Original Article

Sensorimotor reaction indicators as measures of specialized training in qualified volleyball players across different roles

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Abstract:
Objective. Modern scientific research indicates that individual-typological features and the manifestation of sensorimotor reactions, of different degrees of complexity, in players of team game sports influence the success of competitive activity and form the basis of special preparedness in athletes. **The aim** is to determine the manifestation of sensorimotor reactions of different degrees of complexity in players, considering their game role and the relationship between the components of competitive activity and exceptional physical fitness. **Material and methods.** The research involved 44 qualified female athletes aged 19 to 22 years old, members of the youth national volleyball team U-22 and the volleyball team "Dobrodiy-University-SVSM", participants in the Ukrainian volleyball championship among the teams of the Super League for the 2023-2025 season. To determine the manifestation of sensorimotor reactions of different degrees of complexity (simple visual-motor reaction (SVR), simple visual-motor reaction to the beginning of the arrow movement (SVR-AM), complex visual-motor reaction (CVR), complex visual-motor reaction to a light combination of stimuli (CVR-LC), dynamic muscular endurance of the hand movement of the dominant hand (DMEH of the DA), and subdominant hand (DMEH of the SDA)), the diagnostic complex "BOS-test professional" was used. The paired Pearson's coefficient (r) was used to investigate the interrelations between indicators of special physical fitness and components of competitive activity. **Results.** The analysis of sensorimotor reactions in players with different roles reveals significant differences between attacking players, setters, and liberos, which is a consequence of the distinct structure of competitive activity among these players. There are the closest interrelations between the indicators of sensorimotor abilities and exceptional physical fitness of players of different game roles: for outside hitters and opposite hitters - between the manifestation of a complex visual-motor reaction and speed and power abilities (r=0.48 and r=0.83), for middle blockers - between the dynamic muscular endurance of the subdominant hand and speed abilities (r=0.62); for setters - between dynamic muscular endurance of the dominant hand and special endurance (r=0.80); for libero - between the composition of visual-motor reaction and speed abilities (r=0.58). It was also determined that the manifestation of sensorimotor reactions of qualified volleyball players of different roles significantly affects the effectiveness of their competitive activity. **Conclusions.** The characteristics of neurodynamic functions, among which sensorimotor reactions of varying degrees of complexity are essential, significantly influence the development of special physical abilities and the efficiency of competitive activity in qualified volleyball players of different game roles, confirming their importance in the training system of athletes in team sports. Considering the indicators of sensorimotor reactions precisely will optimize the training process for players of different roles and facilitate rational team recruitment, taking into account individual and typological characteristics.
Keywords: **neurodynamic functions, competitive performance, physical preparedness, game positions, training optimization, team sports, individual characteristics, visual-motor response, muscular endurance.**

Introduction

Modern team sports are characterized by the dynamic, high-speed, and unpredictable nature of competitive activity, accompanied by intense rivalry in conditions of limited space and time (Boichuk et al., 2020). The high level of technical and tactical skills exhibited by players in various roles and the effectiveness of their actions stem from the differences in competitive activity and kinematic and spatial-temporal characteristics, which are manifested in the reactions of athletes to the moving ball and teammates based on sensory and perceptual anticipation. Therefore, modern competitive activity imposes high demands on athletes' ability to receive information through various types of analyzers, their prompt processing, and the formation of quick tactical decisions for implementing game actions. In this regard, the sensorimotor abilities of players in different roles are a prerequisite for technical and tactical skills, which include the ability to predict game situations. This

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significantly increases the importance of special training as a leading factor in selecting and suitability for competitive actions, thereby predicting the success of their competitive activity.

Today, scientists pay considerable attention to the issues of preparedness of players of different roles based on the criteria of technical and tactical (Kostiukevych et al., 2023; Boichuk, 2025), physical (Beck & Zahno, 2023; Joksimovic et al., 2023), psychological (Malikov et al., 2020; Xu et al., 2023) preparedness, taking into account the most significant and informative indicators for monitoring the training and competitive activity of athletes at different stages of sports improvement. In our opinion, indicators of sensorimotor reactions of different degrees of complexity can predict the effectiveness of players' competitive activity.

One of the issues related to the search for rational ways to increase the efficiency of competitive activity in team sports is analyzing sensorimotor reactions of varying degrees of complexity in players of different roles. Some studies have noted that the sensorimotor reactions of athletes in different roles did not differ in most of the studied indicators, which may indicate the formation of modern requirements for selecting players in sports of higher achievement (Lyzohub et al., 2019).

Others point to the need to build a training process considering the peculiarities of the manifestation of sensorimotor reactions by players, considering their game functions, where the most important role is played by choice reactions as the main factor in the success of competitive activity in high-performance sports (Przednowek et al., 2019). The ambiguity of the research results highlights the need to explore new directions and scientific and methodological approaches for analyzing the manifestation of sensorimotor reactions in players of different roles as an integral factor in enhancing the efficiency of competitive activity.

