventions	Not set
Outcome	PST or GIRD	(posterior shoulder tightness) OR PST OR (glenohumeral internal rotation deficit) OR GIRD
Study Design	RCTs, prospective cohort studies, controlled laboratory studies	Not set

MET: Muscle energy technique, GIRD: Glenohumeral internal rotation deficit, PST: Posterior shoulder tightness, RCTs: Randomized controlled trials.

groups differences for either HA or IR (11). Avci et al. concluded that a single session of MET improved IR ROM more than no intervention (20).

Short Term Effects of MET on PST and GIRD

Two studies reported the results over two weeks (29,30), while three reported the results over four weeks (28,31,32) of MET intervention. Bathia et al. reported that MET for Habd significantly improved IR and HA ROM after two weeks, but effects were similar to static stretching in supine cross-body position (29). Another study showed MET for ER improved IR ROM and IR strength after two weeks of intervention, whereas two weeks of static stretching showed no corresponding statistically significant improvement (30). Akula et al. showed that MET for Habd has similar improvements to a self-sleeper stretching regarding GIRD after four weeks (28). Similarly, Kumar et al. found that MET for Habd and sleeper stretching were both equally beneficial in terms of gains in GIRD and PST after four weeks (31). Additionally, Kini et al. reported that MET for ER and Mulligan mobilization were successful in improving rotational ROM after four weeks of intervention (32).

Table 2. Risk of Bias Assessment in the Included Studies

Study	1	2	3	4	5	6	7	8	9	10	11	Total
Akula et al. (2017)	1	1	0	1	0	0	0	0	1	1	1	5/10
Kumar et al. (2021)	1	0	0	0	0	0	0	1	1	1	0	3/10
Moore et al. (2011)	1	1	0	1	0	0	1	1	1	1	1	7/10
Bathia et al. (2016)	1	1	0	1	0	0	0	0	1	1	1	6/10
Avci et al. (2021)	1	1	1	1	1	0	1	1	1	1	0	8/10
Reed et al. (2018)	1	1	0	1	0	0	0	1	1	1	1	6/10
Seghal et al. (2016)	1	1	0	1	0	0	0	0	1	1	1	5/10
Kini et al. (2021)	1	0	0	1	0	0	0	0	1	0	1	3/10

PEDro scale: 1, eligibility criteria; 2, random allocation; 3, concealed allocation; 4, similarity at baseline; 5, blinding of participants; 6, blinding of therapists; 7, blinding of assessors; 8, measures of at least 1 key outcome from at least 85% of participants initially allocated to groups; 9, intention-to-treat analysis; 10, between-groups comparison; 11, point measures and measures of variability. 1 = Yes (1 point), 0 = No (0 point), maximum score = 10 (criterion 1 is not included in scores).

