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A Time-Motion Analysis of the Cross-Over Step Block Technique in Volleyball: Non-Linear and Asymmetric Performances

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Abstract: Blocking performance in volleyball is strongly affected by the time in which the action is executed. This study analyzes the time-motion variables in terms of the player's role and movement direction (right or left), in different phases of the displacement and jump actions in the cross-over step block technique. A kinematic analysis was conducted with 10 senior male volleyball players. Two series of five repetitions were each recorded and classified in terms of middle-blockers (block in the center and sides of the net) and wing-players (only block in the sides). The results showed that the middle-blockers were significantly slower than the wing-players in the first (0.75 ± 0.24 vs. 0.66 ± 0.19 sec; p = 0.020; ES = −0.37 ± 0.30) and fourth phases (0.33 ± 0.8 vs. 0.29 ± 0.8 sec; p = 0.001; ES = −0.44 ± 0.31), and in the total time for blocking (3.15 ± 0.6 vs. 3 ± 0.58 sec; p = 0.003; ES = −0.23 ± 0.31). Overall, players were significantly faster when moving to the right side, showing performance asymmetries. The fastest phases were also performed just before the jump. These findings provide specific knowledge about the cross-over step block technique in its different phases and displacement direction. This information can be used to improve the movement time in the first defensive action in volleyball.

Keywords: asymmetric training; kinematic analysis; defensive action; movement speed; technique

1. Introduction

In volleyball, most game actions are performed while jumping [1,2], especially those that allow a point to be scored (serve, spike and block), which are fundamental to achieving a good performance in competition [3–5]. An important part of planning training is thus the search for ways to improve the jumping capacity of the players [6–9]. Explosive strength and displacement speed are key aspects for trainers [10]. These parameters, among others, contribute to increasing the performance of athletes [11].

Among the jump actions, spiking and blocking have the greatest effect on the outcome of a match [12]. Trainers make sure that their athletes are strong, quick and great jumpers in order to score attack points [13]. On the other hand, the team must build a quick, solid and strong first line for defense, which requires the blocker to be a good technical executer and have great control of individual tactical aspects. Decision making, movement speed and jumping capacity are key aspects of a successful block action, which happen as an adaptation to the time-related variables (set tempo and spiker's technique), and in a non-linear context due to the complexity of the game [14]. Moreover, blocking performance is a key indicator of success in competition; in fact, it has been reported as the most accurate parameter with which to differentiate between winning and losing teams [12,15,16].

Various studies have analyzed the variables that affect the performance of the blocking technique from three different perspectives: (a) its relevance in the game as a technical-tactical action that affects the success of the team [12,17]; (b) the types of movements that players use most frequently when blocking, through movement analysis techniques [14,18,19]; (c) a biomechanical analysis of the vertical jump in the blocking action [19]. According to the movement analysis, in order to block effectively, players must execute the technique that allows them to use as little time as possible to reach the blocking zone with the longest side movements along the net and finish with a good vertical jump. During the aerial phase, arm penetration and hand angulation over the net are fundamental for the creation of an efficient screen which controls the contact and bounce of the ball [16,18,20]. This justifies the view of trainers that the "frontality" of the body, with respect to the net (pelvis and shoulders must be parallel to the net), is an important factor of blocking [21,22]. The speed at which these movements are executed is also crucial for the performance of this action, since responding to the temporal demands of the rival attack is one of the main factors affecting the way in which volleyball actions are conducted, especially the type of displacement and the way this is done [13,14]. The non-linear adaptation to different attack tempos leads to specific block movements during the game.

Displacement during blocking is usually performed in one of the following three ways: the slide step, the cross-over step or the running step [3,23,24]. In the slide step, the leading foot, in the direction of the displacement, initiates the movement by separating from the other foot, which then moves towards the former without changing the original orientation of the body with respect to the net [24]. In the cross-over step, the non-leading foot, in the direction of the displacement, crosses over the other foot, passing near the net, and the leading foot closes the movement until it is parallel with the non-leading foot, just before jumping [23]. Sometimes, this movement is performed with an initial small sliding step by the leading foot in the direction of the displacement, which is why this technique is also known as the three-step technique [3]. Lastly, the combination of steps in the running step is similar to that involved in the spike action, in which, during the thrust phase, the body loses the parallel position with respect to the net, and the side that is closer to the net acts as the rotation axis until the body faces the net again during the flight phase [25].

