EFFECTS OF A STRUCTURED PHYSICAL TRAINING PROGRAM ON REACTION TIME IN U15 VOLLEYBALL PLAYERS

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https://doi.org/10.35189/dpeskj.2025.64.4.1

Abstract. *Volleyball is a high-intensity sport characterized by repeated jumps, sudden changes of direction, and rapid transitions between offensive and defensive phases. In such a dynamic context, reaction time becomes a decisive factor of performance, directly influencing the efficiency of technical and tactical actions and the players' ability to adapt to the unpredictability of the game. The purpose of this study was to analyze changes in reaction time in U15 volleyball players following the implementation of a specific physical training program based on the principles of microperiodization. The sample consisted of 22 athletes, evaluated in two distinct stages: initial testing (February 2025) and final testing (September 2025). Between the two assessments, the participants followed a structured training program focused on developing speed ability and reaction time. Reaction time was measured using the Witty system under standardized conditions, with each athlete being evaluated individually. Statistical analysis revealed significant differences between the two testing sessions, confirming the effectiveness of the implemented training program. The results show that a microperiodized training program, applied in the medium term, can generate measurable motor adaptations, contributing to the optimization of reaction speed in juvenile volleyball players. These findings support the importance of integrating specific exercises aimed at developing reaction time into the training methodology and provide a basis for developing training models adapted to age and performance level.*

Keywords: *reaction speed; volleyball; specific physical training; microperiodization; training.*

Received: *13 October 2025 /* **Accepted:** *28 November 2025 /* **Published:** *30 December 2025*

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Introduction

Volleyball requires a high level of physical fitness, technique, and tactical intelligence (Sheppard & Newton, 2012). Modern volleyball is characterized by increased intensity and accelerated game action. In this type of competition, athletes are subjected to intermittent effort, characterized by alternating phases of maximum psychophysiological demand and short periods of active or passive rest (Ziv & Lidor, 2010).

Volleyball is a complex sport in which performance depends on a combination of physical, cognitive, and technical-tactical requirements. The ability of players to integrate cognitive processes with explosive movements, to adopt reactive positions depending on the context of the game, and to execute technical actions with precision and speed plays an essential role in competitive success (Afonso et al., 2005).

Research has shown that performance in volleyball is significantly influenced by the quality of visual functions and associated processes. The ability to quickly select visual information in dynamic contexts, anticipate the trajectory of the ball, and generate effective visual-motor responses is a key determinant of game efficiency (Piras et al., 2014; Mann et al., 2007). The development of anticipation and decision-making is evident in experienced players, thus highlighting the role of perceptual-cognitive training. (De Waelle et al., 2021). Concentration is also an essential component, influenced by memory and learning mechanisms and individual characteristics (Abernethy, 1990).

From a motor control perspective, reaction time reflects central processing stages that precede movement execution. Reaction time is described as being primarily associated with stimulus identification and response selection, which occur before the initiation of the motor response. These perceptual–cognitive components play a decisive role in reactive performance, particularly in team sports characterized by time pressure and environmental uncertainty (Mann et al., 2007).

Reaction speed represents a key coordination-related motor ability in athletes, as it plays a significant role in performance across a wide range of sports. Its importance is particularly evident in disciplines that require rapid responses to constantly changing game situations, such as team sports, tennis, or volleyball. Reaction speed involves not only simple stimulus–response actions, but also complex decision-making processes that must be executed within very short time intervals (Polechoński & Horbacz, 2025).

The accuracy of decisions in competitive sports depends on the rapid processing of visual information and the use of effective visual search strategies, which differentiate expert players from novices (Sarmento et al., 2018). Visual training has become an important component in optimizing athletic performance, with over 80% of the information processed in competitions being visual in nature, highlighting the critical role of the visual system in interpreting game situations, decision-making, and technical execution (Vișan et al., 2023).

Physical performance is a decisive component, alongside technical and tactical skills, in competitive success. Optimizing physical training, in parallel with the development of technical and tactical factors, is fundamental to achieving performance. Short reaction times, speed of execution, and speed of movement are considered major influencing factors in volleyball due to the fast pace of the game (Suchomel et al., 2016).

Reaction time is commonly classified based on the number of stimuli and response alternatives involved. It is defined as the interval between the onset of a stimulus and the initiation of a motor response. It is influenced by the characteristics of the stimulus, nerve transmission speed, information processing time, and the particularities of the motor segment involved. In volleyball, these variables influence the promptness of decision-making and the efficiency of technical and tactical actions, being indicators of specific training (Kosinski, 2008). In open-skill sports such as volleyball, choice and discrimination reaction time predominates due to the continuous need for perceptual–cognitive processing (Mann et al., 2007).

Existing research has shown that reaction time is a major determinant of performance in situational sports, being analyzed both as an indicator of sensorimotor coordination and of the decision-making process (Mann et al., 2007). However, most studies have focused on comparisons between performance levels or the particularities of reactions in specific contexts

with less data available on reaction time adaptations following training programs systematically applied to juvenile athletes (Zemková, 2016).

Similarly, short-term perceptual-cognitive interventions, such as stroboscopic training or the use of reactive technologies (e.g., Fitlight), have demonstrated immediate improvements in visual-motor reaction speed, but these tend to be difficult to maintain in the absence of an integrated program (Zhu et al., 2024).

