Baltic Journal of Health and Physical Activity

Volume 15 | Issue 2 Article 5

2023

Action distance as a predictor of winning and losing matches at FIVB Volleyball Men's World Championship

Dariusz Mroczek
Wroclaw University of Health and Sport Sciences, dariusz.mroczek@awf.wroc.pl

Damian Pawlik
Wroclaw University of Health and Sport Sciences, damian.pawlik@awf.wroc.pl

Recommended Citation

Mroczek D, Pawlik D. Action distance as a predictor of winning and losing matches at FIVB Volleyball Men's World Championship. Balt J Health Phys Act. 2023;15(2):Article5. https://doi.org/10.29359/BJHPA.15.2.05

Action distance as a predictor of winning and losing matches at FIVB Volleyball Men's World Championship

Abstract

Introduction: Technology determines the emergence of functional tools to monitor and control motor activity during the game. One of the solutions for monitoring the player in indoor sports are computer video analyses, which determine basic kinematic parameters. The study aims to compare team and player activity with the outcome of a given set and the effect of the game status on player activity during a championship-level match. Materials and Methods: The study analysed 140 volleyball players aged 19 to 40 years (27.05 ± 4.33 years, height: 197.15 ± 9.63 cm, body mass: 88.51 ± 9.23 kg) participating in the FIVB Volleyball Men's World Championship. The observed matches were categorised by score (3:0, 3:1, 3:2 and 0:3, 1:3 and 2:3). Depending on winning or losing, each set was described as W – a winning set, P – a losing set and O – as the first set. Results: The average distance covered in all observed matches was 10.7 ± 0.09 m, while for matches completed in 3 sets, it was 10.48 ± 0.13 m. Attackers covered the longest distance in action (11.43 ± 1.68 m), while the libero covered the shortest distance from among all observed players (8.79 ± 1.91 m). The losing teams covered a significantly greater distance in action (10.87 ± 2.24 m) in action than the winning teams (10.54 ± 1.91 m). Conclusion: The results of this study allow the conclusion that teams winning sets cover a smaller average distance in action than their opponents. The highest covered distance was observed in the first set and in sets 4 and 5 when teams were losing a set after losing the previous one. The smallest distance was covered by teams that lost set 5 after winning the previous set.

Keywords

elite volleyball players, mean rally distance, game status

Cover Page Footnote

This research was financially supported by the Ministry of Science and Higher Education (Poland) / Wroclaw University of Health and Sport Sciences.

Baltic Journal
of Health and Physical Activity
e-ISSN 2080-9999

Article

Action distance as a predictor of winning and losing matches at FIVB Volleyball Men's World Championship

Dariusz MROCZEK[1]*, Damian PAWLIK[2]

[1] Wroclaw University of Health and Sport Sciences, Poland
ORCID 0000-0002-4783-3152
[2] Wroclaw University of Health and Sport Sciences, Poland
ORCID 0000-0003-2618-0129

* Correspondence: Dariusz MROCZEK, Wroclaw University of Health and Sport Sciences, 35 Paderewski Av, 51-612 Wroclaw, Poland; dariusz.mroczek@awf.wroc.pl

Abstract: Introduction: Technology determines the emergence of functional tools to monitor and control motor activity during the game. One of the solutions for monitoring the player in indoor sports are computer video analyses, which determine basic kinematic parameters. The study aims to compare team and player activity with the outcome of a given set and the effect of the game status on player activity during a championship-level match. Materials and Methods: The study analysed 140 volleyball players aged 19 to 40 years (27.05 ± 4.33 years, height: 197.15 ± 9.63 cm, body mass: 88.51 ± 9.23 kg) participating in the FIVB Volleyball Men's World Championship. The observed matches were categorised by score (3:0, 3:1, 3:2 and 0:3, 1:3 and 2:3). Depending on winning or losing, each set was described as W – a winning set, P – a losing set and O – as the first set. Results: The average distance covered in all observed matches was 10.7 ± 0.09 m, while for matches completed in 3 sets, it was 10.48 ± 0.13 m. Attackers covered the longest distance in action (11.43 ± 1.68 m), while the libero covered the shortest distance from among all observed players (8.79 ± 1.91 m). The losing teams covered a significantly greater distance in action (10.87 ± 2.24 m) in action than the winning teams (10.54 ± 1.91 m). Conclusion: The results of this study allow the conclusion that teams winning sets cover a smaller average distance in action than their opponents. The highest covered distance was observed in the first set and in sets 4 and 5 when teams were losing a set after losing the previous one. The smallest distance was covered by teams that lost set 5 after winning the previous set.

