Assessment of volleyball players' performance during the game using jump indicators

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Abstract

This study analysed the number and height of jumps performed by 13–14-year-old volleyball players during match play. Young athletes playing as attackers, middle blockers, and liberos took part in the research, with their jumps recorded and classified using a G-walk device and video analysis. The results showed that the highest number and greatest height of jumps occurred during attack hits and blocking actions, confirming their role as the team's most effective movements. Although the number of service jumps decreased over the course of the match, the height of these jumps increased by the final set. In contrast, setting jumps showed a sharp decline in number but remained stable in height. By position, attackers led in overall jump frequency, middle blockers achieved greater jump heights in attack and block, while liberos demonstrated higher results in service and block jumps. Statistical analysis revealed significant differences across certain jump types and court positions. Overall, the findings indicate that young volleyball players' jump activity varies depending on type and position, which has practical value for coaches in differentiating training loads and planning position-specific preparation.

Keywords: volleyball, young athletes, jump activity, G-walk, attack hit, block, service, set, playing position, load monitoring.

Introduction

Jumping ability has been widely recognised as one of the most decisive components of volleyball performance. Numerous studies have shown that vertical jump height is closely associated with successful execution of attack and block actions, which directly contribute to point-scoring opportunities (Sheppard & Newton, 2012). Furthermore, jump frequency during matches is often used as an indicator of both physical workload and technical involvement in play (Ziv & Lidor, 2010).

Research on adult and elite volleyball players has consistently demonstrated positional differences in jump activity. Middle blockers typically achieve the greatest jump heights in blocking and attacking due to their central role at the net, whereas outside hitters perform the highest number of jumps throughout a match (Palao, Manzanares & Ortega, 2015). Liberos, although generally less involved in offensive actions, may also engage in jumping activities such as jump serves, depending on tactical demands.

In the context of youth volleyball, studies remain relatively limited. Investigations involving adolescent athletes suggest that jump performance is influenced not only by technical-tactical role but also by physical maturation and training background (Trajković et al., 2016). Given that young players are still developing strength, coordination, and neuromuscular control, the monitoring of their jump activity is particularly important for optimising training loads and preventing overuse injuries.

Technological advances such as wearable inertial measurement devices (e.g., G-walk, accelerometers) and video-based motion analysis have allowed for more precise quantification of jump performance in match conditions (Charlton et al., 2017). These tools provide reliable data on both the number and height of jumps, making it possible to evaluate the external load demands of different playing positions and actions in real time.

Despite the growing body of evidence, research specifically addressing jump characteristics in 13–14-year-old volleyball players remains scarce. More detailed analyses are required to better understand how match demands differ by position and action type at this developmental stage. Such knowledge is essential for coaches seeking to design age-appropriate, position-specific training programmes that support both performance enhancement and long-term athlete development.

In volleyball, height at the net is considered a significant advantage, as the game relies on the ability to effectively execute offensive and defensive actions over the net against opponents. Specifically, jumping height, in addition to the player's stature, is a crucial factor in both attacking techniques such as spiking and defensive techniques like blocking. Indeed, numerous researchers have pointed out that jumping ability can significantly influence victory and

defeat (Fukuda et al., 1987; Kurokawa, 2000; Okano & Tanigawa, 2016). While height is an important aspect of volleyball, there are also several studies dedicated to jump height and jumping technique. The main focus areas of this research are summarized below in categories of jump height and number of jumps.

Methods

The study involved six youth volleyball players aged 13–14 years. Participants were assigned to specific playing positions as follows: attackers (n = 9), middle blockers (n = 6), and liberos (n = 3). All participants had prior volleyball training experience and regularly participated in school-level matches. Written informed consent was obtained from the players' parents or guardians, and the study protocol adhered to ethical standards for research with minors.

