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Research article

Spike Arm Swing Techniques of Olympics Male and Female Elite Volleyball Players (1984-2021)

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Abstract
In the last decades, indoor volleyball has experienced significant rule changes and a high player specialization in both sexes. Different spike attack arm swing techniques have developed which might affect performance and risk of injury. While a variety of arm swing techniques was already shown in world class beach volleyball players, it is unclear if this is also true for world class indoor volleyball. Therefore, the purpose of this study was to assess the spike attack arm swing techniques of Olympic volleyball winners and finalists (1984-2021) and to investigate possible differences between sex, playing position, scoring system, and compared to beach volleyball. Eighty-two male (M) and 85 female (F) players were assessed from video recordings from ten competitions. Five different arm swing techniques in the cocking phase (Straight, Bow-and-arrow high, Bow-and-arrow low, Snap, Circular) were classified by two experts. The most frequent technique for both sexes was the Circular (M = 40.2%; F = 38.8%), followed by Snap (M = 28.0%; F = 23.5%), Bow-and-arrow low (M = 20.7%; F = 21.2%), Bow-and-arrow high (M = 7.3% F = 11.8%), and Straight (M = 3.7%; F = 4.7%). Bow-and-arrow high and Straight techniques were significantly less used than other techniques in both sexes. There were no significant differences ($p > 0.05$) in arm swing techniques between sexes, playing positions, and scoring system but significant differences ($p < 0.001$) to beach volleyball. Although most volleyball textbooks only describe the Bow-and-arrow techniques, most of the world class indoor volleyball players used Circular and Snap arm swing techniques. Reasons for that could be the implicit knowledge of players (and coaches) regarding increased performance (ball speed) and injury prevention. Based on these results we suggest to critically revise arm swing technique training especially for young players and players with shoulder problems.

Key words: Spike attack, biomechanics, shoulder injuries, overarm movement, beach volleyball.

Introduction

Indoor volleyball was introduced in the Olympic Games in 1964 and has experienced several significant rule changes like the change of the scoring system from the side-out system to the rally-system and the introduction of the libero, a specialized player for defense who is not allowed to attack. Such changes have affected the game tactics and player's specialization, e.g., depending on the playing position. The development of the game has led to anthropometric differences between attacking players (middle blockers, outside hitters, and opposites) compared to non-attacking players (setters and liberos) in females and males (Gualdi-Russo and Zaccagni, 2001; Palao et al., 2014).

One of the most important technical parts of the game is the spike attack, which was identified as a major performance indicator (Drikos and Vagenas, 2011). Therefore, much emphasis is put on the development of the overarm movement. Following the take-off, the spike technique is subdivided into the wind-up, the cocking phase, the acceleration phase, and the follow through phase. While there is little inter-individual variety in the acceleration and follow through phases (Coleman et al., 1993; Oka et al., 1976; Selinger and Ackermann-Blount, 1986), there are different techniques applied during the wind-up and cocking phase (Seminati et al., 2015). Already in 1986 Selinger and Ackerman-Blount described five different types of arm swing techniques during the spike attack, however, until recently, little scientific attention has been given to these techniques. Decades later, Seminati et al. (2015) analyzed the kinematics of different arm swing techniques. Based on their experimental findings of unfavorable range of motion and trajectories of the humerus in traditional techniques, they hypothesized that alternative techniques might be less harmful for the shoulder joint. This is of great importance since shoulder injuries in indoor volleyball, like other overhead sports, are very common (16-19% of all overuse injuries, Seminati and Minetti, 2013) due to the high amount of more than 40000 attacks/year (Kugler et al., 1996). Athletes with chronic shoulder pain present symptoms of impingement as a result from different shoulder conditions like rotator cuff tendinopathy, shoulder instability, scapular dyskinesis, biceps pathology, SLAP (superior labrum anterior-superior) lesions, and GIRD (glenohumeral internal rotation deficit) (Cools and Reeser, 2017). The high specialization in indoor volleyball regarding the different playing positions could lead to the repeated use of harmful movements like arm swing techniques due to specific movement conditions e.g., for fast ball players. Furthermore, shoulder injuries could be sex specific. Although there exists little data, there is some indication that female players suffer more often from shoulder problems than men in beach volleyball where the same arm swing techniques are applied as in indoor volleyball. Lajtai et al. (2009) reported more shoulder surgeries (13.3% vs. 9.3%) and worse shoulder function (strength and flexibility) in females compared to males. This might be related to sex differences in the distribution of arm swing techniques during spike attack, which were observed in professional beach volleyball where only female beach volleyball players used the so-called Straight arm swing or Snap techniques and only males used the Circular technique (Giatsis et al., 2019; Giatsis et al., 2022). However, up to date, no data exists on

