International Journal of Sport, Exercise & Training Sciences

e-ISSN 2149-8229 | Vol 6, Issue 2, 73–79, (2020) | *Original Article*

http://dergipark.gov.tr/useeabd

# The kinematical analysis of blocking skill in volleyball and their relationships with the explosive force of lower limbs

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**Abstract**

**Aim:** The study aims to conduct a kinematical analysis of blocking skill in volleyball and their relationships with the explosive force of lower limbs, for the athletes from the elite Algerian team.

**Methods:** A total of 06 male Volleyball Players from the elite Algerian team as volunteers (Age: 25.66+3.32 yr, Length:198.00+3.68 cm, Weight: 86.66+6.62 kg). We used for kinematical analysis the software Dartfish9. For video capturing, we used three cameras (AEE Magic Cam) for record the performance during an Experimental competition, two $CAM^{I\&II}$($^{X}$1m, $^{Y,Z}$1.5m) were placed in the sides of volleyball Court, and $CAM^{III}$($^{X}$4.5m,$^{Y}$1m, $^{Z}$1.5m) behind the elite Algerian team. Also, two force Explosive tests were executed; Squat Jump (SJ) and Counter Movement Jump (CMJ). The data were analyzed in SPSS 22.0 program. Descriptive statistics (mean±SD) and P test for the correlations between variables studied.

**Results:** Through the statistical analysis, there were significant correlations between values of CMJ test with both of the $^{D}Height_{BCG}$ ($p<0.01$), & $^{D}$Max height ($p<0.01$), and between variable $^{D}$Max height with each of the $^{\circ}$Trunk ($p<0.01$), & $^{\circ}$Knee ($p<0.01$), and $^{D}Low_{BCG}$ ($p<0.01$), and $^{D}Height_{BCG}$ ($p<0.01$) respectively, at the 0.05 level. Also, between $^{D}Low_{BCG}$ with $^{\circ}$Trunk ($p<0.01$), and with $^{\circ}$Knee ($p<0.01$).

**Conclusion:** This study was able to produce results that are helpful to coaches when deciding when they are considering vertical jump heights during the performance of blocking skill in volleyball, through: developing the technical aspect of the blocking skill by training players to improve the kinematical properties of a certain degree; especially, the angles of the lower limbs of the body, such as the angles of the trunk, knee, and ankle.

**Keywords**

Kinematical Analysis, Volleyball, Blocking Skill, Explosive Force,

**Article Info**

Received: 04.05.2020

Accepted: 28.06.2020

Online Published: 30.06.2020

**DOI:**10.18826/useeabd.731462

## INTRODUCTION

Volleyball is one of the most popular team sports games in the world. Pass, set up, attack, block, etc., can be mentioned as examples of individual basic skills creating the game. All of them utilize various motor skills and abilities as jumps, swings or different ways of locomotion as well as power, agility, flexibility and speed of reaction (Lehnert et al. 2017), The spike, block and serve are the three most important skills to score points in volleyball (R. Lobietti, Michele, and Merni 2006), In volleyball, the skill of blocking, in which a player or players jump and extend their hands above and over the net (without touching the net) to block an attack (spike) by the opponent, is crucial to team success (Ficklin, Lund, and Schipper 2014), Blocking in volleyball is a very important skill, this is particularly true at the more advanced and competitive levels, Blocking has been associated with a team's winning percentage, Next to spiking, the team with the best blocking will most likely win (Farokhmanesh and McGown 1988). According to Lobietti (2009), a successful defense in the game of volleyball starts with a well-trained and disciplined block, blocking in volleyball is one of the key components to a team's success. As volleyball has evolved and spiking has become more powerful, the skill of blocking has become a crucial aspect of the game and is highly correlated with team success (Lobietti 2009).

