ISSN: 2978-2333

Journal of Sports Psychology and Medicine

SCIENTIFIC Research and Community

Research Article

Open Access

Defensive Reaction Time in Under-16 Female Volleyball Players

Georgi Georgiev Birbochukov* and Ivan Bogdanov Kolev

National Sports Academy Vassil Levski, Bulgaria

ABSTRACT

The dynamics of volleyball require rapid actions and minimal reaction time. Timely and accurate responses are crucial in defensive play, as players must instantly analyze the situation and respond effectively to the opponent's attack.

The objective of this study was to determine the preparation and execution time required for defensive actions in volleyball. The research was conducted among national under-16 girls' volleyball teams participating in the 2025 European Qualification Tournament. We measured the time it takes for the ball to travel from the setter to the attacker, and from the attacker to the moment the ball lands in the opposing court. Data collection and analysis were performed using the video analysis software Kinovea.

Sets from the setter to the attacker were categorized based on the attacking zone - zones 1, 2, 3, 4 and 6 and only attacks following a positive reception to the setter were included. To summarize the measurement data and determine both the fastest attacks and average values, we applied variation analysis. A frequency analysis was also conducted to identify the most commonly observed outcomes. We identified the timeframe within which blockers and defenders need to reposition themselves for defense, as well as their available reaction time after an opponent's spike. The average time required to move to a defensive position was: 1.29 seconds for attacks from zone 4, 0.56 seconds from zone 3, 1.29 seconds from zone 2. The average ball travel time from the attacker to the opponent's court was: 0.78 seconds from zone 4. 0.52 seconds from zone 3, 0.67 seconds from zone 2. The collected data indicates that quick movement and tactical discipline are fundamental for successful defensive performance. During the fastest attacks, players have insufficient time to reposition. Therefore, if defenders are not already in the correct positions, effective defense becomes nearly impossible.

***Corresponding author**

Georgi Georgiev Birbochukov, National Sports Academy Vassil Levski, Bulgaria.

Received: April 14, 2026; **Accepted:** April 20, 2026; **Published:** April 28, 2026

Keywords: Reaction Time Training, Youth Sports Performance, Defensive Tactics, Video Motion Analysis, Sensorimotor Skills

Introduction

Volleyball is one of the most dynamic team sports, where success depends on the player's ability to react quickly and adequately to constantly changing game situations. As emphasized by Altundag et al. rapid reaction time is particularly useful in fast-paced sports such as volleyball, football, basketball, and tennis, where it often influences the outcome of individual actions [1]. This is also supported by Maciel et al. who point out that reaction time is a fundamental factor for success in sports like volleyball, as athletes must be able to respond instantly to counter the opponent's moves [2].

The physiological basis of quick reactions is explained by Aladzhov who describes reaction as the rapid transmission of signals through the central nervous system (CNS) to the muscles [3]. This is complemented by who note that reaction time reflects the efficiency of sensorimotor coordination and performance, involving processes such as stimulus processing, decision-making, and programming of responses - all of which are essential for defensive play [4].

Studies show that quick reactions are especially beneficial in sports like volleyball, where players are required to adapt rapidly to unpredictable ball trajectories [4]. Volleyball players' reactions must be precise and timely enough to allow adaptation to a variety of attacks, including those with different force levels and originating from different court zones.

The speed of reaction becomes particularly important in defensive actions in volleyball, where players must analyze and respond to opponents' attacks within fractions of a second. Research indicates that reaction time is a crucial component of athletic performance, especially in ball sports like volleyball, where rapid transitions between offense and defense are continuous. Li et al. underline that in volleyball, these rapid shifts between offensive and defensive play force athletes to anticipate each hit within a very limited time. According to Liu the capacity to react effectively in defensive situations is one of the main determinants of both defensive skills and overall defensive performance in volleyball [5,6].

