A BIOMECHANICAL COMPARISON OF JUMPING TECHNIQUES IN THE VOLLEYBALL BLOCK AND SPIKE

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The present case study kinematically analysed the spike and the block movements of a single volleyball player. The aim was to verify the hypothesis that for a right handed player the spike approach and the cross-over step in blocking after a move to the left are similar in coordination, whereas moving to the right before blocking requires a different movement pattern. The spatial and temporal variables of the jumps and the joint angles of the lower limbs during the countermovement were analysed. The results showed a high repeatability of the collected data. The similarity between the spike and the block when moving to the left confirmed the hypothesis. These results from a single subject should be extended by further studies of more athletes of varying skill levels.

KEY WORDS: stereophotogrammetry, variability, laterality, coordination.

INTRODUCTION: The spike, block and serve are the three most important skills to score points in volleyball (Lobietti et al., 2006). Jumping techniques in these three skills has become increasingly important to offence in advanced volleyball. The biomechanics of the spiking technique have been investigated by Coleman et al. (1993) and more recently by Kuhlmann et al. (2007) and Shabbazi et al. (2007). As described by these authors, the spike consists of four phases: a three-step approach (left-right-left), the jump, the hitting action and the landing. Recently, biomechanical analyses of the block (Lobietti et al., 2005; Donà et al., 2006) have focussed on the footwork techniques used by blockers. One of the major limitations is that none of these previous studies have analysed the same subjects performing spiking and blocking actions. To our knowledge, only Quade (1993) and Lawson et al. (2006) have previously presented data relative to the kinematics of both the block and the spike when executed by the same players. However, the movements acquired in these latter studies (a spike executed with only one step of approach before the jump, and a vertical block with no prior lateral movement) are used only very infrequently in game situations. During the game, it is much more likely that the spikers will have at least three steps of approach and that the blockers will have to move laterally before jumping. Lobietti et al. (2005) looked at blocking, and found in case of an outside set, the majority of the previous investigations showed an advantage in terms of time taken and height reached when using cross-over steps (XS) as opposed to slide-steps (SS) when moving prior to block jumping at the left side of the net. These findings were explained as result of the similarity in coordination and rhythm between this movement (XS to the left) and the spike approach but no data were presented to support this argument.

Therefore, the aim of the present is to test that explanation by comparing the biomechanical parameters of the jumps performed by a player when blocking after a XS to left and also to the right to those obtained when spiking with a three step approach.

METHODS: A Qualisys Capture System using 6 infrared cameras (Proreflex MCU 500 Hz) was used to acquire the execution of spikes and blocks of a single female hitter (25 years old, 174 cm height, one-handed reach 219 cm, mass 65 kg, 10 years of experience) who plays regularly in Scottish National League Division 1.

The lower limbs were considered as a kinematic chain of seven rigid body segments: right and left feet, right and left shanks, right and left thighs and pelvis. Anatomical landmarks and bone-embedded anatomical reference frames were defined according to the CAST protocol (Cappozzo et al, 1995; Benedetti et al., 1998)). For each body segment, four spherical reflective markers (19 mm) were attached to the skin. The trajectories of all 32 skin markers were collected by the motion capture system in each trial. In figure 1 an example of the CAST volleyball marker set (left) and a reconstruction of the spiking approach performed by the system (right) are shown.

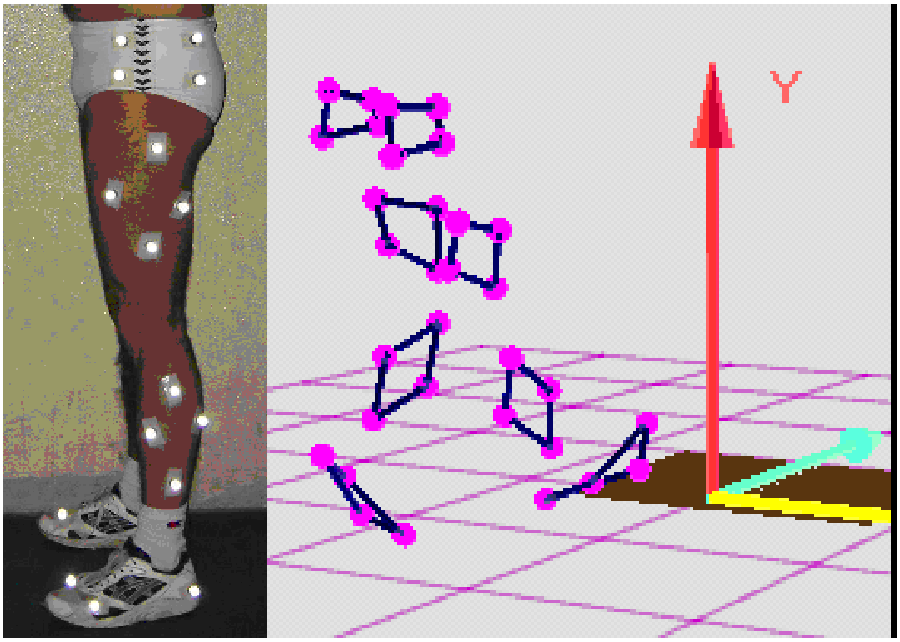

Figure 1: The marker set CAST volleyball and the reconstruction of a spiking trial

