

DOI: 10.1515/tpelj-2016-0006

Considerations regarding the optimisation of the spike in modern volleyball

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Abstract

The aim of this paper is to analyse in detail the aspects regarding increased efficiency of the spike in the game of volleyball, given the requirements of a flawless technique that will maximize the potential of the players. Our intention was to verify whether the steps of approach are unfolding in a uniformly accelerated motion and are leading to a vertical leap in the desired parameters at the moment of take off. We also wanted to check if the range of upper body motion is a determinant in the efficiency of the spike consisting in a high striking point and a remarkable hitting force.

Material and methods: The video footage was obtained from 6 players of "U" Timișoara's volleyball team and 6 international players. For the analysis and processing of the footage the program Kinovea was used and the following parameters were assessed: striking speed(m/s), range of motion (cm and °), flexion between arm and forearm, angle of arm with the vertical at contact, movement speed for the first, second and third approach steps.

Results: The international subjects had a 12 cm longer path of the hand in striking motion. Given the shorter segments of "U" Timișoara's players, they compensate by having a 2° larger range of motion, above the elite players. We recorded different angles of the spiking arm with the vertical for the 2 groups, namely a mean of 24.5° for the elite players and just 15° for the players of "U" Timișoara. These aspects lead to a striking speed 3m/s higher for the international spikers compared to "U" Timișoara sportsmen. Having measured a uniformly accelerated approach for the international subjects, "U" Timișoara's players don't respond to the same requirement with close values of the second and third step of approach.

Key words: *analysis, technical execution, efficiency, performance*

Rezumat

Lucrarea își propune să analizeze în detaliu aspectele legate de eficientizarea atacului în jocul de volei, în condițiile în care sunt îndeplinite cerințele unei tehnici de execuție fără fisuri care să valorifice la maximum potențialul sportivului. Am intenționat să verificăm dacă succesiunea pașilor de elan se desfășoară într-o viteză uniform accelerată și conduce, în momentul efectuării bătăii, într-o desprindere pe verticală la parametrii doriți. De asemenea, am cercetat dacă amplitudinea mișcării determină o eficiență superioară a atacului constând într-un punct de lovire cât mai înalt și o forță deosebită. **Material și metode:** Au fost recoltate materialele video de la 6 voleibaliști din echipa "U" Timișoara și 6 voleibaliști de talie internațională. Pentru analiza și prelucrarea materialului video s-a folosit programul Kinovea fiind determinate: viteza de lovire (m/s), amplitudinea mișcării (cm și °), flexia antebrăului pe braț, unghiul brațului cu verticala în momentul contactului cu mingea, viteza de deplasare în timpul pașilor 1, 2 și 3 de elan. Sportivii de elită urmăriți au prezentat o medie a cursei palmei din momentul pregătitor și până la lovire cu 12 cm mai mare decât cei de la "U" Timișoara. Date fiind dimensiunile mai scăzute ale segmentelor trenului superior la sportivii de la "U" Timișoara, aceștia compensează execuția printr-o amplitudine a mișcării cu 2° peste sportivii de elită. Unghiul format de verticală și membrul superior îndemânat prezintă valori diferite pentru cele două grupuri studiate, înregistrându-se o medie de 24,5° la sportivii de elită și de doar 15° la sportivii de la "U" Timișoara. Aceste aspecte conduc la o viteză de lovire mai mare la sportivii de elită cu peste 3 m/s față de sportivii de la "U" Timișoara. Dacă sportivii de elită efectuează un elan uniform accelerat, cei de la "U" Timișoara nu răspund aceleiași exigențe, având valori apropiate ale vitezei la pașii 2 și 3 de elan.

Cuvinte cheie: *analiză, tehnică de execuție, eficiență, performanță*

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Introduction

The modern volleyball game is characterized by speed and variety of actions, continuous improvement of technique, and an ever higher spiking point, creativity in attack combinations and flexibility in choosing the defence system. The emotional factor of the game is also increased, especially with the change of regulations and the introduction of the tie-break rule [1, 2, 3].

The spike as we will reveal in this study, is the main way of obtaining points, being closely linked with ball trajectory, opposition of the block and existing score at the moment. This game action also requires certain traits such as: vertical jump, explosive arm strike, reaction speed and execution speed, space orientation, analysis capacity and decision swift decision making, responsibility [1,4].

The aim of this paper is to analyse in detail the aspects regarding increased efficiency of the spike in the game of volleyball, given the requirements of a flawless technique that will maximize the potential of the players. Our intention was to verify:

- the steps of approach are unfolding in a uniformly accelerated motion and are leading to a vertical leap in the desired parameters at the moment of take-off;
- the range of upper body motion is a determinant in the efficiency of the spike consisting in a high striking point and a remarkable hitting force.