Previous research has shown that structured training programs can improve physical and perceptual–motor capacities related to reactive performance. Plyometric training has been reported to enhance explosive strength and neuromuscular coordination (Markovic, 2007), while agility and reactive training emphasize the interaction between perceptual-decision-making processes and explosive movement execution (Sheppard & Young, 2006).

Structured physical training programs require precise control of exercise intensity and stimulus duration in order to induce specific neuromuscular adaptations that can influence motor response efficiency, even in short-time training or testing conditions (Takagi et al., 2014).

In youth athletes, improvements in reaction time are closely related to the quality of perceptual-motor stimulation within training programs, as visual attention and motion perception significantly contribute to faster and more accurate motor responses (Wilkins & Gray, 2015).

Unlike acute interventions, neuromuscular and perceptual-cognitive adaptations require extended periods of exposure to specific stimuli in order to stabilize and transfer to real game situations. The literature shows that the development of reaction speed, coordination, and neuromuscular control in young athletes requires interventions lasting between 12 and 24 weeks (Lloyd & Oliver, 2012). In this regard, microperiodization - the strategic organization of training stimuli into weekly microcycles - is an effective method for the progressive accumulation of specific adaptations (Issurin, 2010).

The seven-month duration used in this study is thus justified by the need for sufficient volume and repeated exposure to specific stimuli in order to consolidate changes in reaction speed and transfer them to real-life play.

Consequently, the present study aims to investigate the effects of a microperiodized physical training program, conducted over a period of seven months, on the visual-motor reaction time of U15 volleyball players, contributing to filling a gap in the literature on medium-term interventions in youth sports.

Methodology

Research purpose

The purpose of the study is to investigate the effects of microperiodized training on reaction time in female volleyball players by analyzing the consistency and variability of the results obtained under different testing conditions and validating them while using statistical methods

Research hypothesis

Applying a seven-month microperiodized physical training program will develop the reaction efficiency in volleyball.

Participants

The study was conducted on a group of 22 U15 volleyball players registered with the CTF Mihai I Bucharest School Sports Club, participating in the U15 National Junior Championship, a competition organized by the Romanian Volleyball Federation. The group analyzed constituted the core of the U15 category and also represented a source of selection for the national youth teams, with prospects of participating in official international competitions.

The selection of participants was based on rigorous criteria to ensure the relevance and homogeneity of the sample. Only athletes who:

• accumulated a minimum of 300 minutes played in official matches in the 2024–2025 season;

• played at least seven full matches in the National Junior Championship;

• had at least four years of organized training experience;

• had participated in at least four weekly training sessions in the last 12 months;

• had not suffered any major injuries in the last six months and were able to participate fully in the training program.

The anthropometric characteristics of the participants indicated an adequate level of group homogeneity, as assessed using the coefficient of variation (CV). The average body height was 169.63 ± 6.18 cm (CV = 4.4%), reflecting a very good level of homogeneity, while the average body mass was 59.58 ± 8.38 kg (CV = 15.3%), indicating an acceptable degree of variability for this age category. These values are consistent with the anthropometric profile of an under-15 volleyball team. In addition, all athletes presented comparable competitive experience and training volume, which supports the internal validity of the study and facilitates the interpretation of the differences observed between the two testing moments.

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki, ensuring the confidentiality and anonymity of participants. Prior to the initiation of the research, written informed consent was obtained from the parents/legal guardians of all athletes involved.

Measures and Procedure

The study was designed as a longitudinal study conducted over a period of seven months, with two assessment points: initial testing (February 2025) and final testing (September 2025). Both tests were conducted in Bucharest, at the National University of Physical Education and Sport, on a group of 22 U15 players active in national competitions.

During the interval between the two assessments, the participants followed a specific, microperiodized physical training program designed and implemented by the first author, who also served as the participating team's coach.

The structure of the program was based on short training cycles (weekly microcycles) that combined exercises aimed at developing reaction speed, explosive strength, agility, and specific endurance. Each microcycle has been included the following categories of exercises (see an example in Table 1):

• Visual-motor reaction speed: reactions to visual stimuli, quick decision-making tasks;

• Speed and acceleration: 5–10-meter sprints, changes of direction on command;

• Explosive strength: plyometric jumps, drop jumps, blocking exercises, and spike jumps;

• Agility and coordination: multidirectional exercises, sudden changes of direction, reactions to multiple stimuli, always integrated into ball engagement contexts.

Adapting the program to the competition schedule was a central element of microperiodization. The physical load was adjusted according to the competition density, as follows:

Period with frequent matches (February–April): emphasis on maintenance; the volume of exercises was reduced and the intensity controlled, with a predominance of reaction speed exercises.

Period with low competition density (May–June): gradual increase in load; integration of a greater number of plyometric exercises and repeated sprint series.

Basic training period (July–August): emphasis on consolidation; reaction speed exercises were integrated into practical contexts and simulated game situations.

