BALTIC JOURNAL OF HEALTH AND PHYSICAL ACTIVITY
© Gdansk University of Physical Education and Sport in Gdansk, Vol. 5, No. 2, 2013, 199-206
ORIGINAL ARTICLE
DOI: 10.2478/bjha-2013-0019

An assessment of a volleyball player's loads in a match on the basis of the number and height of jumps measured in real-time conditions

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Key words: *volleyball, height of reach, attack, block, service.*

Abstract

Background: *The value of volleyball players' reach is often critical to their efficient functioning in the game. It depends on the jumping ability factor and the player's body build. An analysis of this parameter is particularly difficult to carry out in real conditions of the game. The objective of the research was to determine the height of reach in basic technical and tactical actions of leading Polish volleyball players during a match in regard to their maximum values measured in laboratory conditions.*

Material/Methods: *The study involved five volleyball players, Polish representatives of different specialization in the game: the attacker, the setter, the middle blocker and two receivers. The study made use of a camcorder and an innovative computer program AS-4, which enables measuring the value of reach at which tactical and technical actions are carried out in the game.*

Results: *A total of 378 tactical and technical actions of the tested players were registered. It turned out that they were performed at the level of (reach) 87.4% in comparison to the maximum reach measured in laboratory conditions.*

Conclusions: *Values of reach achieved by the tested volleyball players have a significant, positive correlation with results obtained in individual sets. The values closest to the value of the maximum reach were reported in attack, the lowest ones in setting.*

Word count: 2,540
Tables: 2
Figures: 4
References: 31

Received: December 2012
Accepted: August 2013
Published: October 2013

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Introduction

A study of a player's dynamics is mainly performed with a dynamometric platform and 3D analysis systems (e.g. Ariel, Vicon, etc.). Using KISTLER platforms, Kabaciński set jump parameters for various actions of the national team volleyball players [1]. The greatest value of the vertical component of ground reaction forces were for a jump to attack from the back row (max RZ = 2.93 weight), and the strength impulse was the highest for the block with a jump – 630 Ns (570 Ns for attack). There are many different methods of measuring the jumping ability, from very simple ones without complicated apparatus to those carried out in specially designed laboratories [2]. There were also several studies carried out already in the 1980s and the 1990s on the influence of the body build [3] and strength characteristics of leg muscles on the efficiency of the vertical jump [4, 5, 6], and on the impact of various types of weight training [7, 8, 9, 10] on an athlete's jumping skills. Of particular interest here are studies related to plyometric workout [11,12], assessing its impact on the development of lower limbs muscle strength. The results of this research have become the basis for determining the physiological characteristics of movements associated with performing so-called vertical jumping in individual and team disciplines [13, 14, 15, 16]. Research results have shown a close correlation between results in the jump and the muscle explosive strength of the lower limbs, reaching up to r = 0.93 [17]. In studies on power, it was found that the relative maximum and average output power are factors strongly related to the vertical jump height among professional players of male and female teams in beach and indoor volleyball [18, 19]. It was also found that different types of jumps require unique to them only conditions of obtaining muscle strength and that training in one kind of jump does not necessarily improve the result in another kind [20]. Other authors' research showed that the jumping ability formation of an extra load during the eccentric phase of the so-called counter-movement gives better results when compared to a typical training of volleyball players' jump consisting in a large number of jumps [21, 22, 23].

To test the lower limbs muscle strength, ergometric testing, jumps with resistance [18,8], static jumps, tests on tensoplatforms, short runs, lifting the maximum weight [24, 25], pressing with legs [26], side jumping from the spot [7,10] and isometric [24] and isokinetic tests [10] are applied.

There are, however, few studies related to the registration of jumping ability parameters directly in the match, although laboratory tests to create biomechanical efficiency evaluation criteria of an attacking volleyball player have been carried out [29]. Volleyball is a team game in which the reach at which the player executes a typical for that sport action (attack, block, serve and setting) is of particular importance. It determines the player's ability to operate effectively and efficiently.

The purpose of research

The aim of the study was to estimate the number and the value of mechanical parameters of jumps recorded in real conditions and specifying the height, time and coordinates on the court of actions performed while jumping during a volleyball match. Next the dynamics of changes in the reach of players at the highest level of sports mastery were also examined in subsequent sets.

