DOI: 10.5114/areh.2023.128014
Original article
Advances in Rehabilitation, 2023, 37(2), 21–27

A – Research concept and design
B – Collection and/or assembly of data
C – Data analysis and interpretation
D – Writing the article
E – Critical revision of the article
F – Final approval of article

Received: 2023-03-20
Accepted: 2023-06-06
Published: 2023-06-07

Influence of Muscle Activation of Posterior Oblique Sling in Different Hip Positions among Three Different Shoulder Movements in Overhead Athletes: An Observational Study

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Abstract

Introduction: Overhead movement demands optimal pelvic and scapular stability and alignment for efficient energy transfer during shoulder movements. Throughout a sports game, hyperactivity of the pelvic and scapular musculature might affect performance. As a result, we can establish goals for muscle strength and injury prevention. To study the muscles activation of posterior oblique sling muscles (POS) in different hip positions (Standing, Sitting and Lunge) with three different shoulder movements (flexion, extension & abduction) among a sportsman population.

Material and methods: Muscle activation was recorded by surface electromyography in 38 male athletes of different sports cricket (bowlers)-10; baseball-9; volleyball-9; control group (recreational overhead)-10. Maximum voluntary isometric contraction (MVIC) measurements were collected in order to compare muscular activation. Every player performed shoulder flexion, abduction and extension in standing, sitting and lunge positions.

Results: Significant differences in muscle activity were noted using a 3-way ANOVA and Bonferroni post hoc test. The results of the study showed statistically significant interactions between individual groups, positions and muscles with shoulder movements ($p = 0.001$) and a pairwise comparison between subjects showed a significant difference ($p = <0.05$).

Conclusions: All hip position changes may be beneficial in scapular rehabilitation training because more muscles are employed. However, in shoulder extension motions, posterior oblique sling muscles are activated more than abduction muscles. While sitting, the serratus anterior is the most active muscle, more than the lower trapezius, latissimus dorsi, and gluteus maximus.

Keywords: electromyography, muscles, overhead, sports

Introduction

When muscles work together or influence kinematic patterns, this is referred to as a muscular chain. There are synergists, muscle slings, and myofascial chains in the muscular chain, and each has an interdependent interaction with neural organs and joints [1]. Myofascial or connective tissue units were used to create three principal lines (the superficial back line, superficial front line, and lateral line). The nuchal ligament, trapezius, latissimus dorsi, Erector spine, thoracolumbar fascia, gluteus maximus, hamstrings, gastrocnemius, and plantar fascia make up the superficial back line, which is oriented similarly to the elements of the POS [2,3].

It's unclear how or if changing the hip posture affects humeral translation via the myofascial linkages within the oblique sling. The rotator cuff muscles are activated more when the humerus is elevated. When considering humeral elevation, keep in mind that motion in the frontal plane causes the trapezius muscles to become more active. The activation of the serratus anterior is an important stabilizing force for proper scapular mobility and placement. As a result, during humeral elevation in this investigation, activation of the upper and lower trapezius, as well as the serratus anterior, were investigated [4].

The global muscles are largely involved in spine movement and control, as well as the transfer of stresses from the spine to the lower extremities during movement. During functional exercises that rely on lower extremities, the gluteus maximus is critical for transmitting stress through the hip. The myofascial sling is physically interrelated and can ease the passage of force through the trunk, particularly from the lower extremity to the arm [5].

Sling systems allow for successive muscle activation patterns during walking and running. They also provide reciprocal patterns between the upper and lower extremities, in addition to rotational lumbo-pelvic stability during actions such as locomotion [6]. While supporting the lumbopelvic hip complex, the posterior oblique sling aids locomotion and helps an individual keep their balance during a highly dynamic activity. Furthermore, malfunction in this system reduces strength, speed and performance [7]. The anatomical and myofascial linkages between the lumbopelvic region and the contralateral glenohumeral joint suggest that sacroiliac joint dysfunction may affect force transmission to the contralateral glenohumeral joint [8,9].

Only a few studies have been done on activating the posterior oblique sling muscle, so the purpose of study was to analyse activation of the posterior oblique sling muscles in different hip positions (Standing, Sitting and Lunge) with three different shoulder movements (flexion, extension & abduction), which suggests a pattern of muscle activation and force transmission from the lower to the upper extremities, enabling us to strengthen particular muscles if any disturbances are seen.