Additionally, in sports science, numerous studies focus on the management of player training in various team sports and the validation of methodological approaches to organizational aspects. The first direction is the individualization of the training process, specifically focusing on the peculiarities of team selection in game sports, considering the individual indicators of physical, technical, tactical, and psychological preparedness of players (Kozina et al., 2017; Koryahin, 2016). The second area of research concerns the analysis of the physiological characteristics of players in team game sports, where most authors address the issue of selecting athletes taking into account the peculiarities of neurodynamic characteristics as the basis of special training of players in basketball (Badau et al., 2022; Frolova, 2024; Mishchuk et al., 2023), handball (Hinz et al., 2022), football (Wik et al., 2019; Singh L. T. and Singson, 2020).

The primary criterion for special training of players is the speed of sensorimotor reactions, which facilitates the development of sensorimotor reactions to a high level under conditions of significant psycho-emotional tension, the realization of creative abilities, mental efficiency, memory, and attention (Silva et al., 2020). It is essential to recognize that in volleyball, the success of competitive activity relies on a high level of sensorimotor reactions, serving as an indicator of the players' central nervous system's functional state. In volleyball, a complex visual-motor reaction enables the ability to predict opponents' actions (Costa et al., 2024; Zwierko et al., 2010), which is particularly important in the competitive activity of connecting and middle blocking players. At the same time, the manifestation of simple reactions ensures the effective implementation of technical and tactical actions, which involve developing elementary speed, as observed in the competitive activity of libero players.

In several studies, it has also been noted that there is a need to explore the interconnections between indicators of physical fitness and the manifestation of sensorimotor reactions. In this context, analyzing sensorimotor indicators about the manifestation of special physical abilities in volleyball players of different game roles will enable the definition of individual player features and compliance with training and competitive activity requirements.

The results of our research aimed at analyzing the manifestation of sensorimotor reactions in qualified volleyball players (Shlonka et. al., 2024, 2025), as well as the level of their special physical preparedness (Hammoodi et al., 2022) became a significant contribution in determining the peculiarities of training volleyball players of different game roles.

However, at the same time, there are few scientific developments devoted to analyzing sensorimotor indicators of players in different game roles as an integral factor in ensuring effective competitive activity in volleyball, which has become the scientific and methodological basis for the formation of the problem field of our research. Namely, the significance of sensorimotor reactions of players in different roles becomes informative if there are reliable interrelations between the parameters of competitive activity and specialized physical fitness, which becomes extremely important, especially in the context of staffing teams with players of different roles within the club's training system.

Considering the above-mentioned points, our research aimed to investigate the manifestation of sensorimotor reactions of varying degrees of complexity in players, taking into account their game role, and to examine the interrelation between indicators of sensorimotor reactions, parameters of competitive activity, and specialized physical fitness.

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Methods

The research involved 44 qualified female volleyball players, aged 19 to 22 years old, who were members of the women's youth volleyball team U-22 (18 players) and the volleyball team "Dobrodiy-Meduniversity-SVSM" (26 players). Psychophysiological testing was carried out during the competitive period of preparation for the qualifying stage of the European Championship among U-22 youth teams and the Ukrainian Volleyball Championship among women's Super League teams in the 2024-2025 season.

The diagnostic complex "BOS-test professional" (Complex for Psychological Testing "BOS-test") was used to determine the features of sensorimotor response and dynamic muscular endurance of hand movement (DMEH) in sportswomen, as indicated by the warm-up test. For the purpose, the following parameters of manifestation of sensorimotor reactions were investigated: latent periods (LP), stability (SR), number of errors of a simple visual-motor reaction (SVR), a simple visual-motor reaction to the beginning of movement of an arrow (SVR-AM), a complex visual-motor reaction (CVR), and a complex visual-motor reaction to a light combination of stimuli (CVR-LC). The analysis of the obtained results involved interpreting the following leading indicators: latent period (LP, ms), stability of reactions (SR, ms), as estimated by the standard deviation (SD), and the total number of errors.

The SVR technique was used to assess the average reaction time of subjects to a simple visual stimulus, providing a rapid assessment of central nervous system (CNS) activation. This assessment is based on the analysis of the level and stability of human sensorimotor responses to visual stimuli. During this test, the examinee must react as quickly as possible to the presentation of a green spotlight that flashes. The SVR-AM was also used to assess the average reaction time of subjects to a simple visual stimulus, providing a rapid assessment of CNS activation. However, to pass this test, subjects must react as quickly as possible to the start of the stopwatch's movement. CVR - during this test, the subject had to react as quickly as possible to the presentation of a searchlight that could flash green, red, or blue (thus, not only the time of the signal's appearance, but also its color, was random).

The CVR-LC was used not only to assess the characteristics of the choice response, but also to detect (isolate) the signal against the background of adequate interference (i.e., interference similar to the perception of the target signal). The essence of the SVR-LC technique was to determine the timing and accuracy of responses to one given combination of two-color stimuli in a set of 3 color stimuli, regardless of the value of the third stimulus.

