BLOCKING THE QUICK ATTACK IN VOLLEYBALL: A 3D KINEMATIC ANALYSIS

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The importance of the volleyball block against the quick attack is more important in the modern volleyball with new scoring system. Two types of tactics are used normally: the Read Block System (RBS) and the Commit Block System (CBS). A preliminary study was conducted to identify variables that quantified the differences between these two techniques. Four young players performing the RBS and the CBS were acquired by means of stereo-photogrammetry and kinematic variables were identified. The quantified analysis confirms coaches experience: in the RBS the hands arrive over the net in a shorter time, the feet start "naturally" wider but the jump performed has a lower height with respect to the CBS. Further longitudinal and transversal studies will be conducted with more subjects of different level and gender.

KEY WORDS: volleyball, block, 3D kinematic analysis, quick attack.

INTRODUCTION: The importance of the volleyball block against the quick attack is more important in the modern volleyball with new scoring system. Especially in the set or match ball, setters like to use the quick hitters. The aims of the block are: stuff the ball, to score a direct point, or deflect it to help the floor defence and continue with a counterattack. The Middle Blocker (MB) has the responsibility to protect the middle zone of the net against all quick attacks, yet he has also to form tight block against other opponent attacks moving laterally. Players have to decide between two types of tactics: the Read Block System (RBS) or the Commit Block System (CBS). In the first case, the blocker starts close to the net looking to the opponent's setter, with hands up and bent legs, ready to react jumping vertically from this position, in case of the quick set, or to move feet and follow the ball, in case of an outside set. Outside blocker (OB) starts also ready to help the MB against the quick set or to move laterally against an outside set in front of him. In the second tactic system, the MB has to jumps at the take off of the quick hitter's spike without worrying about the set. OBs starts wider, not worrying about the middle attack, and wait for his direct opponent.
Several aspect of the volleyball block have been analysed in previous studies. Different footwork techniques were investigated using the analysis of the timing (Cox 1982, Chang-Soo et al. 1989, Buekers 1991), by means of stereo-photogrammetry (Lobietti et al. 2005) and of force platforms (Chang-Soo et al. 1989). Gollhofer and Brun (2003) studied the volleyball jumps by means of electromyography and force platforms. Coleman (1994) described qualitatively the biomechanics of the block proposing a new starting position for the RBS with feet wider, in order to allow the player to react more promptly. The movement of the arm at the net was also investigated by means of video analysis (Lehnert et al. 2001). Kinematics characteristics of movement and block jump height were positively affected by dropping hands during lateral displacement (Lehnert et al. 2001). However, no quantitative comparison between the two block system by means of an accurate 3D kinematic analysis of total body, such as stereo-photogrammetry, was performed.
The purpose of this preliminary study was to identify differences in the execution of the two block systems by means of a total body 3D kinematic analysis. From these information coaches will be able to decide between the two types of tactics not only from opponent observation but also from technical characteristics of blockers, inter-individual and role difference.

METHODS: Four (1 and 2 are OB, 3 and 4 are MB) male volleyball players (age 16,5 ± 1 y, height 182,7 ± 2,8 cm, weight 72 ± 5 Kg) of an Under 18 Team were acquired during blocking exercises. Players had 4 years experience of playing volleyball and had a similar

experience in the tactics of the RBS and CBS. A previous informed consent from the subjects was obtained.
3D kinematics was estimated by means of stereo-photogrammetry (Vicon Motion Systems, Oxford, UK). Six infrared cameras (max resolution 300.000 pixel, frequency 100 Hertz) filmed 33 passive markers (25 mm) attached to different anatomical landmarks. Four additional markers where fixed to the net. Helen Hayes protocol (2000) was used.
Players started in a natural ready position close to the net and they had to execute the block trying to reach the maximum elevation of the jump and the maximum hands penetration of the plan of the net. In the CBS, the player decided by himself when to jump. Whereas, in the RBS, the player was prompt to react, reading the coach miming of the opponent set in all the three possible directions (left, right, or up) and then move or jump consequently. Three trials for each type of block were acquired. The best trials were identified from the maximum elevation for the CBS and from the reaction time of the vertical jump for the RBS.
Variables Analysis
The following variables were selected: temporal phases of the block, hands time to arrive over the net, elevation and max displacement of the centre of mass (COM), feet distance (calculated as the distance between left and right toes), knee and hip angles, penetration angle (calculated as the mean value of angles between the forearms and the vertical axis of the net), and the angle between the hand and the forearm (mean value of the wrist angles).

RESULTS: In table 1 temporal data of different phases of the jump, displacement of the Com, elevation and distance between feet in the starting position and vertical velocity at T.O were reported.
Data regarding knee angle value in principal phases of the jump were shown in table 2.
In table 3 the upper limbs parameters were reported.

TAB. 1

Subject	**Duration (sec)**				**Distance (cm)**			**Velocity (m/sec)**
	preparatory phase	**push-off phase**	**flight phase**	**total time**	**Range of movement of the COM**	**Elevation of the COM**	**Feet distance at T.O.**	**Vertical at T.O.**
1CBS	0,49	0,39	0,61	1,49	1151	477	346	3,19
2 CBS	0,27	0,31	0,61	1,19	992	450	273	3,12
3 CBS	0,51	0,29	0,60	1,40	934	434	269	3,03
4 CBS	0,25	0,30	0,59	1,14	927	408	412	3,05
1 RBS	0,46	0,29	0,57	1,32	863	400	414	2,99
2 RBS	0,20	0,25	0,57	1,02	782	384	343	2,98
3 RBS	0,04	0,18	0,55	0,77	671	344	410	2,73
4 RBS	0,02	0,14	0,53	0,69	636	328	484	2,70
M	0,28	0,27	0,58	1,13	870	403	369	2,98
SD	0,19	0,08	0,03	0,29	170	51	75	0,17
MIN	0,02	0,14	0,53	0,69	636	328	269	2,70
MAX	0,51	0,39	0,61	1,49	1151	477	484	3,19
CV	69,1	29,2	5,0	25,5	19,6	12,6	20,3	5,8
Mean CBS	0,38	0,32	0,60	1,31	1001	442	325	3,10
Mean RBS	0,18	0,22	0,56	0,95	738	364	413	2,85
SD CBS	0,14	0,05	0,01	0,17	104	29	68	0,07
SD RBS	0,20	0,07	0,02	0,28	104	34	58	0,16