Method and subjects

The research took place at the Physical Education and Sport Faculty from Timisoara, video footage being collected from training sessions of the divisionary volleyball team Universitatea Timisoara in the competition year 2013-2014. We chose to collect data from six spikers. Additionally to these subjects we also gathered and analysed video footages from 6 representative international players. The subjects of the research were:

Position in team	Universitatea Timisoara players	International Players
Outside hitter	SS VS	D18 P8
Oposite	DD RE	F13 M15

Middle blocker	UC RM	A16 M9
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For the analysis and processing of the video footage the program Kinovea was used [5]. In order to calibrate the measurements related to the video footage we had to select a known value (the width of the net - 100 cm). The following parameters were assessed:

- **Striking speed (m/s)**

We selected the point which will be tracked, in our case the hand, fixing it frame by frame during the whole movement. We can observe the trajectory of the hand in the air and also its movement speed as it closes in for the strike. Having the measures calibrated the length of the trajectory and the time between the frames (30 frames/second) the program can display the speed of a moving point in space in real time (Fig. 1).



Figure 1. Striking speed

- **Range of motion (cm)**

For calculating the range of motion we changed the application's unit of measure from speed to length so it shows the range of the hand trajectory (Fig. 2).

- **Range of motion (°)**

This is the angle between the forearm at the beginning of the movement in its initial position and at end of movement in contact with the ball.

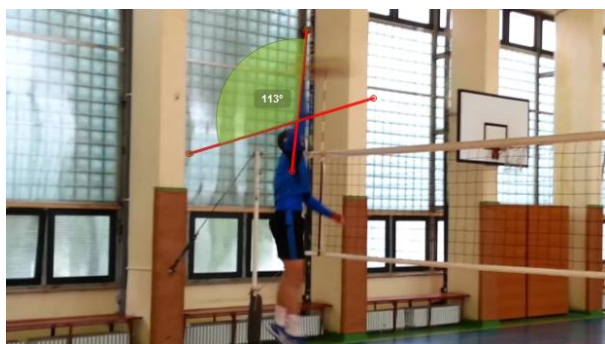


Figure 2. Range of motion

• **Flexion between arm and forearm**

It's represented by the angle between the forearm and the arm at the beginning of the striking phase just before the hand starts to move upward (Fig. 3).



Figure 3. Flexion between arm and forearm

Angle of arm with the vertical at contact

It is the angle formed between the outstretched arm at striking contact and the line perpendicular to the ground (Fig. 4). This is a crucial factor in a high spiking point.



Figure 4. Angle of arm with vertical at contact

Table I Data obtained from "U" Timisoara players

Subject	Average range of motion (cm)	Average range of motion (°)	Striking speed (m/s)	Arm/Forearm flexion	Arm/Vertical angle
SS	142	140	18,42	77	17
VS	98	123	14,70	68	6
RE	116	126	17,08	113	14
DD	121	132	17,45	121	19
UC	136	136	18,27	72	22
RM	108	112	15,53	104	12
\bar{x}	120,16	128,16	17,02	92,5	15

Table II. Data obtained from elite players

Subject	Average range of motion (cm)	Average range of motion (°)	Striking speed (m/s)	Arm/Forearm flexion	Arm/Vertical angle
P8	120	113	19,1	90	22
A16	153	141	21,3	64	32
M9	127	132	19,84	83	29
D18	132	129	20,4	75	19
F13	129	117	19,2	82	24
M15	131	126	20,38	84	21
\bar{x}	132	126,33	20,23	79,83	24,5

Movement speed for the first, second and third approach steps

In order to determine the speed of movement at the moment of each approach step we chose the player's centre of mass as the tracking point. The speed is measured during each contact with the floor of the player's approach for the last three steps.

Table III. "U" Timisoara players average speed on first, second and third step of approach

Subject	S1 (m/s)	S2 (m/s)	S3 (m/s)
SS	1,26	2,54	3,37
VS	0,98	3,32	3,87
RE	0,85	3,35	4,91
DD	0,81	2,84	3,48
UC	1,08	3,29	4,31
RM	1,17	3,53	3,94
\bar{x}	1,02	3,14	3,98

Table IV. Elite players average speed on first, second and third step of approach

Subject	S1 (m/s)	S2 (m/s)	S3 (m/s)
P8	0,52	2,80	4,20
A16	1,55	2,50	4,96
M9	1,20	3,42	5,31
D18	0,98	2,67	4,82
F13	1,32	2,42	3,98
M15	1,46	3,2	5,07
\bar{x}	1,17	2,83	4,72

Results

The elite players had a longer trajectory of the hand than "U" Timisoara's who fall 12 cm short (Fig 5). This may be due to the difference of height between the two groups.



Figure 5. Average range of motion (cm)

When measuring the angle motion of the forearm, the players from "U" Timisoara have a slight advantage of 2° to be exact (Fig. 6). It may be a mean of compensating for the shorter reach of the players.

