(RESEARCH ARTICLE)

Kinematic profiling of the shoulder and its relationship with pain in a population of Nigerian volleyball players

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Abstract

Objectives: Volleyball players are at high risk of shoulder injury due to faulty shoulder kinematics which results in subsequent shoulder pain. There is a dearth of information on kinematic profiling of the shoulder in Volleyball players in Nigeria. This study investigated the shoulder kinematics and the relationship with shoulder pain in volleyball players in Lagos, Nigeria.

Methods: This was a cross-sectional analytical survey which involved 81 professional and amateur Volleyball players who had been playing actively for at least a year. Goniometry measurements for shoulder flexion, extension, and internal rotation were obtained using a standard goniometer. Forward Shoulder Posture (FSP) and scapular static position were evaluated for each participant with the upper extremity abducted to 0°, 45°, and 90° in the coronal plane using the Lateral Scapular Slide Test (LSST). All data were analyzed using descriptive statistics of mean and standard deviation, frequency and percentage. Student's T-test was used to determine the differences in kinematics between the dominant and non- dominant shoulder.

Results: The prevalence of pain in the dominant shoulder was 49.2%. There were significant differences in the kinematic profiles between the dominant and non-dominant sides (p<0.01) which were not significantly associated with shoulder pain (p>0.05)

Conclusion: There was significant asymmetry in shoulder kinematics of volleyball players which was not significantly related to shoulder pain. Volleyball players will, however, benefit from preventative programs to forestall future shoulder injury.

Keywords: Shoulder Pain; Shoulder Kinematics; Volleyball Players; Forward Shoulder Posture

1. Introduction

Volleyball is a fast-paced and physically challenging sport that necessitates athletes to execute repetitive high-intensity actions, including jumping, spiking, and blocking [1]. Matches typically last between 60 and 100 minutes, during which athletes execute over 250 jump-related actions, which account for about 50- 60%, defence with landings about 15%, and rapid changes of direction 27-33% [2,3]. These often result in significant overuse injuries that affect the knees, lower back, and shoulders. This type of injury can be a major source of disability and pain that can result in the inability of the players to engage in physical activity or competition [4]. Multiple factors play a role in the occurrence of injuries, the most common ones being improper technique, fatigue, and overtraining [5]. Also, professional volleyball players are at greater risk of injuries compared to amateur players due to more intense training and competition schedules [6,7]

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Upper extremity injuries in the overhead athlete are prevalent in competitive sports, accounting for approximately 20% of all injuries [8]. In volleyball-related injuries, the shoulder is one of the four most commonly injured locations, accounting for about 15% of all injuries [9, 10]. In a prior study, it was reported that the point prevalence of shoulder complaints was 27% during the preseason, with 47% of the players reporting shoulder problems at some point during the 12-week study [11]. In another study, researchers sampled men and women university players and reported a combined point prevalence of 22% for shoulder pain [12]. The upper arms undergo the greatest strain during overhead movements in volleyball, as they do in other sports activities like basketball, baseball, tennis and swimming, in which degenerative diseases of the rotator cuffs are also common [13, 14]. Repetitive stress from sports activities can result in specific postural changes, which may ultimately lead to pain and injury [15]. Symptoms like pain or functional limitations typically develop gradually and may be temporary. As a result, it is common for a volleyball player to continue training and competing even when experiencing overuse conditions, particularly at the early stages [16].

Volleyball-specific techniques such as spiking, blocking, and serving place significant stress on the shoulder girdle [17]. One recurring identified risk factor is the volleyball spike which requires an athlete to move the upper arm through an enormous range of upper arm motion while airborne, this is believed to place the shoulder under significant load [14]. Spiking has been consistently linked to a high number of overuse shoulder injuries. A study reported that 80% of all shoulder injuries are from spiking which consequently leads to anterior instability and shoulder impingement syndrome [9,14,18]. Volleyball players, who continuously repeat quick and intense movements of the dominant limb during the serve and spike motion experience range of motion changes, asymmetries in Rotator muscle strength, and postural differences compared to the non-dominant side [19, 20].