Table 1. *Weekly microcycle – Basic Training Period III*

Day	Dominant content	Objectives		Dosage	Intensity
Monday	Plyometrics combined with reaction speed	Development of jump height and reactivity in complex sequences	• Jump to block → retreat → attack jump → retreat and reaction to placed ball. (coach's arm);	3x15;P-1`	90%
			• Drop jump from 40 cm followed by anticipating the direction of lift and jump to block (setter cue and ball trajectory);	3x10;P-1`	
			• Drop jump + lateral movement followed by reaction to placed ball (teammate's arm, ball)	3x10;P-1`	
			• Drop jump + jump attack and retreat and reaction to attacked ball (ball, coach's arm.	3x10;P-1`	

Wednesday	Complex reactions in technical-tactical situations	Improvement of rapid visual processing in unpredictable situations	• Reaction to a ball deflected by the block + lateral movement; (deflected ball); • Reaction to consecutive placed balls in different zones; (ball trajectory, coach's arm); • Reaction to short diagonal attack or attack combinations; (ball trajectory); • Quick reaction to variable setting: fast/high/imprecise (Setter action).	3x20;P-1` 3x20;P-1` 3x15;P-1` 3x15;P-1`	85%
Friday	Multidirectional accelerations + reactive speed under visual stimuli	Developing reaction speed in multidirectional movements + rapid transition to game actions	• Sprint start triggered by a the coach's signal forward–backward–sideways (coach's signal) • 3–5 m reactive accelerations after random visual stimulus (ball signal); • Lateral slides with sudden change of direction at visual cue (coach's arm); • "Reaction T-Drill": athlete changes direction in a T-pattern based on unexpected stimulus; (coach/ ball).	3x20;P-1` 3x20;P-1` 3x10;P-1` 3x20;P-1`	90%

Legend: p = *rest interval (pause between exercises).*

Data collection

Figure 1 illustrates the testing setup used to assess visual reaction time with the Witty system. The protocol involved 10 light sources arranged symmetrically over a length of 2 meters, positioned at three height levels: 50 cm (5 sources), 75 cm (2 sources), and 100 cm (3 sources). During the test protocol, light stimuli were activated in random order by the Witty system software. Each trial had a predetermined duration, during which participants had to respond as quickly as possible to each illuminated target. The time interval between successive light stimuli was variable and unpredictable, ensuring random presentation of stimuli and preventing anticipatory responses.

This configuration was chosen to replicate spatial coordinates similar to those encountered during game actions, facilitating an efficient transfer of perceptual-motor demands to real competition situations.

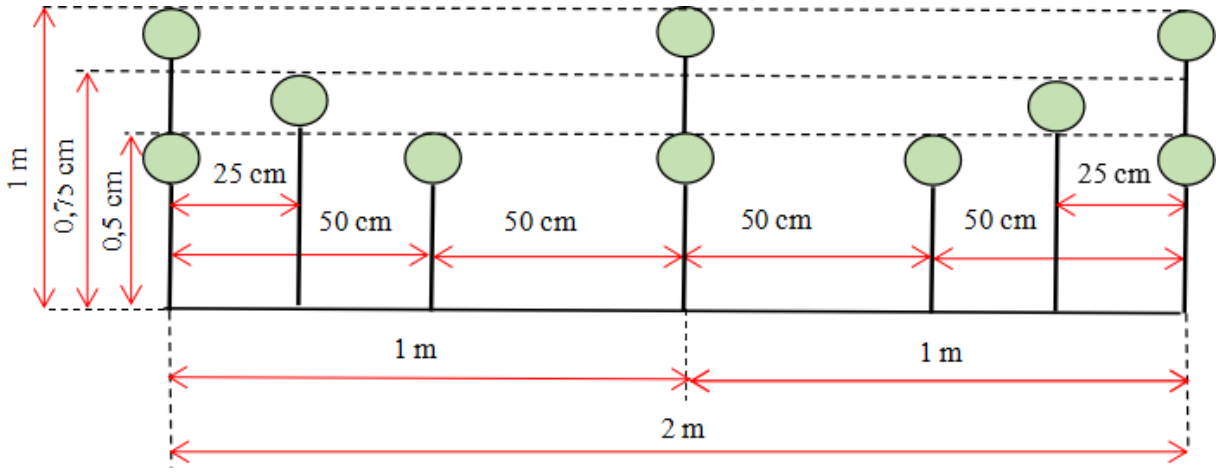

Figure 1. The Witty Green Test

Results

To examine whether the intervention produced meaningful changes in performance, the statistical analysis employed students' t-test for paired samples. This approach is appropriate in situations where the same participants are assessed at two different time points, ensuring the comparison of dependent observations.

The methodological assumptions required for the application of the paired samples t-test were fully satisfied, namely:

• the variables were measured on a continuous scale;

• each athlete contributed with two related values (pre- and post-testing);

• the difference scores exhibited an approximately normal distribution, consistent with parametric testing requirements.

Under these conditions, the paired samples t-test represents a valid analytical procedure for determining the statistical significance of the differences identified between the two testing sessions.