DMEH of hand movement of the examined sportswomen was determined by the maximum rate of movement of the hand of the dominant (DA) and subdominant (SDA) hand during 30 s by the method of the warming test (Makarenko at al., 2014), the ratio of these indicators (DA / SDA) - functional asymmetry (FA) was also studied.

The obtained data were processed using standard statistical methods included in the Statistics 7.0 software package. To describe the manifestation of sensorimotor reactions, the method of averages was used to determine the mean value and standard deviation. The Pearson pair correlation coefficient (r) was used to determine the interrelations between the manifestation of sensorimotor reactions in volleyball players of different game roles and parameters of competitive activity and special physical abilities. The statistical reliability of the data was determined using a critical value (t). The data were checked for normality of distribution using the Shapiro-Wilk test.

Results

One of the key questions in the modern system of preparation is the features of team completion in team game sports by players of different roles, considering the neurodynamic properties of nervous processes. In our opinion, special attention should be paid to the peculiarities of sensorimotor reactions in the training of athletes with different game roles, as these are the main indicators of success in competitive activity. Leading experts in the field of psychophysiology (Korobeynikov et al., 2019; Macías et al., 2023; Lyzohub et al., 2017) emphasize the need for psychophysiological diagnostics of athletes, which will minimize the process of training players, identify the leading makers of their preparedness, and optimize the composition of teams of different qualifications. At the same time, analyzing the neurodynamic properties of nervous processes will enable the determination of model indicators for players in different roles, which will be one of the factors in forming the training system.

Table 1 presents the features of the manifestation of sensorimotor reactions of volleyball players of different game roles (average values of the measured indicators).

According to the research results on the manifestation of sensorimotor reactions in skilled volleyball players of different game roles, significant differences were revealed. It was found that the highest reliable and significant differences ($p < 0.001$) in the performance of the SVR were observed when comparing pre-play and connecting players, middle blocking and connecting, and connecting and libero.

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Table 1

Features of the manifestation of sensorimotor reactions of different degrees of complexity of qualified volleyball players of different game roles (n=44)

Indices	Playing roles				
	outside hitter	Opposite	Middle blocker	setter	libero
LP SVR, мс	279.5***	288.7***	276.0***	302.3***	265.9***
SR SVR, мс	10.1	19.3	8.0	21.7	8.1
SD	10.1	19.3	8.0	21.7	8.1
LP SVR-AM, мс	315.8	315.8	316.3	325.9***	309.8***
SR SVR-AM, мс	6.1	10.1	8.0	8.0	7.2
Mistakes SVR-AM, quantity	1.7	1.2	2.1	1.3	2.0
SD	6.1	10.1	8.0	8.0	7.2
LP CVR, мс	493.3***	470.1***	488.5*	503.4***	489.6
SR CVR, мс	25.6	24.2	18.5	22.9	18.9
Mistakes CVR, quantity	1.7	1.6	2.5	0.6	1.8
SD	25.6	24.2	18.5	22.9	18.9
LP CVR-LC, мс	625.4***	562.8***	549.8***	624.4***	586.2***
CR CVR-LC, мс	45.6	23.5	23.3	45.2	36.1
Mistakes CVR-LC, quantity	1.0	0.2	0.5	0.2	0.6
SD	45.6	23.5	23.3	45.2	36.1
DMEH DA, number of taps	166.7***	169.6**	173.8**	176**	178.8***
SD	5.8	3.3	6.8	5.1	6.8
DMEH SDA, number of taps	145.7***	157.4***	146.1*	149.3**	149.2*
SD	7.4	3.9	6.2	5.4	9.6
FA	16.0	7.9	19.3	12.0	20.6

Notes: LP - latent period, SR - reaction stability, SVR - simple visual-motor reaction, SVR-SR - simple visual-motor reaction to the beginning of the arrow movement, SVR-CR - complex visual-motor reaction,   CVR-LC - complex visual-motor reaction to light stimulus combination, DMEH - dynamic hand muscle endurance, DA - dominant arm, SDA - subdominant arm, FA - functional asymmetry: * - $p<0.05$; ** - $p<0.01$; *** - $p<0.001$ - statistically significant indicators by the critical value of the Student's criterion

According to the results of the analysis of the character of manifestation of neurodynamic characteristics of nervous processes of sportswomen it was found that the best results on indicators of LP SVR and LP SVR-AM were shown by libero players (respectively, 265.9 and 309.8 ms): the obtained differences on these indicators between groups of libero and players of other game roles acquired the level of statistical significance ($p<0.001$). In our opinion, this relates to the specificity of the competitive activity of these players, specifically their performance of a large number of jerks, movements, falls, and defensive play, which significantly distinguishes them from other game roles.