One of the factors limiting performance in volleyball sport is a decreased range of motion at the shoulder joints. The coupling of scapular and humeral motions is important for normal shoulder motion which is predominantly internal rotation, external rotation and circumduction [21, 22]. The glenohumeral joint is basically the major component of the shoulder complex, and like most successful groups, it does not work alone but rather depends on individual efforts of the sternoclavicular, acromioclavicular and scapulothoracic joints. The purpose of these joints of the shoulder complex is to move and stabilize the glenoid optimally during upper extremity movement [22]. The assessment of posture and biomechanics is a useful clinical tool in identifying the factors contributing to injuries and shoulder pain in athletes. Shoulder antepulsion, commonly referred to as "rounded shoulders," is defined by a position where the scapula rotates downward and tilts forward; this increases cervical lordosis and upper thoracic kyphosis [4,23]. It was previously documented that postural or biomechanical alterations such as forward head position, shoulder antepulsion, altered scapular kinematics or scapula dyskinesis, reduced shoulder range of motion (ROM), glenohumeral internal-rotation deficit (GIRD) and imbalance of muscle activity are associated with shoulder pain [4, 24, 25]. The shoulder joint has the greatest range of motion among all the joints and careful assessment of shoulder range of motion is important in the diagnosis of disorders of the shoulder, and for the evaluation of mechanisms that may alter shoulder function.

Kinematic analyses are important in understanding the mechanisms of athletes' injuries and this has been demonstrated among athletes with decreased upward scapular rotation in shoulder impingement [26, 27]. A better understanding of movement system function is one of the conditions for the cultivation and development of game performance in volleyball [28]. In order to prevent recurrent shoulder injuries, Cools et al [29] advocated establishing risk factors with cut-off values for shoulder range of motion (ROM) based on normative databases. Kibler [30] described normative values of the bilateral differences in kinematics between the dominant and non-dominant shoulders. Posture deviations such as reduced glenohumeral internal rotation ROM may need to be addressed to prevent and/or rehabilitate shoulder injuries in volleyball athletes. The purpose of this study was therefore to profile and compare the kinematic variables of the dominant and non-dominant shoulders and evaluate their relationship with shoulder pain among volleyball players in Lagos, Nigeria.

2. Materials and Methods

This study was a cross-sectional analytical survey. Purposive sampling technique was used to recruit participants into the study.

2.1. Participants

Eighty-one (81) active volleyball players (male and female) were recruited from six different volleyball teams across Lagos, Nigeria. Forty-four (44) were professional players who had played nationally and internationally while thirty-seven (37) were amateur players who had played actively at college level in the past one year. Ethical approval was sought and obtained from the institutional Health Research and Ethics committee (ADM/DCST/HREC/2136). Written informed consent was also obtained from each volleyball player prior to participation. All players completed a personal

data questionnaire to report their hand dominance during play, pain history, if they had any and duration of pain. The body height and weight were measured to the nearest meter and 0.1kg with the height meter and weighing scale respectively. The participant's shoulder mobility, forward shoulder posture and the symmetry of the two scapulae were measured at the beginning of their club training sessions.

2.2. Methods

2.2.1. Determination of Sample Size

The sample size was calculated using the Cohen's formula, for sample size determination [31]

2.3. Outcome Measures and Instruments

2.3.1. Range of Motion (ROM)

Active shoulder range of motion was measured as described by Norkin and White [32] using a universal goniometer. Each participant was measured for shoulder flexion, extension, abduction and internal rotation.

2.3.2. Forward shoulder posture assessment (FSP)

This was carried out as described by Peterson et al [33]. Participants were asked to stand in front of the wall, roll their shoulders forward and backward. They were then asked to move backwards to the wall until their buttocks touched the wall; they remained in this position until the test was completed. The distance (mm) between the wall and the posterior border of the acromion process was measured using the Double Square method (Vanier Calipers) and converted to (cm) for recording.