A simulated match was conducted in the school gymnasium to assess jump performance under match conditions. The match consisted of five sets: four sets played up to 25 points and a final set played up to 15 points. A total of 558 jumps were recorded during the simulated match. Each set was analysed to examine jump frequency, height, and type in relation to playing positions and match progression.

Jump performance was measured using a G-Walk wearable inertial measurement device, which was secured to the participants' waist throughout the match. Jump height was recorded for both attack (spike) jumps and vertical jumps during defensive and offensive actions. For each measurement, three attempts were performed, and the highest value was recorded as the maximum jump height.

Jump types were categorised based on Lima et al. (2019) into four main categories:

Attack jumps (spike jumps)
Blocking jumps
Setting jumps
Serve reception or ball delivery jumps

Other jump types, as well as unsuccessful attempts, were excluded from the analysis due to low relevance or minimal contribution to overall match performance.

Video recordings were used to confirm the type of each jump. Three experienced volleyball specialists, including coaches and researchers, independently reviewed the footage to ensure accuracy in jump classification.

Jump frequency and height were recorded for each set, and data were segmented according to playing positions. Key performance indicators included:

Number of jumps per set
Maximum jump height per jump type
Relative jump height expressed as a percentage of the player's maximum vertical jump

Statistical analyses were conducted using repeated-measures ANOVA to examine differences in jump height and frequency across sets and positions. Post-hoc pairwise comparisons were performed where significant main effects were observed. Statistical significance was set at $p < 0.05$.

This methodology allowed for a detailed assessment of youth volleyball players' jump activity in relation to playing position, jump type, and match progression, providing insights into position-specific performance and training load management.

Results and discussion

Experimental work was conducted with six young volleyball players aged 13-14. The players' playing positions were distributed as follows: forward (n = 9), central defender (n = 6), and libero (n = 3). The conditional game, conducted as part of the experimental work, took place at the school in the form of a five-part meeting. A total of 558 jumps were recorded, with the first four halves analyzed based on 25-point game data and the final half based on 15-point game data.

Before the conditional game, after it, and between each half, the maximum height of reach for the jump and vertical jump when executing an attack shot was measured three times each time using the G-walk device.

During the conventional game, the participants fastened the G-walk device to their waist, collecting data on the type of jump, the number of jumps, and the height in the section for each location. The number and height of jumps were recorded using G-walk, and the type of jump was determined using a video recording taken from above behind the last line of the field. The type of jump was visually confirmed and classified by three experienced volleyball players and a volleyball specialist with coaching and research experience.

Types of jumps Lima et al. (2019) are divided into four main types: jumps in striking (attacking), jumps in blocking, jumps in executing a pass. The remaining types of jumps and unsuccessful jumps were excluded from the analysis due to low altitude and relatively small impact on the game. The conditional game was

played in four 25-point halves and the final 15-point half.

Table 1 shows the indicators of the number and height of jumps by various types of jumps during the game sections of volleyball players. According to the table, the results of the dribbling jumps show that the number of dribbles decreased from 15 in the 1st half to 12 in the 5th half. The height indicators varied from 0.32 m to 0.43 m, the lowest result was recorded in the 3rd section (0.32±0.11 m), and the highest in the 5th section (0.43±0.09 m). In general, by the end of the game, the scoring jumps decreased in number, but increased in height.

According to the results of the setting jumps, the number of jumps, which was 20 in the 1st section, decreased to 9 by the 5th section. However, the jump height remained practically the same, in the range of 0.30-0.35 m. In general, while the number of setting jumps decreased during the game, the height indicators remained stable.

The results of the spiking jumps (attack) show that they were recorded with the highest number during the game, ranging from 27 to 35 times. The jump height was in the range of 0.45 -0.49 m, which is significantly higher than in other types of jumps. In general, attacking jumps were used regularly and with high intensity throughout the game as the team's main effective action.

The results for blocking jumps show that they were recorded in high numbers during the game, ranging from 27 to 39 times. The jump height was in the range of 0.39-0.44 m, and a relatively stable result was recorded. In general, blocking jumps were performed consistently in all sections and manifested as a key element of the team's defensive activity.