The selection and execution of a displacement technique in the blocking action is affected by the role of the player and the demands of the game. Thus, the middle player performs the largest number of jumps, with the greatest jump intensity and height [26,27]. Their defensive position in the blocking action at the center of the net requires the player to execute displacements towards both sides, while wing-players move only to one side of the net. These displacements must be made at greater speeds at higher competitive levels, where the attack time is shorter [28]. In order to respond to the game's demands, most middle-blockers choose to use the cross-over step technique [18,25], which justifies the type of displacement analyzed in this study. Indeed, the different player roles may lead to different speeds and asymmetries, especially when players move to a non-usual side [29]. Despite the relevance of the displacement technique in blocking, there is little knowledge about what happens in each of the movement phases, i.e., how much time is spent, and whether this varies depending on the displacement direction or on the player role. The different demands of the game could affect the way in which each part of the movement is executed, as well as the displacement towards the zones where the rival has greater participation. The aim of the present study was therefore to analyze the time spent in the different phases of the displacement and jump in the execution of the cross-over step based on the player role and the displacement direction (right or left side). The information obtained could help to improve the displacement technique according to the specific demands of a player's role, and aims to achieve an effective movement in both displacement directions, based on non-linear movement adaptations and intra- or inter-players asymmetries.

2. Materials and Methods

2.1. Sample

Ten male volleyball players (24 ± 4.5 years; 1.87 ± 0.13 m in height; 87.6 ± 8.33 kg) from a top-level team that competes in the Spanish First League participated in the study (2017–2018 season). The players had these playing roles in the competition: setter (1), opposite (2), middle-blocker (3), and outside-hitter (4) (Sheppard et al., 2009). Given the nature of the technique analyzed, however, the players were classified into two groups: (a) middle-blockers (MBs), who perform more jumps than the rest of the players in top-level male volleyball [8], especially when blocking [30], and (b) wing-players (WPs), which was composed of the other player roles (setter, opposite and outside-hitter). MBs are characterized by covering long distances in blocking, while the WPs usually travel shorter distances because they are closer to the blocking zone [4]. This sample size is commonly analyzed in top-level contexts [14,18,19].

All players had a minimum of ten years of experience in volleyball competitions and were not injured during the study. These players usually train four or five times per week (around 180 min), with two additional gym sessions, and they play a match every weekend. Each player was informed about the goals of the study and agreed to participate after signing an informed consent form. The study was conducted according to the principles of the Declaration of Helsinki.

2.2. Test Measurement

The cross-over technique was divided into four phases, plus the jumping time. The time was recorded in each phase according to the direction of the movement and the player role (MB or WP). A complete movement is described as follows (in this case, explained when moving towards the right (Figure 1)):

- Phase 1 (lateral momentum): the player stands close to the net. This phase starts when the player raises the heel of the foot and moves to the right side (right foot). This phase ends when the right foot is entirely set on the floor.
- Phase 2 (cross-over step): from the end of Phase 1 to the entire setting of the left foot after crossing it over the right foot.
- Phase 3 (control): from the end of Phase 2 to the moment in which part of the right foot is set on the floor.
- Phase 4 (vertical momentum): from the end of Phase 3 to the last moment in which part of the foot (or feet) is touching the floor.
- Phase 5: period (in seconds) from the player taking off to the player landing.

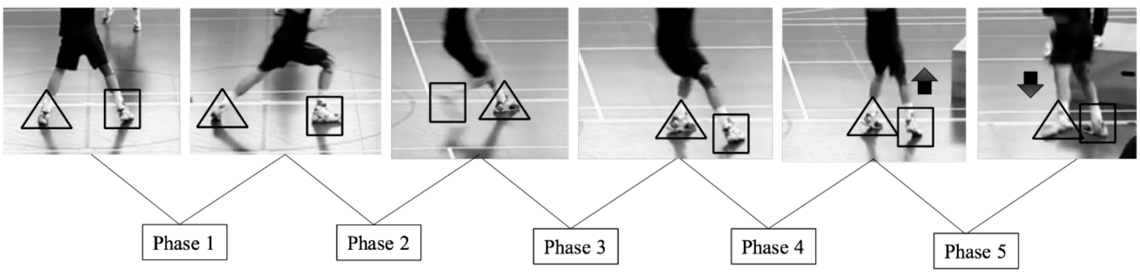

Figure 1. The crossing step sequence.