Keywords: elite volleyball players, mean rally distance, game status.

Citation: Mroczek D, Pawlik D. Action distance as a predictor of winning and losing matches at FIVB Volleyball Men's World Championship. Balt J Health Phys Act. 2023;15(2):Article5. https://doi.org/10.29359/BJHPA.15.2.05

Academic Editor:
Aleksandra Bojarczuk

Received: May 2022
Accepted: July 2022
Published: June 2023

Publisher's Note: BJHPA stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

The development of computer technology determines the emergence of new tools to monitor and control motor functions during sporting activity [1–3]. The most commonly used tools are accelerometers, gyroscopic sensors or ones that require marking points on the player's body [4, 5]. Their functionality is significantly limited and almost impossible in a championship game. One of the solutions for monitoring a player in indoor sports are computer video analyses, which determine basic kinematic parameters such as jump height, distance covered, and the number of individual actions [6, 7]. In outdoor sports, Ground Positioning System (GPS) based exercise control tools are standard [8]. Rugby, football, or baseball have made significant changes in the approach to the player's training and control and the influence of individual kinematic parameters on his/her performance [9, 10]. Hybrid diagnostic tools should be sought to understand the nature of effort and the influence of kinematic parameters on performance in indoor sports.

In volleyball, the height, the number, and the frequency of jumps are the most frequently diagnosed parameters [7, 11, 12]. The jump height equates with the player's higher

efficiency in the serve and attack and is considered one of the determinants of success in volleyball [13–15]. However, the effectiveness of play and attack mainly depends on the quality of the opponent's reception and defensive play. Both offensive and defensive activities require the team's considerable commitment at the level of movement around the field. It would seem reasonable to use the activity as a parameter affecting an action, set, and match outcome. The distance covered during the action by each player can determine his/her activity.

Distance has been diagnosed globally as the distance covered during a match and as the distance of a single action, such as the flight distance during an attack, a serve, or a block [3 ,6, 7]. Although those authors presented the distance covered by players in a match, none of the studies confirms the influence of the covered distance on the result taking a form of a won or lost set and match in a championship-level match. According to Miskin et al., volleyball coaches should identify different performance skills of each volleyball player during a game and accordingly adjust a training cycle of a team and focus on the development of the efficacy of key skills that considerably determine players' scoring abilities and consequently contribute to match success. To our knowledge, there is a lack of research on the effect of the match status, understood as the set score of a match on the volleyball players' activity.

The study aims to compare team and player activity with the outcome of a given set and the effect of the game status on player activity during a championship-level match.

2. Materials and Methods

2.1. Participants

The study analysed 140 volleyball players aged 19 to 40 years (27.05 ± 4.33 years, height: 197.15 ± 9.63 cm, body mass: 88.51 ± 9.23 kg) participating in the FIVB Volleyball Men's World Championship in Poland. The players were senior representatives of Poland, Russia, Serbia, Argentina, Canada, Australia, Bulgaria, Cuba, Finland, China, Venezuela, and Cameroon. The diagnosed players were categorised according to their position on court: an attacker (OPPOSITE, $n = 20$), a middle blocker (MIDDLE, $n = 40$), a libero (LIBERO, $n = 20$); a setter (SETTER, $n = 20$); and a receiver (RECEIVER, $n = 40$).

The study was approved by the Ethical Committee of the University of Health and Sport Sciences and was conducted in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

2.2. An Experimental Approach to the Problem

A cross-sectional study was conducted on professional volleyball players during the FIVB Volleyball Men's World Championship 2014 in Poland. The study consisted of collecting video observations of matches from the Centennial Hall in Wrocław. The recordings were made with three cameras in the Full HD format. Then the obtained results were analysed in terms of the distance covered in action during the game. The concept of a method to analyse individual parameters was described and developed by Mroczek [6] and applied at the level of height and jumping distance parameters by Pawlik [7]. Moreover, information on the studied volleyball players' age, height, and body weight (current as of 2014) and detailed results of the matches played were gathered.