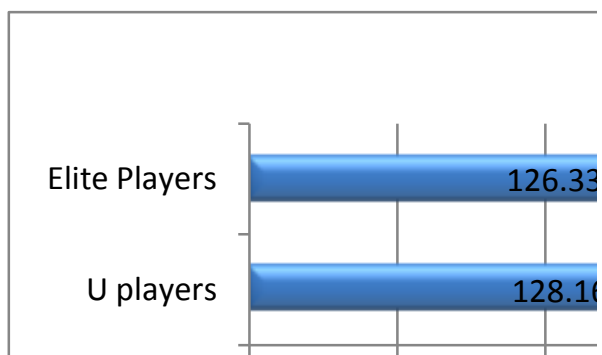


Figure 6. Average range of motion (°)

We noticed a substantial difference between the average striking speeds of the elite players compared to the subjects from Timisoara (Fig. 7).

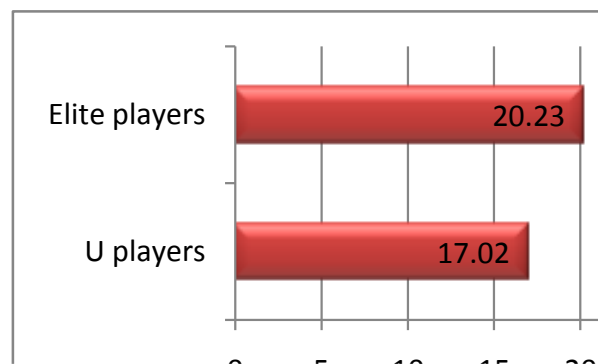


Figure 7. Average striking speed (m/s)

We also observed how the elite sportsmen spike the ball with the arm at an average angle of 24.5° from the vertical, that's over 10° better than Universitatea's volleyball players (Fig. 8). This matter drastically enhances the range of motion as the hand travels a longer distance through space gathering greater speed and momentum at ball contact. It also lowers the overall spiking point height but it's a fair trade for the force of the attack having in mind the much taller internationals. Regarding elbow flexion players from "U" Timisoara proved to be less mobile being outclassed with 12° by the elite players. A more pronounced flexion also contributes to the range of motion.

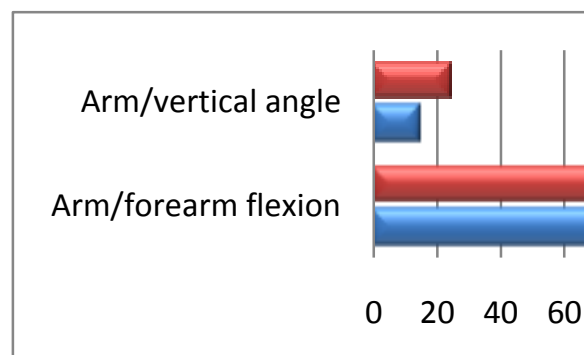


Figure 8. Angle of arm with the vertical at contact, Flexion between arm and forearm

From Figure 5 we observed that the elite players' approach is much closer to a uniformly accelerated motion for the three steps. Timisoara's players' line of acceleration has a more pronounced angle. We

concluded that this approach is less uniformly accelerated.

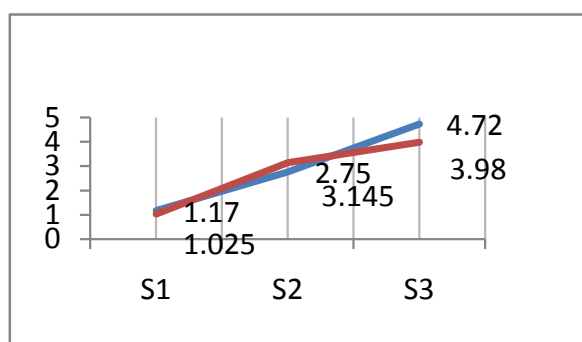


Figure 9. Average speed of first, second and third step of approach

Discussions

Published literature reveals no similar studies regarding details of the volleyball spike.

We considered the convenience of studying these fundamental aspects, as they are defining in acquiring, consolidating and perfecting this offensive action.

Conclusions

From the undertaken research, the following conclusions were drawn:

1. Studying the details of spiking execution allows optimisation of this action through the technique comparison between elite players and those of "U" Timisoara.
2. The international subjects had a 12 cm longer path of the hand in striking motion than the players from Timisoara.
3. Given the shorter segments of "U" Timisoara's players, they compensate by having a 2° larger range of motion, above the elite players.
4. We recorded different angles of the spiking arm with the vertical for the 2 groups, a mean of 24.5° for the elite players and just 15° for the players of "U" Timisoara.
5. The aspects studied and presented above lead to a striking speed of the hand 3 m/s greater for

the international players compared to sportsmen from "U" Timisoara.

6. Having measured a uniformly accelerated approach for the international subjects, "U" Timisoara's players don't respond to the same requirements with close values of the second and third step of approach.

In order to increase the execution efficiency of game actions in volleyball we propose:

1. In-depth knowledge of game action execution mechanism should be a major concern of volleyball coaches, especially of those working with early aged players.
2. Insisting in the act of coaching on forming the correct specific skills with immediate intervention when execution mistakes appear, knowing that incorrect technique is a limiting factor of performance.
3. Specialists working in the field of coaching to show an increased interest in the orientation of successful volleyball schools worldwide.

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