2.3. Procedure

The players were filmed for two days in the middle of the season (February), and the movement time was analyzed. The tests were performed in the competition court, with the same training schedule and identical environmental conditions (temperature, humidity, etc.). One week before the test, the players were familiarized with the test protocol. Training in this blocking technique is widely practiced throughout the season.

During the test session, an initial warm-up was performed (five minutes of free movements, three minutes of running, five minutes of ball control and two minutes of blocking movements, performing six repetitions to each side). During the test itself, each player performed five blocking movements with a blocking jump at the end to each side (10 movements in total). A one minute rest was set after each repetition, and an extra minute was added when the direction changed. The assessment was performed on two different days, recording all the jumps (200 jumps in total: 60 in MBs and 140 in WPs, 50% for each side). Twenty-five percent of actions were randomly selected to calculate the intra-observer reliability because one observer measured the actions recorded. An intraclass correlation coefficient (ICC) = 0.98 was obtained.

The players did not receive any technical information about specific movements/techniques, and were only encouraged to do the movement as fast as possible, and to jump as high as they could. The players started in a static position with their hands up (ready to block). This is the position that players adopt to get ready for the movement. From the center of the net, each player used the cross-over step technique to the sides of the net, arriving at the place in which the jump should be performed. Movement analysis was performed for each frame of the images recorded with the high-speed cameras (HD DMC-FZ 200 Lumix, 300 Hz, San Diego, CA, USA), using a slow-motion option. These motion analyses were undertaken in 2D using the Kinovea 9.0 software. This strategy was appropriate as the players moved only to the sides with a net in front of them (closed task), and they had a great experience. The players did not perform in a sagittal plane [18]. Finally, the data were managed with SPSS v.25 (Statistical Package for the Social Sciences, SPSS Inc., Armonk, NY, USA) and graphically shown with Prism 7.0 (GraphPad Software, Inc., La Jolla, CA, USA).

2.4. Statistical Analyses

A descriptive analysis (mean ± standard deviation, median, interquartile range, and coefficient of variation) was conducted for each movement phase, based on the player's role and the movement direction. The normality test (Kolmogorov–Smirnov) was applied, and a Mann–Whitney U-test ($p < 0.05$) was carried out to measure the differences between MBs and WPs. The differences in each variable were also calculated by effect size (ES) at 95% confidence intervals (CI). The magnitude threshold was set at 0–0.2 (trivial), >0.2–0.6 (small), >0.6–1.2 (moderate), >1.2–2 (large) and >2 (very large) [31].

3. Results

Table 1 shows the different blocking time-motion results by direction and player role. In general, Phase 3 was the fastest, followed by Phases 4, 1, 2 and 5. Similar coefficients of variation were found, with more differences, in Phase 3. When comparing MBs with WPs, statistically significant differences were only found in Phase 1 (z = −2.32; $p = 0.020$), Phase 4 (z = −3.48; $p = 0.001$) and in the total blocking time (z = −3.00; $p = 0.003$). Small differences were also found in Phase 1 (−0.37 ± 0.30) and Phase 4 (−0.44 ± 0.31 (Figure 2)).

In each player role, MBs exhibited statistically significant fast movements to the right side in Phase 2 (z = −4.10; $p = 0.001$), Phase 3 (z = −3.60; $p = 0.001$), Phase 4 (z = −2.87; $p = 0.004$) and flying time (Phase 5 (z = −3.70; $p = 0.001$)). With the same tendency, WPs showed a statistically significant fast displacement to the right side in all measured phases: Phase 1 (z = −2.59; $p = 0.010$), Phase 2 (z = −5.54; $p = 0.001$), Phase 3 (z = −6.69; $p = 0.001$), Phase 4 (z = −3.03; $p = 0.002$), Phase 5 (z = −8.02; $p = 0.001$), and total block time (z = −5.20; $p = 0.001$). The rightward movement, however, showed more variability in all player roles, and in all movement phases. Finally, the effect size demonstrated large and very large differences, with a slower leftward movement in all players.

