

BIOMECHANICAL ANALYSIS OF THREE DIFFERENT BLOCKING FOOTWORK TECHNIQUES IN VOLLEYBALL: A PILOT STUDY

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The purpose of this study was to analyse three different blocking footwork techniques in volleyball. In particular the attention was focused on the correlation between anthropometric and kinematic parameters. Three female athletes playing in the first national league were recruited for a pilot study. Bosco tests were executed to have a morphological classification. A stereophotogrammetric system was used to acquire three blocking footwork techniques: slide step, running and jab cross over patterns. Parameters of interest included the blocking time, the jump height, the horizontal and vertical speed of the centre of mass, the frontal position of the body with respect to the net and the invasion angle of the hands over the net. A correlation between jump height and blocking time was observed only in the running step technique. The time of centre of mass maximum speed was significantly less for the jab cross-over step technique. The most effective blocking technique for every athlete was finally obtained.

KEY WORDS: volleyball, blocking, step technique.

INTRODUCTION: During the last two decades a number of studies have been performed on various aspects of volleyball. Only a few of them were devoted to the defensive aspect of the game, specifically to the skill of blocking. This is one of the most difficult volleyball fundamentals to master because it depends on many different factors, including jumping ability, speed of movement, anticipation and decision making. In particular, Cox (1978) was the first to investigate the most effective blocking footwork technique in long distances. The slide step, cross-over step, and jab cross-over step techniques were analysed and the slide step resulted to yield significantly shorter movement times than the other two techniques. In addition, it was concluded that the cross-over step technique was faster than the jab cross-over. Buekers (1991) also tested another technique, the running step. He concluded that the optimal step technique should vary as a function of the lateral distance to be covered. The purpose of the present study was to further investigate the blocking kinematic analysis by including a morphological characterization of the athletes. In particular the relationship between selected kinematic variables involved in the blocking action, like relative effectiveness of utilizing slide step, running and jab cross-over patterns, is studied. These findings could help in describing the parameters of a personal training program.

METHOD:

Data Collection: For this pilot study three female volunteer volleyball players from Megius Volley Club team of Padova (first national league), were recruited, aged from 22 to 25 years. Written informed consent was obtained from all the subjects. Three Bosco tests were executed: Squat Jump (SJ), Counter Movement Jump (CMJ) and Stiffness or Series of Jumps (SJ). A stereophotogrammetric system (BTS, Padova) composed by 6 cameras working at 60 Hz was used to acquire the blocking movement. An appropriate "full-body" marker-set (Figure 1), designed to give a description of both upper and lower limb kinematics was conceived. It consisted of 42 reflective markers applied to hands, forearms, arms, trunk, pelvis, thighs, shanks and feet. This protocol allows to obtain as much information as possible on the movement of the whole body, from the lower limb position to the invasion angle of the hands over the top of the net. After a self-directed warm-up, each subject performed three variations of lateral translation: slide step, running step, jab cross-over step with the task of blocking the lateral spike coming from an opposing player. Each type of translation was recorded at least three times.

Data Analysis: On the basis of jump characteristics obtained through Bosco tests, a morphological classification of the athletes was obtained following Mencarelli (*report of Level IV Course for Volleyball National Coaches*). An athlete is classified as “reactive” if the contact time is less than 222 ms and mean height for SJ is superior to 87.4% of the height reached with the CMJ. A subject is considered “elastic” if the increment of height between SJ and CMJ is more than the 4.4% of the mean height of the SJ. Finally an athlete is defined “strong” if the jump height values for the SJ test are greater than 93.8% of the CMJ value.

3D marker coordinates were interpolated and filtered and the three acquired repetitions of every variation were normalized and averaged, using laboratory software. Three principal kinematic parameters were evaluated:

- the frontal position of the body with respect to the net in the range of time which goes from the take-off to the instant of impact with the ball,
- the position of the hands during the flight phase,
- the vertical and horizontal velocities of the body centre of mass (COM) during lateral movement and jump.