The MBs, as shown in table 1, had shorter preparatory phase (0,02 and 0,04 sec) in the RBS whereas OBs (0,46 and 0,20) flexed more the legs and spent more time in both preparatory

and push off phases. In the CBS, players jumped higher (mean value of the difference is 7,8 cm); feet were narrower (about 9 cm) than in the RBS.

TAB. 2	Type of jump	Sub.1 OB	Sub.2 OB	Sub.3 MB	Sub.4 MB	MEAN	SD	CV
Hip Angle Max flexion (deg)	CBS	77	92	94	91	88	7	7,4
	RBS	97	106	128	121	113	12	10,8
Knee Angle Max flexion (deg)	CBS	68	74	75	95	78	12	15,1
	RBS	84	106	100	105	99	10	10,2
Knee Angle at Starting Position (deg)	RBS	114	124	110	105	113	8	7,3
Countermovement of the knee in RBS(deg)	Delta	30	18	10	0	15	13	86

All the players started in the RBS with legs flexed: the mean value of the knee angle at the starting position was 113° ± 8° and the variability was not so high (C.V.=7,3). The maximum value reached by the hips angle in the CBS was also similar among subjects (C.V.=7,4). All the players flexed their hips and knees more in the CBS than in the RBS. The countermovement of the knee in RBS was very different when comparing the two MBs (Delta=10° and 0°) and the two hitters (30° and 18° of Delta).

TAB. 3	$1C_{BS}$	$2C_{BS}$	$3C_{BS}$	$4C_{BS}$	$1R_{BS}$	$2R_{BS}$	$3R_{BS}$	$4R_{BS}$	MEAN	SD	MIN	MAX	CBS	RBS
Hands time to arrive over the net (sec)	0,91	0,63	0,84	0,62	0,81	0,52	0,18	0,20	0,59	0,28	0,18	0,91	0,75 ± 0,15	0,43 ± 0,30
Penetration Angle (deg)	128	133	143	138	140	140	144	141	138	6	128	144	135 ± 7	141 ± 2
Wrist Angle (deg)	164	156	162	158	164	166	156	162	161	4	156	166	160 ± 4	162 ± 4

Data related to the hands movements shown a shorter time of the MBs to arrive over the net in the RBS with respect to the CBS. For OBs this difference was negligible. The penetration angle and the wrist angle at the moment of the maximum elevation of the COM is similar in both type of tactics.

DISCUSSION: Two different blocking system, RBS and CBS, to the quick attach were compared by means of 3D kinematic analysis of total body. In this preliminary study, four players were acquired. In the RBS, the elevation was lower, the hands time to arrive over the net shorter and the feet naturally wider. The knee and the hip were more flexed in the CBS. The quantitative upper limbs analysis showed similar penetration and wrist angle over the net, although reached with different movement strategies.

In the CBS, a countermovement permitted to jump higher. This can be explained by the eccentrically preloading of the hip extensors and of the knee flexors as described previously in a standard block jump by Gollhofer and Brun (2003). On the other hand, the starting position of the RBS requires directly to jump without any countermovement. Thus, the characteristic of the movement, although with higher knee flexion angles (mean value of 113°), can be considered similar to a squat jump (90°). As observed by Komi (1983) the

countermovement jump allows the athletes to perform a higher jumps with respect to the squat jump. Furthermore, in the CBS, the higher elevation was affected by the arms countermovement. This is true not only in a block after a lateral movement (Lehnert et al. 2001) but also in a vertical block jump as analysed in the present study. However, the lower elevation of the RBS was compensated by a shorter time necessary to the hand to arrive over the net. This was true only for the MBs that were faster to arrive to the target (Table 3) and had only little countermovement.
The wider position of the feet in the RBS confirms the observations of previous studies (Coleman et al. 1994, Lehnert et al. 2001). Our players were not instructed to start in different position in the two types of blocking system. Thus, during the RBS trials they start naturally at the net with hands up, legs bent (knee angle around 110° deg) and feet wider. These results suggested that this starting position is an automatic choice by the players in order to be ready to go to block all types of opponent sets.
For the first time, to the knowledge of the present authors, data relatives to the position reached by the hands (penetration of the plan of the net) and wrist angles were presented. The 160° found between the hands and the forearms fit well with coaches requirements: to open hands as much as possible and aligned with the forearms in order to form a good solid and firm block.
A limit of this, as well as all previous studies, is the absence of the ball and of the attackers. Thus the current results should be considered as a description of a typical blocking drill session.

CONCLUSIONS: The method is useful and permits to analyse volleyball blocking movements in order to identify differences in kinematics parameters. Although with few players, some differences between the RBS and the CBS were found. Although with different movement strategies the efficiency of the block can be reached in both tactics. These information are fundamental for coaches to teach and train the blockers technically.
Further longitudinal studies will be conducted in order to study the improvement of the players blocking ability. Further transversal studies with a larger number of players will be conducted as well to find difference between roles, levels and genders.

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