Table 1. Time-motion analysis (Mean ± SD, Median ± Interquartile range, and CV) of the block technique according to the direction and the player role.

	Wing-Players (n = 3)								
	Right (n = 30)			Left (n = 30)			Total (n = 60)		
	Mean ± SD	CV	Median ± IQ	Mean ± SD	CV	Median ± IQ	Mean ± SD	CV	Median ± IQ
Phase 1	0.76 ± 0.27	35.53	0.73 ± 0.32	0.74 ± 0.21	28.38	0.73 ± 0.34	0.75 ± 0.24 *	32.00	0.73 ± 0.34
Phase 2	0.79 ± 0.19 †	24.05	0.93 ± 0.33	0.98 ± 0.05 †	5.10	0.93 ± 0.29	0.88 ± 0.17	19.32	0.93 ± 0.29
Phase 3	0.12 ± 0.06 †	50.00	0.14 ± 0.07	0.17 ± 0.04 †	23.53	0.14 ± 0.07	0.14 ± 0.06	42.86	0.14 ± 0.07
Phase 4	0.30 ± 0.09 †	30.00	0.33 ± 0.10	0.37 ± 0.05 †	13.51	0.33 ± 0.10	0.33 ± 0.08 *	24.24	0.33 ± 0.10
Fly time	0.93 ± 0.23 †	24.73	1.08 ± 0.37	1.15 ± 0.09 †	7.83	1.08 ± 0.27	1.04 ± 0.21	20.19	1.08 ± 0.27
Total block time	2.89 ± 0.75	25.95	3.35 ± 1.30	3.42 ± 0.18	5.26	3.35 ± 0.82	3.15 ± 0.60 *	19.05	3.35 ± 0.82
	Wing-Players (n = 7)								
	Right (n = 70)			**Left (n = 70)**			**Total (n = 140)**		
	Mean ± SD	**CV**	**Median ± IQ**	**Mean ± SD**	**CV**	**Median ± IQ**	**Mean ± SD**	**CV**	**Median ± IQ**
Phase 1	0.62 ± 0.19 †	30.65	0.70 ± 0.33	0.71 ± 0.18 †	25.35	0.70 ± 0.33	0.66 ± 0.19 *	28.79	0.70 ± 0.33
Phase 2	0.78 ± 0.21 †	26.92	0.91 ± 0.23	0.97 ± 0.13 †	13.40	0.91 ± 0.23	0.88 ± 0.20	22.73	0.91 ± 0.23
Phase 3	0.13 ± 0.04 †	30.77	0.15 ± 0.08	0.19 ± 0.05 †	26.32	0.15 ± 0.08	0.16 ± 0.06	37.50	0.15 ± 0.08
Phase 4	0.27 ± 0.09 †	33.33	0.31 ± 0.12	0.32 ± 0.05 †	15.63	0.31 ± 0.11	0.29 ± 0.08 *	27.59	0.31 ± 0.12
Fly time	0.88 ± 0.20 †	22.73	1.09 ± 0.37	1.13 ± 0.06 †	5.31	1.09 ± 0.27	1 ± 0.20	20.00	1.09 ± 0.37
Total block time	2.69 ± 0.65 †	24.16	3.29 ± 1.14	3.33 ± 0.20 †	6.01	3.29 ± 0.86	3 ± 0.58 *	19.33	3.29 ± 1.14

Notes. * $p < 0.05$ between middle-blockers and other player roles; † $p < 0.05$ between the right and left side in each player role.