Table 2. *Verification of the statistical difference between the two Witty Green tests – Student's t-test*

Witty Green		Statistic	Degree of freedom	p	Average difference	Standard error of the difference	95% Confidence interval		Cohen's d
Students' t							Min	Max	
TimeI	TimeF	3.3522	21	0.03	1.18727	0.3542	0.45073	1.9238	0.7147
GapI	GapF	0.5852	21	0.57	0.20727	0.3542	-0.52927	0.9438	0.1248
L_L1I	L_L1F	1.0999	21	0.28	0.06318	0.0574	-0.05628	0.1826	0.2345
L_L2I	L_L2F	0.5188	21	0.61	0.04364	0.0841	-0.13128	0.2186	0.1106
L_L3I	L_L3F	1.5071	21	0.15	0.12045	0.0799	-0.04576	0.2867	0.3213
L_L4I	L_L4F	-1.3959	21	0.18	-0.09045	0.0648	-0.22521	0.0443	-0.2976
L_L5I	L_L5F	-0.6401	21	0.53	-0.03864	0.0604	-0.16417	0.0869	-0.1365
L_L6I	L_L6F	0.8297	21	0.42	0.04636	0.0559	-0.06985	0.1626	0.1769
L_L7I	L_L7F	3.5059	21	0.00	0.15545	0.0443	0.06324	0.2477	0.7475

L_L8I	L_L8F	0.8519	21	0.4	0.08955	0.1051	-0.12905	0.3081	0.1816
L_L9I	L_L9F	0.1831	21	0.86	0.01227	0.067	-0.12714	0.1517	0.039
L_L10I	L_L10F	2.1809	21	0.04	0.12455	0.0571	0.00578	0.2433	0.465
L_L11I	L_L11F	1.0283	21	0.32	0.085	0.0827	-0.0869	0.2569	0.2192
L_L12I	L_L12F	0.3932	21	0.7	0.02045	0.052	-0.08772	0.1286	0.0838
L_L13I	L_L13F	1.6587	21	0.11	0.10682	0.0644	-0.02711	0.2407	0.3536
L_L14I	L_L14F	-0.1438	21	0.89	-0.00909	0.0632	-0.14055	0.1224	-0.0307
L_L15I	L_L15F	0.8217	21	0.42	0.04591	0.0559	-0.07028	0.1621	0.1752
L_L16I	L_L16F	2.1892	21	0.04	0.13864	0.0633	0.00694	0.2703	0.4667
L_L17I	L_L17F	2.1699	21	0.04	0.13318	0.0614	0.00554	0.2608	0.4626
L_L18I	L_L18F	0.0628	21	0.95	0.00364	0.0579	-0.1168	0.1241	0.0134
L_L19I	L_L19F	2.192	21	0.04	0.13636	0.0622	0.00699	0.2657	0.4673
GL_L1I	GL_L1F	-0.4669	21	0.65	-0.02682	0.0574	-0.14628	0.0926	-0.0995
GL_L2I	GL_L2F	0.3999	21	0.69	0.03364	0.0841	-0.14128	0.2086	0.0853
GL_L3I	GL_L3F	0.381	21	0.71	0.03045	0.0799	-0.13576	0.1967	0.0812
GL_L4I	GL_L4F	-2.3219	21	0.03	-0.15045	0.0648	-0.28521	-0.0157	-0.495
GL_L5I	GL_L5F	0.1883	21	0.85	0.01136	0.0604	-0.11417	0.1369	0.0401
GL_L6I	GL_L6F	0.6507	21	0.52	0.03636	0.0559	-0.07985	0.1526	0.1387
GL_L7I	GL_L7F	1.9272	21	0.07	0.08545	0.0443	-0.00676	0.1777	0.4109
GL_L8I	GL_L8F	0.7567	21	0.46	0.07955	0.1051	-0.13905	0.2981	0.1613
GL_L9I	GL_L9F	2.4205	21	0.03	0.16227	0.067	0.02286	0.3017	0.5161
GL_L10I	GL_L10F	1.6555	21	0.11	0.09455	0.0571	-0.02422	0.2133	0.353
GL_L11I	GL_L11F	1.2703	21	0.22	0.105	0.0827	-0.0669	0.2769	0.2708
GL_L12I	GL_L12F	0.3932	21	0.7	0.02045	0.052	-0.08772	0.1286	0.0838
GL_L13I	GL_L13F	2.1245	21	0.05	0.13682	0.0644	0.00289	0.2707	0.4529
GL_L14I	GL_L14F	-0.4602	21	0.65	-0.02909	0.0632	-0.16055	0.1024	-0.0981
GL_L15I	GL_L15F	0.6427	21	0.53	0.03591	0.0559	-0.08028	0.1521	0.137
GL_L16I	GL_L16F	2.8208	21	0.01	0.17864	0.0633	0.04694	0.3103	0.6014
GL_L17I	GL_L17F	2.1699	21	0.04	0.13318	0.0614	0.00554	0.2608	0.4626
GL_L18I	GL_L18F	-1.1459	21	0.27	-0.06636	0.0579	-0.1868	0.0541	-0.2443
GL_L19I	GL_L19F	1.3883	21	0.18	0.08636	0.0622	-0.04301	0.2157	0.296

Note. H_a μ Measure 1 - Measure 2 ≠ ; TimeI / TimeF = reaction time recorded at initial and final testing;
GapI / GapF = inter-stimulus interval between consecutive visual stimuli at initial and final testing;
L_LxI / L_LxF = reaction time recorded for each individual light source (L1–L19) during the Witty Green test at initial and final testing;
Gap = time interval between consecutive visual stimuli (inter-stimulus interval); Lap = reaction time recorded for each stimulus.