Analysis of the table shows that during the game, the volleyball players performed the most spike (27-35 times) and block (27-39 times) jumps, and the height indicators were also higher (0.39-0.49 m) for these types of jumps. Serve (12-19 times, 0.32-0.43 m) and set (9-20 times, 0.30-0.35 m) jumps were distinguished by a relatively small number and lower height. Significant differences were observed across sections: in the 5th section, the height of the serve reached its highest level (0.43 ± 0.09 m), while the number of sets sharply decreased (to 9 times). These changes are explained by the athletes' level of fatigue, tactical decisions, and game strategy.

The table below shows the jump height, number, and relative indicators of 13-14-year-old volleyball players according to their playing positions.

Table 1. Indicators of the number and height of jumps by game sections according to jump type

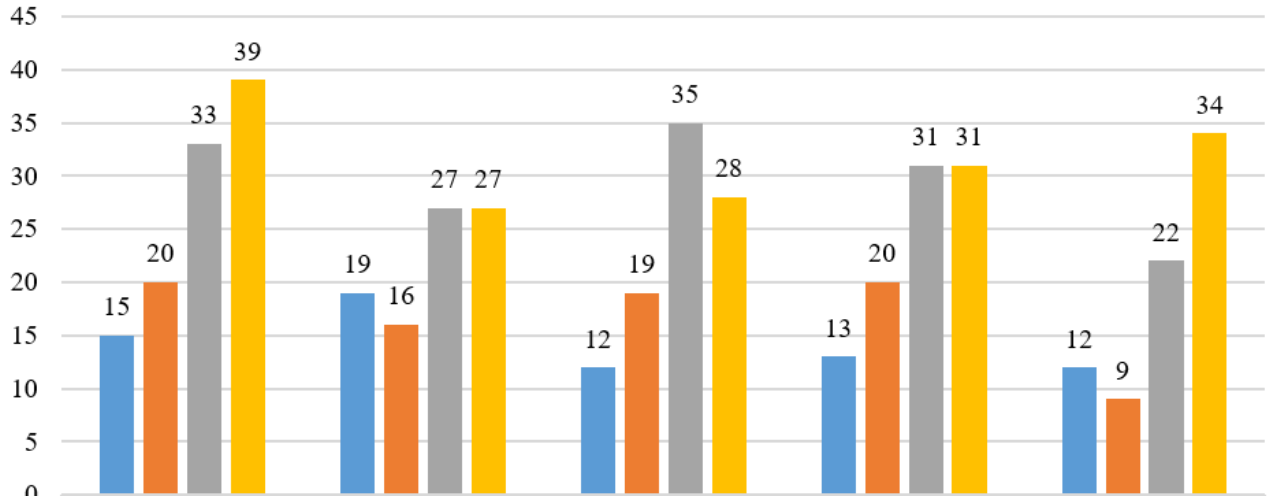
Jump type	Section 1		Section 2		Section 3		Section 4		Section 5	
	Number and height (m)		Number and height (m)		Number and height (m)		Number and height (m)		Number and height (m)	
Serve	15	0.38±0.10	19	0.39±0.09	12	0.32±0.11	13	0.35±0.10	12	0.43±0.09
Set	20	0.32±0.08	16	0.30±0.07	19	0.35±0.08	20	0.34±0.08	9	0.31±0.07
Spike	33	0.45±0.12	27	0.47±0.11	35	0.49±0.10	31	0.47±0.09	22	0.49±0.10
Block	39	0.42±0.09	27	0.44±0.08	28	0.39±0.09	31	0.40±0.08	34	0.42±0.08

The number of serve jumps for middle blockers was 25 times, with a height of 0.22±0.04 m and a relative indicator of 72.0±8.5%. For liberos, this result was 12 times, with a height of 0.44±0.05 m and a ratio of 80.0±7.0%. Hitters, however, recorded the highest number of serve jumps (35 times), with a height of 0.43±0.10 m and a ratio of 70.0±13.0%. The results show that, although the hitters performed more serve jumps, the liberos had superior jump height.