Table 3. Summary of the Included Studies

Study	Participants	Interventions	Outcome Measures	Results	Study Design
Moore et al. (2011)	Asymptomatic elite male baseball players (N=61). Age: 19.5±1.0 years (MET for HAbd group), 20.4±1.1 years (MET for ER group) and 19.8±1.1 years (control group)	The following interventions were performed • MET for HAbd group (n=19): Cross-body stretch with PIR was applied to the dominant side in the supine position. Participants were asked to move their arms towards horizontal ADD until the first barrier of movement. Then they performed a 5-s isometric contraction (%25 MVC) followed by a 30-s active assisted stretch, 3 repetitions. • MET for ER group (n=22): PIR stretching was applied to the ER as the same protocol as above. • Control (n=20): no intervention.	The following were assessed immediately before and after the stretching intervention. • Passive IR and ER ROM at 90° ABD. • Passive HAbd ROM.	MET for the HAbd group had a significantly greater increase in horizontal ADD and IR ROM compared with the control group ($p<0.05$) and a greater increase in IR ROM compared with MET for the ER group ($p<0.05$) and the control group ($p<0.05$).	RCT
Bathia et al. (2016)	Cricket bowlers with GIRD>10° (N=34) Age 22.47±3.84 years (MET for HAbd group) 21.29±3.98 years (Passive stretch for HAbd group)	The following interventions were performed • MET for HAbd group (N=17): cross-body stretch with PIR was applied for GIRD shoulder in the supine position. Participants were asked to move their arm towards horizontal ADD until the first barrier of movement and performed 7-s isometric contraction (%25 of MVC) followed by 30-s active assistive stretch, 3 repetitions a session, 4 sessions a week of total 2 weeks. • Passive stretch for HAbd group (N=17): 30-s passive stretch in supine cross-body position 3 repetitions a session, 4 sessions a week of total 2 weeks.	The following were assessed before treatment (1st day), 1st week, and 2nd week. • Passive IR and ER ROM at 90° ABD. • Passive HAbd ROM.	Both MET and Passive stretch groups significantly improved in HAbd and IR ROM after 1st and 2nd weeks ($p<0.05$). There was no statistical difference between groups for passive IR, ER, and HAbd ROM at 1st and 2nd week ($p>0.05$).	RCT
Sehgal et al. (2016)	Overthrowing athletes with GIRD between 18° to 20° (N=30) Age between 16-30 years	The following interventions were performed • MET for ER group (n=15): Participants were positioned supine with shoulder at 90° ABD and elbow at 90° FLEX. Participants were asked to move their arms towards IR until the first barrier of movement. Then they performed 5-s isometric contraction (%25 MVC) followed by a 30-s active assisted stretch, 3 repetitions a session, 3 sessions a week for 2 weeks. • Static stretching group (n=15): Participants were positioned supine with shoulder at 90° ABD and elbow at 90° FLEX. The shoulder was stabilized at the acromion with one hand and the arm was passively rotated with the other hand. Stretch was maintained for 10-s and repeated 3 times a session, 3 sessions a week for 2 weeks. All participants received a hot pack with the stretching.	The following were assessed before treatment (1st day), 1st week, and 2nd week. • Passive IR ROM • IR isometric muscle strength	MET for the ER group significantly improved in IR ROM and IR strength ($p<0.05$) and the static stretching group showed no significant results in IR ROM and IR strength ($p>0.05$).	RCT
Akula et al (2017)	Overhead athletes with GIRD>20° (N=40) Age: 22.05±2.89 years (EG) and 24.10±3.08 years (CG)	The following interventions were performed • MET for HAbd group (N=20): cross-body stretch with PIR was applied for GIRD shoulder in the supine position. Participants were asked to move their arm towards horizontal ADD until the first barrier of movement and performed 7-s isometric contraction followed by 5-s relaxation, 3 repetitions a session, 2 sessions a week of total 4 weeks. • SS group (N=20): A self-stretching method was performed in a standing position. Participants placed their shoulders and elbows at 90° FLEX and put their elbows and scapula against the wall for stabilization. Then they moved their shoulder into IR with their other hand and held it for 30-s for 3 times with 30-s rest between.	The following were assessed at the baseline and after the 4 weeks. • Passive IR ROM • SPADI score	Both EG and CG significantly improved in IR ROM and SPADI scores after 4 weeks ($p<.05$). There was no statistical difference between groups for IR ROM and SPADI scores after 4 weeks of treatment ($p>0.05$).	RCT
Reed et al. (2018)	High school baseball or softball players (N=42) Age 17.07±1.0 years (METG),16.43±0.8 (Joint mobs), 16.50±1.2 years (CG)	The following interventions were performed • MET for HAbd group (N=14): cross-body stretch with PIR was applied for throwing the shoulder in the supine position. Participants were asked to move their arm towards horizontal ADD until the first barrier of movement and performed 5-s isometric contraction (%25 of MVC) followed by 3-s active assistive stretch, 4 repetitions. • JM group (N=14): Participants received the joint mobilization in the supine position. The participant's shoulder was abducted to 90° and internally rotated to the first barrier of resistance, with the elbow flexed and relaxed. The clinician's hand applied overpressure to the GHJ in the posterior direction and then applied fifteen, one second, grade III posterior oscillations to the humeral head parallel to the glenoid treatment plane. Total of 15 oscillations in 30-s. • CG (N=14): No intervention	The following were assessed before, immediately after, and 15 minutes posttest. • Passive IR ROM at 90° ABD. • Passive HAbd ROM.	METG had significantly more passive HAbd ROM post-treatment compared with the CG ($p=0.04$). There were no significant differences between JMG and METG ($p=0.16$) or JMG and CG ($p=0.48$) for HAbd ROM. There was no significant between-group difference in IR ROM post-intervention ($p=0.28$). There were no significant between-group differences for either HAbd ($p=0.70$) or IR ROM ($p=0.91$) after 15 mins.	RCT