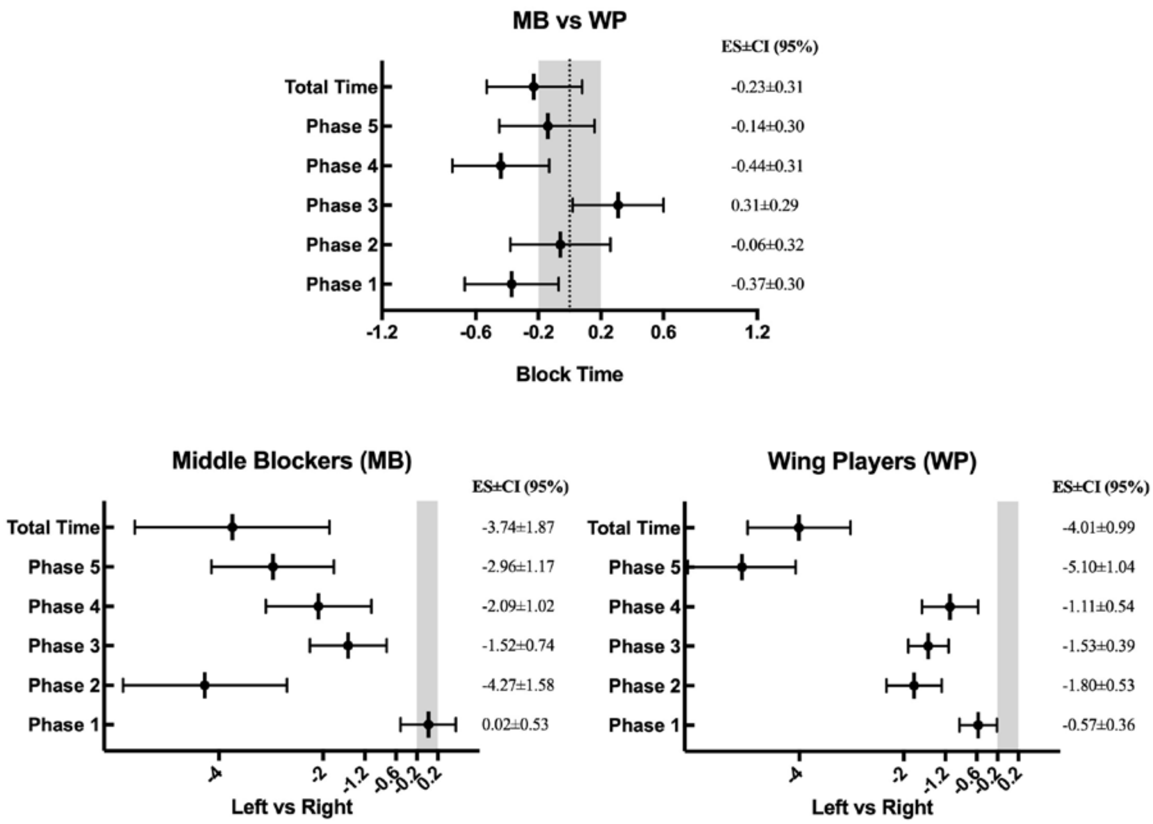

Figure 2. Effect Size ± Confidence Interval (CI (95%)). MB: middle-blockers; WP: wing-players.

4. Discussion

This study analyzed the time spent in the different displacement phases of the cross-over step technique, as well as the jumping time, based on the player role and the movement direction (right or left side of the net). In general, the results show that Phases 3 and 4 were the fastest, which coincide with the arrival in the blocking zone and the beginning of the jumping action. These phases of the movement aim to transform the speed of the horizontal component into vertical thrust, which affects the jump height and, consequently, the success of the blocking action [14]. The fastest displacements were those performed towards the right side of the net, emphasizing the asymmetry in this movement. Finally, the central player was the slowest one in the execution.

The total time for each blocking phase (except for Phase 3) was shorter for wing-players than middle-blockers. This fact could be explained by the inter-players unbalance. The central players begin the blocking action at the center of the net [32,33], from which they either move towards one side of the net or stay in that position, depending on the rival attack, and thus they begin with a read-and-react technical-tactical position. The slower movements performed by the central player in Phase 1 could be due to the high starting position, based on the aforementioned blocking distribution, which would imply a delayed motor response depending on the game situation. This player role has to attend to the multiple attack combinations from the opposition because they have to block in all zones of the net, performing an adaptable movement in terms of a complex context that affects this non-linear open skill. These results are in line with those reported by Fleddermann and Zentgraf [34] in a study with volleyball players in the German League, where the longer blocking times and shorter jumping height are attributed to the effect of the demands of the game on the motor pattern of the player. The longer total blocking time in the central players could be explained by an increase in the jumping capacity (flight time, Phase 5). Such an increase in the jumping time [27] could be related to a greater capacity to transform the horizontal displacement into vertical thrust [18]. In any case, these results indicate a need to conduct a differentiated analysis, adjusting the tasks to the different demands of the game (number of jumps, displacement speed, attention, tactical situation, etc.) [8,19,27,29]. This non-linear training should also be implemented with the displacement asymmetries.