Material and method

The study involved 5 male volleyball players representing the highest sports level in volleyball (members of the national team and the Plus League). The relevant parameters associated with an analysis of jumping are presented in Table 1. Actions of players participating in the game at different positions and pursuing various functions: the receiver, the middle blocker, the attacker and the setter were examined. Only the libero was omitted from the study, because due to rules of the game he does not perform attack, block and setting.

Tab. 1. The characteristics of the studied players (laboratory tests)

Player	Specialization	Body height [cm]	Body mass [kg]	Reach in attack [cm]	Reach in block [cm]	Arm span [cm]
1	receiver	195	90	345	318	250
2	middle blocker	204	104	360	340	264
3	receiver	197	94	344	324	256
4	setter	200	88	336	317	257
5	attacker	196	98	348	330	252

A video footage of a league game (the Plus League) recorded by means of a digital camcorder placed on a side grandstand on a tripod at a height of 5 m was used for the analysis. A computer program AS-4 (an optoelectronic method) was used to determine biomechanical parameters of the players' jumps. The software algorithm allows calculating geometry in 3D space without knowing the camera location and parameters [26]. Court coordinates of the take-off and landing, the height of the jump and the time of action were directly determined from the program. Next, the percentage height in relation to the maximum height of the jump was calculated. The significance of differences in individual sets was examined by means of the one-way analysis of variance ANOVA in the Statistica software with probability at $p < 0.05$.

Results

On the basis of the video recording of the match and the optoelectronic analysis with the AS-4 program, the number of jumps and their parameters for each player in particular sets were determined. Table 2 presents a list of mean heights of the jump and the percentage heights in relation to the maximum jump, with a breakdown into sets of the match and the action in the game: attack, block, serve and setting.

Tab. 2. The number and height of jumps of the studied volleyball players

Type of action/ set		N	Absolute height		Relative height	
			x [cm]	SD x	% max	SD %
Attack	whole match	87	315.2	17.59	90.7	5.06
	set 1	19	329.4*	14.74	94.7*	4.67
	set 2	23	308.1	18.89	89.0	5.13
	set 3	23	315.1*	15.13	90.7*	4.61
	set 4	22	310.5	14.31	89.1	3.99
Block	whole match	133	292.7	17.09	88.9	5.37
	set 1	28	307.2*	16.77	93.4*	4.27
	set 2	20*	288.9	18.03	88.1	5.95
	set 3	36	288.5	14.08	87.5	4.69
	set 4	49*	289.2	14.73	87.7	4.93
Serve	whole match	83	309.5	25.74	89.4	7.76
	set 1	23	320.0*	16.82	92.0*	5.16
	set 2	15	307.7	23.33	88.8	7.22
	set 3	22	305.5	36.92	88.5	11.05
	set 4	23	303.9	19.17	88.1	5.70
Setting	whole match	75	261.3	24.63	77.6	6.25
	set 1	24	255.7	32.84	76.0	8.38
	set 2	17	269.8*	25.81	80.0*	7.21
	set 3	21	259.3	18.90	76.9	4.31
	set 4	13*	263.5	15.81	78.4	3.82
total		378	295.3	28.34	87.2	7.72

**statistically significant at p < 0.05*

A total of 378 jumps were registered during basic technical and tactical actions in volleyball. The mean reach was 295.3 cm, which represents 87.2% of the maximum reach measured in the laboratory. The most jumps were observed in the block – 133, then in attack – 87 and in the serve – 83. There were 75 settings which were made by setter 4, which was in accordance with the tactical provisions. Figure 1 shows the average position of the start of the jump. One can see the advantage of the block in the middle and of the attack on the left side.

