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Does Spike Technique and Hand Velocity differ between Volleyball Players with Infraspinatus Syndrome and those without: An Observational Study

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Introduction

Athletes competing in sports with excessive, repetitive overhead movement have a high risk of overuse shoulder injuries[1], with overuse shoulder injuries accounting for approximately 19% of all volleyball injuries[2].

The spike movement has been reported to be responsible for over 80% of all shoulder injuries in volleyball[3] and, given that elite players may perform roughly 40,000 spikes per year, small differences in technique could be associated with different injury risks[4].

One such injury, Infraspinatus Syndrome (IS), results from paralysis of the terminal branch of the suprascapular nerve at the spinoglenoid notch leading to isolated atrophy of the Infraspinatus muscle[5].

Infraspinatus syndrome results in a loss of strength in external rotation[5] and reduced proprioceptive sense of position of the hitting shoulder[6], but injury is normally incomplete in nature and no performance deficit is reported because of compensatory action of Teres minor[7].

There is a paucity of evidence comparing the technique of volleyball players with and without IS in order to establish whether it differs in the presence of IS. This is likely because IS does not result in loss of game or practice time

Aims

1) To establish whether spike technique is significantly different in players with IS to those without IS at two key event points.
2) To establish whether or not the velocity of spike movement is different.

Hypothesis

There will be a significant difference in the average of the biomechanical angles involved in the spike technique of players with and without IS, with an increased average velocity of the arm also observed.

The null hypothesis is that there will be no significant difference in either technique or velocity of spike.

Methods

2-D video kinematic analysis was used to compare the spike techniques of two groups, those with and without IS.

Participants

- Ethical approval was obtained from QMUL Ethics Committee
- 26 healthy volleyball players – 14 with IS and 12 without atrophy – were recruited between October 2016 and May 2017 (see table 1)
- They were free from musculoskeletal shoulder injury and were all members of elite Brazilian teams, both national and Superliga. All athletes were right-hand dominant attackers.

Table 1 –Anthropometric characteristics of participating athletes

	Age (years)	Height (m)	Body mass (kg)
Group 1 – IS	28.9 ± 5.0	2.00 ± 0.05	98.4 ± 9.32
Group 2 – No IS	31.1 ± 5.5	2.00 ± 0.06	95.4 ± 8.3

Protocol

- ❑ Footage recorded during competition of spike movement (JVC GZ-MG670, 30fps, 60Hz)
- ❑ Footage was cropped to individual spikes using VirtualDub and labelled by a unique player identifier, frame numbers and position of court aimed for.
- ❑ The position of the court that the player is aiming for will alter the biomechanical angles associated in order to direct the ball. Therefore, the court was separated into 6 sections, each 3x6m.
- ❑ The direction of the ball was noted relative to these sections and clips grouped by this, thus ensuring that all the spikes being compared are as similar as possible. For example, a ball landing on X will be tagged "2X" and a ball landing in Y will be tagged "2Y", see figure 1.
- ❑ Clips were digitised using DLTdv3 on MATLAB and only frames where the player's body is orthogonal during the spike movement were marked
- ❑ 8 biomechanical markers were then added at the locations shown in figure 1, which a 9th marker being used to indicate the key event frames
- ❑ Custom code was used to convert 2D [x,y] points to angles at 2 key event points:
  1. Maximum backswing
  2. Point of contact

Outcome measures

These coordinates were then converted to angles, using trigonometry and a custom code on an individual spike basis, to give 5 outcome measures, which were:

1. Trunk angle (cosθ =vertical line from lower trunk/back line)
2. Wrist angle (tanθ =vertical line from wrist/horizontal line from elbow)
3. Elbow angle (using cosine rule) – cosC = $(a^2+b^2-c)/(2ab)$
   - A= distance from shoulder marker to elbow marker
   - B= distance from elbow marker to wrist marker
   - C = distance from shoulder marker to wrist marker
4. Shoulder angle (tanθ=vertical line from elbow/horizontal line from shoulder)
5. Normalised velocity of wrist between maximum backswing and hit