Regarding the displacement zones, all players obtained shorter times when moving towards the right side of the net, showing a strong asymmetry. These times were shorter in all the phases of the movement and in both groups of players (except for Phase 1 in the middle-blockers). One possible explanation for the time differences lies in the analysis of offensive trends during a competition. Some studies have found a greater frequency of attacks on the left side of the net (forward passes from the setter) [35,36], which, from the perspective of the blocker, would imply a larger number of displacements to that area of the court (towards the right side of the blocker). This difference in the number of displacements suggests that a player has better automation in the technical movement to the side that they use the most, that is, in this case, towards the right side. If this situation occurs in a competition context, training tasks may be increased, and timing may be addressed. Better control of the movement mechanics will allow a player to perform a faster displacement, allowing for more effective blocking towards that side of the net.

Another factor that contributes to obtaining shorter times for this side of the net is the better application of the displacement technique when performed towards the dominant side [37]. When determining the dominant side of the displacement of the blocker, considering the steps involved in the spike action (beginning with the foot on the side of the executing arm) in the case studied (all players were right-handed), the shortest times occurred when the player moved to block towards the right (dominant) side of the net (intra-player asymmetry). Although no previous studies have analyzed the time differences based on the direction of the blocking action displacement, some authors have reported results that may support the idea of asymmetry. Male and female players in the Italian League showed differences in the number of supports used in landing after the blocking action, which depended on whether the previous displacement was performed towards the left side (landing on two supports) or towards the right side (landing on one support) [19]. The landing with the smallest number of supports could be associated with a faster displacement and, consequently, a greater difficulty in stabilizing the landing. Similarly, differences in kinetic and kinematic parameters (energy absorption, momentum and maximum knee flexion action, etc.) were found in university players based on the displacement direction [37]. In these cases, the different context may have a strong influence on the different types of movements.

All the above demonstrates the need to establish training targeted towards improving the mechanics of the movement specific to the player role, and also to aim for greater symmetry regarding displacement direction. This study analyzed the time spent by the players in each phase, differentiating the displacement direction and specificity in terms of blocking at the center of the net (middle-blocker) or at the sides of the net (wing-blocker (inter-player asymmetry)). There are limitations related to the absence of measurements in different stages of the season, however, which would show the evolution of the displacement technique, as well as measurements in competition matches, which would show the effect of the rival attack on the displacement. A larger sample, in both genders, would also provide more representative results, as well as using more central players, to confirm or refute the findings of this study. The sample in this study was from a volleyball team that plays in a specific context, and therefore the statements made should be carefully analyzed. The individual differences in the same player role, and the inter-individual differences between players, should also be taken into consideration. Indeed, future studies should address these gaps in knowledge and analyze the effect of anthropometric and physiological factors on the displacement speed. Moreover, future studies should implement 3D strategies to measure other type of movements.

The players analyzed, who used the cross-over step technique to perform the displacement movement, demonstrated faster execution when blocking towards the right side of the net. The players with a central role exhibited slower times in their displacement compared to the rest of the players. The fastest phases of this displacement technique were those performed at the end of the movement, and they coincided with the arrival in the blocking zone and beginning of the jump.

5. Practical Applications

This study shows the need to train differently depending on a player's role and frequency of displacement to both sides of the net. It is necessary to undertake specific exercises in order to reach a greater symmetry in both displacement directions, and to monitor the time spent, as well as the execution, in each of the movement phases. Similarly, physical training exercises in terms of movement amplitude and adequate execution could be used to improve this technique. All this would increase the displacement speed, which could improve blocking performance.