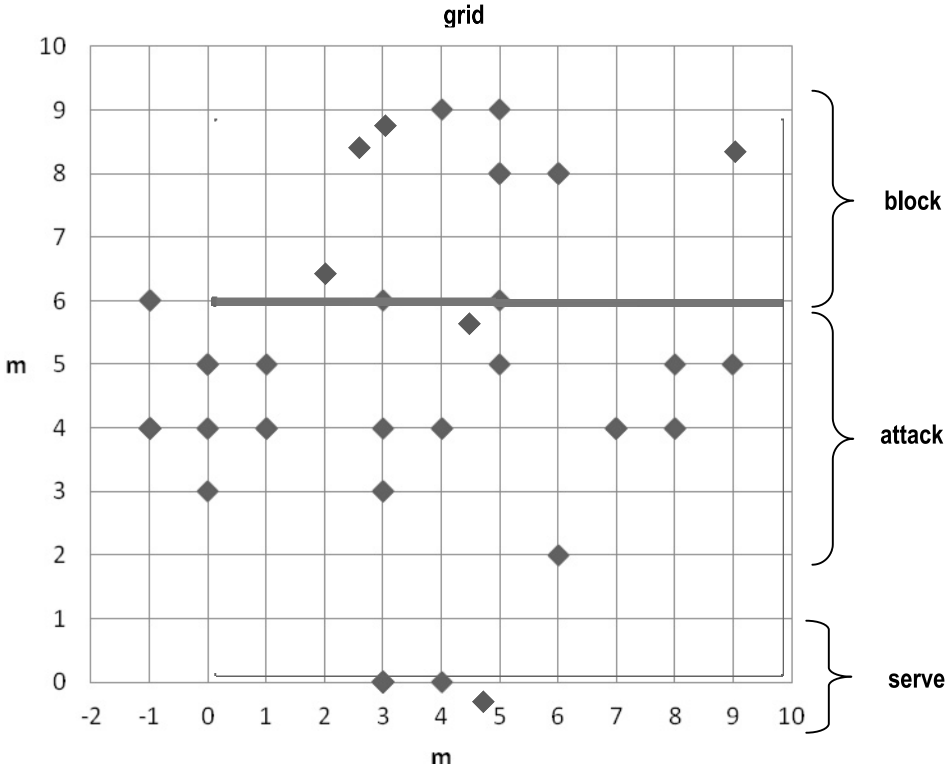

Fig. 1. Coordinates of the players' positions on the court during the jump start – the whole match

The highest jumps were observed in the course of attack – the average of 315.2 cm (90.7% of the maximum reach). During the block and the serve the height of the jump was within the limits of 292-309 cm (85-90% of the maximum reach).

While analysing the distribution of heights in individual sets, a decline in the results during the progress of the match is noticeable. In the first set the height of the jump in attack (mean value 329.4 cm) and in the block (mean value 307.2 cm) was over 93% of the maximum. In the second set the jump height fell to 87-89% max, the mean value in attack – 308.1 cm and in the block – 288.9 cm. In the third and fourth set the values in the block and during the serve did not change significantly, although in the third set the height of attack slightly increased to 90.7% max (315.1 cm). Changes in the percentage height compared to the maximum reach are shown in Figure 2.

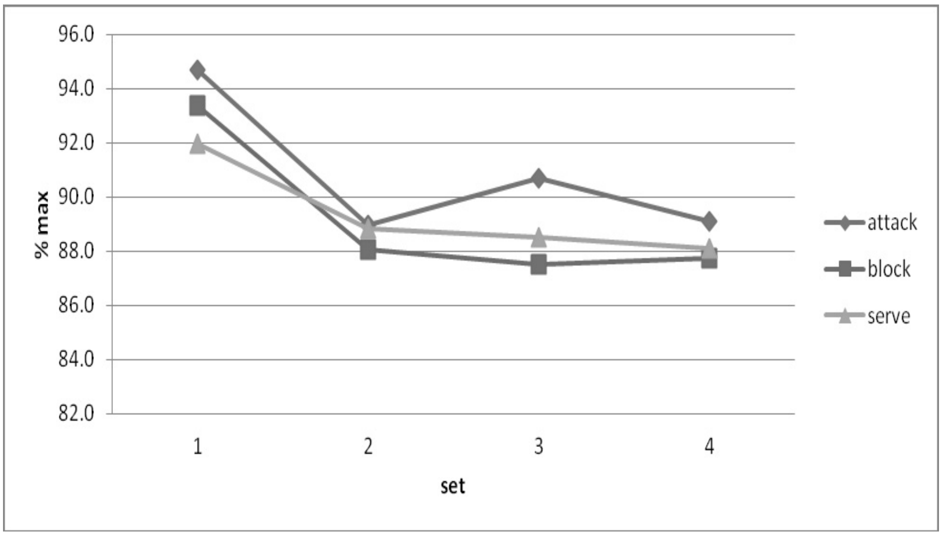

Fig. 2. The mean percentage of the height of the team's jumps in the whole match

Having data on the height of jumps, one can analyse the work performed by different players in relation to their maximum jumping potential, their level of involvement in the match and how they respond to increasing fatigue. Figure 3 illustrates mean values of particular players' relative jump height in attack in subsequent sets of the analysed match. Jump values of player no. 5 deviate from the mean value; in the second set he showed better results than in the remaining sets. Opposite dependence was reported in the other players, who in the second set jumped the lowest to attack.