In the analysis of LP CVR, the most significant and reliable differences ($p < 0.001$) were observed between opposite hitters and libero players, as well as between opposite hitters and outside hitters. The highest speed of a complex sensorimotor reaction by the index of LP CVR was noted in opposite hitter players (470.0 ms), and the highest speed of a complex sensorimotor reaction to a light combination of stimuli by the index of LP SVR-AM in middle blocking players (549.8 ms). This is explained by the fact that modern competitive activity requires middle blocking players to perform blocking in greater quantity when interacting with other attacking players and a binder. At the same time, the effectiveness of their technical and tactical actions depends on the relationship between the speed of movement, decision-making, and spatial orientation. The competitive activity of opposite hitter players should be based on their ability to quickly switch between defensive and offensive actions, as well as a high level of individual technical and tactical skills.

The most significant differences ($p<0.001$) in the performance of the warm-up test with the dominant hand were found between the setters and outside hitter players, with the subdominant hand - between the setters and opposite hitter and setters and middle blockers (Table 1), which confirms the presence of specific differences in their preparedness, where the leading factor is the game load. Thus, the most significant number of presses with the dominant hand among attacking players was carried out by middle blockers (173.8 presses). In comparison, the subdominant hand was used by opposite hitter players (154.7 presses).

Table 2

Correlations between the indicators of sensorimotor reactions of different degrees of complexity of skilled volleyball players taking into account their game roles, r (n=44)

Показники	LP SVR	LP SVR-AM	LP CVR	LP CVR-LC	DMEH DA	DMEH SDA
Role – Outside Hitter						
LP SVR		0.618	0.653	0.363	-0.072	-0.091
LP SVR-AM			0.814	0.274	-0.381	-0.413

	LP SVR	LP SVR-AM	LP CVR	LP CVR-LC	DMEH DA	DMEH SDA
LP CVR				0.368	-0.371	-0.294
LP CVR-LC					0.208	0.366
DMEH DA						**0.613**
DMEH SDA						
Role – Opposite Hitter						
LP SVR		**0.937**	**0.826**	**0.764**	**-0.953**	-0.393
LP SVR-AM			**0.699**	**0.893**	**-0.985**	-0.466
LP CVR				**0.581**	**-0.799**	0.004
LP CVR-LC					**-0.856**	-0.145
DMEH DA						0.429
DMEH SDA						
Role – Middle Blocker						
LP SVR		**0.764**	0.129	-0.050	0.033	0.234
LP SVR-AM			0.445	-0.179	**-0.565**	-0.107
LP CVR				0.143	**-0.649**	-0.276
LP CVR-LC					0.177	0.227
DMEH DA						**0.536**
DMEH SDA						
Role- Setter						
LP SVR		**0.814**	**0.879**	**0.856**	0.009	**-0.837**
LP SVR-AM			**0.646**	**0.713**	-0.289	**-0.674**
LP CVR				**0.872**	-0.127	0.054
LP CVR-LC					-0.138	**-0.746**
DMEH DA						-0.069
DMEH SDA						
Role - Libero						
LP SVR		**0.579**	**0.524**	**0.813**	**-0.601**	**-0.706**
LP SVR-AM			**0.775**	**0.552**	**-0.519**	**-0.582**
LP CVR				**0.642**	**-0.581**	**-0.681**
LP CVR-LC					-0.192	-0.360
DMEH DA						**0.984**
DMEH SDA						

The majority of scientists who tried to solve the problem of the peculiarities of the manifestation of sensorimotor reactions of different degrees of complexity in martial arts (Romanenko et al., 2022) and team game sports (Hinz et al., 2022; Artemenko et al., 2020) note the presence of certain types of relationship between the indicators of simple and complex sensorimotor reactions. Table 2 presents the analysis of interrelations between the manifestation of sensorimotor reactions of different degrees of complexity of qualified volleyball players of different game roles.