Kumar et al. (2021)	Male volleyball players with GIRD GIRD>10° (N=60) and subacute shoulder pain Age between 18-25 years	The following interventions were performed • MET group: PIR was applied for IR, ER, EXT, FLEX, ABD, and ADD for 40 mins, 5 days a week and 4 weeks. Participants were asked to perform a forceful isometric contraction for 3 5-s at the end of the available range then the participants were asked to relax for 2-s. • SS group: Sleeper stretch was applied while participants' shoulders and elbows were positioned into 90 degrees of FLEX with the lateral border of the scapula positioned firmly against the treatment table. The knees were bent for a stable base. The pressure was applied from the arm just below the wrist and the forearm was slowly pushed (rotated) toward the floor. The pressure was held constant at the end range of motion for 30 seconds and then repeated twice with 30 seconds of rest between stretching. This Technique is given two times per session, 5 days per week for 4 weeks.	The following were assessed at the baseline and after the 4 weeks. • IR, ER, EXT, FLEX, ABD, ADD ROM • Pain with NPRS	Both the MET group and SS group improved significantly after 4 weeks of treatment ($p<0.001$) regarding all parameters. There were no significant differences in any parameters between groups ($p>0.05$).	Quasi-RCT
Avci et al. (2021)	Male volleyball players with GIRD GIRD>18° (N=18)	The following interventions were performed in a cross-over design • MET for HAbd group: cross-body stretch with PIR was applied for GIRD shoulder in the supine position. Participants were asked to move their arm towards horizontal ADD until the first barrier of movement and performed 5-s isometric contraction (%25 of MVC) followed by 30-s active assistive stretch, 3 repetitions. • Sham MET group: The athlete's arm was positioned in 90° shoulder FLEX and with the elbow flexed. The athlete was asked to perform an isometric contraction with minimum effort in the same position. After the contraction, the athlete was asked to abduct his harm and then instructed to relax. The number of sets and time intervals were similar to the MET application.	The following were assessed 1st day (before procedures), 2nd day (after the first application according to the group allocation), and 3rd day (after the other procedure). • IR and ER ROM • Isokinetic muscle force for IR and ER.	• IR after MET was significantly different than control ($p<0.05$) and control and MET ER were significantly different than sham ($p<0.05$). • 60° IR and ER and 180° IR peak torque values showed a significant increase between the MET and control/sham trials ($p<0.05$). Also, the 180° ER peak torque value showed a significant difference between the experimental and sham trials ($p<0.05$).	RCT
Kini et al. (2021)	Male cricket bowlers with GIRD (N=30) Age under 19 years	The following interventions were performed • MET for ER group (n=15): Participants were positioned supine with shoulder at 90° ABD and elbow at 90° FLEX. Participants were asked to move their arms towards IR until the first barrier of movement. Then they performed a 5-s isometric contraction (%25 MVC) followed by a 30-s active assisted stretch. • Mulligan group (n=15): Participants were positioned supine with shoulder at 90° ABD and elbow at 90° FLEX. The therapist grasped the distal humerus with both hands and the mobilization belt was secured around the therapist's waist and was perpendicular to the humerus. The therapist pulled the mobilization belt and shifted its weight backward to track the joint. Therapists sustained the traction force with the belt meanwhile the participant performed active IR. The program was continued for 4 weeks with 6 sessions a week. All patients were given hot packs for relaxation after the treatments and before treatment patients were asked to do stretching for IR.	The following were assessed at the baseline and after the 4 weeks. • Active shoulder range of motion	Both MET for ER and Mulligan group improved significantly after 4 weeks of treatment ($p<0.001$) There were no significant differences between groups ($p>0.05$).	Quasi-RCT

ABD: Abduction, ADD: Adduction, ER: External Rotation, EXT: Extension, FLEX: Flexion, GHJ: Glenohumeral Joint, GIRD: Glenohumeral Internal Rotation Deficit, Habd: Horizontal Abductor, JM: Joint Mobilization, IR: Internal Rotation, MET: Muscle Energy Technique, NPRS: Numeric Pain Rating Scale, PIR: Post Isometric Relaxation, RCT: Randomized Controlled Trial, ROM: Range of Motion, SPADI: Shoulder Pain Disability Index, SS: Sleeper Stretch.