This type of jump is characteristic only of liberos, who performed 85 setting jumps. The height was 0.32±0.09 m, and the relative value was 60.0±14.0%. This result shows that the main task of the libero is related to setting.

Central defenders recorded 65 jumping strikes with an average height of 0.48 ± 0.09 m and a relative indicator of 72.0 ± 11.0%. For forwards, while this indicator was numerically the highest (85 times), their jump height was relatively lower at 0.44 ± 0.11 m, with a relative indicator of 63.0 ± 13.5%. This result shows that central defenders have superiority in attack height compared to forwards, but for-

Fig 1. Dynamics of the number of jumps by game sections according to jump type

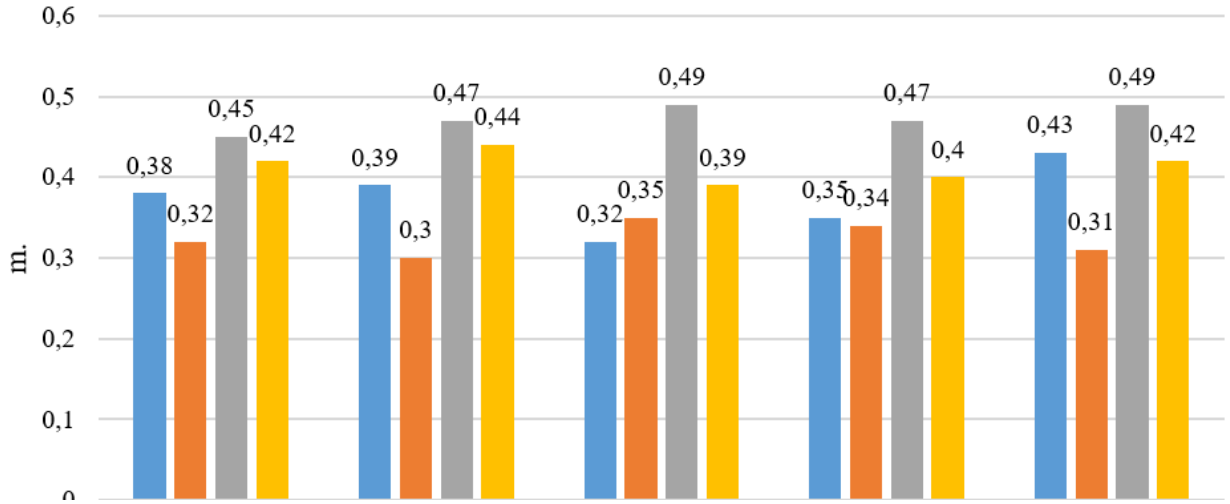


wards performed a greater number of striking actions.

Central defenders performed the most blocking jumps (75 times) with a height of 0.38±0.08 m and a relative indicator of 60.0±12.0%. In Libero, the number of blocks was 20 times, the height was 0.46±0.07 m, and the ratio was 75.0±10.5%. For the forwards, the number of blocks was 60 times, the height was 0.41±0.08 m, and the ratio was 67.0±12.0%. This result indicates that the central defenders are leading in number of blocking jumps, while the libero perform relatively fewer blocking jumps at higher heights.

In 13-14-year-old volleyball players, jumping activity differs depending on the location: Forwards led in the number of goals and shots, but recorded a slightly lower indicator in height. Centre-backs have shown superiority in height and effectiveness in attack and blocking. The Liberos achieved high heights in passing and scoring jumps, but performed fewer movements in terms of number compared to other positions. These results show the peculiarities of the placement of jumping types in the game in 13-14-year-old volleyball players and justify the need for a differentiated distribution of loads in the training process.