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References

1. Lidor, R.; Ziv, G. Physical and physiological attributes of female volleyball players—A review. *J. Strength Cond. Res.* **2010**, *24*, 1963–1973. [CrossRef] [PubMed]
2. Mroczek, D.; Januszkiewicz, A.; Kawcynski, A.S.; Zbigniew, B.; Chmura, J. Analysis of male volleyball players´ motor activities during a top-level match. *J. Strength Cond. Res.* **2014**, *28*, 2297–2305. [CrossRef]
3. Lobietti, R. A review of blocking in volleyball: From the notational analysis to biomechanics. *J. Hum. Sport Exerc.* **2009**, *4*, 93–99. [CrossRef]
4. Millán-Sánchez, A.; Morante, J.C.; Ureña, A. The middle blocker in volleyball: A systematic review. *J. Hum. Sport Exerc.* **2019**, *14*, 24–46. [CrossRef]
5. Newton, R.U.; Kramer, W.J.; Häkkinen, K. Effects of ballistic training on preseason preparation of elite volleyball players. *Med. Sci. Sports Exerc.* **1999**, *31*, 323–330. [CrossRef] [PubMed]

6. Brazo-Sayavera, J.; Nikolaidis, P.T.; Camacho-Cardenosa, A.; Camacho-Cardenosa, M.; Timón, E.; Olivares, P.R. Acute effects of block jumps in female volleyball players: The role of performance level. *Sports* **2017**, *5*, 30. [CrossRef] [PubMed]
7. Falces-Prieto, M.; González-Fernández, F.T.; Baena-Morales, S.; Benítez-Jiménez, A.; Martín-Barrero, A.; Conde-Fernández, L.; Suárez-Arrones, L.; Sáez de Villarreal, E. Effects of a strength training program with self-loading on countermovement jump performance and body composition in young soccer players. *J. Sport Health Res.* **2020**, *12*, 112–125.
8. García-de-Alcaraz, A.; Ramírez-Campillo, R.; Rivera-Rodríguez, M.; Romero-Moraleda, B. Analysis of jump load during a volleyball season in terms of players role. *J. Sci. Med. Sport*. in press.
9. Manzanares, P.; Palao, J.M.; Ortega, E. The coach's perception of the performance of game actions in training sessions. A case study in volleyball. *Int. J. Perf. Anal. Sport* **2014**, *14*, 896–908. [CrossRef]
10. Waller, M.; Gersick, M.; Holman, D. Review various jump training styles for improvement of vertical jump performance. *Strength Cond. J.* **2013**, *35*, 82–89. [CrossRef]
11. Cetin, E.; Ozdol, Y. Jump shot performance and strength training in young team handball players. *Procedia Soc. Behav. Sci.* **2012**, *46*, 3187–3190. [CrossRef]
12. Palao, J.M.; Santos, J.A.; Ureña, A. Effect of team level on skill performance in volleyball. *Int. J. Perf. Anal. Sport* **2004**, *4*, 50–60. [CrossRef]
13. Coleman, J.; Neville, B. *Blocking*; USVBA: Colorado Springs, CO, USA, 1990.
14. Neves, T.J.; Johnson, W.A.; Myrer, J.W.; Seeley, M.K. Comparison of the traditional, swing, and chicken wing volleyball blocking techniques in NCAA Division I female athletes. *J. Sport Sci. Med.* **2011**, *10*, 452–457.
15. Eom, H.J.; Schutz, R.W. Statistical analyses of volleyball team performance. *Res. Q. Exerc. Sport* **1992**, *63*, 11–18. [CrossRef]
16. Lenberg, K.S. *Coaching Volleyball: Defensive Fundamentals and Techniques*; Coaches Choice: Monterey, CA, USA, 2004.
17. Afonso, J.; Mesquita, I.; Palao, J.M. Relationship between the use of commit-block and the numbers of blockers and block effectiveness. *Int. J. Perf. Anal. Sport* **2005**, *5*, 36–45. [CrossRef]
18. Ficklin, T.; Lund, R.; Schipper, M. A Comparison of jump height, takeoff velocities, and blocking coverage in the Swing and Traditional volleyball blocking techniques. *J. Sport Sci. Med.* **2014**, *13*, 78–83.
19. Lobietti, R.; Coleman, S.; Pizzichillo, E.; Merni, F. Landing techniques in volleyball. *J. Sports Sci.* **2010**, *28*, 1469–1476. [CrossRef]
20. Farokmanseh, M.; McGown, C. A comparison of blocking footwork patterns. *Coach. Volleyb.* **1988**, *1*, 20–22.
21. Beal, D.; Crabb, T. Blocking. In *The AVCA Volleyball Handbook*; Bertucci, B., Ed.; Master Press: Miami, FL, USA, 1987; pp. 65–71.
22. Kiraly, K. *Championship Volleyball*; Human Kinesthetics: Champaign, IL, USA, 1990.
23. Cox, R.H.; Noble, L.; Johnson, R.E. Effectiveness of the slide and cross-over steps in volleyball blocking a temporal analysis. *Res. Q. Exerc. Sport* **1982**, *53*, 101–107. [CrossRef] [PubMed]
24. Kwak, C.S.; Jin, S.T.; Hwang, K.S.; Yoon, S.W. A biomechanical analysis of the slide and crossover steps in the volleyball blocking. *Korean J. Sport Sci.* **1989**, *1*, 71–83.
25. Hernández-Hernández, E. Do we train as we block? Case study applied to the men's volleyball super league. *JUMP* **2020**, *1*, 9–16.
26. Bahr., M.A.; Bahr, M. Jump frequency may contribute to risk of jumper's knee: A study of interindividual and sex differences in a total of 119343 jumps video recorded during training and matches in young elite volleyball players. *J. Sports Med.* **2014**, *48*, 1322–1326. [CrossRef] [PubMed]
27. Sheppard, J.M.; Gabbett, T.J.; Stanganelli, L.C.R. An analysis of playing positions in elite men's volleyball: Considerations for competition demands and physiologic characteristics. *J. Strength Cond. Res.* **2009**, *23*, 1858–1866. [CrossRef] [PubMed]
28. García-de-Alcaraz, A.; Ortega, E.; Palao, J.M. Technical-tactical performance profile of the block and dig according to competition category in men's volleyball. *Motriz* **2016**, *22*, 102–109. [CrossRef]
29. Maloney, S.J. The relationship between asymmetry and athletic performance: A critical review. *J. Strength Cond. Res.* **2018**, *33*, 2579–2593. [CrossRef]
30. Vilamitjana, J.J.; Soler, D.; Barrial, J.M.; Del Grecco, P.; Montes, M.; Rodríguez, F. Jumping profile of elite volleyball male players by field positions during a competitive season. *Med. Sci. Sports Exerc.* **2008**, *40*, S383. [CrossRef]