Table 4. Comparison of Within-Group Effect Sizes

Study	Outcome measure	Intervention	Effect size [95%CI]
Moore et al. (2011)	**IR**	**MET for HAbd group**	0.40 [-2.99 to 3.78]
		MET for ER group	0.02 [-2.46 to 2.51]
	HA	**MET for HAbd group**	0.71 [-2.30 to 3.73]
		MET for ER group	0.62 [-1.79 to 3.02]
Bathia et al. (2016)	**IR**	**MET for HAbd group**	1.97 [-1.55 to 5.49]
		Passive stretch for HAbd group	2.68 [0.71 to 4.65] *
	HA	**MET for HAbd group**	2.11 [-0.13 to 4.34]
		Passive stretch for HAbd group	1.51 [-1.73 to 4.75]
Sehgal et al. (2016)	**IR**	**MET for ER group**	*
		Static streching group	*
Akula et al (2017)	**IR**	**MET for HAbd group**	0.43 [-2.71 to 3.13]
		SS group	0.15 [-3.63 to 3.93]
Reed et al. (2018)	**IR**	**MET for HAbd group**	0.56 [-2.70 to 3.83]
		JM gruop	0,22 [-3,94 to 4,38]
	HA	**MET for HAbd group**	1.15 [-1.54 to 3.85]
		JM gruop	0.23 [-2.05 to 2.50]
Kumar et al. (2021)	**IR**	**METG**	*
		SS group	*
	HA	**METG**	*
		SS group	*
Avci et al. (2021)	**IR**	**MET for HAbd group**	0.54 [-3.25 to 4.32]
		Sham MET group	0.12 [-3.12 to 3.35]
Kini et al. (2021)	**IR**	**MET for ER group**	1.70 [-2.52 to 5.92]
		Mulligan group	2.44 [-0.98 to 5.85]

MET: Muscle Energy Tecnique, HAbd: Horizontal Abduction, SS: Sleeper Stretching, HA: Horizontal adduction, IR: Internal rotation, JMG: Joint mobilisation group, CG: Control group, CI: Confidence interval.

*The necessary data were lacking in two studies to calculate the effect size. We contacted to corresponding authors by e-mail. However, we could not reach the authors. Because of this reason, the data is not available.

*Effect size statistically significant

DISCUSSION

To the authors' best knowledge, the current systematic review is the first to attempt to integrate English and Turkish-language studies on the effectiveness of MET for PST and GIRD in overhead athletes; however, no Turkish language research on this topic was discovered. According to this systematic literature review, MET has favourable effects and is highly recommended for the treatment of GIRD and PST in acute or short-term durations.

Based on the research results, three studies of high to moderate quality showed MET's greater effectiveness on GIRD and PST compared to no intervention (11,19) or sham intervention (20), while moderate to poor quality studies comparing MET with other interventions showed no such greater effectiveness (11,28–32).

Additionally, the study by Avci et al. evaluated glenohumeral rotators' isokinetic torque values. Their results showed glenohumeral rotators' isokinetic torque values improved more than sham or control group in the MET group (20). Furthermore, Sehgal et al. reported improvements for IR isometric strength only in MET for ER group (30).

Source of Bias and Limitations of Included Studies

Larger effects of MET were shown in studies without allocation concealment or adequate blinding for participants, therapists or assessors, (11,29), suggesting Type 1 error. Four studies did not report whether any dropouts occurred (28–30,32). Because of these methodological shortcomings, the intervention effects might have been overestimated, and therefore favourable results should be viewed with caution.

Within-group effect sizes were generally found as moderate to large in most studies (11,19,20,29,32); however, 95% CIs around effect sizes included zero, i.e., no effect in all MET groups (11,19,20,28–32) (Table 4). Two studies lacked sufficient data to calculate the effect sizes. E-mails sent to the corresponding authors brought no response, and the relevant information is therefore unavailable (30,31).

Some of the studies were conducted on asymptomatic young overhead athletes with or without GIRD (11,19,20,28–32). One study, by Kumar et al., included athletes with subacute shoulder pain (31) whereas the others only included asymptomatic overhead athletes (11,19,20,28– 30,32). Very few studies focused on symptomatic athletes, and therefore these studies' findings cannot be generalized. Furthermore, three studies investigated the immediate effect of MET stretching (11,19,20) and the other five studies investigated the short-term effect (28–30,32,33), but none involved long-term follow-up.

Limitations of This Systematic Review

The present systematic review has several limitations. Only Turkish and English databases were searched, which resulted in language bias. Furthermore, the heterogeneity of included studies in aspects such as total treatment period, stretching durations, and frequency of repetitions prevents an objective summary of the present review findings.