The results of the correlation analysis show that the highest direct correlations in pre-play players are observed when performing a simple visual-motor reaction and a simple visual-motor reaction to the beginning of the arrow movement (r = 0.618) and with a complex visual-motor reaction (r = 0.814). For opposite-hitter players, there are high correlations between all components except for the performance of the teetering test with the subdominant hand. The highest statistically significant correlations are observed for the teetering test using the dominant hand with the LP of the SVR (r = -0.953) and the LP of the SVR-AM (r = -0.985). In middle blocking players, the highest correlation is observed between LP SVR and LP SVR-AM (r = 0.764), and between LP CVR and indicators of performance in the teetering test with the dominant hand (r =- 0.649). In the group of setters, when compared with other game roles, high inverse correlations were found between the index of DMEH of the SDA by the teasing test and LP SVR (r=-0.837), LP SVR-AM (r=-0.674), LP CVR-LC (r=-0.746). According to the results of testing of libero players, high direct correlations are noted, including the connections between LP SVR and LP CVR, LP CVR-LC (respectively, from r=0.524 to r=0.813), LP SVR-AM and LP CVR, LP CVR-LC (respectively, r=0.775, r=0.552), inverse correlations - between DMEH DA, DMEH SDA and indicators of sensorimotor reactions of varying degrees of complexity, namely: LP of the SVR (respectively, r=-0.601, r=-0.706), LP of the SVR-AM (respectively, r=-0.519, r=-0.582), LP of the CVR (respectively, r=-0.581, r=-0.681) (Table 2). The psychophysiological functions of a person depend on the peculiarities of the nervous process course that characterizes the formation of motor abilities (Platonov, 2018; Satsiashvili et al., 2023). Given this, it becomes extremely necessary to search for interconnections between sensorimotor reactions of different degrees of complexity and specialized physical abilities of qualified volleyball players in various game roles, as presented in Figure 1.
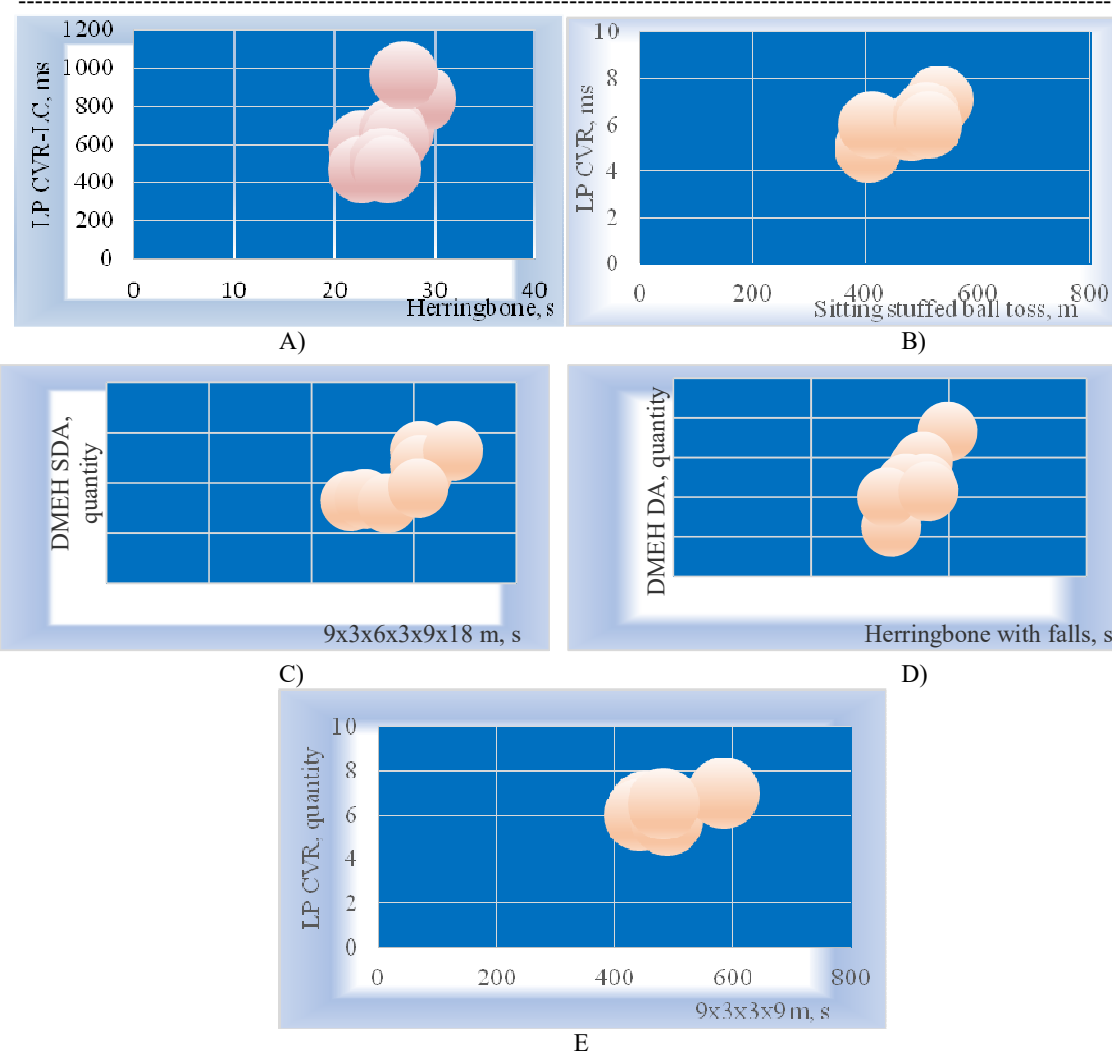
Figure 1. Correlation field of relationships between the indicators of sensorimotor reactions of different degrees of complexity and the results of testing the special abilities of players of different game roles: A) Outside Hitter (r=0,48); B) Opposite Hitter (r=0,67); C) Middle Blocker (r=0,81); D) Setter (r=0,80); E) Libero (r=0,69)

The correlation analysis of the interrelations between indicators of sensorimotor reactions and special physical fitness in pre-players revealed that the closest connection exists between indicators of CVR-LC and the pedagogical test "Harringbone" (r = 0.58). The presence of inverse correlations between indicators of sensorimotor reactions of LP SZMR-SC and the results of jumping (r = -0.69 and r = -0.67) and DMEH DA (r = -0.61 and r = -0.66) becomes interesting.