The vertical jump is a fundamental part of the spike, block, and the topspin and floating serves (Borràs et al. 2011). Successful performance in volleyball often depends on the ability of the individuals to perform high enough high jumps (Milosevic et al. 2000). Vertical jumping is probably the most important manifestation of explosive strength in volleyball (Borràs et al. 2011). Jump height achieved in countermovement jumping is also correlated to the height achieved in spike jumping for the attacker

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(Wagner et al. 2009). The use of strength during the play is determined by the fact that the usage of maximum strength lasts from 0.5 to 0.7 seconds; however, most of the explosive moments take substantially less time. For this reason, the optimal usage and transformation of the gained maximum muscle strength into the "explosivity" of the main muscle group of the lower limbs, which take part in the takeoff, require special power training (Lehnert, Lamrová, and Elfmark 2009). Specific jumping can be measured in different ways (Lidor and Ziv 2010). Most frequently used nonspecific tests for assessing jumping are squat jump, countermovement jump without arm swing and countermovement jump with arm swing (Glatthorn et al. 2011).

Biomechanics has been defined as the study of the mechanical laws relating to the movement or structure of the living organism, an analysis of the biomechanics of the specific skills that are performed by volleyball athletes permit optimal sports performance while minimizing the injury (Reeser and Bahr 2017). Examples of well-known athletes easily display the importance of biomechanical technology in improving performance (Zahálka et al. 2017). Kinematics is the study of bodies in motion without regard to the causes of the motion. It is concerned with describing and quantifying both the linear and angular positions of the bodies and their time derivatives (Harpreet S et al. 2017). The assessment of relevant biomechanical factors of performance is essential for appropriate training progression, especially at high skill levels (Fuchs et al. 2019). As the biomechanical analysis of sports performance provides an objective method of determining the performance of any particular sporting technique (Abdelkader et al. 2018), because it is a science concerned with studying kinetic technology and movement performance in order to make the skill work well and this requires various elements of physical fitness from speed, flexibility, agility, and great muscles force. Therefore, this study was aimed to the kinematical analysis of blocking skill in volleyball and their relationships with the explosive force of lower limbs, for the athletes from the elite Algerian team. In order to determine the kinetic transfer mechanism by transferring muscular force to give a better model of mechanical blocking skill.

## METHOD

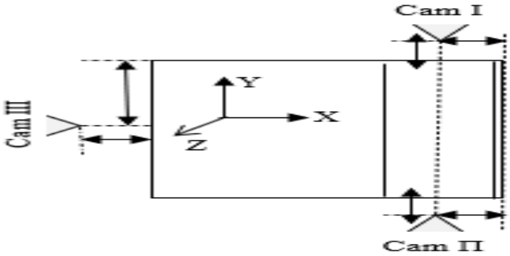
### Participants

The Ethics committee protocol was approved by the institute of physical and sport education, laboratory of physical and sports activity, society, education, and health in Hassiba Benbouali University of Chlef Algeria on 31.07.2016 with 935 number. A total of six healthy male Volleyball Players from the elite Algerian team provided their informed consent to participate in the study as volunteers. They averaged 25.66±3.32 years of age, 14.33±4.27 years for experience, 1.98±0.36 m in height, and 86.66±6.62kg in mass. Four athletes were right-hand dominant and two were left-hand dominant. To ensure the athlete's eligibility for the study, we collected a brief medical history from each athlete. None reported a history surgery and none complained of pain at the time of the testing.

***Research Design and Data Collection:*** In this study, we have analyzed the kinematic variables of volleyball blocking skill in two-dimensional. The analysis of the present study was with the software Dartfish 9 (release 5-9.0.11219.0), the video capture of volleyball blocking skill with three cameras (AEE Magic Cam, 170° view, MOV Format Video, 720p Video Resolution, 120 ips NTFS, Screen Resolution 1280*720 16:9). Sites of the three cameras depicting the blocking skill in volleyball as Fig.1.two CAM$^{I \& II}$ were placed in the sides of the volleyball Court from the right and left ($^{X}$ 1m, $^{Y, Z}$ 1.5m), and the third CAM$^{III}$ was behind the elite Algerian team ($^{X}$4.5m, $^{Y}$1m, $^{Z}$1.5m). Also, two force Explosive tests were executed; Squat Jump (SJ) and Counter Movement Jump (CMJ).