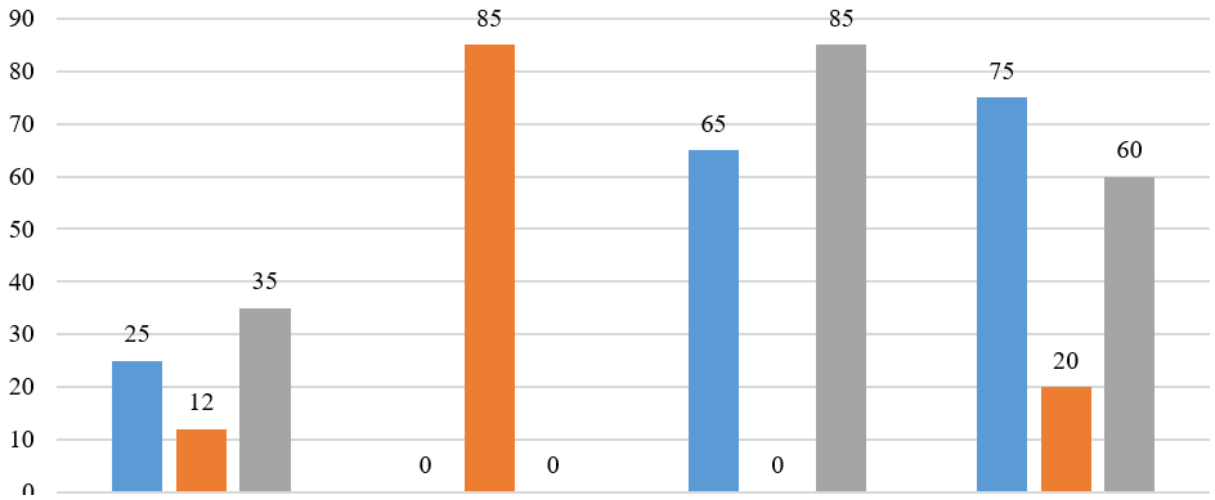
Fig 2. Dynamics of jump height by game sections according to jump type



The results of statistical analysis show that in the cross-section of sections, a noticeable main effect in the height of the jump was observed in the jumps on the strike (attack) ($F(4,...) \approx p < 0.05$), while in other types of jumps, no statistically significant difference was found ($p > 0.05$). The results of pairwise comparison showed a significant difference in the height of the serve between the 3rd and 5th sections ($p < 0.05$).

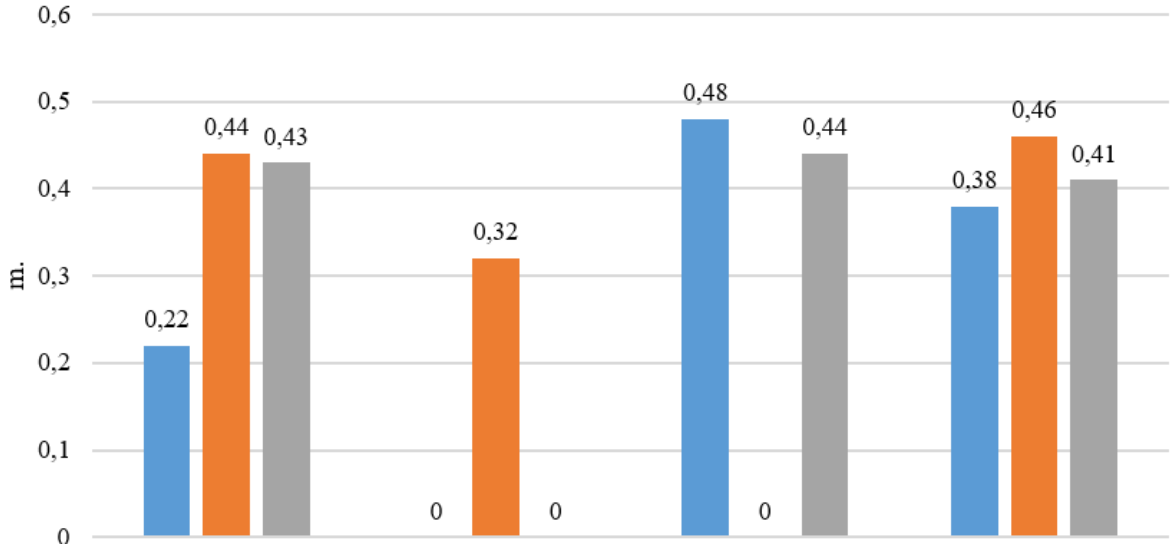
The general trend means that: attacking jumps were recorded in the largest number (27-