2.3. Procedure

The observed matches were categorised by score (3:0, 3:1, 3:2 and 0:3, 1:3 and 2:3). Depending on winning or losing, each set was described as W – a winning set, P – a losing set and O – as the first set. The game-status was marked as set 1 won (OW), set 1 lost (OP), a winning set after a winning set (WW), a losing set after a winning set (WP), a winning set after a losing set (PW) and a losing set after a losing set (PP) to observe the influence

of the result of the previous set on the effect of the next one. Another analysis was performed to divide the effect according to the set in which it occurred, i.e., set 1–5, to evaluate the match situation in more detail. The resultant effects were compared with the average distance covered by the players during the action.

2.4. Distance Calculation

Knowing the dimensions of the volleyball court and its constancy regardless of the camera setting allowed us to develop a concept for calculating the distance covered by players. Thus, it is possible to define transformation, also known as a perspective transformation or homography [16], which map any point from the camera perspective into the 9 × 18-metre rectangle:

$$s_i \begin{bmatrix} x'_i \\ y'_i \\ 1 \end{bmatrix} = H \begin{bmatrix} x_i \\ y_i \\ 1 \end{bmatrix}$$

where H is an arbitrary 3 × 3 matrix. Finding H is not hard and is done by minimizing a back-projection error (O'Reilly Media 2008):

$$\sum_i \left[\left(x'_i - \frac{h_{11}x_i + h_{12}x_i + h_{13}}{h_{31}x_i + h_{32}x_i + h_{33}} \right)^2 + \left(y'_i - \frac{h_{21}x_i + h_{22}x_i + h_{23}}{h_{31}x_i + h_{32}x_i + h_{33}} \right)^2 \right]$$

Achieving H allows determining the position in metres of any player for all movie frames.

$$x'_i = \frac{h_{11}x_i + h_{12}x_i + h_{13}}{h_{31}x_i + h_{32}x_i + h_{33}}, \; y'_i = \frac{h_{21}x_i + h_{22}x_i + h_{23}}{h_{31}x_i + h_{32}x_i + h_{33}}$$

Finally, calculating Euclidean distance between the position in two consecutive frames allows finding a total distance d of player's movement. Jump frames are excluded from the calculation [7].

$$d = \sum_{i=1}^{n} \sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2}$$

2.5. Statistical Analysis

The software for calculating movement distance was built upon OpenCV (accessed as of June 28, 2018, on https://opencv.org/) library. All calculations are performed in double precision (accessed as of June 28, 2018, on https://docs.microsoft.com).

The average distance covered in all observed matches was 10.7 ± 0.09 m, while for matches completed in 3 sets, it was 10.48 ± 0.13 m. The intraclass correlation coefficient (ICC = 0.76 and 0.60) and Cronbach's alpha reliability coefficients (CA = 0.76 and 0.60) were calculated to determine the reliability between distances covered in each game rally. The within-person variability was determined by calculating the variation coefficient (CV = 0.15 and 0.13). The Confidence Interval coefficient (CI) was calculated for the determined mean values of the covered distance in 3- and 5-set matches. For 5-set matches, the CI was 10.53 (-95%) and 10.88 (+95%), while for matches completed in 3 sets it was 10.46 (-95%) and 10.96 (+95%). All coefficients were found to be significant at the 95% level ($p < 0.05$). An independent T-test was used for variables relative to the groups to detect differences in the distance covered in winning and losing sets. To observe differences between the distance covered in winning and losing sets according to the game-status, sets were observed using ANOVA and post-hoc NIR.

3. Results

Figure 1 shows the average action distance covered in winning or losing sets after winning or losing a set (WW, PW, WP, PP), winning or losing sets at 0:0 (OW and OP). In losing sets at 0:0 (OP), the players record the highest distance covered of all observed sets (11.32 ± 2.60 m). The first set won (OW) has higher mean values of distance covered (10.85 ± 1.58 m) than sets WW, PW, WP and PP (10.21 ± 2.03 m; 10.56 ± 1.80 m; 10.69 ± 1.98 m and 10.84 ± 2.28 m, respectively). The lowest distance covered by the athletes was recorded for WW, and it significantly differed from the distance covered in sets OW (p = 0.044), OP (p = 0.001), and PP (p = 0.027) at a significance level of p<0.05. The results of OP and PW were also significantly different (p = 0.025).