Each athlete was required to wear tight-fitting clothing (i.e. spandex shorts and a sleeveless shirt). The tape Reflective markers were bilaterally attached on the surface of the skin over the following Joints; the neck, wrist, hip, knee, and ankle. Reflective markers on all volunteers were attached by one investigator. Also, all athletes were encouraged to warm up according to the normal routine to ensure optimal performance. Once warmed up, the athletes performed a Friendly Experimental competition with a team from the first division in Volleyball (CRBC Team), the data were collected from the best blocking skill in volleyball of our sample (the athletes of Algerian National Elite). Data collection occurred in Harcha Hacen multisport hall, Algiers by the researchers (APAAS Laboratory, Chlef, Algeria).

**Fig.1.**Distance sites of the three cameras used for capture video




***Kinematic Variables:*** Based on similar studies, we were choosing the following kinematical variables for the analysis; Times ($^{T}$Absorption, $^{T}$Pushing, $^{T}$Takeoff/Flight, $^{T}$Height **BCG**), angles ($^{\circ}$Trunk, $^{\circ}$Knee, $^{\circ}$Ankle), Distance ($^{D}$Low **BCG**, $^{D}$Height **BCG**, $^{D}$Max height), and Velocity of Body's center of gravity (Velocity **BCG**).

### Statistical analysis

The data analysis procedures used in this study consisted of the computation of the means, standard deviations (SD), variance as descriptive statistics, and the Pearson Test for the correlations between all variables identified in based on similar studies. Statistical results were analyzed at ($p<0.05$) and ($p<0.01$) significance levels. We used SPSS (SPSS for Windows, version 22.0, SPSS Inc. Chicago, Illinois, USA) statistical program for that analysis of the data obtained.

## RESULTS

**Table 1.** Description results of the analysis of the kinematical variable of blocking in volleyball

| Variables | | | Mean ± SD | Variance | Min Value | Max Value |
|---|---|---|---|---|---|---|
| **Kinematics** | **Time (s)** | **$^{T}$Absorption** | 0.032±**0**.006 | 0.000 | 0.023 | 0.043 |
| | | **$^{T}$Pushing** | 0.026±**0**.004 | 0.000 | 0.020 | 0.033 |
| | | **$^{T}$Takeoff/Flight** | 0.060±**0**.006 | 0.000 | 0.047 | 0.067 |
| | | **$^{T}$Height $_{BCG}$** | 0.056±**0**.006 | 0.000 | 0.050 | 0.067 |
| | **Angle (°)** | **$^{\circ}$Trunk** | 27.250±5.972 | 35.659 | 18.000 | 36.000 |
| | | **$^{\circ}$Knee** | 84.000±9.155 | 83.818 | 70.000 | 98.000 |
| | | **$^{\circ}$Ankle** | 75.833±5.781 | 33.424 | 69.000 | 89.000 |
| | **Distance (m)** | **$^{D}$Low $_{BCG}$** | 0.833±**0**.072 | 0.005 | 0.690 | 0.930 |
| | | **$^{D}$Height $_{BCG}$** | 1.660±**0**.033 | 0.001 | 1.600 | 1.710 |
| | | **$^{D}$Max height** | 2.858±**0**.038 | 0.001 | 2.790 | 2.920 |
| | **Velocity $_{BCG}$(m/s²)** | | 30.550±2.884 | 8.316 | 25.870 | 34.890 |
| **Explosive Force** | **Squat Jump $_{SJ}$(m)** | | 0.960±0.084 | 0.007 | 0.840 | 1.060 |
| | **Counter Movement Jump$_{CMJ}$(m)** | | 0.788±0.062 | 0.004 | 0.713 | 0.860 |

Table 1. shows the description results of the analysis of the kinematical variables during the performance kinetic of blocking skill in volleyball, the results explain the values of mean±SD, variance, minimal and maximal values of variables.