31. Hopkins, W.; Marshall, S.; Batterham, A. Progressive statistics for studies in sports medicine and exercise science. *Med. Sci. Sports Exerc.* **2009**, *41*, 3–12. [CrossRef]
32. Costa, G.C.T.; Ceccato, J.S.; Evangelista, B.F.B.; Freire, A.B.; de Oliveira, A.S.; Milistetd, M.; Rodrigues, H.A.; Ugrinowitsch, H. Tactic determinants of game practiced by middle attacker in men's volleyball. *Revista Brasileira de Cineantropometria e Desempenho Humano* **2016**, *18*, 371–379. [CrossRef]
33. Millán-Sánchez, A.; Morante, J.C.; Hernández, M.A.; Femia, P.; Ureña, A. Participation in terminal actions according to the role of the player and his location on the court in top-level men's volleyball. *Int. J. Perform. Anal. Sport* **2015**, *15*, 608–619. [CrossRef]
34. Fleddermann, M.T.; Zentgraf, K. Tapping the full potential? Jumping performance of volleyball athletes in game-like situations. *Front. Psychol.* **2018**, *9*, 1375. [CrossRef]
35. Afonso, J.; Mesquita, I. Determinants of block cohesiveness and attack efficacy in high level women's volleyball. *Eur. J. Sport Sci.* **2011**, *11*, 69–75. [CrossRef]
36. Afonso, J.; Mesquita, I.; Marcelino, R.; Da Silva, J.A. Analysis of the setter's tactical action in high-performance women's volleyball. *Kinesiology* **2010**, *42*, 82–89.
37. Mercado-Palomino, E.; Richards, J.; Molina-Molina, A.; Benítez, J.M.; Ureña, A. Can kinematic and kinetic differences between planned and unplanned volleyball block jump-landings be associated with injury risk factors? *Gait Posture* in press. [CrossRef] [PubMed]