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Original Article

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*

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ABSTRACT

Objective: The purpose of the present study was to investigate acute effects of muscle energy technique (MET) for the posterior shoulder on glenohumeral joint (GHJ) range of motion (ROM) and isokinetic peak torque values of GHJ rotators.

Methods: Eighteen male volleyball players volunteered to participate. All participants attended both MET trial for the GHJ horizontal abductors and sham trial. Preintervention and postintervention internal rotation (IR) and external rotation ROM and GHJ rotators isokinetic peak torque values were measured. Repeated measures one-way ANOVA and Bonferroni correction were used for analyzing the differences in the ROM and isokinetic parameters among the trials. Significance was defined as $P \leq .05$.

Results: The experimental group had a significantly greater increase in GHJ IR ROM postintervention compared to the control group ($P = .005$). No significant difference between the experimental group and control group was found for external rotation ROM ($P > .05$). However, a significant increase between the control/experimental and sham trials was found for external rotation ROM postintervention ($P = .005$). Besides, 60° internal rotator ($P = .001$) and external rotator ($P = .008$), and 180° internal rotator ($P = .019$) and external rotator ($P = .049$) peak torque values showed significant increase between the experimental and control/sham trials.

Conclusion: A single application of an MET for the posterior shoulder provides immediate improvement in GHJ IR ROM and isokinetic peak torque values of both GHJ internal and external rotators in asymptomatic volleyball players.

Keywords: Volleyball, muscle strength, shoulder joint

INTRODUCTION

Volleyball is a highly technical sport in which exceptional velocities and extreme forces repetitively generated. An elite volleyball player may perform as many as 40,000 volleyball attacks (spike) a year, which belongs to overhead/throwing motion. In a spike performance, velocities and forces produced by the arm transmitted to the ball while the maximum level of accuracy maintained simultaneously. This is performed by initially abducting and externally rotating the dominant arm at maximal positions, following adducting and internally rotating it rapidly.[1,2] This demanding high technical movement may result in shoulder injuries as well as various adaptations of the hitting shoulder as described in the relevant literature.[2–4]

Specifically, as described in the majority of the studies, the dominant shoulder may demonstrate external rotation gain, increase in external rotation range of motion (ROM) and GHJ internal rotation deficit (GIRD) (decrease in internal rotation (IR) ROM), muscular imbalance mainly due to the increased strength of IR with unchanged or lower external rotation (ER)

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strength, which have been linked with morphological shoulder adaptations and consequently shoulder pathology.[5–7] Posterior capsule tightening from repetitive microtrauma during throwing phases and posterior shoulder muscle tightness secondary to increased deceleration forces of the arm after throwing phases are the most common causes for those adaptations.[8,9] As a result, the length–tension relationship of the muscles involved in throwing such as internal and external rotators may be manifested through changes in capsular tightness and decreased ROMs.[10] It was confirmed that the altered length–-tension relationship of the muscle fibers could limit the maximum force-producing capacity of the muscle.[11]

There are several treatment approaches for GIRD in the literature particularly related to stretching intervention with conflicting results.[10–14] One of these approaches is the muscle energy technique (MET), which is time and cost-effective in the clinical settings.

MET is a relatively new manual therapy technique with just a few published studies.[15–17] The technique has been used to increase the flexibility[16] and ROM of a restricted joint.[15] During MET, the patient creates a force by activating the targeting musculotendinous unit against an accurately directed counterforce applied by the physiotherapist, and then a passive stretch applied by a physiotherapist following relaxation.[16] Mainly, two underlying mechanisms are expressed for treating a specific muscle. The reciprocal inhibition reflex is assumed to occur to inhibit antagonist muscle during contraction of agonist muscle to perform a smooth motion. Following repetitive isotonic contractions agonist progressive resistance could increase muscle tone and performance. Afferents from both Golgi tendon organs and gamma afferents from muscle spindle feedback to the medulla spinalis. Efferents from medulla spinalis with a new information return to the intrafusal fibers to resetting their new resting length and weak muscle tone can be increased by both repetitive isometric contractions and optimum length–tension relationship.[18]

Therefore, we hypothesized that the MET application would improve in glenohumeral internal rotation deficit of the shoulder and performance of the rotator muscles of athletes playing volleyball regularly. The purpose of the current study was to investigate the immediate effects of the MET on ROM of IR and isokinetic performance of rotator muscles in volleyball players with GIRD.