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the distribution of arm swing techniques in elite indoor volleyball. Biomechanical differences in jump techniques were already reported between sexes (Fuchs et al., 2019b) and between indoor and beach volleyball (Tilp et al., 2008) and could hence also be expected for arm swing techniques. Summarized, the existence of differences related to sex, playing positions, scoring system, and type of sports (indoor vs. beach volleyball) might indicate a greater risk for shoulder injuries for specific groups.

Therefore, the aim of the study was a) to present the distribution of arm swing techniques of world class indoor volleyball players of both sexes b) to analyze the data for possible differences depending on sex, playing position, and scoring system and c) to compare the distribution of arm swing techniques to world class beach volleyball players.

Methods

Ethics committee approval statement

The Ethics Committee of the School of Physical Education and Sport Science, of the Aristotle University of Thessaloniki at Thessaloniki approved the design of the study (Approval number 95/2022). Informed consent from the players was not obtained as the analyses were performed from publicly available broadcasts for which they agreed on participation.

Sample description

The Olympic Games winners and finalists players from 1984 to 2021 (N = 10) were included in the sample (male = 82, female = 85). In case a player has won or participated in a final more than once, he or she has been included once in the data. Only the six players who participated in the starting line-up of the matches were included in the data.

Parameters measured and their selection

The arm swing technique in the cocking phase of spike attacks was categorized. Video recordings from television broadcasts were captured using a Mac mini desktop computer. QuickTime Player (version: 10.5) in normal speed, slow motion speed, and frame-by-frame modus was used to analyze every spike. The spike movements chosen for analysis were assessed during the match only when the serve reception was 'perfect or positive' or a free ball from opponents which means that all attack combinations are possible. This implies that the setter could set to every attacker and the player could attack under ideal conditions (Data project, 2017). The spikes performed after a poor reception (setter couldn't set to middles or pipe attack) were excluded from the analysis to avoid any unwanted variations due to the specific playing situation. All spike attacks under ideal conditions of each player during the final match were categorized. Furthermore, the players were categorized in other matches in the same or another competition to check if there was a difference in the technique they used. From these pilot analyses we did not observe any intra-athlete variations in arm swing technique under ideal conditions, irrespective of the position (left, middle or right and front or back row), direction (line or cross), or technique (wrist in or out) of the attacks. Players used the same technique consistently when positioning and ball trajectory were ideal.

We observed three major positions in Volleyball which used the spike in the attack. These were wing spikers (or outside hitters), opposite spikers (or universal), and middle blockers. The other two specialties were setters and libero (introduced in Sydney Olympics 2000). The main difference in the attack between the playing positions is the tempo (i.e. the speed) they execute from the moment the ball is released by the hands of the setter. Middle blockers are using quick attacks while wing spikers and opposite spikers are using fast or high ball attacks.

Furthermore, female middle blockers often used the slide attack where the approach is different from classical two-foot jump techniques. During a slide attack, the player moves past the setter and in parallel with the net with a single-foot jump. Most of the female middle blocker players used this technique, especially those who were next to the setter in the starting line-up rotation. We observed the slide attack mainly when the setter was in the front row (positions 2, 3 and 4).

All teams used the 5-1 system (with five attackers and one setter who is not attacking) except for one female team that used the 6-2 rotation system where two attacking setters, two swing spikers, and two middle blockers are on the court at once. The 6-2 rotation system allows three attackers to spike when they're in the front row all the time as the setters become attackers when they are in the front row.