For opposite hitter players, the highest level of interrelation (r=0.82) is noted between indicators of LP CVR and results of throwing a stuffed ball. Along with this, there is a high degree of interrelation between indicators of sensorimotor reactions of LP SVR and LP CVR and results of tests "Fir-trees" (r=0.83 and r=0.82), "Fir-trees with rolls" (r=0.67 and r=0.83); results on tests on display of high-speed abilities: 9x3x6x3x9x18 m (r=0.67) and 9x3x3x9 m (r=0.63). There is an inverse correlation between the results of the test assessing jumping endurance and the LP of the SVR (r = -0.98) and between the LP of the SVR-LC (r = -0.88). For middle blocking players, the closest correlation is traced between the DMEH of the DA and the manifestation of speed abilities: 9x3x3x9 m (r=0.73), 9x3x6x3x9x18 m (r=0.81). It is noted that in setters, a correlation relationship is also observed between DMEH DA and the results of the "Harringbone" test, with falls (r = 0.80). There is also a close connection between the manifestation of a simple visual-motor reaction and speed abilities (r = 0.69), as well as between the LP of the VSR and the manifestation of jumping (r = 0.61), for libero players the highest degree of interrelation (r=0.69) is traced between the manifestation of a complex visual-motor reaction and a speed test 9x3x3x9 m.

The effectiveness of competitive activity among qualified volleyball players depends on the speed of perception, information processing, and making optimal decisions, considering the opposition of opponents and a constantly moving ball, limited space, and time constraints (Ottoboni et al., 2021). In such conditions, the

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success of the team is determined not only by the individual technical skills of the players but also by the manifestation of their sensorimotor reactions, which are a type of neurodynamic function. Given this, it is extremely necessary to analyze the relationship between the effectiveness of technical and tactical actions and the manifestation of sensorimotor reactions of varying degrees of complexity in players of different roles. For example, Figure 2 illustrates the correlations between the components of preparedness for an opposite hitter player.
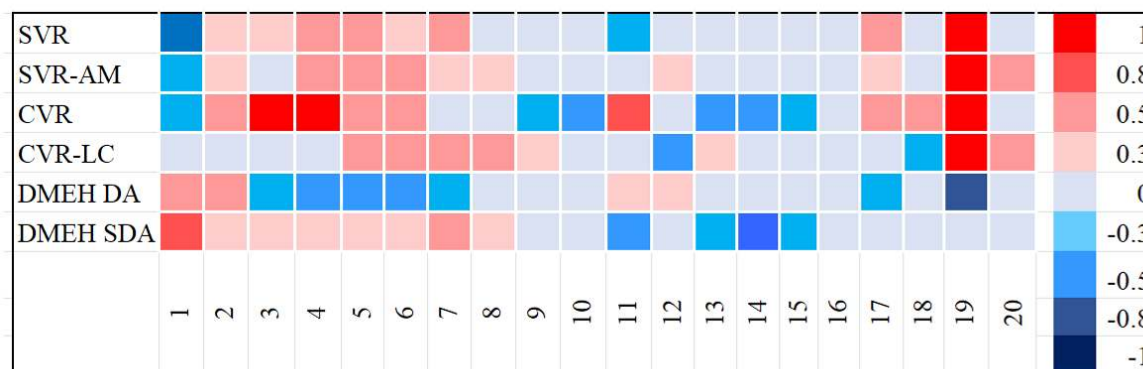

Figure 2. Correlations between indicators of the manifestation of sensorimotor reactions of different degrees of complexity and parameters of competitive activity of skilled volleyball players of different game roles:

1 - number of executed serves; 2 - volume of serves, %; 3 - number of winning balls from a serve; 4 - efficiency of a serve, %; 5 - number of executed passes; 6 - volume of passes, %; 7 - number of winning balls from a pass; 8 - efficiency of a pass, %; 9 - number of executed attacking strokes; 10 - volume of attacking strokes, %; 11 - number of winning attacking shots; 12 - efficiency of attacking shots, %; 13 - number of blocks performed; 14 - volume of blocks, %; 15 - number of winning balls from the block; 16 - efficiency of the block, %; 17 - number of defensive actions performed; 18 - volume of defensive actions, %; 19 - number of winning balls in defense; 20 - efficiency of defensive actions, %.