**Table 2.** The connectivity relationships between kinematic variables and SJ, CMJ tests.

| Variables | SJ | | CMJ | |
|---|---|---|---|---|
| | Correlation Coefficient | Sig. p | Statistic | Sig. p |
| **$^{T}$Absorption** | -0.459 | 0.067 | -0.475 | 0.059 |
| **$^{T}$Pushing** | -0.311 | 0.162 | -0.327 | 0.150 |
| **$^{T}$ Takeoff/Flight** | 0.104 | 0.374 | 0.206 | 0.260 |
| **$^{T}$Height BCG** | -0.420 | 0.087 | -0.543 | 0.034* |
| **$^{\circ}$ Trunk** | 0.258 | 0.209 | 0.677 | 0.016* |
| **$^{\circ}$ Knee** | -0.533 | 0.037* | -0.610 | 0.018* |
| **$^{\circ}$Ankle** | 0.287 | 0.183 | 0.352 | 0.131 |
| **$^{D}$Low BCG** | -0.225 | 0.241 | -0.775 | 0.030* |
| **$^{D}$Height BCG** | 0.521 | 0.041* | 0.815 | 0.001** |
| **$^{D}$Max height** | 0.776 | 0.030* | 0.816 | 0.000** |
| **VelocityBCG** | 0.257 | 0.210 | 0.358 | 0.127 |

***p<0.05**** **Correlation is significant at the 0.05 level. p*<0.01*** Correlation is significant at the 0.01 level.**

Table 2; shows the correlation results between kinematic values analysis for our sample in the performance of blocking skill in volleyball and the explosive force tests squat jump (SJ) and countermovement jump (CMJ). Positive significant correlations were observed between values of the countermovement jump test with the angle of the trunk (P<0.05), and values of squat jump test with the distance of height BCG (P<0.05), and with the distance of max height (P<0.05); also, between values of countermovement jump test with the distance of height BCG (P<0.01), and with the distance of max height (P<0.01).

**Table 3.** The connectivity relationships between kinematics variables of study during the performance.

| Variables | Time (s) | | | | Angle (°) | | | Distance (m) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Absorption | Pushing | Takeoff/Flight | HeightBCG | Trunk | Knee | Ankle | LowBCG | HeightBCG | Max height |
| TPushing (s) | 0.295 | | | | | - | | | | |
| | 0.176 | | | | | | | | | |
| TTakeoff/Flight | -0.245 | 0.065 | | | | - | | | | |
| | 0.222 | 0.420 | | | | | | | | |
| THeightBCG | 0.089 | -0.019 | -0.228 | | | | - | | | |
| | 0.391 | 0.477 | 0.238 | | | | | | | |
| °Trunk | 0.179 | 0.386 | -0.338 | -0.003 | | | - | | | |
| | 0.289 | 0.108 | 0.141 | 0.496 | | | | | | |
| °Knee | -0.062 | -0.069 | 0.378 | -0.220 | -0.753** | | | - | | |
| | 0.424 | 0.415 | 0.113 | 0.246 | 0.002 | | | | | |
| °Ankle | -0.456 | -0.326 | 0.403 | -0.521* | -0.543* | 0.424 | | | - | |
| | 0.068 | 0.150 | 0.097 | 0.041 | 0.034 | 0.085 | | | | |
| DLowBCG | -0.202 | -0.176 | 0.321 | -0.341 | -0.828** | 0.865** | 0.312 | | - | |
| | 0.264 | 0.292 | 0.155 | 0.139 | 0.000 | 0.000 | 0.162 | | | |
| DHeightBCG | -0.264 | -0.120 | 0.062 | 0.166 | 0.622* | -0.623* | 0.151 | -0.769** | - | |
| | 0.204 | 0.355 | 0.425 | 0.303 | 0.015 | 0.015 | 0.320 | 0.002 | | |
| DMax height | 0.030 | 0.121 | -0.284 | -0.093 | 0.833** | -0.727** | 0.065 | -0.845** | 0.810** | - |
| | 0.463 | 0.354 | 0.185 | 0.386 | 0.000 | 0.004 | 0.421 | 0.000 | 0.001 | |
| VelocityBCG | -0.421 | -0.158 | 0.457 | -0.560* | -0.281 | 0.504* | 0.534* | 0.532* | -0.070 | -0.121 |
| | 0.087 | 0.312 | 0.068 | 0.029 | 0.188 | 0.047 | 0.037 | 0.037 | 0.414 | 0.354 |