Clinical Recommendations for Future Research

The present review presents the results of MET applications on asymptomatic overhead athletes. Future research should also focus on symptomatic shoulders. Larger sample sizes might provide greater statistical precision. Efforts should be made to include more female athletes to ensure the greater generalizability of the studies. The long-term effects of MET on GIRD and PST remain unclear and should be investigated. Effects of the frequency of weekly sessions should be investigated to allow frequency standardization. Different types of MET should also be studied.

This systematic literature review describes the effectiveness of MET on PST and GIRD in overhead athletes. There is strong evidence to support both the immediate and short-term positive effects of MET on PST and GIRD among overhead athletes; METs were found to be more effective than no intervention (11,19) or sham intervention (20) immediately after the intervention. All the included studies showed improvements after MET intervention but reported no additional effects on other interventions in short term (28–32). There is a need for high-quality studies examining the long-term effectiveness of MET on PST and GIRD.

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REFERENCES

1. Laudner K, Sipes R. The Incidence of Shoulder Injury among Collegiate Overhead 299 Athletes. J Intercoll Sport. 2009; 2 (2):

260–268.
2. Borsa PA, Laudner KG, Sauers EL. Mobility and stability adaptations in the shoulder of 301 the overhead athlete: A theoretical and evidence-based perspective. Sports Medicine. 302 2008; 38: 17–36.
3. Salamh PA, Liu X, Hanney WJ, Sprague PA, Kolber MJ. The efficacy and fidelity of clinical interventions used to reduce posterior shoulder tightness: a systematic review with meta-analysis. Journal of Shoulder and Elbow Surgery. 2019; 28: 1204–13.
4. Kirsch JM, Bakshi NK, Ayeni OR, Khan M, Bedi A. Clinical Outcomes and Quality of Literature Addressing Glenohumeral Internal Rotation Deficit: A Systematic Review. HSS Journal. 2020; 16 (3): 233–41.
5. Dong W, Goost H, Lin XB, Burger C, Paul C, Wang ZL, et al. Treatments for shoulder impingement syndrome a prisma systematic review and network meta-analysis. Medicine (United States). 2015; 94(10):e510.
6. Tyler TF, Nicholas SJ, Roy T, Gleim GW. Quantification of posterior capsule tightness and motion loss in patients with shoulder impingement. Am J Sports Med. 2000; 28 (5): 668-673.
7. Muraki T, Yamamoto N, Zhao KD, Sperling JW, Steinmann SP, Cofield RH, et al. Effects of posterior capsule tightness on subacromial contact behavior during shoulder motions. J Shoulder Elb Surg. 2012; 21(9): 1160-1167.
8. Tyler TF, Nicholas SJ, Lee SJ, Mullaney M, McHugh MP. Correction of posterior shoulder tightness is associated with symptom resolution in patients with internal impingement. Am J Sports Med. 2010; 38 (1): 114-119.
9. Cools AM, Declercq G, Cagnie B, Cambier D, Witvrouw E. Internal impingement in the tennis player: Rehabilitation guidelines. British Journal of Sports Medicine. 2008; 42 (3): 165-171.
10. Cools AM, Johansson FR, Cagnie B, Cambier DC, Witvrouw EE. Stretching the Posterior Shoulder Structures in Subjects with Internal Rotation Deficit: Comparison of Two Stretching Techniques. Shoulder Elb. 2012; 4 (1): 56-63.
11. Reed ML, Begalle RL, Laudner KG. Acute Effects of Muscle Energy Technique and Joint Mobilization on Shoulder Tightness in Youth Throwing Athletes: A Randomized Controlled Trial. Int J Sports Phys Ther. 2018; 13 (6): 1024.
12. McClure P, Balaicuis J, Heiland D, Broersma ME, Thorndike CK, Wood A. A randomized controlled comparison of stretching procedures for posterior shoulder tightness. J Orthop Sports Phys Ther. 2007;37(3):108–14.
13. Manske RC, Meschke M, Porter A, Smith B, Reiman M. A randomized controlled single- blinded comparison of stretching versus stretching and joint mobilization for posterior shoulder tightness measured by internal rotation motion loss. Sports Health. 2010; 2 (2): 336 94-100.