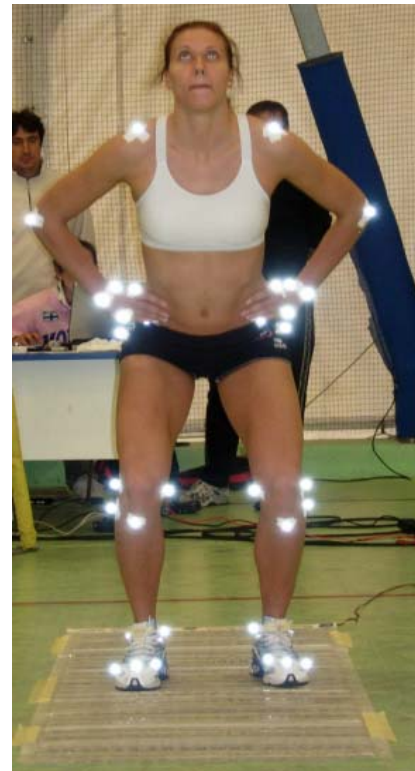


Figure 1: “Full-body” markerset

Trajectories and velocities of the centre of mass were estimated adopting the Dempster convention. The effects of the three footwork techniques on blocking performance (analysis of jump height, lateral movement and jump speed) were then assessed using mean, standard deviation and analysis of variance (Mann-Whitney Test). Correlation between variables was evaluated through a regression analysis.

RESULTS: We first focused on the difference among the three techniques without taking into account the peculiarities of the subjects. The investigated variables were the jump height, represented by the difference between the maximal height reached by the COM during the jump and its position at the take-off, and the time of lateral movement and jump. Analysis of variance showed no significant difference ($p > 0.05$) among the three techniques.

An interesting correlation between the jump height and the blocking time was present in the running step technique ($R=0.86$), while absent in the others.

The body frontal position was estimated, frame by frame, through the analysis of pelvis (angle between the anterior iliac spines and the net) and shoulder (angle between the acromions and the net) orientation in the transversal plane. The angles, averaged among the three repetitions of every trial, were plotted for every subject to assess the differences among the three footwork techniques. Figure 2 shows the evolution of the pelvis angle as function of the percentage of time between the take-off and the end of the jump. The invasion of the hands was summarized in a similar plot (not shown).