*p<0.05** **Correlation is significant at the 0.05 level.** *p<0.01*** **Correlation is significant at the 0.01 level.**

Table 3; shows the correlation results between kinematic variables for our sample in the performance of blocking skill in volleyball. The significant correlation was observed at the 0.01&0.05 level (1-tailed) and degrees of freedom (n-1) between the values of kinetic. The correlations are positive significant between variables; the distance of Low BCG with the angle of the knee (P<0.01), and between the distance of Max height with the distance of Height BCG (P<0.01). Also, between the distance of Height BCG with angle of Trunk (P<0.05), and between Velocity BCG with angle of Knee (P<0.05), and with the angle of Ankle (P<0.05), and with the distance of Low BCG (P<0.05).

The correlations are negative significant between variables; angle of Knee with the angle of Trunk (P<0.01), and between the distance of Low BCG with angle of Trunk (P<0.01), and between the distance of Height BCG with the distance of Low BCG (P<0.01), and between the distance of Max height with angle of Trunk (P<0.01), and with the angle of Knee (P<0.01), and with the distance of Low BCG (P<0.01); also between variables of the angle of Ankle with time of Height BCG (P<0.05), and with the angle of Trunk (P<0.05), and between the distance of Height BCG with angle of Knee (P<0.05), and between Velocity BCG with the time of Height BCG (P<0.05).

## DISCUSSION

The results of correlation between variables in our study (Ankle angle with each of the Time of Height BCG & and the Trunk angle) confirmed the previous findings of Lobietti et al 2006; that the legs bent (knee angle around 110°) and feet wider suggest that the starting position is an automatic choice by the players in order to be ready to go to block all types of opponent sets (Roberto Lobietti, Fantozzi, and Merni 2006). Athletes should employ more strength training of lower limb extension, engaging small joint angles ( full squats) (Hartmann et al. 2012).

The player during blocking without approach steps has a stable equilibrium and the BCG is located at a point lower than the spin axis where the player benefits from it. Therefore, he gets more height (Hicham, Bouabdellah, and Yacine 2018). Here, the characteristic of the movement, although with higher knee flexion angles (mean value of 113°), can be considered similar to a squat jump (90°) (Roberto Lobietti et al. 2006); whereas strength and power undoubtedly contribute to jump performance (Sheppard et al. 2008). As volleyball has evolved and hitting has become more powerful and offensive, the skill of blocking became a more crucial aspect of the game, which requires volleyball players to create a more rigid kinetic chain to impart force to the ball during blocking (Linebach 2014).