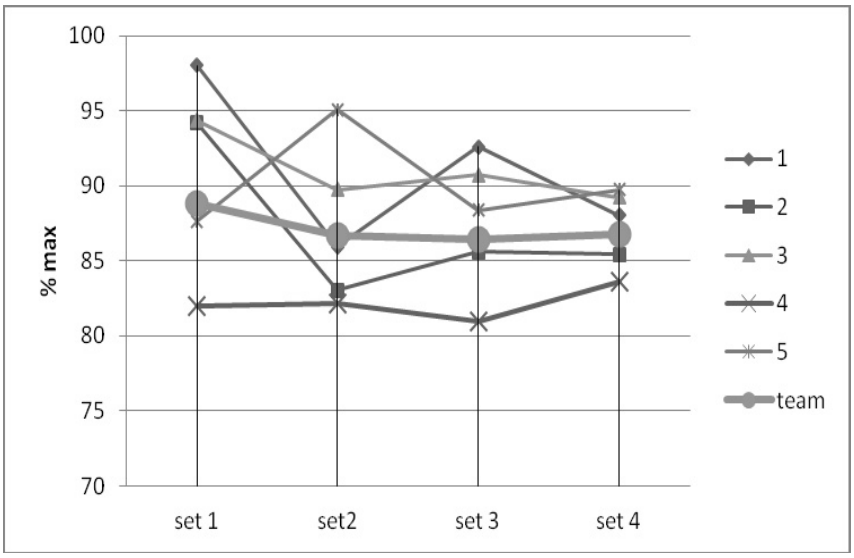

Fig. 3. The mean relative heights of jump in attack for particular players

The dynamics of changes in the volume of the players' work during the match can be specified on the basis of an analysis of the heights of jumps during subsequent sets. Figure 4 shows how the heights of jumps fell and rose in individual sets.

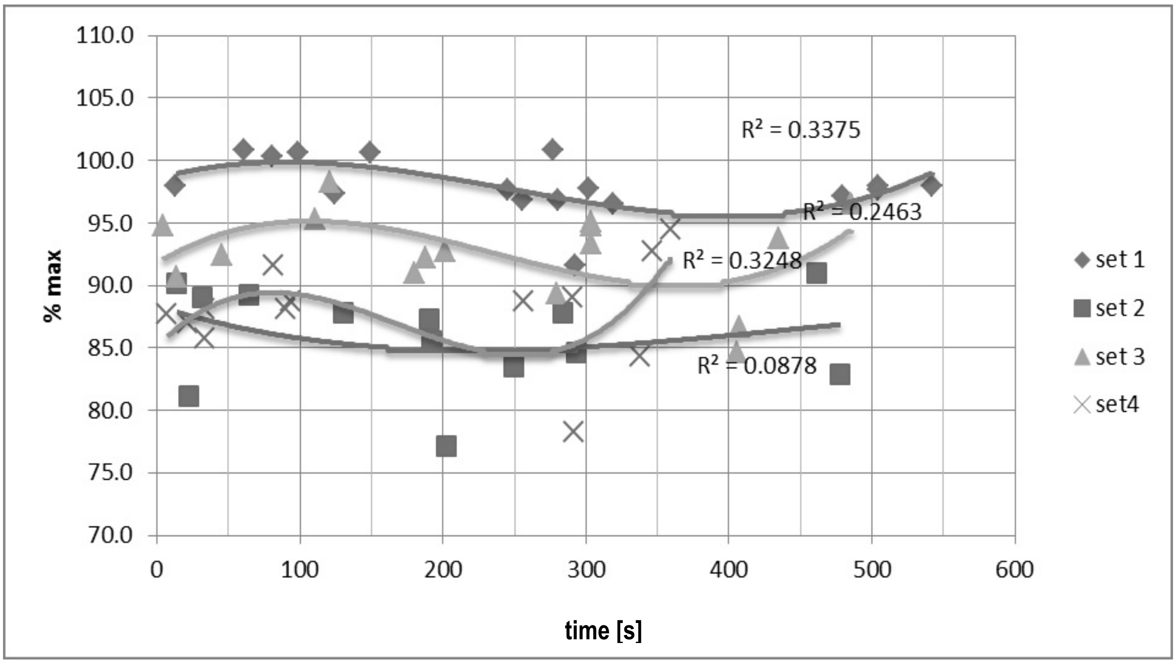

Fig. 4. Distribution of the relative height of jump during a set

The trend lines designated by the third-degree polynomials (best reflecting the course of changes in time; the determination coefficient R^2 had the highest values) show characteristic tendencies in the course of the game. In individual sets players achieve the greatest values of reach (jump) in the early minutes of the game and in its final stage.