Main Points

- Immediately after muscle energy technique (MET) application, internal rotation range of motion of shoulder would improve in volleyball players with glenohumeral internal rotation deficit.
- MET application had an immediately positive impact on shoulder rotator muscles isokinetic strength.
- Optimizing muscle length–tension relationship using MET application could improve contraction capacity of muscle, which results in higher isokinetic muscle strength production.

Table 1. Demographics of the Participants (n = 18)

	Mean	Standard Deviation
Age (year)	20.39	2.25
Weight (kg)	79.61	11.97
Height (m)	1.87	0.08
BMI (kg m^{-2})	22.74	2.88
Adduction right (°)	35.28	8.24
Adduction left (°)	32.17	7.37
ROM right IR (°)	52.44	10.86
ROM right ER (°)	99.22	8.30
ROM left IR (°)	68.39	9.97
ROM left ER (°)	95.11	7.78
60° peak torque IR (Nm)	43.11	7.93
60° peak torque ER (Nm)	33.44	6.45
180° peak torque IR (Nm)	31.50	4.63
180° peak torque ER (Nm)	25.22	4.77

Abbreviations: BMI, body mass index; ROM, range of motion; IR, internal rotation; ER, external rotation.

METHODS

Participants

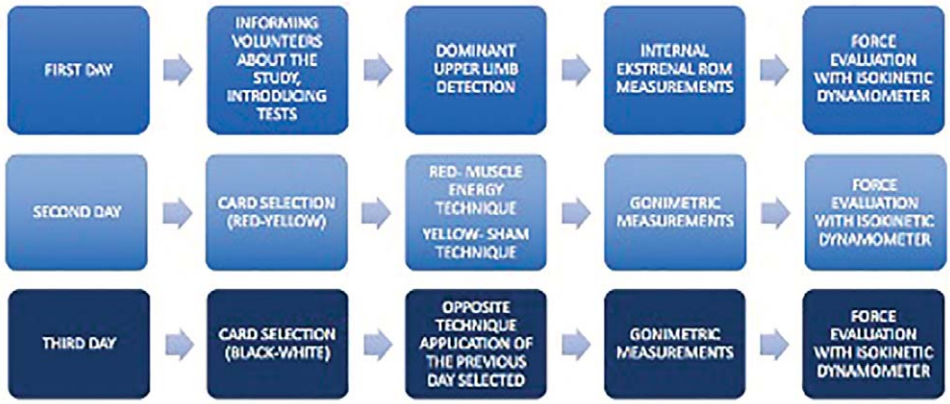
Thirty-six volleyball players participated in the current study voluntarily. All participants had been playing volleyball for 1-4 years. Their weekly program included an amateur match and three training sessions lasting for at least 2 hours on alternate days. Table 1 demonstrated the demographic information of the participants. Exclusion criteria were as follows: having any abnormality in body biomechanics, any shoulder injury in the last 6 months, any shoulder surgery history, any systemic pathology observed in the last 3 months, corticosteroid injection in any glenohumeral joint (GHJ) in the last 3 months, and lack of active joint motion deficit of dominant side GHJ.

Procedure

This study was carried out in the performance laboratory. All participants were informed about the procedure of the study, and an informed consent was obtained from all volunteers. This study was approved by the ethical committee (approval no: 2017/384).

The participants who met with inclusion criteria were recruited for further assessments of the study. Twenty-one of the 36 volleyball players had GIRD on their dominant extremity according to goniometric measurements. GIRD was defined as a difference in active IR ROM more than 18° between dominant and

Figure 1. The description of the randomization.



nondominant sides.[19] Nondominant IR ROM of the participants was found to be within the normal ranges as described in the previous literature.[20]

Participants were performed isokinetic muscle testing (Cybex HUMAC 2015; v.9.7.1; CSMI Solutions) for their dominant internal and external rotators (data obtained at the baseline measurements were determined as control). On the following day, participants were invited for interventions. Three of them did not attend, and 18 of the volunteers were included in the current study. The methodology of the study was planned as a randomized controlled double-blind.

Although all participants had planned to have both intervention methods during the study, they were asked to select one of the yellow and red cards to determine which intervention to undergone first and second days. The red card represented the MET, while the yellow card indicated the sham application.