The study also revealed the results of the relationship between Knee angle with each of the SJ & CMJ tests, that can be explained through countermovement which permitted higher jumps, by the eccentrically preloading of the hip extensors and the knee flexors (Gollhofer and Bruhn 2008); i.e. the low angle of the knee causes the distance of the BCG to decrease. Also, the best blocking performance is achieved when the jump is at its maximum height, approximately around 50 % of the flight time (Donà et al. 2006). Meaning, wherever the explosive force for lower limbs increases, the vertical jump will increase where the vertical distance is equal to the sum of the vertical distances of the steps that preceded it. Thus, it will increase the explosive force to push the body up (Linebach 2014). Nevertheless, the explosive force of lower limbs depends on the degree of the knees flexion which we determined on (5°) in our study, confirming the previous findings of Gollhofer et al 2008; elaborating that the elastic muscular strength is much more effective when the knees are flexed around (6°), whereas going to the higher countermovement requires a greater concentric muscular activation during the push-off phase of the jump due to the greater flexion (Gollhofer and Bruhn 2008). As observed by Komi, the countermovement jump allows the athletes to perform a higher jump with respect to the squat jump (Komi 1983).

When looking at the CMJ as a whole, it is a combination of muscles lengthening and shortening in order to produce a goal (i.e. the jump), The research shows that the CMJ yields a jump height that is greater than its squat jump (SJ) counterpart. Typically, a 20-30% increase above the SJ height, although this may not always be the case (Bosco et al. 1987); where a very strong athlete with poor ability to effectively transfer energy may yield an SJ that is higher than the CMJ (Dias et al. 2011), and this is the athlete that spends a lot of time working on absolute strength and fails to incorporate any plyometric movement in their training (Klavora 2000). This suggests that performances in the CMJ are linked with maximal speed, maximal strength, and explosive-strength. When the CMJ is performed using the arm-swing, performances can be ≥10% higher than when they include no arm-swing (Feltner, Fraschetti, and Crisp 1999).

Ultimately, this study was able to produce results that are helpful to coaches when deciding to consider vertical jump heights. Key points for the effectiveness of the block are anticipation, decision-making, movement speed, and jumping ability (Lobietti 2009), where kinematical analysis is useful and permits to analyze volleyball blocking movement in order to identify differences in kinematics parameters (Roberto Lobietti et al. 2006). The data could be evaluated with coaches alongside strength and conditioning coaches to design effective training modules, specific to (Plyometric) to enhance overall lower extremity strength and explosiveness off the floor (Sato and Mokha 2007).

## CONCLUSION

The kinematical analysis of any technical skill in volleyball includes dividing the movement that we want to analyze in its overlapping sections and knowing the nature of each part of the movement for the purpose of applying the foundations and mechanical and anatomical laws appropriate to the ideal movement technically. A vertical jump begins with a preparatory phase, which involves eccentric muscle activity with gravity providing the driving force and certain degree of flexion at the trunk and knee joints (knee angle around 110°). Since the kinetic transfer from the limbs to the trunk comes from giving the limbs of the body an additional force, it moves from the lower limbs to the top to perform the skill well.

## PRACTICAL APPLICATION

Based on the findings and conclusions of this study for thus we confirm the working on developing the technical aspect of the blocking skill, by training players to improve the kinematical properties of a certain degree; especially, the angles of the lower limbs of the body, such as the angles of the trunk, the knee, and ankle. Moreover, during the movement of blocking skill, core muscles play a very important role in transferring the force from the lower to the upper body. This is particularly emphasized during swift transitions from a pushing into a block jump. The authors suggest further research of explosive force structure for volleyball players. There is especially a lack of longitudinal studies which would analyze the structure of this important motor ability in the period from the start of practicing volleyball up until the peak of the sports career.

Essentially, placing subjects under competitive conditions, subjects may respond with maximal effort. It is recommended that future investigators attempt to use a portable force platform that can be placed on a volleyball court during a game-like or actual competition situation.

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**CITATION OF THIS ARTICLE**

Benelguemar, H., Sba, B., & Mouissi, F. (2020) The Kinematical Analysis of Blocking Skill in Volleyball and Their Relationships with the Explosive Force of Lower Limbs. *International Journal of Sport, Exercise & Training Sciences – IJSETS, 6(2), 73–79.* DOI: 10.18826/useeabd.731462