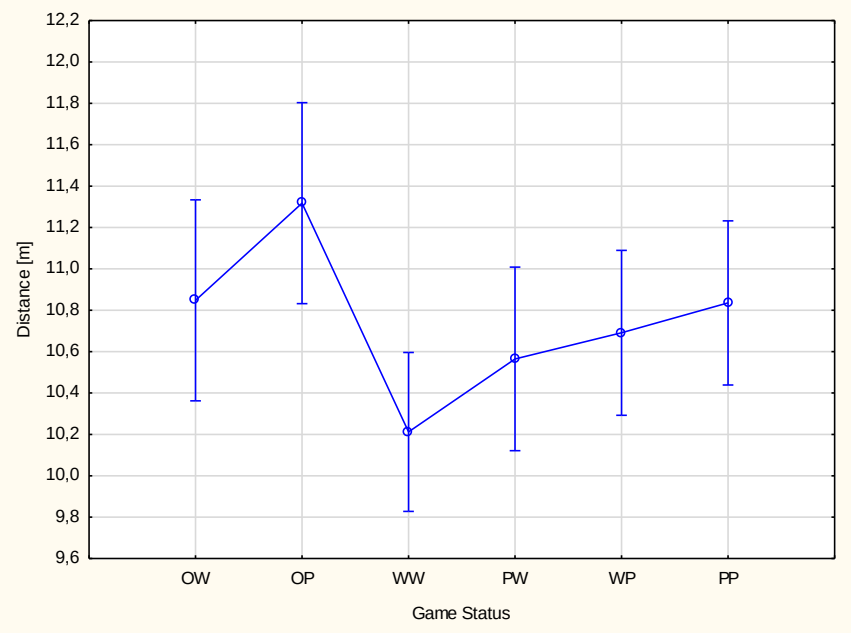

Figure 1. Average distance covered depending on the match status.
(* significant difference between OP vs. WW, WW vs. PP, WW vs. OW, PW vs. OP)

OW – the first winning set; OP – the first losing set; WW – a winning set after a winning set; PW – a winning set after a losing set; WP – a losing set after a winning set; PP – a losing set after a losing set

Analysing the average distance covered in action in individual sets, it is worth noting the trends in sets 2, 4, and 5. Especially in the decisive sets 4 and 5, the covered distance sharply increased when the previous set was lost. There were no statistically significant differences between the individual game statuses in sets 1 and 2. For set 3, statistically significant differences were recorded between WW and PW (p = 0.047), WW and WP (p = 0.008), and between WP and PP (p = 0.042). For set 4, statistically significant differences at the level of p < 0.05 occurred between sets PP and WW (p = 0.000), PP and PW (p = 0.000) PP and WP (p = 0.002), and WW and WP (p = 0.003). For set 5, statistically significant differences at p < 0.05 occurred between PP and WP (p = 0.000), PP and PW (p=0.015), and WP and PW (p = 0.002) (Figure 2).

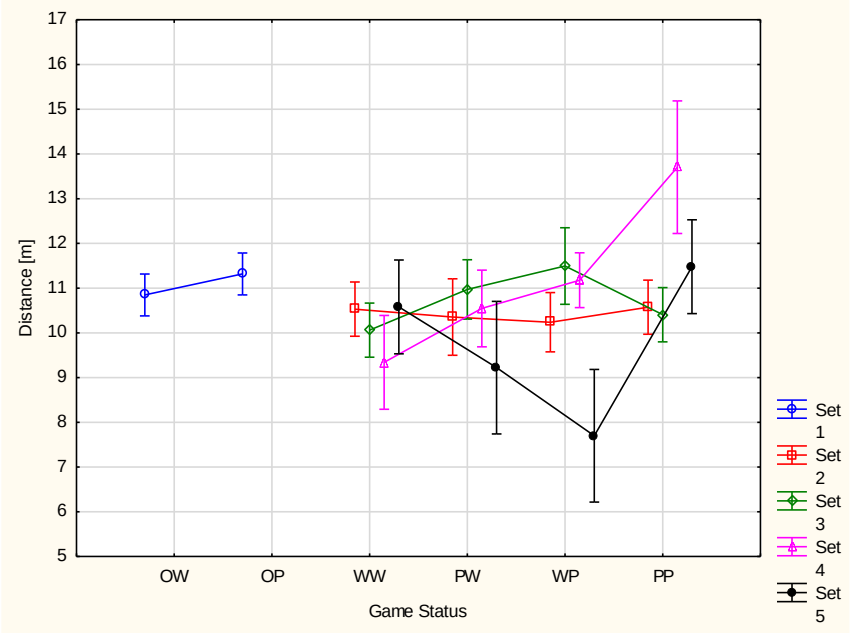

Figure 2. Average distance covered in sets 1–5 depending on the game status.