According to the data presented in Table 2, the analysis performed using the t-test for paired samples showed a significant improvement in total reaction time between the initial and final tests ($t(21) = 3.35$, $p = .003$, $d = 0.71$), confirming the effectiveness of the microperiodized training program implemented over a seven-month period. The significant reduction in overall reaction time suggests that the players developed a faster speed of visual information processing and a superior ability to quickly transform visual stimuli into precise motor responses.

Although the GAP indicator did not show significant differences ($t(21) = 0.59$, $p = .57$), the segmentation results show selective improvements in certain phases of the test, namely L7, L10, L16, L17, L19, and, in terms of inter-lap differences (GAP LAP), GL4, GL9, GL13, GL16, GL17. These segments can be interpreted as critical moments of the motor task, in which the ability to react and reconnect to the stimulus is most intense. Significant progress in these

areas indicates a functional adaptation of the neuromuscular system, possibly due to the repeated and varied stimulation of the exercises in the training program.

The effect size (Cohen's d) between 0.45 and 0.75 for the significant segments suggests a medium to high degree of improvement, confirming that the changes observed are not the result of chance, but the direct consequence of the application of a planned and progressive program. In practical terms, these developments can be associated with an increase in neuromotor efficiency and coordinative control, which are essential for performance in volleyball, where rapid reaction to visual stimuli (the ball, the opponent, the teammate) determines the success of actions.

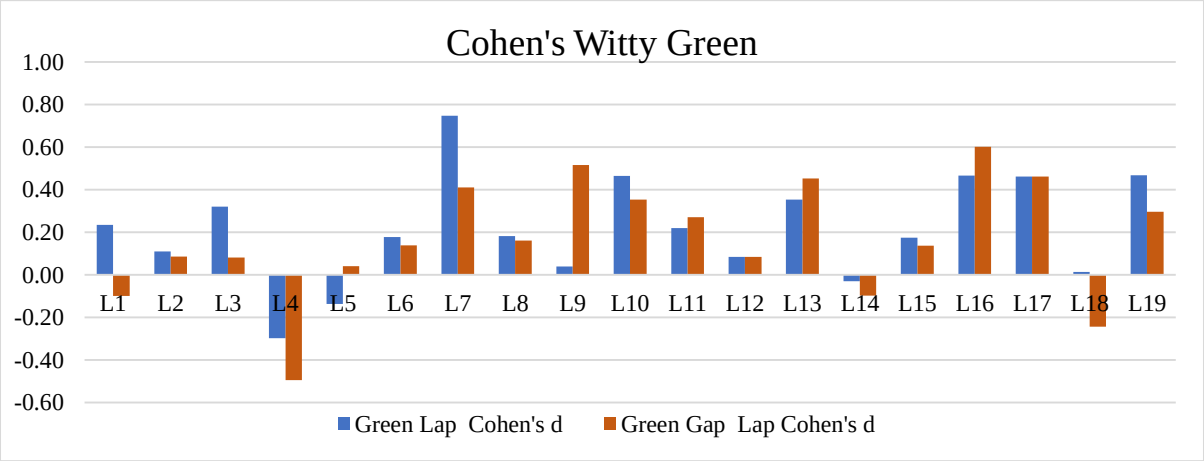

Figure 2. Amplitude of the Witty green test effect

According to Figure 2, the data obtained for the Witty Green test show a steady and significant improvement in results in terms of reaction speed, as confirmed by the reduction in total time and the progress recorded on critical segments of the test. Although light stimuli were activated in random order, critical segments in the Witty Green test refer to specific light positions that consistently required higher perceptual-motor demands, as evidenced by slower or more variable reaction times in repeated trials. This suggests that, following the training program, the athletes developed an increased ability to quickly process visual information and coordinate motor responses, reflecting effective neuromotor adaptation. Although the GAP indicator did not show statistically significant differences, the stability of its values, correlated with the positive evolution of the other parameters, confirms that the athletes achieved a higher level of control and consistency of response, characteristic of motor skill consolidation processes.

These findings confirm that applying a medium-term microperiodized training program leads to visible and relevant progress in the training of young athletes by simultaneously stimulating the sensory and motor mechanisms involved in responding to visual stimuli. In the context of volleyball, these adaptations can translate into faster responses to sudden changes in the direction of the ball, more effective anticipation of the opponent's actions, and more precise technical execution at decisive moments in the game.

The results also emphasize that through careful planning and appropriate alternation of effort tasks, reaction speed can be improved without compromising other components of training. Thus, microperiodization proves to be a valuable training strategy for the U15

category, providing a coherent framework for the integrated development of motor, cognitive, and perceptual skills. In the long term, these improvements contribute to increasing the overall performance of players and consolidating a solid foundation for higher stages of training and competition.

Figure 3 highlights the difference between the initial and final tests at Witty Green, the test that assesses reaction speed, i.e., the total time required for the athlete to respond to a series of visual stimuli.

Most players recorded a noticeable decrease in total time in the final test, indicating a significant improvement in reaction speed. Reductions of 2–4 seconds confirm increased response promptness and more efficient processing of visual stimuli.

For a few athletes (e.g., DS, GO, HM, LA), times remained constant or increased slightly, variations that can be explained by momentary factors such as fatigue, decreased attention, or motivational variability, common aspects in reaction tests. Even so, the overall trend for the group is downward, reflecting clear progress.