The obtained results of the research allow to emphasize that for opposite hitter players the highest level of direct correlations is established between indicators of simple visual-motor reactions of SVR, SVR-AM and the number of balls won when performing defensive actions (respectively, r=0.83 and r=0.85); CVR and the number of balls won from serving (r=0.85), CVR with the efficiency of serving the ball (r=0.93) of complex visual-motor reactions (CVR and CVR-LC) and the number of winning actions in defense (respectively, r=0.90 and r=0.83). In setters, the manifestation of the SVR-AM is positively correlated with the volume of ball delivery (r=0.49); the manifestation of the SVR has an inverse relationship with the number of passes (r=-0.51). The closest correlations were noted for middle blocking players: LP SVR-AM with the efficiency of blocking (r=0.64), complex visual-motor reaction (LP CVR) with the efficiency of attacking blows (r=0.65), and the volume of defensive actions (r=0.73). At the same time, there is a presence of inverse correlations between indicators of sensorimotor reactions of CVR-LC and the number of balls won in defense (r=-0.69), their efficiency (r=-0.71).

In addition, the inverse correlations of DMEH SDA with the efficiency of serving (r=-0.71) and the number of defensive actions (r=-0.70), DMEH DA - with the efficiency of blocking (r=-0.56) and serving (r=-0.66), respectively. For setters, the closest direct correlations with the manifestation of a simple visual-motor reaction are observed in the number of passes (r = 0.75) and their winning percentage (r = 0.83), and an inverse correlation with the volume of blocking (r = -0.65). The manifestation of a complex sensorimotor reaction in these players was associated with the number of completed passes (r = 0.73) and their winning percentage (r = 0.82). At the same time, there is an inverse correlation of the CVR-LC with the number of winning balls on the block (r=-0.71). For libero players there is mostly an inverse correlation between the manifestation of a simple visual-motor reaction and the number of successful ball receptions (r=-0.90); complex visual-motor reaction - and the effectiveness of ball reception (r=-0.70), the number of winning passes (r=-0.73); DMEH DA and passing efficiency (r=-0.81), DMEH SDA and passing efficiency (r=-0.75).

Discussion

The speed characteristics of sensorimotor reactions in the preparation of qualified athletes in team game sports, such as volleyball, are of particular importance today. Indicators of sensorimotor reactions of different degrees of complexity reflect the dynamics of nervous process speed, the ability to switch attention in conditions of competitive activity, decision-making in situations that tend to be repeated within separate cycles of performing technical and tactical actions, motor coordination, and overall working capacity. The level of

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physical fitness and efficiency in competitive activities among athletes depends on the manifestation of sensorimotor reactions of varying degrees of complexity.

The analysis of the manifestation of sensorimotor reactions in skilled volleyball players of different roles showed that the latencies of simple visual-motor reactions (VMR and VMR-RS) had minimal differences among attacking players. This is because, first, the method of averaging values was used for these indicators, which does not account for the maximum values of sensorimotor reactions in the strongest players; second, the main factor influencing the development of high-speed sensorimotor reactions is the training process and operational control of special preparedness at various stages of the annual training cycle; third, individual typological features of players performing different game roles also play a role. These findings suggest trends toward the unification of modern volleyball, a trend also observed in football (Singh & Singson, 2020) and handball (Hinz and Lehmann, 2022), according to research by leading international scientists.

The special physical fitness of players in different game roles has specific features that modern competitive activity presents to them, and the analysis of sensorimotor reactions should reflect their current state of physical fitness. The analysis of the interrelation between the indicators of sensorimotor reactions of different degrees of complexity and the manifestation of special physical abilities in qualified volleyball players of various game roles allowed us to identify the following tendencies in their fitness.

According to the results of the study of interrelation between indicators of sensorimotor reactions, components of competitive activity and special physical fitness of qualified volleyball players taking into account their game role for pre-playing players the smallest number of significant correlations was noted (in representatives of the specified role the manifestation of high-speed abilities and special endurance correlated only with the latent period of a complex visual-motor reaction). This fact can be attributed to the pre-game players' insufficient development of special physical abilities, particularly speed, power, and coordination, compared to other game roles, which results in inadequate performance of offensive strokes and defensive actions. In this regard, it becomes necessary to develop specialized training programs to enhance the level of physical fitness among pre-players in the national club training system. Regarding the special preparedness of opposite hitter players, there are close correlations between the indicators of sensorimotor reactions and other indicators of special physical abilities. The closest feedback is observed for all indicators of sensorimotor reactions and jumping endurance. Direct connections were made with the manifestation of special endurance, speed, and power abilities. For central setters, the manifestation of simple sensorimotor reactions had inverse relationships with special physical abilities (speed, speed-power, and special endurance), indicating an insufficient development of elementary forms of speed ability manifestation, where the main factor is high anthropometric data. On the contrary, the manifestation of complex sensorimotor reactions had direct correlations with high-speed and power abilities, high-speed and jumping endurance, which requires the performance of a large number of attacking strikes (and their imitations) and blocking in the course of competitive activity and forms the basis of competitive activity of these players. For setters, the most significant correlations can be observed between the indicators of simple visual-motor reaction and jumping and speed abilities. This confirms that players in this game role make most of the passes in an unsupported position, and their speed abilities allow them to reach the ball in the shortest possible time, which is the main condition for organizing group attack tactics. Additionally, for setters, there are inverse correlations between the indicator of dynamic muscular endurance for the dominant hand and the manifestation of speed and power abilities, as well as speed endurance.