The markers were fixed to the player's skin and shoes and a series of anatomical calibrations were performed. After a 10 minute warm-up, the players executed the following trials in order:

1. 20 spikes: players had to touch a Vertec jump monitor (Sports Imports, USA) as high as they possibly could, and the measurement of the height reached in each trial was registered.
2. 10 blocks performed moving laterally to the left to a target (ball hung from the ceiling over the net at a height of 2.5 m) and 10 blocks moving to the right with the same target.

Movements were repeated twice for a total of 60 jumps: 40 blocks and 20 spikes. The total number of jumps, plus warm-up simulated a normal match or training session of volleyball. To prevent any effects of fatigue, a rest of 30 seconds between trials and a pause of 3 minutes between series was performed.

After tracking, because there was marker occlusion or trajectory gaps longer than 20 samples only 14 spikes, 9 trials blocking to the left and 13 moving to the right were analysed.

The jump height was calculated as the difference between the height of the COM of the lower limbs at the peak of the jump and at the take-off. The Range of Motion (ROM) of the COM was defined as the difference between maximum and minimum values of the COM.
Joint angles were calculated in the sagittal plane according to Grood and Suntay convention, (1983).

Mean, Standard Deviation and Coefficient of Variation of the dependent variables (jump height, flight time, ankle knee and hip joint angles at the moment of the countermovement) were calculated.

RESULTS: Table 1 shows the mean, standard deviation and coefficient of variance of the temporal and spatial variables of the 3 movements.

Table 1 Temporal and spatial variables

	Flight time (msec)	Upward motion time (msec)	COM max (mm)	COM min (mm)	ROM (mm)	Jump Height (mm)
Block to the left	618±41	316±31	667±15	315± 4	353±13	283±38
Block to the right	589±28	292±25	661±9	304± 4	357±11	252±34
Spike	634±12	293±13	732±10	323± 11	410±11	291±18
CV for block to the left	7	10	2	1	4	14
CV for block to the right	5	9	1	1	3	14
CV spike	2	4	1	4	3	6

In Table 2 displays the flexion-extension angles (according to Grood and Suntay convention, 1983) of the ankles, the knees and the hips at the moment of the minimum value (lowest vertical point) reached by the COM during the countermovement executed before the jump.

Table 2 Ankle, knee and hip angles (degrees) during the countermovement

Joint Angles (degree)	Right ankle	Left ankle	Right knee	Left knee	Right hip	Left hip
Block to the left	30 ± 2	34 ± 3	61 ± 2	66 ± 3	28 ± 4	39 ± 3
Block to the right	33 ± 2	41 ± 3	42 ± 3	92 ± 4	22 ± 2	52 ± 8
Spike	21 ± 5	20 ± 4	63 ± 7	69± 5	30 ± 4	43 ± 7
CV for block to the left	7	9	2	3	13	7
CV for block to the right	8	8	2	4	8	16
CV spike	23	21	6	5	15	17

DISCUSSION: The results of the jump height confirmed the previous findings of Lobietti et al (2005): this hitter performed the highest jump when spiking (291 ± 18 mm), then blocking to the left (283 ± 38 mm) and the lowest elevation when blocking to the right (252 ± 34 mm). She showed a higher repeatability in jumping to spike (CV=6%) whereas when blocking, the variability was higher than spiking but similar in the two block directions (CV=14%). Furthermore, the ROM of the COM showed a higher repeatability than jump height in all movements acquired. Thirdly the reliability of the countermovement was similar between trials (spiking CV=2.6%; block in 2 CV=2.9%; block in 4 CV= 3.7%).

Despite the limitations of a case study, it is still interesting to observe that the two legs show similar values for the joint angles when spiking and blocking to the left, whereas going to the right, the left leg (leading the move in a XS) shows larger flexion by all three joints. The knee joint angles showed higher flexion going to the left (92º ± 4) suggesting this might be one of the causes of the player’s poorer performance when moving in this direction. These results are in agreement with the previous biomechanical description of volleyball jumps by Gollhofer & Brun (2003) showing knee flexion data in the countermovement phase of around 70º. The elastic muscular strength is much more effective when the knees are flexed around 65° (as in the spike and moving to the left), whereas going to the right the higher countermovement requires a greater concentric muscular activation during the push-off phase of the jump due to the greater flexion.

CONCLUSION: This study compared the three typical jump movements performed by a volleyball player: the spike, the block moving to the left and the block going to the right. In the present study, only one subject was analysed but the findings confirmed the hypothesis: the XS in blocking to the left is similar in coordination with the spiking approach but different to that when moving to the left. More subjects will be required to reinforce the findings of this study.

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