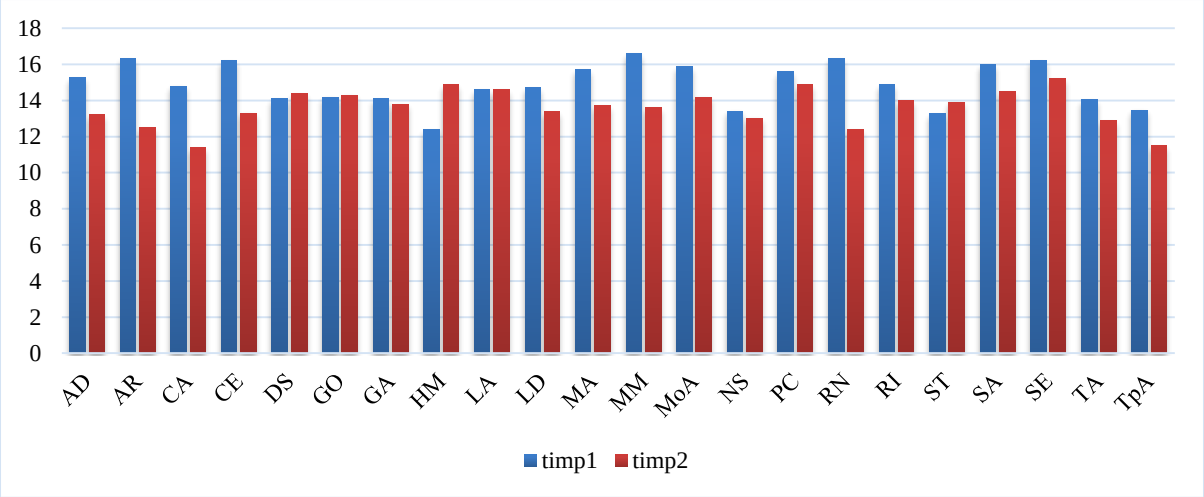

Figure 3. Difference in Witty Green test time between the two tests

Discussions

Reaction speed is a fundamental element in situational sports, and in volleyball it plays a decisive role in the efficiency of players' actions. The ability to respond quickly to visual stimuli allows athletes to adapt to the changing demands of the game and anticipate attack or defense phases. This ability depends on the integration of sensory information and the promptness of the neuromotor response, and is associated with success in youth and performance competitions.

Numerous studies have highlighted the importance of reaction time in team sports. For example, Zwierko et al. (2023) showed that a six-week stroboscopic training program led to significant improvements in visual-motor reaction speed in young female volleyball players. In another study, Cieśluk et al. (2025) demonstrated that reaction times decreased significantly after a RAMP warm-up and repeated volleyball-specific exercises.

Furthermore, the results obtained are in line with recent literature, which has demonstrated that training protocols aimed at reducing reaction time lead to rapid and effective adaptations

at the youth level (Cieśluk et al., 2025). Thus, our study adds empirical evidence supporting the importance of including reaction speed-specific exercises in training planning for the U15 category.

The results obtained in the present study are consistent with trends reported in recent literature regarding the role of visual and perceptual-cognitive training in optimizing athletic performance. Previous research has shown that although visual training methods are increasingly used in applied sport settings, their implementation is often heterogeneous and not always grounded in systematic scientific frameworks. Several authors emphasize that coaches tend to integrate visual exercises intuitively or as complementary tools, rather than as part of structured, evidence-based training programs, which may limit their effectiveness in developing perceptual-cognitive skills relevant to performance (Appelbaum & Erickson, 2018). The authors also showed that reaction time is perceived as the most important visual skill, surpassing eye-hand coordination, anticipation, or depth perception in terms of relevance. These results confirm the growing concern of specialists for the integration of visual-motor training in situational sports, such as volleyball, where quick decisions and immediate responses to visual stimuli directly determine the success of technical and tactical actions.

In this context, the present study makes an important empirical contribution, demonstrating through objective data that a microperiodized specific physical training program focused on the reaction to visual stimuli produces significant improvements in neuromotor performance in U15 volleyball players. The results confirm that repeated exposure to variable visual stimuli, under controlled conditions, leads to adaptations in sensory processing and motor response, reducing reaction latency and increasing the efficiency of motor execution.

These findings reinforce the idea that reaction speed is a trainable and perfectible skill, with a direct influence on the quality of technical and tactical actions in volleyball. The systematic integration of visual-motor reaction exercises into the structure of microcycles contributes not only to improving individual performance, but also to developing sensory-motor coordination and the ability to anticipate, which are essential for success in real game situations.

However, it should be noted that the small number of participants (22 U15 players from the same club) limits the degree of generalization of the results. Furthermore, the lack of a control group makes it difficult to isolate the effects generated strictly by the training program, as these may also be influenced by other factors, such as biological maturation or competitive experience accumulated during the study period.

Another aspect is that differences in playing positions were not analyzed, although physical demands can vary significantly between setters, middle blockers, wing spikers, and liberos. In addition, the seven-month duration of the intervention, although relevant for highlighting progress, may be considered relatively short for observing the long-term effects of microperiodization.

Despite these limitations, the present study provides new data for the literature, demonstrating that a medium-term microperiodized training program can lead to significant improvements in reaction speed in young female athletes.