Statistical analysis

- ❑ Statistical significance was accepted at alpha level 0.05
- ❑ SPSS (version 24)
  - ❑ Test-retest reliablity using intra-class correlation coefficient
  - ❑ Shapiro-Wilks normality test
  - ❑ Levene's test
  - ❑ ANOVA analysis and grand means calculated
  - ❑ Tukey's HSD post-hoc analysis

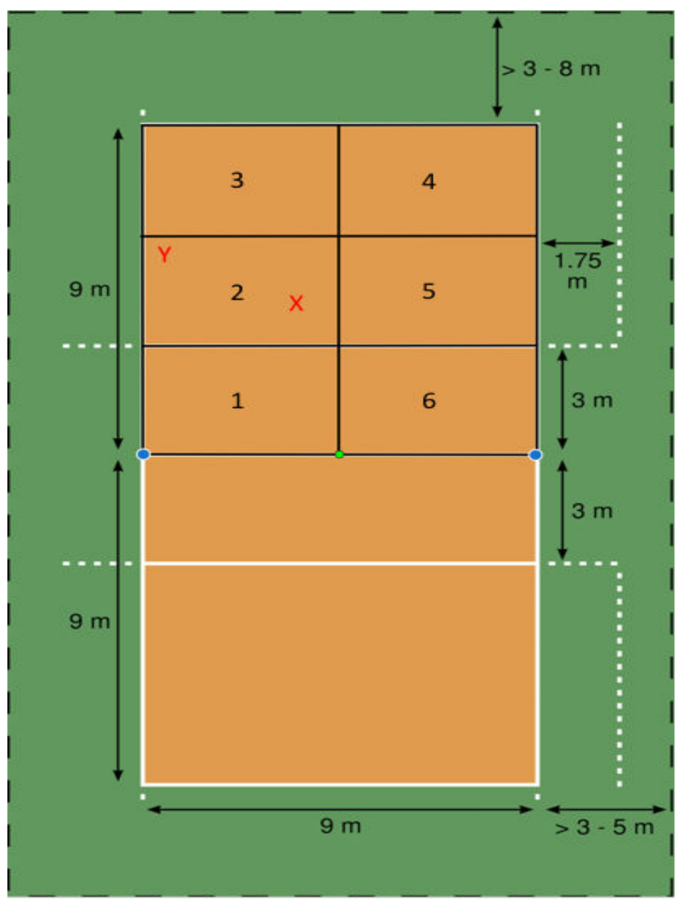

Figure 1 – Figure showing how the court was separated allowing the labelling and collation of spikes