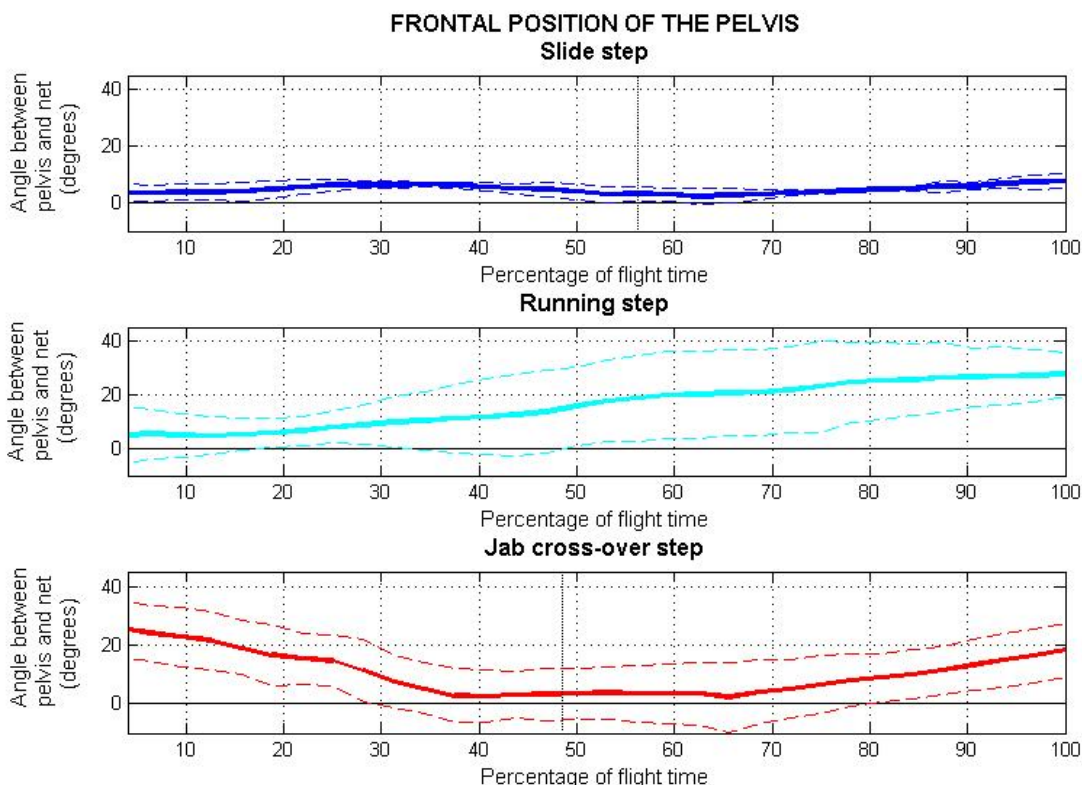


Figure 2: Body frontal position with respect to the net for subject 3

The percentage of flight time at which the impact with the ball occurred are reported in Table 1.

Table 1: Percentage of flight time at which the impact on the ball occurs

Instant of impact (% flight phase)	Slide Step	Running	Jab Cross-Over
# 1	56.2%	48.5%	51.5%
# 2	57%	46.9%	51.5%
# 3	56.2%	40%	48.6%

The maximum value of COM vertical speed did not reveal any particular difference among the three techniques, but the instant of time in which the maximum speed is reached was significantly less for the jab cross-over step technique.

DISCUSSION: In contrast with previous studies, the three investigated footwork techniques did not differ substantially. Performance time and jump height were not significantly different among the three footwork techniques.

Correlation analysis shows that the running step is the only technique providing higher jumps for longer performance times. This could be explained by a longer time spent in loading before the jump; however this hypothesis should be further investigated on a larger number of subjects.

Analysing the athletes separately, we received confirmatory support of the idea that each athlete should use the technique more adapt to her physical characteristics and role. Subject 3, for example, who plays as middle blocker, is accustomed to adopt the running step technique, in which she presented the best translation time values. In contrast, with

reference to the jab cross-over pattern time standard deviation is very large, pointing out a poor movement repeatability, thus proving athlete's difficulty in adopting this skill.

From the time values of Table 1 we could see how the three footwork techniques had different intervention times. The best blocking performance is achieved when the jump is at its maximum height, approximately around 50% of the flight time. The time data were compared to the analysis of the vertical speed of the COM. From this analysis the jab cross-over technique appeared to be the only strategy allowing the athlete to reach the maximum vertical speed in the instant of impact on the ball. When using the slide step technique, athletes tended to jump too early, whereas the running step technique seemed to cause a slight delay in the jump.

The stereophotogrammetric examination evidenced the following differences in the three subjects. Subject 1, classified as strong and elastic, expressed her best with the slide step technique. From SJ and CMJ tests, reached blocking heights and contact times, we infer that this athlete needs a countermovement in order to reach a high elevation. The footwork technique which enables her best performance should comprise a quick lateral movement time to make up for the delay caused by the loading movement. Subject 2, even if classified as strong and not elastic, had a very short contact time, together with a low jump height. This suggests that an increase in the loading time could lead to a better performance. Subject 3 was classified as reactive and elastic. This was largely confirmed by the kinematic data: jump height, vertical speed and movement correctness were optimal in the running technique. Her blocking footwork technique should then include very fast final steps, in order to best exploit her stiffness.

CONCLUSION: This pilot study evidenced the differences among three blocking footwork techniques in volleyball. The analysis helped the athletes in finding their most effective blocking method and the coach in conceiving a training strategy to improve all the three techniques.

A future study on a larger number of subjects could permit a better quantitative inspection of the relation between the athlete's morphological characterization and the blocking technique most suitable for him/her.

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