Fig 3. Number of jumps according to the playing position of 13-14-year-old volleyball players



35 times) and height (0.45-0.49 m), indicating the team's main resulting action; the number of blocks was also high (27-39 times), but the height was slightly lower (0.39-0.44 m); when scoring, the height increased by the last half (0.43 m), which is explained by the possibility of using a more dangerous service to exert pressure on the opponent; and the number of passing jumps sharply decreased in the last half (from 20 to 9), but the height remained stable (0.30-0.35 m). These results are associated with the fatigue of athletes during the game, changes in tactical decisions and team strategy.

Fig 4. Jump height according to the playing position of 13-14-year-old volleyball players



Statistical analysis in the context of positions in the game showed significant key effectiveness in passing and blocking ($F(2,...) \approx p < 0.001$). The results of pairwise comparison revealed the following: in the shooting jump, the libero (0.44 ± 0.05 m) and the forwards (0.43 ± 0.10 m) showed significantly higher results than the central defenders (0.22 ± 0.04 m) ($p < 0.001$); in the shooting jump, the central defenders (0.48 ± 0.09 m) slightly outperformed the forwards (0.44 ± 0.11 m), although the difference is insignificant; in the blocking jump, the libero (0.46 ± 0.07 m) reached the highest height, having a significant advantage over the forwards (0.41 ± 0.08 m) and the central defenders (0.38 ± 0.08 m) ($p < 0.05$); the shooting jumps were recorded only in the libero position, averaging 0.32 ± 0.09 m.

Central defenders perform more shooting and blocking jumps, but lag behind libero and attackers in height; although the libero

Table 2. Height and number of jumps according to the playing positions of 13-14-year-old volleyball players

Jump type	Middle blocker			Libero			Attacker		
	Number	Height	Ratio %	Number	Height	Ratio %	Number	Height	Ratio %
Serving	25	0.22±0.04	72.0±8.5	12	0.44±0.05	80.0±7.0	35	0.43±0.10	70.0±13.0
Setting	-	-	-	85	0.32±0.09	60.0±14.0	-	-	-
Spiking	65	0.48±0.09	72.0±11.0	-	-	-	85	0.44±0.11	63.0±13.5
Blocking	75	0.38±0.08	60.0±12.0	20	0.46±0.07	75.0±10.5	60	0.41±0.08	67.0±12.0

technically showed high results in shooting and blocking jumps, shooting was not observed in them; the attackers performed the most jumps in the total number and also showed a high result in height.

The results of both tables show a clear difference in the types of jumping activity of volleyball players depending on the type and location in the game. Attacking and blocking jumps are the main resulting movements, while serving and passing jumps depend more on positioning and tactical situations. These differences are even more pronounced in young volleyball players and serve as an important indicator for coaches when planning special positional training.