Based on this principle, reaction in defensive actions is linked not only to sensorimotor skills but also to cognitive processes such as attention, anticipation, and adaptability. Young volleyball

players, especially in youth age groups, are still developing these skills, which raises questions about their effectiveness under fast and aggressive attack conditions. Valayi et al. argue that cognitive functions like attention control and the speed of decision-making are strongly correlated with defensive performance in youth volleyball [7].

Besides cognitive aspects, the ability for rapid sensorimotor transformation-that is, fast processing of visual information and its conversion into motor responses-plays an important role. Zwierko et al. emphasize that the quick transformation of visual input into motor actions is especially critical in team ball sports, where recognizing and analyzing motion features such as ball speed, trajectory, and spin are vital for performance, particularly under conditions of fatigue [8].

In youth athletes, a particular interest lies in the available reaction time and how it affects the effectiveness of defensive actions.

Methodology

This study aimed to determine the preparation and execution time of defensive actions.

Using the video analysis software Kinovea, we measured the flight times of the ball from the setter to the attacker and from the attacker to the opponent's court. Over 450 actions were analyzed, involving teams from Italy, Poland, Turkey, Bulgaria, and Serbia. The ball flight time was collected only after a positive reception to the setter. The data were grouped according to the organization of the attack through zones 4, 3, 2, 6, and 1.

The Tasks Set to Achieve Our Aim Were

- To record the ball flight times from the setter to the attacker in each of the attack zones (4, 3, 2, 6, and 1);
- To record the ball flight times from the attacker's spike to the moment the ball reaches the defender or hits the floor;
- To calculate the average times for all data groups, categorize them into five intervals, and distribute them as percentages among these intervals.
- To accomplish these tasks, we employed variance and frequency analysis.

Results

Table 1: General Data - Number of Actions and Average Times of All Attacking Zones

SET- ATT	Zone 4		Zone 3		Zone 2		Zone 6		Zone 1	
	Total act.	Avg. time (sec.)	Total act.	AVG time (sec.)	Total act.	Avg. time (sec.)	Total actions	Avg. time (sec.)	Total act.	Avg. time (sec.)
	188	1.3	82	0.56	90	1.24	54	1.24	39	1.41
ATT - DEF	188	0.71	82	0.52	90	0.67	54	0.77	39	0.86

Table 1 presents the number of actions and average times for the analyzed movements. There were 188 attacks through zone 4, 82 through zone 3, 90 through zone 2, 54 through zone 6, and only 39 through zone 1. It is noticeable that most attacks are conducted through zone 4, while zones 1 and 6 are rarely used following a positive reception to the setter.

The average ball flight time from the setter to the attacker is similar for attacks from zones 4, 2, and 6, ranging from 1.24 to 1.30 seconds. For attacks from zone 1, the ball reaches the attacker in 1.41 seconds, while zone 3 shows the shortest flight time - an average of 0.56 seconds. Regarding ball flight after the attacker's strike, zones 4, 2, and 6 show comparable times: zone 4 - 0.71 s, zone 2 - 0.67 s, zone 6 - 0.77 s. Zone 1 lags behind with 0.86 s, and zone 3 has the shortest average flight time of 0.52 s.

Using frequency analysis, we compiled five tables grouping data into five intervals and presenting the percentage distribution of various attacks through different zones.

Table 2: Attack Intervals and Frequency from Zone 4

Zone 4			
SET - ATT		ATT - DEF	
Intervals (sec.)	Frequency	Intervals (sec.)	Frequency
0.95-1.14	30%	0.35-0.55	33%
1.15-1.34	36%	0.55-0.75	18%
1.35-1.54	29%	0.75-0.95	25%
1.55-1.74	4%	0.95-1.15	17%
1.75-1.94	1%	1.15-1.35	7%

In attacks through zone 4, the fastest sets from the setter to the attacker occur mostly between 0.95 and 1.14 seconds (30% of cases). The most common flight time of the ball from attacker to defender or floor is between 0.35 and 0.55 seconds (33%). In 95% of cases, the setter-to-attacker time ranges from 0.95 to 1.54 seconds, indicating a relatively standardized tempo in attacks through this zone. Regarding the attacker-to-defense trajectory, the most frequent values fall between 0.35 and 0.75 seconds (51% combined), suggesting aggressive and fast attacks requiring quick defensive reactions.