MET application (experimental) to dominant side GHJ horizontal abductors and sham application performed by a physiotherapist-1 (PT). Immediately after that, the dominant side active IR and ER ROM values of the participants' joints were measured using the goniometer by the PT2. Later on, IR and ER muscle peak torque testing was performed using the isokinetic dynamometer and recorded in a computer by the PT2.

In the next study day, the participants were asked to choose the card again. However, second applications were selected regardless of the chosen card, and the color of the cards was changed to black and white to prevent the bias. Second-day applications for each participant were determined according to their previous applications; thus, the participants had MET application before changed to sham for the second application. On these processes, the participants and PT2 had no information about what the cards mean. The description of the randomization was presented in Figure 1.

Isokinetic Dynamometer Tests: The dynamometer was calibrated before the start of the study according to the operating manual. During all tests, participants were directed verbally, and visual feedback from the computer screen was not allowed to prevent the participant's psychological impact. The testing procedure was mentioned previously. Before measurements, athletes performed 5 minutes warm-up protocol in self-selected velocity by using hand dynamometer. After that, the participants were positioned on supine laying down position on the dynamometer, and dominant side GHJ and elbow joint were positioned in 90° of abduction and 90° forearm flexion, respectively. The dynamometer's rotational axis was aligned with the GHJ's axis. Velcro straps were fastened across the abdomen and chest to facilitate the activation of muscles, which affect the ROM and measurements, during exercise. To avoid excessive extension and flexion, the maximal ROM was set with safety stops from the center of the dynamometer's axis of rotation. To optimize muscle performance, the lengths of the forearm and control shaft were adjusted. According to the literature, concentric shoulder rotation was performed with five repetitions at an angular velocity of 60° s^{-1} and 15 repetitions at 180° s^{-1}. There was a 30-second break between sets.[21] Before all measurements, two trials for each condition were performed for familiarization with the protocol. No gravity correction was used for all tests.

Sham Protocol: The sham protocol replicated the treatment condition with the therapist-positioned athletes arm in 90° shoulder flexion 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 asked to abduct his harm. The participant was then instructed to relax. The number of sets and time intervals were similar to MET application.

Muscle Energy Technique: MET was applied to the dominant side GHJ horizontal abductors. The applications were performed in the supine position. The PT1 stabilized the scapula at the lateral border and with the elbow flexed. The shoulder was horizontally adducted to the first barrier of motion, and the participant was asked to perform a 5-second isometric contraction at approximately 25% maximal effort in the direction of

Table 2. Repeated Measures One-Way ANOVA Analysis Results of Measured Values

					95% CI			
		Mean	SD	SE	L. Bound	U. Bound	f	*P*
ROM IR (°)	Control	52.44	10.86	2.56	47.05	57.84	8.004	.005
	Sham	53.61	9.46	2.23	48.91	60.31		
	Experimental	58.67[a]	12.89	3.04	52.26	65.08		
ROM ER (°)	Control	99.22[b]	8.30	1.96	95.10	103.35	8.017	.005
	Sham	97.56	7.48	1.76	93.84	101.27		
	Experimental	99.17[b]	8.35	1.97	95.02	103.32		
60° peak torque IR (Nm)	Control	43.11[b]	7.93	1.87	39.17	47.05	22.326	.001
	Sham	40.22	9.94	2.34	35.28	45.16		
	Experimental	47.56[c]	9.51	2.24	42.83	52.29		
60° peak torque ER (Nm)	Control	33.44	6.45	1.52	30.24	36.65	5.585	.008
	Sham	33.83	6.71	1.58	30.49	37.17		
	Experimental	36.83[c]	7.32	1.73	33.19	40.47		
180° peak torque IR (Nm)	Control	31.50	4.63	1.09	29.20	33.80	4.452	.019
	Sham	29.67	7.41	1.75	25.98	33.35		
	Experimental	34.11[c]	6.80	1.60	30.73	37.49		
180° peak torque ER (Nm)	Control	25.22	4.77	1.13	22.85	27.60	3.201	.049
	Sham	24.06	5.00	1.18	21.57	26.54		
	Experimental	27.61[b]	8.10	1.91	23.59	31.64		

Abbreviations: SD, standard deviation; SE, standard error; CI, confidence interval; IR, internal rotation; ER, external rotation, ROM, range of motion.
[a]Significant difference from control trial.
[b]Significant difference from sham trial.
[c]Significant difference from experimental trial.