When analysing winning (W) and losing (P) sets without the effect of the previous set, there is a tendency for the recorded distance to be more remarkable for losing sets (10.87 ± 2.24 m) than for won sets (10.54 ± 1.91 m). However, these differences are not statistically significant. When broken down by sets, statistically significant differences ($p < 0.05$) in the covered distance were observed in sets 4 and 5 (Table 1). For sets 1, 3 and 4, higher values of the covered distance were characteristic of the teams that generally lost the set. Set 2 is an exception, in which practically no differences were noted between set W and set P (0.05 m) and set 5, in which apparent differences were noted between set W and set P in favour of a greater distance covered by teams that won the tie-break (2.97 m on average).

Table 1. Results of winning and losing sets (W and P).

Set	Average W [m]	Average P [m]	SD W [m]	SD P [m]	*p*
1	10.85	11.32	1.58	2.6	0.20
2	10.47	10.42	1.93	1.86	0.88
3	10.48	10.77	2.11	2.01	0.40
4	10.06	11.55	1.61	2.10	0.00*
5	10.67	7.7	2.3	1.67	0.00*

*significance at $p < 0.05$.

An analysis of the distance covered during the match was also performed according to the player's function and the effect of the given set. After comparing the players according to their position on court, the most significant distance is covered by the attacking player (A) and the smallest by the libero (L) (Table 3). Significant differences in the distance covered are found between the libero (L) and the other players: a receiver (R1, R2), a setter (R), an attacker (A) and a middle blocker (M1, M2). Moreover, statistically significant differences are found between players performing in the R position (R1 and R2) and S, A, M1, M2 and L at the $p < 0.05$ level (Table 2).

Table 2. Average distance covered in action divided by function.

Function	Mean distance covered in action [m]	R1	R2	S	A	M1	M2	L
R1	10.40 ± 1.73		0.07	0.01*	0.00*	0.03*	0.03*	0.00*
R2	10.95 ± 1.64	0.07		0.43	0.16	0.75	0.66	0.00*
S	11.2 ± 1.84	0.01*	0.43		0.46	0.64	0.73	0.00*
A	11.43 ± 1.68	0.00*	0.13	0.46		0.23	0.28	0.00*
M1	11.05 ± 2.49	0.03*	0.75	0.64	0.23		0.90	0.00*
M2	11.09 ± 2.02	0.03*	0.66	0.73	0.28	0.90		0.00*
L	8.79 ± 1.91	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	

* significance at $p < 0.05$.

The matches in which one team dominated were listed. These were all matches ending with a score of 3:0 and 0:3. The following results confirm the observations of all matches (3:0; 3:1; 3:2) and the tendencies occurring in them. The teams that won in 3-set matches recorded lower values of the distance covered than the losing players. These differences are statistically significant at the level of $p < 0.05$ ($p = 0.008193$). When broken down by set, set 1 was significantly different from sets 2 and 3 regardless of the effect (W and P) at the level of $p < 0.05$ (Table 3).

Table 3. Differences in sets 1–3 by the game status (effect).

Status	Set	{1} 12.378	{2} 9.7333	{3} 10.383
P	1		0.00*	0.00*
P	2	0.00*		0.33
P	3	0.00*	0.33	
W	1		0.04*	0.03*
W	2	0.04*		0.84
W	3	0.03*	0.84	

* significance at $p < 0.05$.

4. Discussion

In this study, the average distance covered in action was determined by comparing it with the effect of a given set. Moreover, the effect (set score) of winning or losing a set on the distance covered by players participating in the FIVB Volleyball Men's World Championship was determined. The results of this study allow the conclusion that teams winning sets cover a smaller average distance in action than their opponents.