Table 3: Attack Intervals and Frequency from Zone 3

Zone 3			
SET - ATT		ATT - DEF	
Intervals (sec.)	Frequency	Intervals (sec.)	Frequency
0.35-0.53	47%	0.35-0.55	53%
0.54-0.71	35%	0.55-0.75	30%
0.72-0.88	7%	0.75-0.95	13%
0.89-1.05	8%	0.95-1.15	2%
1.06-1.22	3%	1.15-1.35	2%

Attacks from zone 3 are characterized by the highest speed. In 82% of cases, the set from setter to middle attacker is completed in less than 0.71 seconds. This is expected since the central zone allows shorter and faster sets. Regarding ball flight after the attack, 83% of the hits reach the defender or floor within 0.75 seconds, indicating powerful and fast attacks. These results emphasize the need for excellent defensive reaction against attacks from the central zone.

Table 4: Attack Intervals and Frequency from Zone 2

Zone 2			
SET - ATT		ATT - DEF	
Intervals (sec.)	Frequency	Intervals (sec.)	Frequency
1.00-1.17	29%	0.35-0.55	32%
1.18-1.35	43%	0.55-0.75	43%
1.36-1.53	14%	0.75-0.95	16%
1.54-1.71	9%	0.95-1.15	5%
1.72-1.89	5%	1.15-1.35	4%

Attacks from zone 2 show a more moderate tempo compared to the center, with most sets occurring between 1.00 and 1.35 seconds (72%). The most frequent attacker-to-defense times are between 0.55 and 0.75 seconds (43%). The data reveal some consistency and stability in the attack tempo from this zone, which requires quick judgment and readiness to react, especially for sets of moderate height and speed.

Table 5: Attack Intervals and Frequency from Zone 6

Zone 6			
SET - ATT		ATT - DEF	
Intervals (sec.)	Frequency	Intervals (sec.)	Frequency
1.00-1.17	38%	0.35-0.55	21%
1.18-1.35	25%	0.55-0.75	43%
1.36-1.53	25%	0.75-0.95	8%
1.54-1.71	6%	0.95-1.15	21%
1.72-1.89	6%	1.15-1.35	7%

Attacks from zone 6 show a relatively even distribution of sets between 1.00 and 1.53 seconds, which account for 88% of all sets. The most frequent ball flight time after attack is between 0.55 and 0.75 seconds (43%), close to values seen in zones 2 and 3. Zone 6 attacks are often used as surprise plays or during longer rallies, where variety in the offense is necessary.

Table 6: Attack Intervals and Frequency from Zone 1

Zone 1			
SET - ATT		ATT - DEF	
Intervals (sec.)	Frequency	Intervals (sec.)	Frequency
1.00-1.17	41%	0.35-0.55	30%
1.18-1.35	8%	0.55-0.75	10%
1.36-1.53	8%	0.75-0.95	20%
1.54-1.71	8%	0.95-1.15	30%
1.72-1.89	35%	1.15-1.35	10%

The results for attacks from zone 1 are the most varied. The sets from the setter are concentrated in two main intervals - fast sets (1.00–1.17 seconds, 41%) and significantly slower sets (1.72-1.89 seconds, 35%). This distribution suggests a lack of a unified strategy or varying levels of specialization among attackers in this zone. A similar trend is observed in the ball flight times after attack - with an almost even distribution across the five intervals. This indicates experimentation or limited opportunities to execute fast attacks from this zone in some teams.

Discussion

The analysis of attack organization in under-16 female volleyball teams revealed that most attacks are conducted through zone 4, establishing it as a primary tactical focal point. This is likely due to greater reliability and control in the set, as well as a well-established connection between the setter and the outside hitter. Consequently, the synchronization between these two players is highly developed, resulting in stable and effective execution of attacks from this zone.