horizontal abduction, against a resistance provided by the PT1 at the distal humerus. Perform a 5-second isometric contraction at approximately 25% maximal effort in the direction of horizontal abduction, against an opposing force provided by the examiner at the distal humerus. After the contraction, the participant was asked to pull his arm across his body, as the physiotherapist applied a 30 second active-assisted stretch. Later on, relaxation was instructed, and a new movement barrier was detected by the PT1. The protocol was repeated three times.[16]

Statistical Analysis

The statistician was blinded to group assignments. Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM SPSS Corp.; Armonk, NY, USA) program was used for statistical analyses. The data were expressed as the mean, standard deviation, standard error, and confidence intervals. The Shapiro–Wilk test was used for assessing normality. Repeated measures one-way ANOVA and Bonferroni correction were used for analyzing the differences in the ROM and isokinetic parameters among the trials. Significance was defined as $P \leq .05$.

RESULTS

Table 2 shows the differences between the control, sham, and experimental trials. In the IR ROM measurement, there was a significant increase between the experimental and control trials ($P < .05$). The significant increment was found between the control/experimental and sham trials of external rotation ROM ($P < .05$).

Besides, 60° internal and external rotation and 180° IR peak torque values showed a significant increase between the experimental and control/sham trials ($P < .05$). Also, 180° external rotation peak torque value showed a significant difference between the experimental and sham trials ($P < .05$). Figure 2 shows the control, sham, and experimental trials' values of external and IR ROM measures.

Figure 2.. The control, sham, and experimental trials' values of external and internal rotation range of motion measures.

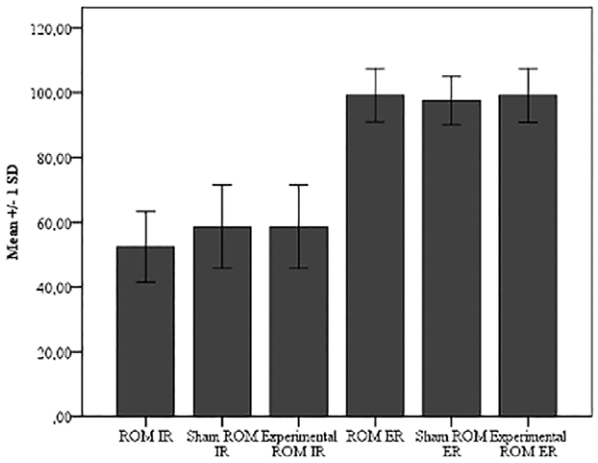
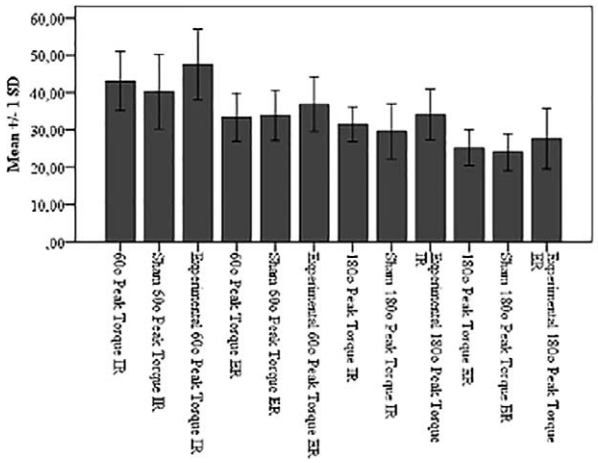


Figure 3.. The control, sham, and experimental trials' external and internal rotation isokinetic peak torque values.



The experimental trials had a significantly greater increase in GHJ IR ROM postintervention compared to control trials ($P = .005$). No significant difference among experimental trials and control trials were found for external rotation ROM ($P > .05$). The significant increase between the control/experimental and sham trials was found for external rotation ROM postintervention ($P = .005$). 60° internal rotator ($P = .001$) and external rotator ($P = .008$), and 180° internal rotator ($P = .019$) and external rotator ($P = .049$) peak torque values showed significant increase between the experimental and control/sham trials. Figure 3 shows the control, sham, and experimental trials' external and IR isokinetic peak torque values.

DISCUSSION

The results of our study confirmed our hypothesis that immediately after MET application, IR ROM of the shoulder and isokinetic rotator muscle performance would improve in volleyball players with GIRD.