The classification scheme of the arm swing motion during the spike was based on the arm swing techniques descripted by Sellinger and Ackermann-Blount (1986) and Giatsis et al. (2019; 2022). We distinguished five techniques for the arm swing, whereby the arm swing is defined as the phase after the take-off until the final cocking phase is reached (full horizontal abduction of the shoulder). These arm swing techniques are the Straight (*please see video from 3D-motion capture at https://www.jssm.org/video/straight.html*), the Bow-and-arrow high (BA-high; *please see video from 3D-motion capture at https://www.jssm.org/video/BA-high.html*), the Bow-and-arrow low (BA-low; *please see video from 3D-motion capture at https://www.jssm.org/video/BA-low.html*), the Snap (*please see video from 3D-motion capture at https://www.jssm.org/video/snap.html*), and the Circular arm swing (*please see video from 3D-motion capture at https://www.jssm.org/video/circular.html*). The five techniques are also described in detail in Table 1 and depicted in Figure 1. To be able to distinguish between the different techniques, the position of the elbow and the wrist joint in relation to the shoulder joint and the forehead were used (Table 1).

To investigate whether there are differences in the players' techniques over time, we divided the ten Olympic Games that we examined into two equal groups of five based on the points scoring system. Therefore, we named group one as "side-out score" (1984-2000) and group two as "rally score" (2004-2021). To control for a possible bias, we checked the techniques of players that participated in the finals in both scoring systems (three males, two females) and could confirm that they did not change their arm swing techniques.

Table 1. Definitions of the different arm swing techniques with regards to wrist and elbow positions of the hitting arm during different phases and dynamics of the movement. Please note that the indicated phases (I, II, III) correspond to Figure 1. Phases IV and V are equal for all techniques and therefore not described (adapted from Giatsis et al., 2022, with permission). BA = Bow-and-Arrow.

Straight	BA-High	BA-Low	Snap	Circular
INITIATION OF THE COCKING PHASE (I): Elevation of wrist and elbow				
Wrist above shoulder	Wrist above shoulder	Wrist above shoulder	Wrist at the same height or above shoulder	Wrist below or at the same height or above shoulder
Elbow above shoulder	Elbow above shoulder	Elbow above or at the shoulder height	Elbow at shoulder height	Elbow below or at the same height with shoulder
WIND-UP PHASE (II): Wrist position				
Wrist above forehead	Wrist above forehead	Wrist between forehead and shoulder height	Wrist at shoulder height	Wrist moves down below elbow
FINAL COCKING POSITION (III): Wrist and elbow position				
Elbow above shoulder; wrist above forehead; forearm above forehead	Elbow above shoulder; wrist above forehead	Elbow above or at the same height with shoulder; wrist between forehead and shoulder height	Elbow and wrist at shoulder height	Elbow and wrist at the same height or below shoulder
MOVEMENT DYNAMICS				
Full stop at final cocking position	Full stop at final cocking position	Full stop at final cocking position	Full stop at final cocking position	Continuous arm movement during the whole attack movement