2.3.3. Lateral Scapular Slide Test (LSST)

This was used to determine scapular static position with the upper extremity abducted to 0°, 45°, and 90° in the coronal plane. To maintain a consistent posture during the various test positions, participants were instructed to fix their gaze on an object in the examination area. Three (3) test positions were performed. For test position 1 of the LSST, participants were instructed to keep their upper extremities relaxed at their sides, their test positions were confirmed and identified through palpation and marked at the inferior angle of the scapula and the closest spinous process in the same horizontal plane. The distance between the two reference points was measured bilaterally with a tape measure. This procedure was repeated for test positions 2 and 3. For test position 2, the participants were instructed to actively place both hands on the ipsilateral hips and, consequently, the humerus was positioned in medial rotation at 45° of abduction in the coronal plane. In test position 3, participants were instructed to actively extend both elbows and to elevate and maximally internally rotate ("thumbs down") both upper extremities to 90° in the coronal plane. The difference between the three (3) test positions were added together to give the sum of the difference [30].

2.4. Data Analysis

All statistical analysis was performed using Statistical Package for Social Science – SPSS (Version 17). All data were analysed using descriptive statistics of mean and standard deviation, frequency and percentage. Independent T-test was used to determine differences in the dominant and non -dominant shoulders.

3. Results

A total of 44 elite players who played at the best professional level (Lagos State registered players) and have actively played between 5 – 15 years and 37 amateur players (active leisure players at college level) who have played actively in the last one year were assessed. Fifty-two (64.2%) of the participants were male while twenty-nine (35.8%) were female. Their ages ranged between 16 and 40 years with a mean of 26.14 ± 7.12. Their body mass index (BMI) ranged between 18kg/m2 and 35kg/m2 with a mean of 23.48 ± 3.63kg/m2. The mean BMI of the elite players was 24.26 ± 3.73kg/m^2 while that of the amateur players was 22.53 ± 3.34kg/m^2. Seventy-nine (97.5%) of the participants had right hand dominance while 2 (2.5%) reported to be left hand dominant as seen in table 1.

The mean and standard deviation of all the kinematic variables (Forward Shoulder Posture (FSP) on the right and on the left, Scapular mobility (LSST) and joint angles of the right and left shoulder flexion, extension and internal rotation) were evaluated for eighty-one participants and compared with the normal values. There were significant differences in the shoulder flexion of the right upper limb (p-value = 0.03), and in the right and left Forward Shoulder Posture (FSP)

(right p-value = 0.02, left p-value = 0.01) of elite players versus amateur players. The difference in the dominant and non- dominant shoulder kinematic variables is described in table 2.

Table 1 Demographic Characteristics of the Participants

Demographics	Mean (SD)
Age (Years)	26.1 ± 7.1
Height (m)	1.7 ± 0.1
Weight (kg)	70.5 ± 14.1
BMI (Kg/m^2)	23.5 ± 3.6
Professional Level	Frequency n (%)
Elite	44 (54.3)
Amateur	37 (45.7)
Gender	
Male	52 (64.2)
Female	29 (35.8)
Hand Dominance	
Right	79 (97.5)
Left	2 (2.5)
History of Shoulder Pain	
Yes	40 (49.4)
No	41 (50.6)

Table 2 Differences in Kinematic Variables between Elite and Amateur Players

	Elite	Amateur		Normal value
Variables	X ± SD	X ± SD	p-value	
BMI	25.5± 3.73	24.3± 3.34	0.03*	18.5 - 24.9
RFSP (cm)	10.26 ± 2.43	9.10 ± 2.04	0.02*	< 2.5
LFSP (cm)	9.51 ± 2.23	8.36 ± 1.86	0.01*	< 2.5
LSST (cm)	2.12 ± 1.33	1.86 ± 1.18	0.36	< 1.5
RSF (°)	145.50 ± 14.04	152.10 ± 12.16	0.03*	160°-180°
LSF (°)	151.81 ± 12.47	150.50 ± 13.77	0.65	160°-180°
RSE (°)	62.62 ± 11.62	60.55 ± 15.60	0.50	60°-70°
LSE (°)	62.48 ± 11.43	63.97 ± 14.03	0.61	60°-70°
RSIR (°)	42.11 ± 14.64	39.11 ± 15.83	0.38	70°-90°
LSIR (°)	45.34 ± 13.44	40.97 ± 10.78	0.11	70°-90°

*Significant at p<0.05; **KEY**: RFSP=Right Forward Shoulder Posture, LFSP=Left Forward Shoulder Posture, LSST=Lateral Scapula Slide Test, RSF=Right Shoulder Flexion, LSF=Left Shoulder Flexion, RSE=Right Shoulder Extension, LSE=Left Shoulder Extension, RSIR=Right Shoulder Internal Rotation, LSIR=Left Shoulder Internal Rotation, Mini. =Minimum, Maxi. =Maximum, SD=Standard Deviation. **Unit of Measurement**: FSP (cm), LSST (cm), Goniometry (⁰).