Attacks from zone 3, however, exhibited the highest speed, significantly limiting the defensive reaction time for both blockers and back-court defenders. Blockers must orient, position, and jump within 0.5 seconds, and defenders have approximately the same timeframe to react to the spike and attempt a dig. These brief windows demand not only excellent physical conditioning, but also pre-planned tactical models and automatized motor reactions.

When attacks are directed toward to ends of the net or back-court, the timing dynamics shift. Blockers have roughly 1.3 seconds for repositioning and reaction, providing a temporal advantage for constructing an efficient block. Back-court defenders face approximately 0.5 seconds of reaction time against zone 4 attacks, increasing to 0.75 seconds for powerful attacks from zones 2 and 6. These values correspond well to the typical ball-flight times recorded in the video analysis.

These types of attacks are among the most dynamic and challenging to defend, so teams should deliberately focus on developing effective defensive strategies against them. Since the defense is at a temporal disadvantage compared to the attack, a realistic target in youth groups is to achieve about 50% defensive effectiveness against hard attacks-considered both feasible and functional for building stable defensive skills.

Special attention should be given to defending zone 3 attacks, where reaction time is extremely limited. In these situations, defenders must rely on pre-established positioning and tactical decisions based on repetitive attack patterns. This anticipatory framework helps minimize cognitive processing time, which is critical in scenarios with extremely short reaction windows.

The study's data clearly indicate that defenders typically have between 0.35 and 1.0 second to respond, depending on the attack zone and strike quality. This confirms the necessity for automatized defensive actions, supported by solid positioning, high concentration, and pre-planned tactical schemes. Cultivating reflexes and game intelligence should be a priority in training female players in this age group. Liu emphasized that volleyball players need strong judgment and adaptability in order to achieve high performance in competition, and that having quick reflexes is a fundamental requirement for being successful in the sport [6].

The data also reveal that movement time to defensive position varies by attack zone- shortest for zone 3 attacks (approximately 0.56 seconds) and longest for zones 2 and 4 (approximately 1.29 seconds). This highlights how critical initial defensive positioning is relative to the anticipated attack. In extremely fast attacks without prior positioning, effective defense is nearly impossible.

Fleddermann et al. pointed out that the dynamic nature of sports games forces players to make rapid decisions and initiate actions that may need to be adjusted or canceled due to sudden changes in the game situation. Aladzhov added that complex reactions demand non-standard management, which is characteristic of dynamic sports like volleyball [3,9].

These results support past research showing that even in youth teams, the ability to anticipate the opponent's attack is a crucial factor in defensive performance. Li et al. indicated that experienced volleyball players demonstrate superior skills in recognizing and predicting potential attacks, which enables them to react defensively more quickly [5].

Therefore, targeted training that simulates realistic game scenarios with attacks from different zones and requiring minimal reaction time is essential for improving defense in youth players. Reaction training should closely imitate actual match situations. Ciesluk et al. stressed that specialized training programs can significantly enhance players' performance, as visual-motor reaction time plays a key role in volleyball [10].

In conclusion, our findings confirm that reaction speed is a determining factor for defensive success in youth volleyball. Reaction time is not just a physiological metric but reflects an integrated cognitive-motor system that must be developed through appropriate training strategies. Overall, it is evident that in volleyball, the pace of the game and the extremely short time available to react to rapidly changing situations make perception and reaction speed essential for performance. Our quantitative data reinforce this thesis and can be utilized to optimize training protocols for young players.

Volleyball's dynamic nature requires not only quick reactions but also adaptability to constantly changing conditions. Mawarti et al. observed that players often need to cover varying distances in multiple directions in order to perform movements such as dives, rolls, and falls to receive the ball, highlighting that agility and reaction time are fundamental for defensive success [11]. Therefore, beyond physical speed, preparing specific drills that replicate rapidly changing game situations is vital.