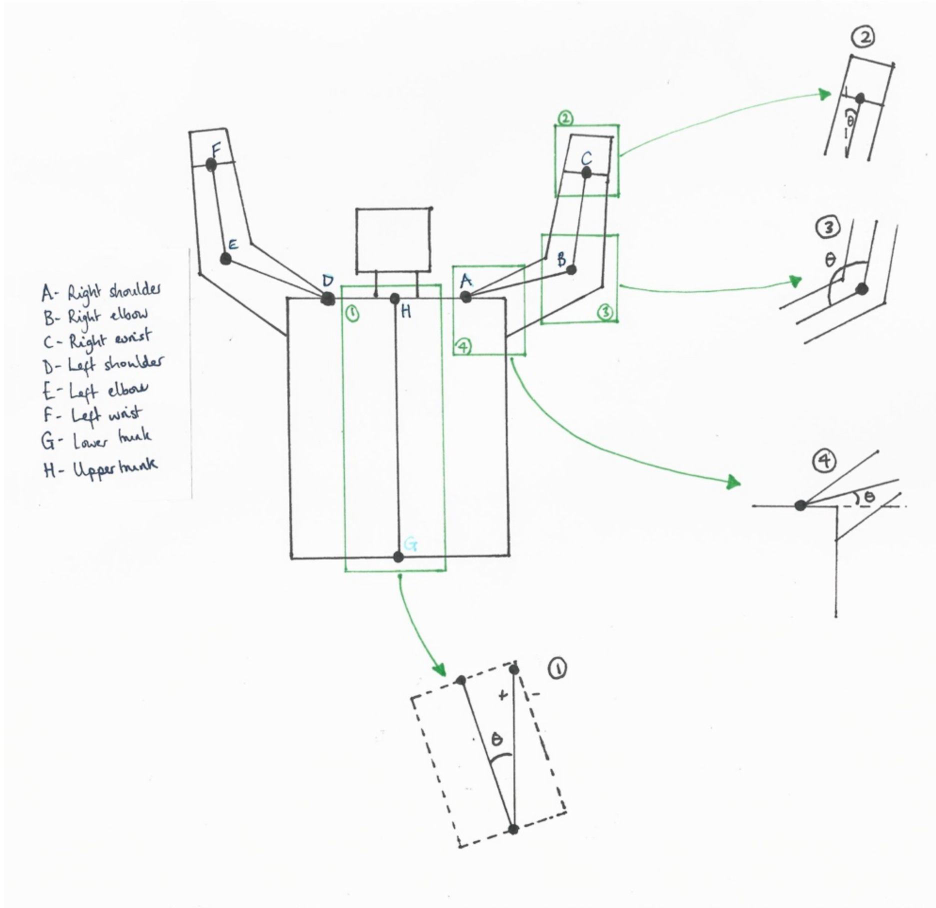

Figure 2 – biomechanical marker positions

Results

- ❑ Reliability (ICC) was found to be 0.88
- ❑ 6 variables violated Shapiro-Wilks normality test
- ❑ 1 variable violated Levene's test so alpha significance for Elbow Angle at contact was lowered to 0.01
- ❑ Due to lack of sufficient data the areas 1X, 1Y, 2X, 2Y, 5X, 5Y, 6X, 6Y were removed from the study
- ❑ Significant ANOVA results:
  - ❑ Main effect (IS) for Wrist Angle at Backswing $F(1,242) = 12.018$, $p=0.001$
  - ❑ Interaction effect (IS*court location) for shoulder angle at point of contact $F(3,321) = 2.764$, $p=0.042$
- ❑ Tukey's HSD

A = Atrophy group
NA = No atrophy group

Wrist Angle at Backswing	3X A	3X NA	3Y A	3Y NA	4X A	4X NA	4Y A	4Y NA
3X A	–	0.432	1.000	0.901	1.000	0.808	0.976	*0.008
3X NA	0.432	–	0.705	1.000	0.42	0.999	0.094	0.337
3Y A	1.000	0.705	–	0.947	1.000	0.928	0.996	*0.028
3Y NA	0.901	1.000	0.947	–	0.869	1.000	0.504	0.343
4X A	1.000	0.420	1.000	0.869	–	0.774	0.995	*0.009
4X NA	0.808	0.999	0.928	1.000	0.774	–	0.293	0.149
4Y A	0.976	0.094	0.996	0.504	0.995	0.293	–	*0.001
4Y NA	*0.008	0.337	*0.028	0.343	*0.009	0.149	*0.001	–

Shoulder Angle at Contact	3X A	3X NA	3Y A	3Y NA	4X A	4X NA	4Y A	4Y NA
3X A	–	1.000	1.000	1.000	0.949	0.896	0.999	0.841
3X NA	1.000	–	1.000	0.998	0.870	0.977	0.988	0.934
3Y A	1.000	1.000	–	1.000	0.980	0.946	1.000	0.887
3Y NA	1.000	0.998	1.000	–	0.999	0.798	1.000	0.737
4X A	0.949	0.870	0.980	0.999	–	0.312	1.000	0.365
4X NA	0.896	0.977	0.946	0.798	0.312	–	0.620	1.000
4Y A	0.999	0.998	1.000	1.000	1.000	0.620	–	0.608
4Y NA	0.841	0.934	0.887	0.737	0.365	1.000	0.608	–