The mean values of all kinematic parameters that were measured for all participants and the difference between the right and the left limb is presented on table 3. There was a significant difference in the Forward Shoulder Posture and Shoulder Internal Rotation of the right and left limbs (p=0.00, p=0.03). Table 4 shows the distribution pattern of shoulder pain between genders and professional level of participants. Table 5 describes the correlation between shoulder pain and kinematic variables.

Table 3 Comparison of Mean Kinematic Parameters of the Right and Left Shoulders of the Participants

Joint Angles	Right Mean ± SD	Left Mean ± SD	Difference X ± SD	t-value	p-value
Forward Shoulder Posture	9.73 ± 2.32	8.98 ± 2.14	0.74 ± 1.32	5.05	0.00*
Shoulder Flexion	148.54 ±13.54	151.22 ± 13.01	2.6 ± 14.20	-1.66	0.09
Shoulder Extension	61.68 ± 13.53	63.16 ± 12.62	1.4 ± 14.00	-0.94	0.35
Shoulder Internal Rotation	40.74 ± 15.17	43.35 ± 12.42	2.6 ± 10.70	-2.16	0.03*

*Significant at p<0.05; **KEY- FSP**=Forward Shoulder Posture, SF=Shoulder Flexion, SE= Shoulder Extension, SIR= Shoulder Internal Rotation.

Table 4 Distribution Pattern of Shoulder Pain among Participants

SHOULDER PAIN HISTORY				
Subcategory	Yes	No	Total	
	n (%)	n (%)	n (%)	Prevalence (%)
Gender				
Male	26 (32.1)	26 (32.1)	52 (64.2)	50.0
Female	14 (17.3)	15 (18.5)	29 (35.8)	48.3
Professional Level				
Amateur	17 (20.9)	20 (24.7)	37 (45.6)	45.9
Elite	23 (28.4)	21 (25.9)	44 (54.3)	52.3

Table 5 Spearman correlation coefficient between shoulder pain and kinematic variables of participants

SHOULDER PAIN			
	Correlation (r)	n	p-value
RFSP	0.12	81	0.276
LFSP	0.11	81	0.329
LSST	0.04	81	0.714
RSF	0.10	81	0.367
LSF	-0.01	81	0.896
RSE	0.13	81	0.247
LSE	0.03	81	0.767
RSIR	-0.15	81	0.169
LSIR	-0.11	81	0.329

KEY: RFSP – Right Forward Shoulder Posture, LFSP – Left Forward Shoulder Posture, LSST – Lateral Scapular Slide Test, RSF –Right Shoulder Flexion**,** LSF –Left Shoulder Flexion, RSE –Right Shoulder Extension, LSE –Left Shoulder Extension, RSIR –Right Shoulder Internal Rotation**,** LSIR – Left Shoulder Internal Rotation

4. Discussion

This study was a cross-sectional survey to profile the shoulder kinematic variables and determine their relationship with shoulder pain among volleyball players in Lagos, Nigeria. In volleyball, it is important to establish descriptive baseline kinematic values which this study provided. Informal interactions with several athletes indicated that there is no structured training program for Elite athletes in this clime as most of them transited from being Amateur to Elite athletes. In addition to this, the available data on shoulder kinematics were generated among Caucasians with limited data on athletes of African descent to account for possible racial variations.

It has been reported that volleyball players experience frequent force exposure that causes chronic shoulder pain, with sport-specific adaptations like shoulder joint hypermobility and alterations in strength and flexibility. These eventually result in upper extremity injuries such as rotator cuff injuries, scapula fractures and glenohumeral internal rotation deficit (GIRD) [34,35]. Previous studies have shown that the shoulder rotation range of motion of the dominant arm in highly skilled volleyball athletes is shifted towards a relatively more external and a less internal rotation position than that of the non-dominant arm [35, 36, 37].