This study confirms that defensive performance in young volleyball players critically depends on reaction time and tactical preparedness. The data show that in fast-paced offensive scenarios, players have insufficient time to correct if they are not pre-positioned. This emphasizes the importance of an integrated training approach, combining physical and cognitive preparation. Future research should extend these observations to elite-level athletes to determine whether similar patterns exist at higher performance levels.

Conclusion

After analyzing the results we obtained, we drew the following conclusions, which summarize the main trends and patterns identified in the study:

Middle blockers must be able to move from the center to the ends of the net within 1 second in order to provide timely and effective blocks against attacks originating from the outside zones.

During zone 3 attacks, which are characterized by the shortest ball-flight times, the reaction time available to blockers is limited to 0.3 to 0.5 seconds. This requires optimal initial positioning and automatized defensive actions.

Back-row defenders must develop the ability to respond to a spiked ball within approximately 0.5 seconds, particularly against powerful and fast attacks from zones 3 and 4.

Coaches should structure their team's defensive tactics to ensure anticipatory readiness and positioning against expected attacks from zone 3, relying on repetitive play patterns and rapid spatial orientation.

Priority in defensive training should be given to counteracting attacks from zone 4, as it is the most frequently used attack zone in under-16 female volleyball. The synchronization between the setter and attacker is most refined in this zone, offering the highest scoring potential.

The development of sensorimotor reaction in youth players is a key component of defensive effectiveness, especially under time-constrained decision-making conditions. Training methodologies should incorporate game-based drills and simulations of fast-paced attacks from various zones in order to cultivate automatized defensive responses.

References

1. Altundag E, Soylu C, Isguzar M G (2024) The relationship between eccentric hamstring muscle strength and reaction time in elite volleyball players: Cross-sectional study. Türkiye Klinikleri Journal of Sports Sciences 16: 7-13.
2. Maciel RN, Morales AP, Barcelos JL, Nunes WJ, Azevedo MA, et al. (2009) Relation between reaction time and specific function in volleyball players. Fitness & Performance Journal 8: 395-399.
3. Aladzhov K (2011) Developing reaction speed in football. Medicina i Sport 7: 28-30.
4. Shejwal K, Kumar N (2020) Comparison of simple reaction time between volleyball and football playing collegiate athletes. International Journal of Research and Review 7: 421-424.
5. Li X, Wang D, Gao S, Zhou C (2024) Impacts of kinematic information on action anticipation and the related neurophysiological associations in volleyball experts. Brain Sciences https://www.mdpi.com/2076-3425/14/7/647.
6. Liu Y (2023) Athletes reaction capacity in the performance during a volleyball competition. Brazilian Journal of Sports Medicine https://www.scielo.br/j/rbme/a/ztCjGTkC9LTPjDpNcCtSZMh/?lang=en.
7. Valayi F, Bagherli J, Taheri M (2024) The impact of performance fatigue on visual perception, concentration,

and reaction time in professional female volleyball players. International Journal of Sport Studies for Health 7: 47-54.

8. Zwierko M, Jedziniak W, Popowczak M, Rokita A (2024) Effects of six-week stroboscopic training program on visuomotor reaction speed in goal-directed movements in young volleyball players: A study focusing on agility performance. BMC Sports Science Medicine and Rehabilitation 16: 59-60.
9. Fleddermann MT, Reichert L, Wieland B, Zentgraf K (2023) Stop it! Relationship between sport expertise and response inhibition in elite athletes. Frontiers in Psychology https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2023.1192483/full.
10. Ciesluk K, Sadowska D, Krzepota J (2025) Assessing changes in reaction time following RAMP warm-up and short-term repeated volleyball specific exercise in young players. Sensors https://www.mdpi.com/1424-8220/25/1/125.
11. Mawarti S, Rohman Syah NA, Hiruntrakul A (2021) Effect of volleyball training program to improve reaction time. International Journal of Human Movement and Sports Sciences 9: 1314-1318.