These results may have direct and relevant applications in the training methodology for competitive volleyball, as they confirm the need to integrate specific exercises aimed at developing reaction speed into the structure of training programs. By systematically including

such stimuli in microcycles, coaches can optimize athletes' neuromotor responses and increase the efficiency of decision-making in highly demanding game situations.

Furthermore, the data obtained suggests that the early development of this quality at the youth level is an important prerequisite for long-term performance, facilitating the transition of athletes to higher levels of training. The results can guide the selection and planning of training sessions, indicating that reaction speed should not be approached as an isolated skill, but as a fundamental component of specific physical training, which correlates with explosive strength, movement speed, and intersegmental coordination.

Thus, the implementation of microperiodized programs that include exercises dedicated to the development of reaction speed not only supports immediate performance improvement but also contributes to the consolidation of a solid training base for participation in international competitions and for the long-term progress of volleyball players.

The results of the study highlight the importance of including visual-motor exercises in microperiodized physical training planning, especially in the training stages of volleyball players. From a practical perspective, coaches can integrate these exercises into weekly sessions, either in the specific warm-up (10–15 minutes) or in the speed and coordination development sequences. It is recommended to use simple visual stimuli (colors, light signals, coach gestures) at the beginning of the program, followed by complex reactive situations involving decision-making and technical-tactical execution.

For example, setters can work on short accelerations (3–4 m) with a net exit followed by lifts in different areas, libero players can perform quick movements anticipating the trajectory of short balls, and middle blockers can combine drop jumps with blocking movements or blocking movements with an emphasis on anticipating the lift. These exercises can be organized into 2–3 consecutive microcycles, with a frequency of 2–3 sessions per week, gradually increasing the complexity and decreasing the allowed reaction time.

The systematic implementation of such a microperiodized program helps stimulate the perceptual-cognitive mechanisms involved in anticipation, spatial orientation, and reaction speed. In addition, the integration of visual-reactive exercises into the usual training structure does not require sophisticated equipment, as they can be adapted and performed by utilizing the specific coordinates of the volleyball game, such as ball movement, player movement, and rapid changes in the direction of attack or defense. Thus, relevant visual stimuli can be generated naturally in game contexts or in applied exercises, allowing athletes to develop their anticipatory reactions and decision-making skills in conditions similar to those of competition. This approach gives the training an authentic and specific character, facilitating the direct transfer of the adaptations achieved to performance on the court.

At the same time, it is important to note that the adaptive responses observed may be influenced by a number of biological and contextual confounding factors that were not specifically controlled for in this study. Biological growth and maturation processes, hormonal variations associated with puberty, as well as differential exposure to competitions and real game situations can modulate the level of neuromotor reactivity and the speed of visual information processing.

Furthermore, interindividual differences in tactical experience or concentration ability may influence the response to visual stimuli.

To gain a more complete understanding of the mechanisms involved, future research should control for these factors and explore the interaction between visual-motor programs and other forms of training, such as cognitive or explosive strength training. Such an integrated approach could better clarify how neuromotor, cognitive, and hormonal development synergistically contribute to optimizing reaction speed in the formative stages of young female athletes.

Conclusions

The results of the study confirm, on an empirical basis, the effectiveness of a microperiodized physical training program in improving visual-motor reaction speed in Under 15 volleyball players. The significant reduction in total reaction time and progress in critical segments of the test indicates real perceptual-cognitive adaptations that can be transferred to game situations. These findings demonstrate that anticipation and rapid reaction can be developed through a planned and repetitive process, without the need for sophisticated equipment, but only through the intelligent integration of visual and motor stimuli into the training structure.

At the same time, the results highlight the potential of the method to contribute to the optimization of technical and tactical decisions in youth volleyball, providing coaches with clear guidance for modernizing specific training.

However, the absence of a control group and the lack of a differentiated analysis by position limit the generalizability of the conclusions, and possible confounding factors, such as growth processes, biological maturation, or competitive exposure, may influence the level of neuromotor adaptations.

Future research should include comparative designs (e.g., stroboscopic vs. microperiodized training) and analyze effects according to position, age, and competitive level to provide a more complete perspective on the mechanisms of reaction speed development.

Therefore, the results obtained confirm the working hypothesis that microperiodized physical training contributes significantly to the development of reaction speed, demonstrating that a structured approach, implemented consistently, can produce measurable functional adaptations that are transferable to the competitive context.

From a practical perspective, these results provide coaches with concrete guidelines for designing modernized training programs based on rational alternation of volume and intensity, integration of visual-motor exercises, and continuous monitoring of progress. Implementing such strategies not only optimizes immediate motor responses, but also contributes to the formation of a sustainable performance base, essential for players' transition to higher levels of competition.

In conclusion, microperiodized training proves to be an effective and adaptable method in youth volleyball training, with beneficial effects on reaction speed, motor control, and anticipation ability, which are fundamental aspects for modern performance in this sport.

Acknowledgement: This study is part of the doctoral thesis entitled "Specific Physical Training – A Conditioning Factor of Sports Performance in Volleyball".

Funding: This research did not receive any external funding.

Institutional Review Board Statement: The research was conducted according to the principles stated in the Declaration of Helsinki and approved by the Research Ethics Committee of UNEFS Bucharest (number assigned 32/20.01).

Informed Consent Statement: Written informed consent was obtained for all participants involved in this study.

Data Availability Statement: Data can be made available upon request to the contact author.