Vuong *et al*, [38] in their study on comparison of shoulder posture, range of motion and shoulder pain between volleyball players and non-volleyball players reported that volleyball players have larger postural deviations and more pain than non-volleyball players. Some studies identified glenohumeral internal rotation deficit (GIRD), rotator cuff imbalance, scapular position and movement as important factors in the assessment of healthy and previously injured overhead athletes in order to define risk factors for future shoulder pathology and injury [18,29, 39]. This agrees with our observation in this study as there was reduced shoulder internal rotation on the dominant shoulder compared to the non-dominant shoulder; limited range of motion being a factor for impairment-risk analysis and performance evaluation.

Our findings show that the forward shoulder posture and range of motion in the dominant arm were significantly different from the non-dominant arm which suggests a structural deviation possibly as a result of repetitive movement of the dominant arm. This shows that an average active volleyball player has some degree of scapular asymmetry which might not necessarily relate to the presence of injury in line with previous findings [29,40]. Ozunlu et al, [40] reported that measurements obtained with the LSST cannot be used to assess the magnitude of scapular asymmetry though a latter review demonstrated that scapular dyskinesis may increase the risk of developing shoulder pain by 43% [41]. The results of our study show that almost half (49%) of the players reported pain though not significantly correlated with the kinematics. In a prior study, scapula dyskinesis was associated with shoulder pain, though it could not be ascertained if the scapular dyskinesis contributed to the development of shoulder pain or it was subsequent to it [41].

Our findings show that shoulder pain was present in about half of the participants which cut across gender and professional inclination. The prevalence of shoulder pain among volleyball players in this study was 49.4% which was much higher than some previously reported studies [11, 12, 42].. However, Skazalski et al. [43] reported that the prevalence of shoulder problems during the season was as high as 67%. That more elite players (52.3%) had shoulder pain compared to amateur players (45.9%) can be explained by the fact that overhead sports shoulder problems are predominant in highly skilled sportsmen, because of the intense practice, short recreational time with high intensity repetitive loads to which the shoulders are subjected [6, 7]. In addition to these, all the professional participants in this study had been playing for a minimum of five years unlike their amateur counterparts who had played for an average period of one year.

Clinicians evaluating overhead athletes need to be mindful of the fact that asymmetric scapular posture in unilateral overhead athletes may indeed be normal in some athletes and not a pathological sign, but rather an adaptation to extensive use of upper limb [29]. However, a prior study found it to be a more important risk factor for lower-grade shoulder injuries which may cause reductions in performance and participation without being severe enough to cause complete withdrawal from sporting activities [39]. The significant asymmetry observed in this study may be predictive of the predisposition of a player to future shoulder injury and pain as suggested by a review that asymptomatic athletes with scapular dyskinesis have a 43% risk of developing future shoulder pain [41]. Another study demonstrated that scapular dyskinesis is not a risk factor in isolation but increases risk of shoulder pain [44]. A recent study reported a moderate positive correlation between scapular dyskinesis and shoulder pain and disability, though this correlation was not statistically significant for either shoulder [45] while another study concluded that Scapular dyskinesis was not significantly associated with the development of shoulder injury in athletes [44]. Another review suggested that scapular dyskinesis may be an important factor not just an interactive risk factor but also an early warning indicator of an increased risk of developing future shoulder pain requiring a preventative intervention [41]. The reasons for investigating risk factors for shoulder pain are to better understand the mechanisms of the pain and to develop

preventative strategies [46]. A commonly proposed strategy is screening to identify those with risk factors and intervene with a preventative programme such as scapular-focused exercises which may be of value for injury prevention. The findings from our study can therefore be utilized as an addition to existing predictive risk factors in screening tests.

5. Conclusion

There was significant asymmetry in shoulder kinematics of volleyball players which was not significantly related to shoulder pain. Volleyball players will however benefit from preventative programs to forestall future shoulder injury.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

Ethical approval was sought and obtained from the institutional Health Research and Ethics committee (ADM/DCST/HREC/2136)

Statement of informed consent

Written informed consent was sought and obtained from each volleyball player prior to participation.

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