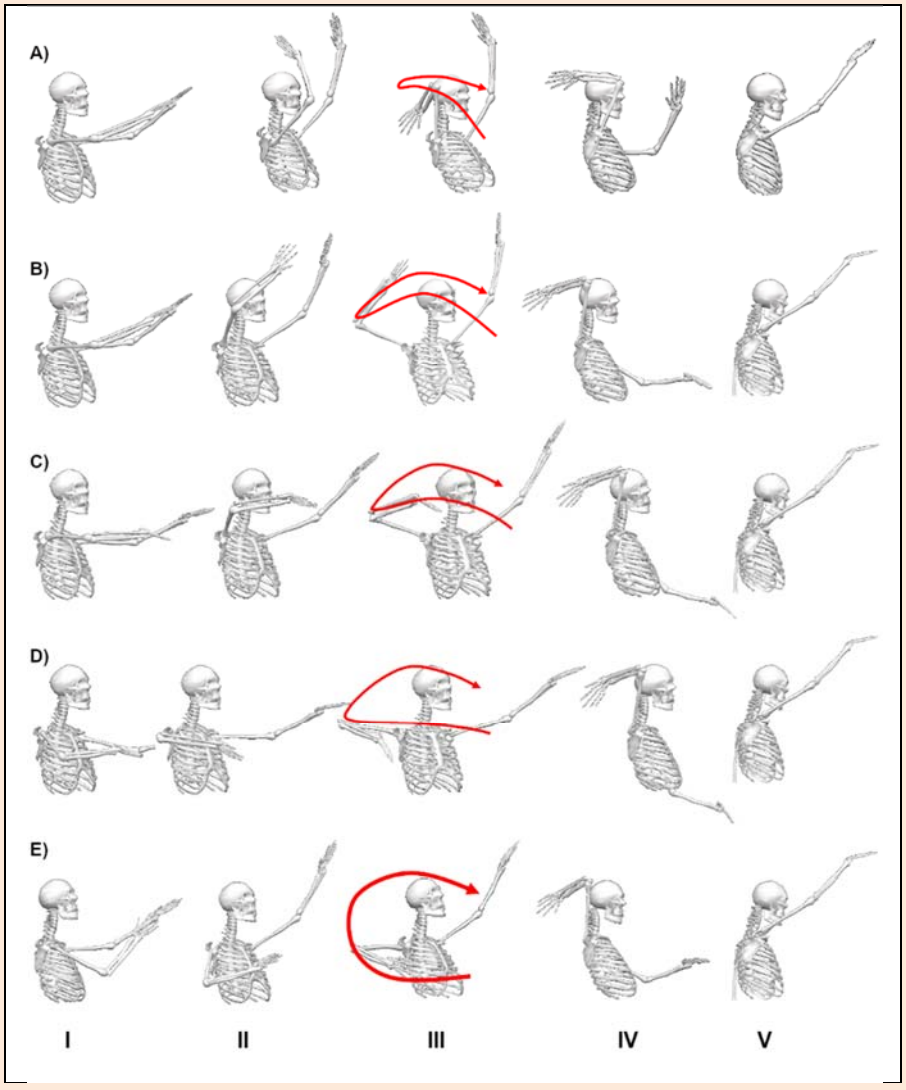

Figure 1. The five phases of the volleyball spike after jumping are the initiation (I), wind-up (II), arm cocking (III), arm acceleration (IV), and ball contact and follow-through (V) in the different arm swing techniques. A) Straight, B) Bow-and-arrow high, C) Bow-and-arrow low, D) Snap and E) Circular. The red line indicates the position of the elbow during the arm swing. Please note that the "A, B, C and D" techniques have a full stop at final cocking position while "E" technique has a continuous arm movement during the whole attack movement. (adapted from Giatsis et al., 2022, with permission).

Data collection

The classification of the different arm swing techniques for all players was performed by a volleyball expert in coaching and kinesiology (observer 1). To test intra- and inter-reliability of the assessments, another expert in volleyball (observer 2) with extensive experience as an athlete and coaching classified 25% (N = 42) of the players. The selection of the players was made randomly including men and women alike. The authors had experience in the analysis of arm swing from previous works related to beach volleyball in high level (Giatsis et. al., 2019; Giatsis et al., 2022).

Statistical analysis

An intra-rater reliability analysis using Cohen's Kappa statistics was calculated for every expert to determine observation consistency of the arm swing classification. The re-test of the arm swing classification was done after a period of one month from the first test to avoid the possibility of carry-over, transfer, memory, and practice effects induced by familiarity with the assessment. Also, an inter-rater reliability analysis using Cohen's Kappa statistics was carried out to find the degree of consistency of the arm swing classification between the two observers.

In the analysis, we present absolute and relative frequencies in percent of all arm swing techniques. Further more, we tested the frequencies of all arm swing techniques for equal distribution with a one-sample χ^2 test (Goodness of Fit) for the data merged from both sexes and Fisher's exact test for the separate sexes due to low number (< 5) of "Straight"-techniques which impeded to use a χ^2 test. Depending on the number of absolute frequencies, we tested differences between the frequencies of five individual techniques with one sample χ^2 test (Goodness of Fit) or Fisher's exact test.

Possible differences in the distribution of arm swing techniques between sex, playing position, scoring system, and type of sports (volleyball vs. beach volleyball, data from Giatsis et al., 2022, see Table 2) were assessed with χ^2 test (Test of Independence) or Fisher's exact tests for cell numbers < 5. Furthermore, Cramer's V effect size (ES) was calculated to assess the magnitude of the of possible differences. The ES were considered to be small (> 0.05), medium (> 0.15), and large (> 0.25) for four degrees of freedom (Kim, 2017). The significance level was $p < 0.05$. Statistical tests were performed with SPSS (version 27).

Table 2. Absolute and relative frequency distribution of arm swing technique of indoor volleyball (males, females, total) and comparison to beach volleyball (total, data from Giatsis et al., 2022).