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

References

Abernethy, B. (1990). Expertise, visual search, and information pick-up in squash. *Perception, 19*(1), 63-77. https://doi.org/10.1068/p190063

Afonso, J., Mesquita, I., & Palao, J. M. (2005). Relationship between the tempo and zone of spike and the number of blockers against the hitters. *International Journal of Volleyball Research, 8*(1), 19–23. https://www.researchgate.net/publication/255995038_Relationship_between_the_tempo_and_zone_of_spike_and_the_number_of_blockers_against_the_hitters

Appelbaum, L. G., & Erickson, G. (2018). Sports vision training: A review of the state-of-the-art in digital training techniques. *International Review of Sport and Exercise Psychology, 11*(1), 160–189. https://doi.org/10.1080/1750984X.2016.1266376

Cieśluk, 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, 25*(1), 125. https://doi.org/10.3390/s25010125

De Waelle, S., Warlop, G., Lenoir, M., Bennett, S. J., & Deconinck, F. J. A. (2021). The development of perceptual-cognitive skills in youth volleyball players. *Journal of Sports Sciences, 39*(17), 1911–1925. https://doi.org/10.1080/02640414.2021.1907903

Issurin, V. B. (2010). New horizons for the methodology and physiology of training periodization. *Sports Medicine, 40*(3), 189–206. https://doi.org/10.2165/11319770-000000000-00000

Kosinski, R. J. (2008). A literature review on reaction time. *Clemson University Technical Report.*

Lloyd, R. S., & Oliver, J. L. (2012). The Youth Physical Development Model: A New Approach to Long-Term Athletic Development. *Strength and Conditioning Journal, 34*(3), 61–72. https://doi.org/10.1519/SSC.0b013e31825760ea

Mann, D. T. Y., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport and Exercise Psychology, 29*(4), 457–478. https://doi.org/10.1123/jsep.29.4.457

Markovic, G. (2007). Does plyometric training improve vertical jump height? A meta-analytical review. *British Journal of Sports Medicine, 41*(6), 349-355. https://doi.org/10.1136/bjsm.2007.035113

Piras, A., Lobietti, R., & Squatrito, S. (2014). Response time, visual search strategy, and anticipatory skills in volleyball players. *Journal of ophthalmology, 2014*: 189268. https://doi.org/10.1155/2014/189268

Polechoński, J., & Horbacz, A. (2025). Assessment of the Validity and Reliability of Reaction Speed Measurements Using the Rezzil Player Application in Virtual Reality. *Multimodal Technologies and Interaction, 9*(9): 91. https://doi.org/10.3390/mti9090091

Sarmento, H., Anguera, M. T., Pereira, A., & Araújo, D. (2018). Talent identification and development in male football: A systematic review. *Sports Medicine, 48*(4), 907–931. https://doi.org/10.1007/s40279-017-0851-7

Sheppard, J. M., & Newton, R. U. (2012). Long-term training adaptations in elite male volleyball players. *Journal of Strength and Conditioning Research, 26*(8), 2180–2184. https://doi.org/10.1519/JSC.0b013e31823c429a

Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences, 24*(9), 919-932. https://doi.org/10.1080/02640410500457109

Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The Importance of Muscular Strength in Athletic Performance. *Sports medicine, 46*(10), 1419-1449. https://doi.org/10.1007/s40279-016-0486-0

Takagi, S., Sakamoto, S., Midorikawa, T., Konishi, M., & Katsumura, T. (2014). Determination of the exercise intensity that elicits maximal fat oxidation in short-time testing. *Journal of Sports Sciences, 32*(2), 175-182. https://doi.org/10.1080/02640414.2013.815360

Wilkins, L., & Gray, R. (2015). Effects Of Stroboscopic Visual Training On Visual Attention, Motion Perception, And Catching Performance. *Perceptual and Motor Skills, 121*(1), 57–79. https://doi.org/10.2466/22.25.PMS.121c11x0

Zemková, E. (2016). Differential contribution of reaction time and movement velocity to the agility performance reflects sport-specific demands. *Human Movement, 17*(2), 94–101. https://doi.org/10.1515/humo-2016-0013

Vișan, R., Stoica, M., & Dreve, A. (2023) Improving coordination skills in young football players aged 8-10 years, Discobolul – Physical Education, Sport and Kinetotherapy Journal, 62(3), 224-238. https://doi.org/10.35189/dpeskj.2023.62.3.2

Zhu, R., Zheng, M., Liu, S., Guo, J., & Cao, C. (2024). Effects of Perceptual-Cognitive Training on Anticipation and Decision-Making Skills in Team Sports: A Systematic Review and Meta-Analysis. *Behavioral Sciences, 14*(10): 919. https://doi.org/10.3390/bs14100919

Ziv, G., & Lidor, R. (2010). Vertical jump in female and male volleyball players: A review of observational and experimental studies. *Scandinavian Journal of Medicine & Science in Sports, 20*(4), 556–567. https://doi.org/10.1111/j.1600-0838.2009.01083.x

Zwierko, M., Jedziniak, W., Popowczak, M., & Rokita, A. (2023). Reactive Agility in Competitive Young Volleyball Players: A Gender Comparison of Perceptual-Cognitive and Motor Determinants. *Journal of Human Kinetics, 85*, 87–96. https://doi.org/10.2478/hukin-2022-0112