Materials and methods

Participants

With the help of G*power version 3.1.9.4, a total of 38 university-level male athletes (Tab. 1) were recruited from the MYAS-GNDU Department of Sports Sciences And Medicine and also approved by the institutional ethical committee of Guru Nanak Dev University, Amritsar, Punjab (approval number 329/HG 12/4/2022). An initial meeting was organized to familiarize the athletes with the protocol and to receive their informed consent. The inclusion criteria were as follows: (i) The population of athletes comprised Cricket (bowlers), Baseball, Volleyball and Control Group (recreational overhead athletes) [21] (ii) Age range: 20 to 25 years old. Exclusion criteria: (i) Any traumatic injury to the lower limb in the previous 6 months like ACL tear, Achilles tendon injury etc. (ii) Any spine surgery within the last 2 years.

Tab. 1. Demographic characteristics of the athletes

Variables	Mean ± SD
Age [year]	22.76 ± 2.19
Height [cm]	173.82 ± 5.59
Weight [kg]	70.47 ± 7.30
Body mass index [kg/m^2]	23.36 ± 2.54

Measurement tools

Surface EMG-Noraxon-USA (MR3 3.8.30) was used to monitor muscle activity, because it has been demonstrated to be the most valid and reliable measuring apparatus for muscle activity [9]. The sampling frequency was 1500Hz [4] and electrodes were placed (2 cm interelectored distance) on muscles according to the recommendations of Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles protocol (SENIAM).

Procedure

The athletes were selected based on inclusion criteria. Then the athletes' body dimensions were measured. A 5-minute warm-up session was organized prior to the initiation of protocol. Electrodes were placed on the POS for contralateral gluteus maximus [5], for the dominant lower trapezius & serratus anterior muscles [10]. For ipsilateral latissimus dorsi [11], a chair without back support was supplied in the sitting and lunge position for perform shoulder flexion, abduction and extension. A 1 kg weight was held in the hand during movement for muscles activation [5]. Maximum voluntary isometric contraction (MVIC) were collected in order to compare muscular activation [4].

The manual muscle testing positions for MVIC of the gluteus maximus, latissimus dorsi, lower trapezius, and serratus anterior were determined in order to normalize each muscle contraction in terms of percentage MVIC (%MVIC) [5,10,12]. In order to induce MVIC in the gluteus maximus, the subject was instructed to lie prone on a table and lift the entire leg against manual resistance applied by the researcher on the distal part of the thigh near the popliteal space. The subject was asked to lie prone on a table with arms by the sides and shoulders internally rotated so that the subject was palm-up for the latissimus dorsi MVIC. Manual resistance was applied to the forearm in a downward direction, while pressure was applied to the contralateral pelvis and the subject attempted to extend the shoulder toward the ceiling [4]. Resistance to Scapular protraction at 90° of shoulder flexion involved resistance applied over the hand and at the elbow with the subject in the supine position, and the EMG activity from this test is used as the MVIC for the serratus anterior muscle. With the subject in the prone position, they raise an arm above their head in line with the lower trapezius muscle fibers as resistance is applied above the elbow [10]. The activation of muscles in the POS was measured in shoulder movements in the standing, sitting and lunge positions.

Data analysis

We used surface EMG to analyze muscle activation. A digital band-pass filter (Lancosh FIR) was used to filter and eliminate movement artifacts between 20 and 450 Hz. The signals were processed using the root mean square(RMS) method with a 50 ms moving window [5]. Following this procedure, all EMG data were exported and uploaded into an Excel spreadsheet (Microsoft, Redmond, WA). The mean RMS value of the two trials for each muscle was normalized to its corresponding MVIC value and expressed as %MVIC using the equation [12].

Statistical analysis

Statistical analysis was done by using IBM SPSS Version 26.0. The normal distribution of data was first confirmed by the Shapiro-Wilk test at $p > .05$ level. A 3-way ANOVA was conducted to assess the interaction between hip positions, shoulder movements and groups. This was followed by post-hoc pairwise comparisons with the Bonferroni adjustment to identify significant differences. Statistical significance was defined at the 5% ($p \leq .05$) level.