		Arm Swing Techniques					
		Straight	**BA-high**	**BA-low**	**Snap**	**Circular**	**Total**
Volleyball	**Males**	3	6	17 [a,b]	23 [a,b]	33 [a,b]	82
		3.7%	7.3%	20.7%	28.0%	40.2%	100%
	Females	4	10	18 [a]	20 [a]	33 [a,b]	85
		4.7%	11.8%	21.2%	23.5%	38.8%	100%
	Total[#]	7	16	35	43	66	167
		4.2%	9.6%	21.0%	25.7%	39.5%	100%
Beach Volleyball	**Total**	3	11	19	6	6	45
		6.7%	24.4%	42.2%	13.3%	13.3%	100%

[a]: Significantly different to "Straight" ($p < 0.01$). [b]: Significantly different to BA-High ($p < 0.01$). [#] Significantly different from the distribution in beach volleyball ($p < 0.01$), BA = Bow-and-Arrow.

Results

The arm swing techniques of 167 (Male = 82; Female = 85) players from 10 Olympic Games (1984-2021) were categorized. The intra-rater reliability analysis using Cohen's Kappa statistics indicated perfect agreement between the two observations for the experts ($\kappa = 1.000$, $p < 0.001$). Also, the inter-rater reliability analysis using the Cohen's Kappa coefficient indicated perfect agreement for arm swing classification of the observers ($\kappa = 1.000$, $p < 0.001$).

Merging the data from male and female players, the Circular (39.5%) was the most common technique followed by Snap (25.7%). The players applied the BA-low technique with 21.0% and BA-high and Straight with 9.6% and 4.2%, respectively (see Table 2). This distribution was significantly different ($\chi^2(4) = 64.59$, $p < 0.001$) compared to an equal distribution. Fisher's exact test confirmed no significant sex difference ($p = 0.88$, Cramer's $V = 0.09$, small effect) in the distribution of arm swing techniques.

The most frequent technique for the males was Circular (40.2%), followed by Snap (28.0%), and BA-low (20.7%). The lowest frequency arm swing techniques were the BA-high (7.3%) and the Straight (3.7%). Fisher exact tests revealed that this distribution was significantly different compared to an equal distribution ($p < 0.01$) and that BA-high and Straight were used significantly less often than the other three techniques ($p < 0.01$), (see Table 2).

For females, the most frequent arm swing techniques were the Circular (38.8%) and the Snap (25.7%) followed by BA-low (21.2%), BA-high (11.8%) and Straight (4.7%). Fisher exact test revealed that this distribution is significantly different compared to an equal distribution ($p < 0.01$). Furthermore, Fisher exact tests revealed that the Straight technique was significantly less often used ($p < 0.01$) than Snap, BA-low, and Circular while the BA-high technique was significantly less often ($p < 0.01$) used than the Circular technique (see Table 2).

Fisher's exact test confirmed no effect of playing position, ($p = 0.71$, Cramer's $V = 0.13$, small effect, Figure 2) and scoring system, ($p = 0.85$, Cramer's $V = 0.09$, small effect, Figure 3) in the distribution of arm swing techniques. Furthermore, Fisher's exact test revealed that the distribution of arm swing techniques in indoor volleyball was significantly different from beach volleyball, ($p < 0.001$, Figure 4). A large (0.33) Cramer's V effect size confirmed the meaningfulness of the observed differences in arm swing techniques between volleyball and beach volleyball (Figure 4).