14. Maenhout A, Van Eessel V, Van Dyck L, Vanraes A, Cools A. Quantifying acromiohumeral distance in overhead athletes with glenohumeral internal rotation loss and the influence of a stretching program. Am J Sports Med. 2012; 40(9): 2105-2112.
15. Tahran Ö, Yeşilyaprak SS. Effects of modified posterior shoulder stretching exercises on shoulder mobility, pain, and dysfunction in patients with subacromial impingement syndrome. Sports Health. 2020;12(2):139–48.
16. Wilk KE, Hooks TR, Macrina LC. The modified sleeper stretch and modified cross-body stretch to increase shoulder internal rotation range of motion in the overhead throwing athlete. Journal of Orthopaedic and Sports Physical Therapy. 2013; 43(12): 891-894.
17. Mine K, Nakayama T, Milanese S, Grimmer K. Effectiveness of Stretching on Posterior 347 Shoulder Tightness and Glenohumeral Internal-Rotation Deficit: A Systematic Review 348 of Randomized Controlled Trials. J Sport Rehabil. 2017;26(4): 294-305.
18. Fryer G. Muscle energy technique: An evidence-informed approach. Int J Osteopath Med. 2011; 14(1): 3-9.
19. Moore SD, Laudner KG, Mcloda TA, Shaffer MA. The immediate effects of muscle energy technique on posterior shoulder tightness: A randomized controlled trial. J Orthop Sports Phys Ther. 2011;41(6):400–7.
20. Avci EE, Sari Z, Ayberk B, Ozdal M, Altindag O. The Immediate Effects of Muscle Energy Technique on Range of Motion and Isokinetic Muscle Strength in Volleyball Players with Glenohumeral Internal Rotation Deficit: A Randomized Controlled Trial. Eur J Ther. 2021;27(3):199–205.
21. Chaitow L. Muscle Energy Techniques. 3rd ed. Edinburgh: Churchill Livingstone; 2006.
22. Mahajan R, Kataria C, Bansal K. Comparative effectiveness of muscle energy technique and static stretching for treatment of subacute mechanical neck pain. Int J Heal Rehabil Sci. 2012;1(1):16–21.
23. Phadke A, Bedekar N, Shyam A, Sancheti P. Effect of muscle energy technique and static stretching on pain and functional disability in patients with mechanical neck pain: A randomized controlled trial. Hong Kong Physiother J. 2016;35:5–11.
24. Mertens MG, Meert L, Struyf F, Schwank A, Meeus M. Exercise therapy is effective for improvement in range of motion, function, and pain in patients with frozen shoulder: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2021;103(5): 998-1012.
25. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Int J Surg. 2021;88:105906.
26. Cohen J. A power primer. Psychol Bull. 1992;112(1):155.
27. De Morton NA. The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. Aust J Physiother. 2009;55(2):129–33.
28. Akula, Indraja; Nagaraj, S; Pearlson K. Effect of Muscle Energy Technique on Glenohumeral Internal Rotation Deficit and Functional Outcomes in Over Head Athletes-A Pre-Post Experimental Study. Int J Heal Sci Res Int J Heal Sci Res. 2017;1767(8):176–84.
29. Bathia K, Eapen C. Effectiveness of Muscle Energy Technique and Passive Stretching on Posterior Shoulder Tightness in Cricket Bowlers-A Randomized Clinical Trial. Int J Sci Res. 2013;5(8):2319–7064.
30. Sehgal S, Sen S, Dhawan A. Effects of muscle energy technique in increasing range of motion and strength of glenohumeral internal rotator, in athletes with glenohumeral internal rotation deficit. Am J Sport Sci. 2016;4(2):43–8.
31. Kumar, T. S., Kumar, K. S., Chakravarthi, C. A., Prakash, K. V. S., & Kumar, M. R. Effectiveness of Muscle Energy Technique versus Sleeper Stretch on Posterior Shoulder 387 Tightness among Volley Ball Players. International Journal. 2021; 4(6): 230.
32. Kini KV, Rathod D, Kumar A. Comparison of Muscle Energy Technique vs Mulligan to Improve Gird in District Level Cricket Bowlers. International Journal of Health Sciences and Research. 2021; 11(5): 88-93.
33. Painkra JP, Kumar S, Anwer S, Kumar R, Nezamuddin M, Equebal A. Reliability of an assessment of deep neck flexor muscle endurance test: A cross-sectional study. Int J Ther Rehabil. 2014;21(5):227–31.