Discussion

One of the easiest, most commonly used by teachers and trainers, tests is to measure the elevation of the body using the vertical jump test (Sargent's test). The measurement can be made after a run-up or from the standing position.

Another simple way to evaluate the jumping ability is Starosta's test. The test is performed on a specially prepared platform with sides of 1 m, which has a measuring tape with a scale accurate to 0.01 m. The end of the tape is attached to the subject's hips by means of a belt. The height of the jump is determined based on the length of stretching of the measuring tape. The advantage of these tests is their widespread availability, practically in all conditions.

Another method, requiring special equipment, is a jumping and power test performed on a dynamometric platform. Subjects perform 6 single standing jumps separated by a 1-minute break. In jumps 1-3 they should achieve the maximum height, while the purpose of jumps 4-6 is to obtain the maximum power at the take-off. A high correlation (0.93) was found between the results of measurements of the jumping ability on the tensometric platform and Starosta's test. However, these are laboratory measurements which do not take into account all the variables affecting a volleyball player's reach in basic actions. Of vital importance for the player's reach in the game is the level of particular players' individual technique, their cooperation (setter – attacker) as well as tactics of, for example, executing the block.

Already at the end of the 20th century research was carried out to specify the height of jump and other mechanical parameters in volleyball, depending on the type of run-up and the technique of attack [30].

It is known that the efficiency of performing mainly attack and block in volleyball is largely affected by the level at which these actions are carried out. Morphological parameters (body height, length of upper limbs) and the jumping ability are the components of reach. There are, however, no methods to determine the value of volleyball players' reach measured directly in conditions of a sports fight and how the dynamics of changes in the game affect the final outcome in particular sets.

Having the height of jumps, one can also trace the load and the work performed by players during the competition, which is possible in practice only by means of non-invasive methods. The optoelectronic method, based on an analysis of the recorded image, which was used in this study is precisely such a method.

The obtained results are in accordance with the course of the sports fight. The worst results (statistically significantly) were reported in the second set, which the tested team lost. Other sets (won) were characterised by higher values of reach. This confirms the fact of a strong correlation between the height of the achieved reach and the sports result in volleyball.

The highest mean height of jumps was in the first set. Then it fell significantly in the second set only to remain at a similar level, though clearly lower than in the first set, in the third and fourth one.

The level of maintaining the mean height of jumps may be an indicator of players' fitness preparation as well as of their tactical and technical level. Having such data as the height of jump, the player's body mass and the time between subsequent jumps, one can estimate the performed work, power and physiological load during a volleyball match. This may be an important hint for the coach who assesses the game. A systematic analysis carried out over a series of competitions can be used to control the effects of volleyball training. Extensive scientific research was devoted to the study of these abilities. However, most of these studies focused on understanding the regularities of development of individual skills and methods of their improvement.

Fewer papers have been devoted to examining the impact of motor skills interdependence on the sports result. This issue is of vital importance for the praxis, because the knowledge of basic regularities of development and interrelationship between motor skills allows applying appropriate training methods. Using optimal training loads will result in the development of all motor skills adequate to the needs. Simultaneously, it is important to examine the correlation between the process of development of motor skills and the processes of shaping movement habits specific to male and female volleyball players. The existence of such a correlation is indisputable; however, only their exact examination and evaluation will help to implement reasonably the process of sports improvement and the building of model characteristics [31].

Conclusions

The largest value in the volleyball players' reach in comparison to the maximum level measured in the laboratory was reported in attack – 90.7%, then in the block and the serve – about 89%. The lowest reach was measured in setting – 77.6% of the maximum value. On average this constitutes 87.2% in all the activities. The subjects most commonly jumped to block – 133, accounting for 35.2% of all the analysed actions. Trendlines show that the highest values of reach were reported at the beginning and end of each set. Throughout the match, however, the relationship was a little different. The players jumped the highest in the first set only to stabilize their performance at a lower level in the subsequent sets. The correlation between the obtained results of reach and the sports result additionally confirms the legitimacy of this kind of research

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