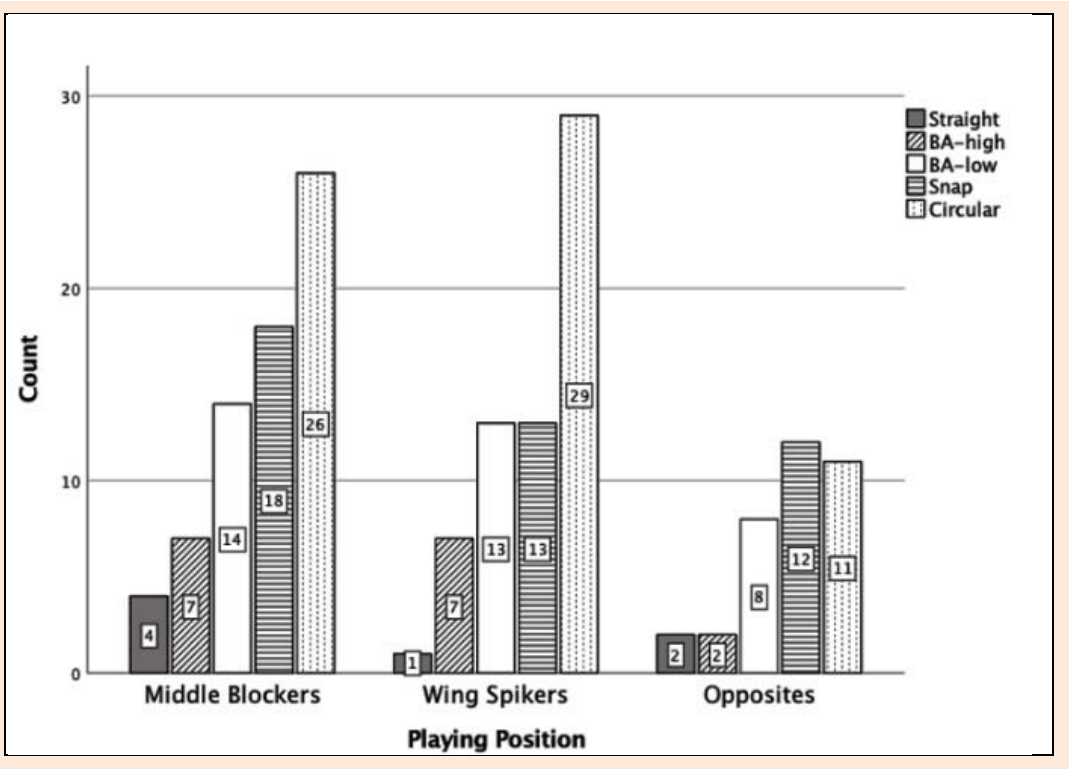

Figure 2. Distributions depending on playing position. Fisher's exact test indicated that there was not a significant statistically association between players in different playing ($p = 0.71$).

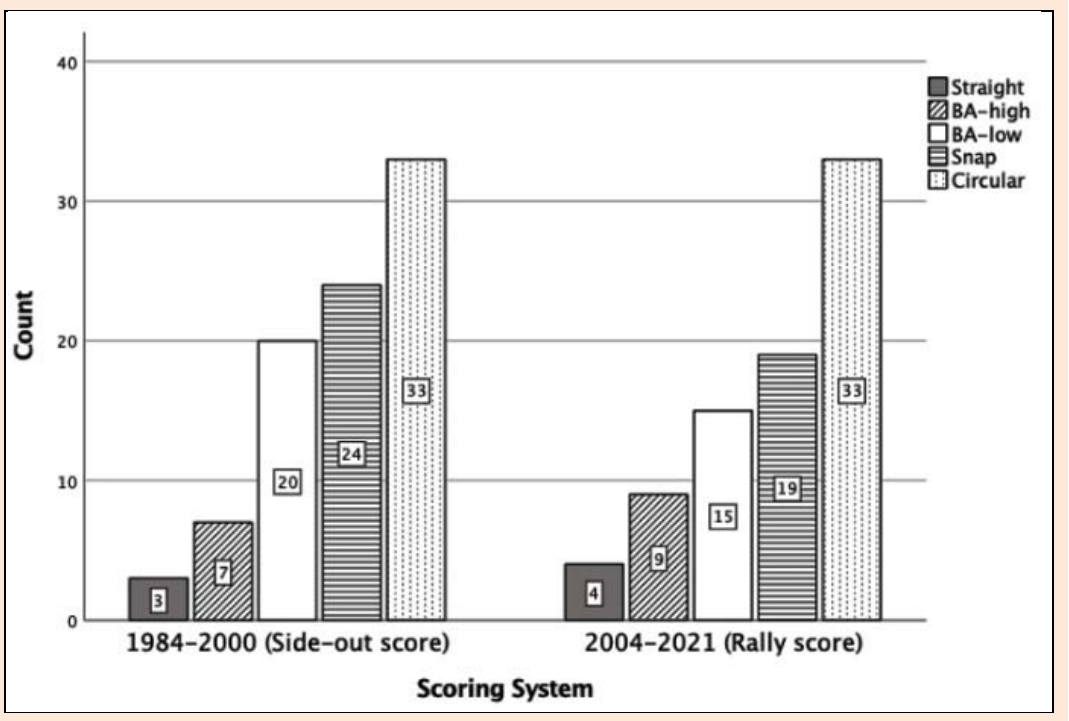

Figure 3. Distributions according to scoring system. Fisher's exact test indicated that there was no significant statistical association between the Side-out and Rally scoring system ($p = 0.85$).