For libero players, the manifestation of complex and straightforward visual-motor reactions related to high-speed and power abilities, and the manifestation of jumping. It was interesting to note the existence of direct correlations between DMV DR and DMV SDR, as well as indicators of high-speed and power abilities, and high-speed endurance. This is explained by the fact that the efficiency of competitive activity by libero players is determined by their ability to perform defensive actions with both the right and left hand, which is now becoming a relevant criterion in assessing their preparedness. The obtained data on the relationship between sensorimotor abilities and physical fitness of players confirm the results of the research of Lyzohub, Nechiporenko L. et al. (2019) on the materials of football players of different game roles, Osadcha L.A., Grebinyuk N. M (2024) on the analysis of the psychophysiological abilities of defensive players in various team sports, where the authors insist on the importance of sensorimotor abilities of players of different game roles and their control at different stages of sports improvement. At the same time, scientists note that the results of sensorimotor reactions and neurodynamic properties of nervous processes in players of different roles did not differ or showed only insignificant differences in most indicators. It also testifies to the existence of a tendency towards universality, on the one hand, and the selection of qualified athletes in teams with a high level of manifestation of these indicators, on the other hand, which is the primary criterion for selecting players in the club's training system.

The efficiency of executing a serve among attacking players depends on a high level of simple visual-motor reaction, indicating the absence of opposition from opponents during its execution. The effectiveness of attacking strokes relies on a high level of complex visual-motor reaction; the strongest correlations are observed in middle blocking players, which is explained by the high complexity of conditions when performing these

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technical and tactical actions (such as transfer speed, trajectory, location of the connecting player, and defenders). In contrast, opposite hitters and setters generally face more standard conditions when performing offensive strokes, which facilitate the manifestation of a simple visual-motor reaction; a high level of this reaction positively influences efficiency. Interestingly, the results regarding the manifestation of dynamic muscular endurance of hand movement showed direct linear relationships with performance outcomes for serving and attacking strokes. We believe this relates to the high-speed and power demands of these actions in attacking players, representing a key factor in their preparedness. The primary technical and tactical action for setters is ball passing, which correlates directly with the manifestation of both complex and straightforward visual-motor reactions; a high level of these reactions positively impacts effectiveness. In analyzing the dynamic muscular endurance of setters' hand movements, an inverse correlation was found between attacking stroke efficiency and DMEH DA, which is typical for the dominant hand, and a direct correlation with DMEH SDA. This can be explained by offensive actions performed with the hand farther from the edge of the net, a natural trend that aligns with global patterns. In libero players, a correlation was also observed between dynamic muscular endurance of hand movement and results in ball passing and defensive actions, reflecting their specialized training and limited participation in striking movements. Although some libero players can perform other roles during their careers, this is mainly applicable to lower-level teams in the national championship. Results for libero players also revealed inverse correlations between simple and complex sensorimotor reactions and the effectiveness of serve reception. This may indicate genetically determined characteristics of nervous processing in these players, which support the high efficiency of this technique and should be considered concerning their interaction with the connecting player. Additionally, the level of technical and tactical training influences these results. Moreover, during competitive play, a positive correlation is observed between ball reception and dynamic muscular endurance, which may serve as an indicator of players' overall functional state and high tempo, rhythm, and motor activity - factors that likely underpin their specialized preparedness. The inverse correlations between defensive effectiveness and the manifestation of complex visual-motor reactions in libero players suggest a high level of preparedness: smaller latent periods (faster visual-motor reactions) correspond to higher defensive effectiveness. Overall, these indicators of complex visual-motor reaction could serve as markers of specialized training for volleyball defenders.

Conclusions

1. Sensorimotor characteristics of varying levels of complexity significantly impact the development of specific physical abilities and the efficiency of competitive performance in qualified volleyball players across different roles. This highlights their importance within the training system for team sport athletes. Focusing on sensorimotor indicators allows for optimizing player preparation for different positions and enables rational team composition based on individual-typological traits.

2. Modern trends in the development of team sports, especially volleyball, highlight the importance of finding effective ways to assess athletes' readiness across different game roles, with a focus on neurodynamic characteristics. This has laid the groundwork for a scientific and methodological approach to evaluating the specialized preparedness of skilled players, emphasizing the unique aspects of sensorimotor reactions of varying complexity in athletes of different roles. Pedagogical analysis of the data shows that in modern volleyball, there are no significant differences in the expression of sensorimotor reactions among attacking players, which supports the trend toward universalization.

3. The results of the correlation analysis between the manifestation of sensorimotor indicators at different levels of complexity showed that the strongest connections are observed in pre-game, opposite hitter players, and liberos between speed and power abilities and complex visual-motor reaction. In middle blockers and connectors, the connections are between dynamic muscular endurance of the hand and special endurance. The data obtained can be used for a personalized approach to training for players in different roles and for optimizing preparation for the main competitions of the macrocycle in other team sports.

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