The diagnosed representatives of 12 countries covered an average distance similar to Mroczek et al. [6]. Those authors estimated the mean distance in action to be 10.92 ± 0.9 m in male volleyball players in the Polish National Volleyball League [6], while Hank et al. [3] determined the mean distance covered in action in female volleyball players in the Champions League to be 8.5 ± 1.04 m. Juxtaposing the covered distance results with the effect of a given set, one can see a low value of the average distance in winning sets after a previously won game (WW) and the highest in losing sets (PP). Similar observations can be made after analysing the average distance covered in sets 1–5 depending on the game status, where similar trends are observed for sets 3 and 4. Sets 2 and 3 are characterised by greater confidence in executing the actions, allowing the technically better teams to

effectively control the game. According to Castro et al. [14], it may be due to a higher level of technical skills, especially in reception and serve, than in the losing teams. The differences in the distance covered in (WW) and (PP) sets are most likely due to the lower level of ball control in the game with a tougher opponent. A less effective serve reception, defence or setting the ball may generate a greater distance covered to construct the action. Teams that play the ball more accurately and are more effective in attacking do not need to generate additional running load during the action.

The players covered the greatest distance in set 1 (OW and OP), which is the beginning of the match effort without significant fatigue compared to the other sets (WW, WP, PW and PP). The teams that win this part of the match (OW) tend to cover less distance in the next set. In the first set, teams take less risk in serve and attack which translates into the length of the action and, consequently, the covered distance. Comparing only the 3:0 and 0:3 matches confirms that, regardless of the result of the set, at 0:0, the players cover the longest average distance during the action (both in OW and OP). The analysis of action efficiency conducted by Castro et al. [14] and Marcelino et al. [15] can confirm the supposition. The conclusions may indicate the influence of high efficiency of actions (technical level) on controlling the course of the game enough to perform less motor work while maintaining a higher quality of actions.

There are apparent differences between sets W and P in sets 4 and 5. If two teams of similar skill level are playing with each other, sets 4 and 5 are usually the deciding ones for winning or losing the entire match. A special commitment is seen in teams that have lost the previous set. Wanting to stay in the championship game, they engage all possibilities not to end the match with a defeat. In the case of losing set 4 and victory or defeat in set 5 (PW and PP), a high ratio of distance covered concerning WP is found. Such a result may indicate a high sporting level of an evenly matched performance and a continuation of the boost from the previous game. The teams that win sets 4 and 5 (WW) maintain an average distance during the action, while the teams that lose set 4 also try to make up for their technique, activity, long defences, and fight for difficult to defend balls. Sets 4 and 5 differ in terms of effect (W and P). There are extremely high values for the teams losing set 4 and low values for the teams losing set 5. It may indicate the use of all motor potential and commitment where the team may lose the opportunity to advance to the later parts of the competition. The aspect of fatigue translating into commitment and activity in set 5 after a heavy load in the previous set is significant.

The last aspect is the individual players' work depending on their position. Receivers in position No. 1 (R1) and libero (L) stand out statistically significantly. They cover the smallest average distances during the action. While the L player is responsible for receiving and defending in a specific zone, the R1 players are surprising. Tactically, player R1 should be an offensive-minded player due to playing in 2 rotations with player S in the attacking area and having fewer reception tasks. Analysis of the number of jump shots of players R1 and R2 proves no essential differences between these players in the number of executed jump shots during the game [7]. The even distribution of the attack between A, M and S and fewer tasks in the defensive game resulted in R1 players and exempted L players covering the smallest distances in the match. The distance covered by S also shows a surprising trend. It would seem that S players are the ones who run the most on the field. They try to set the ball to the attacker, primarily inaccurately received balls. Mroczek et al. [6] reported that in the Polish Ligue S covered the greatest distance among all players. Usually, the best players of each country play in national teams. In representation, attack efficiency may be greater than in a league, which may translate into fewer exchanges in action. A, as a player focused on offensive game, may also be more abused by S than usual. The attacker (A) is the position covering the most significant distance. Despite being exempted from accepting a serve, the A players are the most burdened with offensive play. On average, A players jump the highest during the game and make the highest number of jumps (except for M). The above offensive load results in offensive players being the most loaded position on court [7].

5. Conclusions

The results of this study allow the conclusion that teams winning sets cover a smaller average distance in action than their opponents. The highest activity is observed in the first set and in sets 4 and 5 when losing a set after having lost the previous one. The smallest distance is covered by teams that lose set 5 after winning the previous set. The players covering the smallest distance are the players in position R1 and L, while the largest distance is covered by players A. The results of this study show that the players' activity is inversely proportional to the outcome of the match. Future work in the direction of activity, in addition to the team's set score, should include an evaluation of technique in the form of the effectiveness of individual players' actions. Such an approach to the problem will explain why players covering smaller average distances during actions are generally more effective than teams that lose matches at the highest international level.