Results

Figures 1 and 2 depicts that the POS muscles are stimulated diversely among four groups during shoulder movements.

Post-hoc analysis revealed a significant difference in muscle activation in flexion between cricket players and all other groups (Baseball, Volleyball, and Control) ($p < 0.05$). There was a significant difference in volleyball players compared to baseball players and the control group ($p = 0.001$). Furthermore, shoulder extension would result in differences in hip activation between standing and lunge postures ($p = 0.016$). In all shoulder movements, a pairwise comparison revealed a significant difference between all muscles. In volleyball

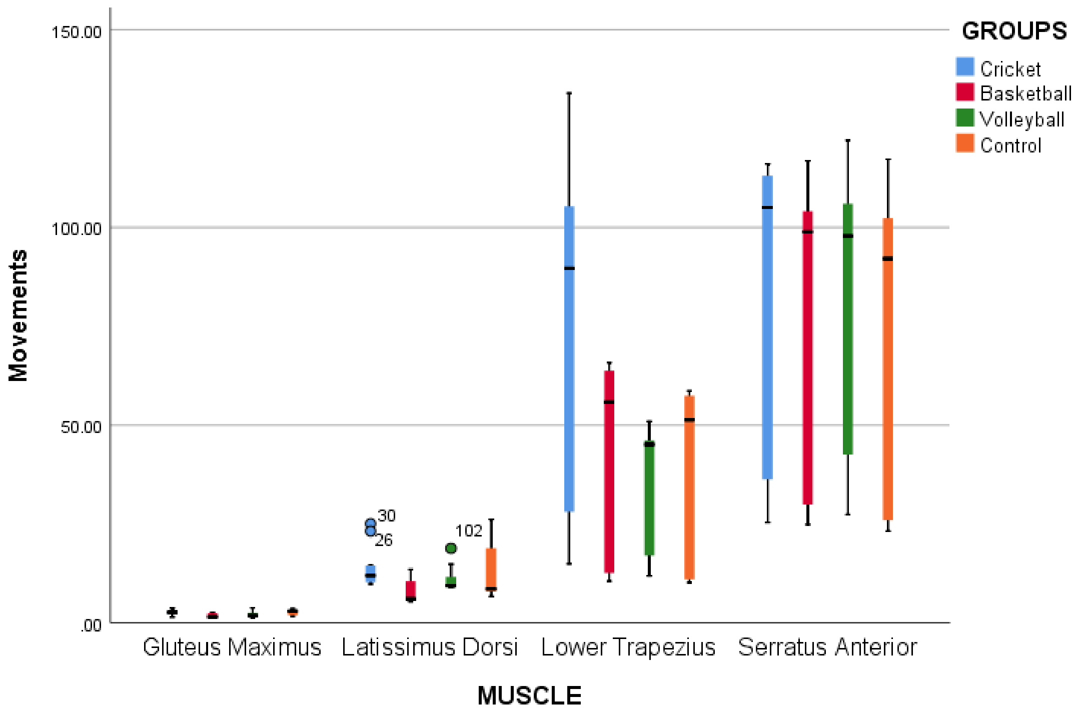

Fig. 1. Cluster boxplot of shoulder movements (Flexion, abduction & extension) with muscle activation in Cricket, Baseball, Volleyball and Control Group