The previous study including athletes with GIRD reported that MET application on horizontal abductors resulted in greater IR ROM, while MET for external rotators did not show any difference than the control group.[22] That is why in the current study only horizontal abductors were selected to apply MET to improve ROM of internal rotators. By improving ROM, it was considered that it would be possible to generate greater muscle activation leading to greater muscle strength.[23]

Several studies have investigated stretching of shoulder joint especially the posterior part, which includes tight posterior capsule in individuals with GIRD as a part of the treatment program. However, most of them used different types of stretching such as passive stretch,[10] sleeper stretch,[8] cross-body stretch,[13] etc. and reported conflicting results. Also, one of the previous studies indicated the improvement in IR ROM at least within 2 weeks.[12] Most of them used this technique during weekly rehabilitation programs. The immediate effect of stretching on ROM is still unclear. On the other hand, our results indicated that MET could improve immediately after the application ROM of IR in the shoulder with GIRD. It may be speculated that the acute effects of any intervention have significant importance for athletes during training and match periods.

Another important factor for an athlete is to achieve maximum performance during functional movements. Isokinetic muscle strength is one of the indicators of muscle performance.[24] In the current study, MET application had a positive impact immediately on rotator muscle isokinetic strength. Unfortunately, we did not include any performance assessments in our study design to make a clear conclusion about improvement in performance.

A study that was conducted to determine whether MET provides improvements in resting pectoralis minor muscle length, forward scapular position, and scapular upward rotation in female collegiate swimmers founded that the MET application increases pectoralis minor muscle length, and the result of that decrease, scapular forward position.[13] This biomechanical positional correction could result in an optimum length–tension relationship of a muscle. In line with this result, MET application in our study could lead to proper shoulder position, which was related to increased IR ROM and isokinetic rotator muscle strength.

On the other hand, ER ROM values of participants reduced after all applications, but unexpectedly, there was much more decrease after the sham application than MET application. The measurements were made while the season was in progress, and there was no extensive time to do the measurement. Because of that, we applied the testing procedure day by day and assessments lasted 3 days. Due to randomization, the number of participants involved in the sham application may have the majority on the last day of the study. In other words, people who involved the sham application may have already involved the MET application, and its effects may continue.

Although some studies involved MET application on cervical, thoracic, and lumbar spine,[13,16,25,26] application on shoulder

joint is lacking. Furthermore, only two studies are investigating the effectiveness of MET application on individuals with GIRD.[16,27] One of these studies performed a randomized controlled trial in 30 athletes and indicated that MET on the shoulder was an effective approach through regaining IR ROM in this population parallel with the results of the current study.

As mentioned previously, one of the limiting factor force production capacity of muscle could be related to its impaired length–tension relationship due to GIRD. Optimizing the length–tension relationship using MET could improve contraction capacity of muscle, which results in higher isokinetic strength production. One of the possible explanations for improvement in rotator muscle isokinetic strength after MET application in the current study could be related to optimizing the length–tension relationship as discussed.

Up to our knowledge, this study is one of the first that investigate the immediate effect of MET application in volleyball players with GIRD through shoulder ROM and rotator muscles isokinetic strength.

The measurements were made while the season was in progress. Therefore, we could not include long-term results of MET application on assessed parameters in the study design. This situation is the limitation of our research. In the future research, the long-term effects of MET application on shoulder ROM and muscle strength could be investigated.

CONCLUSION

Little is known about the immediate effects of MET application on shoulder ROM and muscle performance in volleyball players with GIRD. The results of the study might provide some new insight into the interventions used to treat negative motor outcomes of GIRD in volleyball players who need the optimum performance of shoulder muscles, especially rotators, during training and matches.

Ethics Committee Approval: Ethical committee approval was received from the Gaziantep University (approval no: 2017/384).

Informed Consent: Verbal informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - A.E.E., S.Z., A.B., Ö.M., A.Ö.; Design - A.E.E., S.Z., A.B., Ö.M.; Supervision - S.Z., A.Ö., Ö.M.; Resources - S.Z., A.Ö.; Materials - A.E.E., A.B., Ö.M., A.Ö.; Data Collection and/or Processing - A.E.E., A.B., Ö.M.; Analysis and/or Interpretation - A.E.E., Ö.M.; Literature Search - A.Ö.; Writing Manuscript - A.E.E., A.B.; Critical Review - A.E.E., S.Z., A.B., Ö.M., A.Ö.

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