Discussion

Although different arm swing techniques were mentioned as early as 1976 (Oka et al.), the current study is the first quantitative study of arm swing technique in elite indoor volleyball. The specific aim of the study was to assess the distribution of arm swing techniques among world class indoor volleyball players regarding sex, playing position, and scoring system. A further aim was to compare the arm swing techniques with those from world class beach volleyball using retrospective data from Giatsis et al. (2022). We observed all five major techniques in males and females. The frequencies of the observed techniques were not equally distributed in both sexes and their distribution

was not different between males and females. While the Straight technique was used least often, the Circular technique was the most popular followed by Snap. Furthermore, the distributions of techniques were not different in different playing positions or scoring systems but the observed arm swing techniques in indoor volleyball were different to those from beach volleyball.

A reason for the high amount of Circular and Snap techniques (65.2%) could be their theoretical advantage in arm and ball speed which has been shown by Seminati et al. (2015). They observed higher hand velocities and ball speed (+ 5%) in the alternative techniques (Circular and Snap) compared to traditional arm swing techniques. A great variation in spike technique within the sample of female players was also mentioned by Fuchs et al. (2019a), which impeded clear relationships between upper body kinematics and ball speed. In general, ball speed is an important factor in indoor volleyball (Forthomme et al., 2005) to make it more difficult for the opposing block and defensive players. From a biomechanical perspective, the Circular technique is a continuous movement with a continuous change in arm movement direction from backwards to forwards (see Figure 1). All other techniques include a stop of the movement at the end of the cocking phase before the arm moves forward again. This could reduce the time for the arm swing movement, which should be measured in a future study. The continuous movement of the arm in the Circular technique might also make it more difficult for the block and defensive players to anticipate the attacking direction. In the Snap technique, the greater flexion in the elbow joint compared to other techniques (see Figure 1) reduces the moment of inertia of the arm to the shoulder joint and will therefore allow higher angular velocities and hence, a faster arm swing.

The change of direction at the end of the cocking phase in all but the Circular techniques involves high decelerations and accelerations and therefore high forces in the shoulder joint. In combination with unfavorable kinematics due to greater shoulder flexion and shoulder abduction angles, this could lead to shoulder problems because of impingement of several structures (see Reeser et al., 2013; Seminati et al., 2015; Giatsis et al., 2022 for details). Furthermore, in Circular and Snap techniques the shoulder starts its motion in 90° or less abduction and neutral or internal rotation while traditional techniques with > 90° abduction and external rotation which could lead to internal impingement (Caldwell et al., 2016) and has long been associated with the thrower's shoulder. This happened due to the repetitive contact between the posterior aspect of the rotator cuff and the posterior superior glenoid, which is observed in abduction and external rotation of the shoulder. Seminati et al. (2015) therefore suggested that the alternative arm swing techniques (Circular and Snap) have the potential to reduce shoulder overuse injuries compared to traditional techniques (Straight, BA-high, BA-low). This is underlined by the review from Challoumas et al. (2017) who also reported a glenohumeral internal rotation deficit, a (less pronounced) external rotation gain in the dominant shoulder accompanied with muscular imbalances in volleyball players. Based on their findings they recommend strengthening of the shoulder external rotators and core strengthening, stretching and joint mobilization, and the teaching of adequate spiking and serving techniques including alternative arm swing techniques.

All five-arm swing techniques could be observed in the different attacking positions (middle blockers, wing spikers, and opposites) and their distributions were not different. This was surprising, as the conditions for spiking are rather different between the positions and especially the middle blockers have to act fast because the ball trajectory from the setter is very short (1-2 m) compared to the other positions (3-5 m) (Rocha et al., 2021; Tilp, 2017). Despite the lack of a significant difference, we observed a medium effect size (Cramer's $V = 0.18$) which indicates a lack of sufficient sample size. Hence, we suggest further analyses with greater sample size in the future also including the information about success of attacks. Furthermore, the distribution of arm swing techniques has not changed over the last decades according to the present data. This means that new rule changes like the introduction of a new scoring system or the libero had no effect on arm swing techniques.