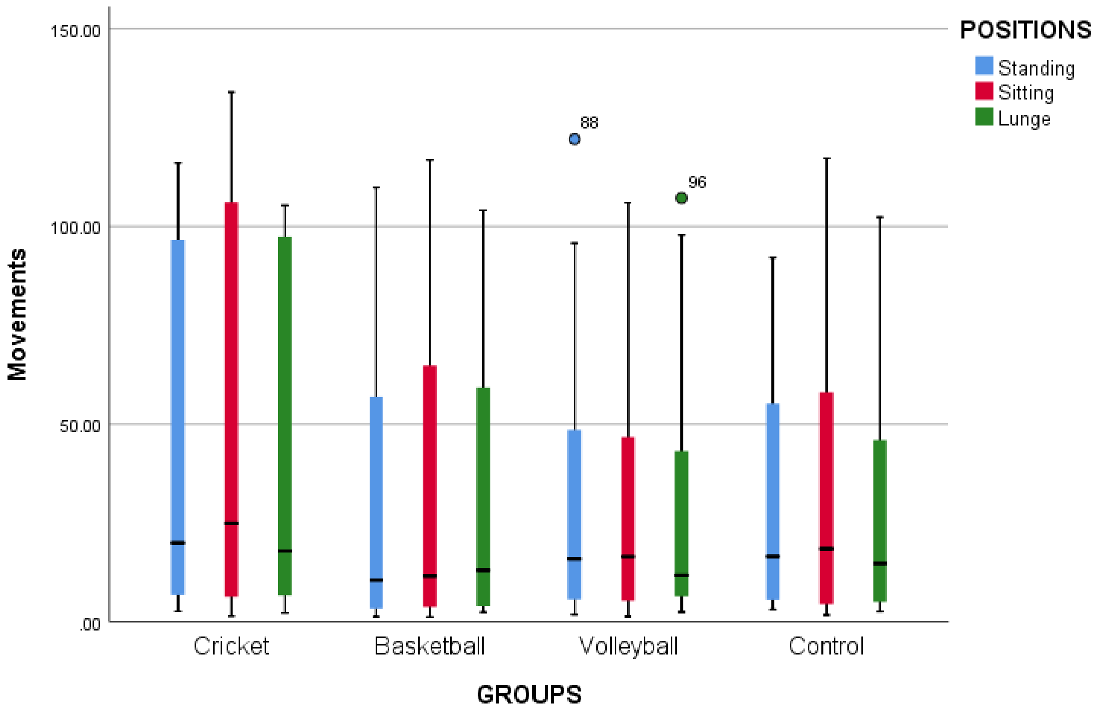

Fig. 2. Cluster boxplot of shoulder movements (Flexion, abduction & extension) among Cricket, Baseball, Volleyball and Control group and three above-mentioned positions

Tab. 2. Results of MANOVA between groups, muscles and hip position interactions

Source	Dependent Variable	df	F	p-value
Groups (Cricket, Baseball, Volleyball & Control Group)	Flexion	3	5.731	0.001**
	Extension	3	5.460	0.001**
Positions (Standing, Sitting & Lunge)	Extension	2	4.273	0.015*
Muscles (Latissimus Dorsi, Lower Trapezius, Serratus Anterior & Gluteus Maximus)	Flexion	3	93.244	0.001**
	Abduction	3	108.512	0.001**
	Extension	3	11.960	0.001**
Groups*Positions	Extension	6	4.840	0.001**
Groups*Muscles	Flexion	9	3.351	0.001**
	Abduction	9	3.620	0.001**
	Extension	9	8.919	0.001**
Positions*Muscles	Extension	6	9.019	0.001**
Groups*Positions*Muscles	Abduction	18	1.641	0.048*
	Extension	18	8.293	0.001**

df – degree of freedom, * – correlation is significant at the .05 level (2 tailed), ** – correlation is significant at the 0.01 level (2 tailed).

players, the difference in shoulder extension between standing and other positions was highly significant ($p = 0.001$) as represented in Figure 2.

Shoulder flexion and abduction movement between lower trapezius, latissimus dorsi, and gluteus maximus showed a significant difference ($p = 0.01$) in all groups.

The results of MANOVA between groups, muscles and hip position interactions are presented in table 2. Shoulder flexion movement between the lower trapezius and serratus anterior with latissimus dorsi and gluteus maximus was significantly different in all hip positions ($p = 0.001$). Every group showed highly significance activation of serratus anterior during flexion movement compared to gluteus maximus and latissimus dorsi in all hip positions ($p = 0.001$) except in the standing position for volleyball players. The abduction movement of cricket and baseball players showed a significant difference in the serratus anterior and lower trapezius compared to the gluteus maximus and latissimus dorsi ($p = 0.001$) in all hip positions. In the sitting positions, lower trapezius activation showed a significant difference in cricket players compared to other athletes ($p = 0.01$) in shoulder flexion, whereas in the standing position, cricket players showed a significant difference compared to volleyball players in terms of flexion and abduction movements. In the abduction of the shoulder, the serratus anterior showed more activation in volleyball than cricket players ($p = 0.01$) as described in Table 2.