Analysis of the jump height showed that although the jumps in blocking were significantly higher in the second half compared to the third, no such difference was found for the jumps in shooting, jumps in passing, and jumps in scoring. These results were obtained by Lima et al. (2019), but Wnorowski et al. (2013) that the jump height decreases as the number of sections increases during the game. This difference can be explained by the adjustment of the jump height performed by the players (Lima et al., 2019). That is, the number of sections and game conditions also affect the height of the jump, since, in addition to scoring, players are forced to adapt their jumps to the actions of teammates and opponents in passes, shots, blocks, and other situations. When calculating the ratio of the height of the jump to the maximum indicator, it was observed that individual results ranged from 76.9% to 88.1% for the jumps with a strike and from 68.7% to 89.6% for the jumps with a barrier. In other words, in each jump type, players jumped at approximately 65-90% of their maximum capabilities and did not always jump at maximum height.

According to the analysis of the relationship between jump height and positions, libero and forward indicators for shooting jumps and blocking jumps were significantly higher than for a central defender/blockers. This result was obtained by Lima et al. (2019) are similar to the conclusions noted in the study. One explanation for the fact that the center-back's indicator is lower than other positions in shooting jumps and blocking jumps is the finger length. Finger reach is 218 cm for the libero, 230.3 ± 2.5 cm for the attacker, and 240.5 ± 4.9 cm for the defender, with the defender having the highest result. Higher toe reach allows for efficient execution of the jump with less force (Lima et al., 2019). In previous studies (Lima et al., 2019), it was noted that the forward's performance in shooting jumps was higher than the defender's, while in this study, on the contrary, the defenders showed a significantly higher result than the forwards.

Also, in relation to the maximum jump height, the indicators for forwards are 71.5%, and for defenders - 82.9%, which indicates the superiority of defenders. One of the reasons for this is that the pace of passing varies for both forwards and defenders. Forwards can independently adapt their jumps to the received ball, while for defenders, the pass is given after the jump. Therefore, defenders are required to apply more force and jump higher.

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Conclusion

Differences in the number of jumps were studied depending on each player and their task. In previous studies of high-level athletes and leading young volleyball players, the number of jumps in one half was approximately 12-23 times for forwards, 18-27 times for defenders, and 18-32 times for libero, with the highest indicator recorded in the libero position (Esper, 2003; Lima et al., 2019; Okano & Tanigawa 2016; Sheppard & Gabbett 2009). Our results were similar: 12.7-16.3 for forwards, 15.5-23.0 for defenders, and 19-32 for libero. It should be taken into account that the level of use of jumping technique increases with the increase in the skill of the passer (libero) and the level of the team (Palao & Martinez, 2013). Based on this, it can be assumed that the level of skill of the player influences the number of jumps during the game, and the results may differ among elementary, middle, and high school students. Determining the number of jumps in games and training allows for the assessment of individualized training loads (Lima et al., 2019), as well as the management of individual loads to prevent injuries (Benson et al., 2020; Skazalski et al., 2018).

No significant difference in jump height was observed between sections for jumps in striking (attacking), passing, and serving. In the jumps of a strike (attack) and a block, the libero and the attacker's indicators were significantly higher than the central defender's. In each jump type, approximately 65-90% of jumps were performed at maximum height, indicating that players do not always move at maximum range. These results are consistent with the findings of Lima et al. (2019).

The number of jumps in each half was 12.7-16.3 for the forward, 18.5-23 for the defender, and 23-32 for the libero. These results are based on previous studies (Lima et al., 2019; Okano & Tanigawa 2016; Sheppard & Gabbett, 2009).

As can be seen from the above, the characteristics of jump height and number of jumps during the game are similar between high-level athletes and amateurs. However, considering that the number of jumps in the game may depend on the level of skill, additional verification within a wider range of participants is necessary. Nevertheless, the results of this study can be useful for coaches in training amateur players.

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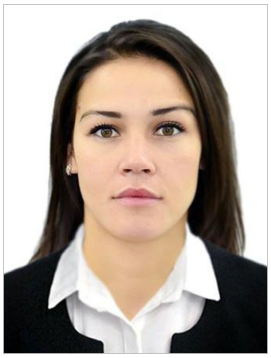
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