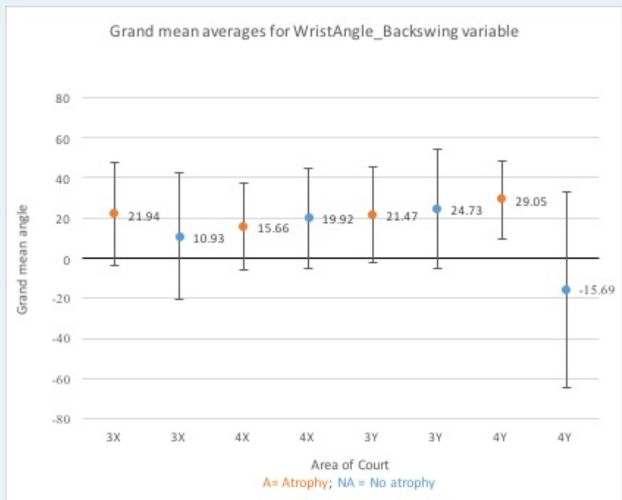

Figure 3 – Grand mean for Wrist Angle at Backswing

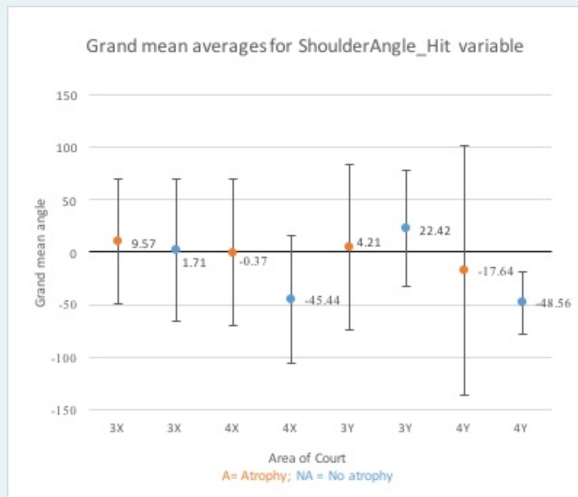

Figure 4 – Grand mean for Shoulder Angle at Contact

Discussion

- ❑ Wrist Angle at Backswing may indicate that atrophied players are "winding up" more during cocking phase than non-atrophied.
- ❑ Furthermore, players in a competition setting must adapt the spike to uncontrollable factors, such as the height and direction of the set or block and so this altered technique will have caused wide variability in the results
- ❑ However, area 4Y accounted for all of the significance found in Tukey's HSD and table 8 showed that by far the largest mean difference was found here. This has the potential to skew the results and create a type I error in the overall results.
- ❑ Shoulder Angle at Contact data corroborates findings in literature that implicate increased shoulder mobility in IS, which was also found by Witvrouw et al[8] and Reeser et al[9].
- ❑ Challoumas et al. also found no difference in spike speed in players with IS, $p = 0.827$
- ❑ Lack of significant results implies another factor is involved, for example anatomical variation
- ❑ More specifically roughly 30% of people the suprascapular nerve divides into 3 branches, forming an acute angle around the spine of the scapula, increasing vulnerability to traction injury thought to cause IS[10].

Limitations

- ❑ The nature of 2D analysis meant that large amount of data loss that was not orthogonal
- ❑ Small rotations of videos may have led to accuracy errors
- ❑ Impossible to ensure anatomical consistency of placed markers due to human error
- ❑ There was a lack on control over the quality of the clips, as competition footage was utilised
- ❑ Only focused on 2 event points and, therefore, did not collect data on the rest of the spike movement
- ❑ No standardisation of technique between "elevations" style and "backswing" style of spike.

Conclusion and Next Step

There is some evidence to suggest technique varies between players with and without IS.

However, based on the strength of our results it cannot be confidently deduced that differences in technique, at the two event points, are due to IS.

The velocity of the arm during the spike does not differ significantly between those with IS and those without.

Due to the limitations of the study it cannot be reliably or confirmed that the overall technique of the spike differs between players with and without IS.

Therefore, high quality, 3-D kinematic research comparing the technique of players with and without IS may yet yield significant results.

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