Discussion

Certain shoulder movements may impact the activation patterns of specific shoulder muscles. The traditional emphasis on individual joint training, on the other hand, has resulted in a limited understanding of scapular muscle recruitment during workouts that activate the complete kinetic chain system. As a result, we evaluated the activation of the lower trapezius, serratus anterior, latissimus dorsi, and gluteus maximus muscles during three hip postures with three shoulder movements, which is regarded as important in the rehabilitation of scapular dyskinesis and concomitant impingement symptoms.

Our data revealed increased activation of the lower trapezius and serratus anterior in shoulder flexion and abduction as illustrated in Figure 1. Additionally, during shoulder extension, standing works more muscles than other positions. Earlier research evaluated the effects of hip position on scapular kinematics and muscle activation in the Oblique Sling, and data relating to changes in the position from sitting to standing reported statistically significant muscle activation, with the latissimus dorsi and lower trapezius being more active in all postures. These findings are similar to those in our study [4]. Higher activation of the latissimus dorsi, lower trapezius, and upper trapezius, as well as strong activation of the serratus anterior, was noted during shoulder abduction and external rotation in this study [13]. The findings of Nakamura et al. [14], who applied loads of 0, 3, and 7% of the subjects' bodyweight, were the same as in, as lower trapezius activation was observed to be greatest at elevations of up to 120º. Shoulder flexion of 120º in the standing posture was the maximum activation position in the serratus anterior [15]. The latissimus dorsi and lower trapezius muscles maintained a constant medium-to-high EMG intensity throughout the throw, indicating their role as stabilizer muscles [16].

Our findings indicate the significance of the lower trapezius and serratus anterior in the sitting posture, as well as lunge in shoulder abduction. However, Demey [17] discovered that retraction exercises engage lower trapezius muscle activation over upper trapezius muscle activation and that a contralateral single squat position stimulates higher trapezius muscular activation levels than the traditional sitting performance of the exercise. In our study, we discovered that in all hip positions, shoulder flexion movement is more significant in the lower trapezius and serratus anterior than in latissimus dorsi and gluteus maximus, and that in the sitting position, the lower trapezius muscles were more active than the serratus anterior. The outcomes of this study confirmed our findings that serratus anterior activities had a higher %MVIC in shoulder diagonal exercises than in scapular diagonal exercises. In a comparison of both scapular pattern exercises, the upper trapezius and lower trapezius activities had a higher %MVIC in the posterior elevation (PE) pattern than in the anterior elevation (AE). PE and D2 flexion exercises, in particular, are more beneficial for activation of the lower trapezius than the AE [18].

In our study, baseball players showed more serratus anterior muscle activation during shoulder extension and abduction and lower trapezius in abduction of shoulder. In contrast to our findings, serratus anterior is more significant during D1 flexion in baseball players, and support for lower trapezius activation is greater in 120-degree shoulder abduction and 90/90-degree shoulder posture [19]. In our study, cricket players had higher lower trapezius muscle activation than other players during shoulder flexion and abduction. However, Oliver [13] discovered that baseball players showed increased lower trapezius activation during shoulder abduction. According to other studies, volleyball players have lower trapezius activation than other groups. Karagiannakis [20] discovered that volleyball players with scapular asymmetry have decreased serratus anterior activity in their dominant hand compared to their non-dominant hand.

Further research is needed to reveal the nondominant side of players. Secondly, the current study was unable to collect kinematic data or measure the precision of diagonal elevation. Finally, the current study was unable to assess the activation of the entire oblique sling muscle group.

Conclusion

According to the findings of this study, the POS muscles (gluteus maximus, latissimus dorsi, lower trapezius and serratus anterior) are stimulated differently in different sports. All hip position alterations may be useful in scapular rehabilitation training because more muscles are recruited. However, in shoulder extension motions, posterior oblique sling muscles are activated more than abduction muscles. In addition, in the standing position, the lower trapezius and serratus anterior muscles both activate in shoulder flexion, although the serratus anterior works more than the lower trapezius in abduction. Lower limb weight transference kinetic chain training may minimise the demands on the shoulder musculature. Cricket and baseball players showed better activation in shoulder flexion and abduction compared to other groups.

Funding
MYAS-GNDU Department of Sports Sciences and Medicine provided funding for conducting this study.

Conflicts of Interest
The authors have no conflict of interest to declare.

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