These results in indoor volleyball in the present study differed from recently presented data in beach volleyball (Giatsis et al., 2022). While most of female and male elite beach volleyball players prefer the BA-low technique, most elite indoor volleyball players prefer the Circular technique. Interestingly, no female elite beach volleyball player used the Circular technique in the categorized sample by Giatsis et al. (2022). There are several explanations for these differences. While indoor volleyball players must use hard attacks in almost all attacking situations (Conti et al., 2018; Rocha et al., 2019; Rocha et al., 2020) due to the amount of opposing defensive and block players, beach volleyball players also use shots, less hard but precise attacks, to score a point (Giatsis et al., 2015). According to Koch and Tilp (2009) especially female beach volleyball players perform a large number of shots (~50%; men: ~41%) which could explain that no female player used the Circular technique. Shots are easier to play with an arm swing technique that includes a stopping motion at the end of the cocking phase like e.g., in the Bow-and-arrow techniques while it is more difficult to slow down or stop the continuous movement with a high angular velocity of the Circular technique. Another explanation could be that high sets are commonly used in Beach volleyball often with forearm pass technique (Tilp et al., 2006) where players wait to see the trajectory of the ball and then start the three or four step approach. This is similar to the approach taken by wing spikers and opposites players on high balls after a poor reception or after a defense (the setter's position is outside the three-meter line). We did not analyze the techniques used by players who may adapt their technique in these situations. Also, in Beach volleyball the Circular technique could not be used so often due to instability of sand and the lower center of mass during the jump as players try to extend the hip in a larger magnitude using the arms in order to maintain the vertical movement of the body during the push off (Giatsis et al., 2018). These kinematic differences are also related to lower jumping heights on sand compared to an indoor surface (Tilp et al., 2008). All the above reasons could explain why the Circular technique was seldomly observed in beach

volleyball.

Shoulder pain due to overuse injuries is common in elite indoor volleyball and beach volleyball players but seems to be more frequent in beach volleyball. Lajtai et al. (2009) reported that about 63% of elite beach volleyball players during a FIVB beach volleyball tournament had acute shoulder pain while Reeser et al. (2010) reported that 44% of the male and 42% of the female indoor volleyball players suffered from shoulder problems in the current season. A reason for such differences could be that the traditional techniques (Straight, BA-high, BA-low) have a higher percentage of all techniques than in indoor volleyball (73% vs. 35%).

This study is not without limitations. First, the results are based on a small sample size, which is always a drawback in the analysis of world class athletes. Second, the presented data of this observational study does not provide a direct relationship between arm swing technique and shoulder injury or performance. Therefore, we strongly recommend future experimental studies, e.g. including biomechanics data, investigating the relationships between injury prevention and technique. Third, the comparison with the beach volleyball data was done on existing data collected in another study.

Conclusion

The presence of five distinguishable arm swing techniques in female and male world class indoor volleyball players demonstrates the need to adapt arm swing technique training as most volleyball textbooks only suggest the Bow-and-arrow techniques. The high frequency of alternative techniques (Circular & Snap) compared to traditional techniques (Straight and Bow-and-arrow high) supports previous results (Seminati et al., 2015) that showed that alternative techniques might be favorable regarding ball speed and injury prevention. This knowledge should be used by coaches to teach young players as well as senior players with shoulder problems a successful and healthy technique. The distribution of arm swing techniques was not significantly related to sex or playing position and did not change due to the change of the scoring system in 2000. Nevertheless, a medium effect for playing position indicates the potential for greater specialization to improve performance. The observed significant differences to beach volleyball, where traditional techniques are more frequent, indicates the potential to improve injury prevention in this type of sport. However, further studies that directly relate the arm swing techniques to performance and injuries are needed.

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Key points

- Five different spike attack arm swing techniques can be observed among male and female world class indoor volleyball players.
- The favourite arm swing technique in both female and male players is the Circular technique used by ~40% of the players. The Straight technique is only used by less than 5% of the players.
- There is no difference in the distribution of arm swing techniques between the sexes or playing positions.
- Arm swing techniques in indoor volleyball are different from in beach volleyball.

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