References

1. He D, Li L, An L. Study on sports volleyball tracking technology based on image processing and 3D space matching. IEEE Access. 2020;8:94258–94267. DOI: 10.1109/ACCESS.2020.2990941
2. Zhongmin W, Shanjia D. Mean-shift algorithm for 3D spatial positioning. Procedia Comput Sci. 2018;131:446–453. DOI: 10.1016/j.procs.2018.04.251
3. Hank M, Malý T, Zahálka F, et al. Evaluation of the horizontal movement distance of elite female beach volleyball players during an official match. Int J Perform Anal Sport. 2016;16(3):1087–1101. DOI: 10.1080/24748668.2016.11868950
4. Struzik A, Konieczny G, Grzesik K, et al. Relationship between lower limbs kinematic variables and effectiveness of sprint during maximum velocity phase. Acta Bioeng Biomech. 2015;17(4):131–138.
5. Borges TO, Moreira A, Bacchi R, et al. Validation of the VERT wearable jump monitor device in elite youth volleyball players. Biol Sport. 2017;34(3):239. DOI: 10.5114/biolsport.2017.66000
6. Mroczek D, Januszkiewicz A, KawczyNski AS, et al. Analysis of male volleyball players' motor activities during a top level match. J Strength Cond Res. 2014;28(8):2297–2305. DOI: 10.1519/JSC.0000000000000425
7. Pawlik D, Kawczyński A, Chmura J, et al. Jumping Flying Distance and Jump Performance of Elite Male Volleyball Players at FIVB Volleyball Men's World Championship. Appl Sci. 2020;10(6):2045. DOI: 10.3390/app10062045
8. Rago V, Brito J, Figueiredo P, et al. Methods to collect and interpret external training load using microtechnology incorporating GPS in professional football: A systematic review. Res Sport Med. 2020;28(3):437–458. DOI: 10.1080/15438627.2019.1686703
9. Konefał M, Chmura P, Tessitore A, et al. The impact of match location and players' physical and technical activities on winning in the German Bundesliga. Front Psychol. 2020;11:1748. DOI: 10.3389/fpsyg.2020.01748
10. Cummins C, Orr R, O'Connor H, et al. Global positioning systems (GPS) and microtechnology sensors in team sports: A systematic review. Sport Med. 2013;43(10):1025–1042. DOI: 10.1007/s40279-013-0069-2
11. Skazalski C, Whiteley R, Hansen C, et al. A valid and reliable method to measure jump-specific training and competition load in elite volleyball players. Scand J Med Sci Spor. 2018;28(5):1578–1585. https://doi.org/10.1111/sms.13052
12. Stankovic M, Peric D, Ruíz-Llamas G, et al. Effects of experimental volleyball rules quantified by type and number of jumps, hits and contacts. Sport Mont. 2017;15(3):9–16. DOI: 10.26773/smj.2017.10.002
13. Challoumas D, Artemiou A. Predictors of attack performance in high-level male volleyball players. Int J Sport Physiol Perform. 2018;13(9):1230–1236. DOI: 10.1123/ijspp.2018-0125
14. Castro J, Souza A, Mesquita I. Attack efficacy in volleyball: Elite male teams. Percept Motor Skill. 2011;113(2):395–408. DOI: 10.2466/05.25.PMS.113.5.395-408
15. Marcelino R, Mesquita I, Afonso J. The weight of terminal actions in volleyball. Contributions of the spike, serve and block for the teams' rankings in the World League 2005. Int J Perform Anal Sport. 2008;8(2):1–7. DOI: 10.1080/24748668.2008.11868430
16. Szeliski R. Image formation. Computer Vision: Springer; 2011, p. 27–86. DOI: 10.1007/978-1-84882-935-0_2

Author Contributions: Study Design, DM and DP; Data Collection, DM and DP; Statistical Analysis, DP; Data Interpretation, DM and DP; Manuscript Preparation, DM and DP; Literature Search, DM and DP; Funding Acquisition, DM. All authors have read and agreed to the published version of the manuscript.

Funding: The study was supported and funded by the statutory research of the Wroclaw University of Health and Sport Sciences, Poland.

Institutional Review Board Statement: The study was approved by the Bioethical Commission at the Wroclaw University of Health and Sport Sciences, Poland.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data available from the corresponding author on request.

Conflicts of Interest: The authors declare no conflict of interest.