Journal of Physical Education and Sport ® (JPES), Vol 19 (Supplement issue 2), Art 60, pp 405 - 412, 2019
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Study of the correlation between the indicators of psychophysiological functions and coordination preparedness of volleyball players (girls) at the age of 15-17

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Published online:Februry 28, 2019
(Accepted for publication January 29, 2019)
DOI:10.7752/jpes.2019.s2060

Abstract.
Purpose: establish the peculiarities and degree of correlation between indicators of psychophysiological functions and coordination preparedness of volleyball players (girls) at the stage of specialized basic training.
Material: the study involved 20 volleyball players (girls) at the age of 15-17.
Results: the importance of improving the process of coordination preparation of volleyball players (girls) has been proved as a necessary condition for qualitative assimilation and effective use of the volleyball technique elements in the competitive activities. The significance of psychophysiological functions for the successful implementation of the process of coordinating the movements of players has been established. The relations of sensory-perceptual, mnemic, intellectual and sensomotor spheres with indicators of coordination abilities of of volleyball players (girls) at the age of 15-17 are presented. The average level of correlation between the integral index of coordination abilities of athletes and the ability to kinesthetic differentiations is revealed. Low and middle level correlations are recorded between the indicators of sensorimotor function of volleyball players (girls) and the ability to quickly manifest spatial orientation, coherence and rearrangement of motor activity, rhythm, and equilibrium. Reliable interrelation of the average level was found between the ability to coordinate movements and the integral index of psychophysiological functions. The indicator of intellectual abilities has a low and intermediate relationship with the ability to spatial orientation, balance, rhythm, consistency of movements. Significant relationship was found between the indicator of perceptual function and the ability to spatial orientation.
Conclusions: high level of coordination abilities does not depend on one psychophysiological function. It is the result of a combination of all or most of them. A greater number of reliable interrelationships between coordination abilities and indicators of sensomotor and kinesthesia in comparison with other psychophysiological functions have been revealed. This testifies to their greater significance in the structure of coordination readiness of volleyball players (girls) at the stage of specialized basic training. Perceptual and intellectual indicators of psychophysiological functions are of greater significance in those motor tasks that are complex in terms of content and are manifested in unusual conditions for players.
Key words: volleyball players (girls), preparation, function, coordination, abilities, correlation.

Introduction.

It is impossible to train professional athletes in sports games without a profound and versatile scientific provision of a multi-year training system for a sports reserve (Ekinci et al., 2016; Kalinicenko et al., 2018). The current problem at the present stage of the development of sports games and volleyball in particular is the optimization of the training process of young athletes. Other studies found that such an approach would improve the performance of athletes' techniques during the gaming process (Cazzola, Pavei, & Preatoni, 2016; Lejani, Markovski, & Telai, 2017; Trajkovic, Kristicevic, & Sporis, 2017). Game activity is a special kind of mental activity, which greatly influences the development of intellectual processes. In particular, so-called divergent thinking is at the heart of creative abilities and game efficiency (Claver, Jimenez, Garcia-Gonzalez, Fernandez-Echeverria, & Moreno, 2016; Koryagin et al., 2018). Analysis of sports training activities in volleyball shows that the effectiveness of the game is largely determined by the initial technical and tactical readiness of young athletes. The technical and tactical factor is decisive, because it allows the player to timely

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perceive and adequately assess the game situation and accurately implement it in motor action (Palao, & Valades, 2016; Boychuk et al., 2018). Small size of the sports ground and restrictions on touching the ball, require the player to complete all technical techniques accurately and purposefully. Coordination abilities in volleyball are manifested when performing all technical and tactical actions. These abilities are also closely linked to the strength, speed, endurance and flexibility of the volleyball player. They affect the speed of assimilation of sports technique, as well as its further stabilization and situational-adequate diverse applications. Coordinating abilities in volleyball are conventionally divided into acrobatic (motor actions in defense) and jumping (motor actions in an attack, blocking, other jump transfers) (Boychuk, Iermakov, M. Nosko, Kovtsun, & Y. Nosko, 2017; Polevoy GG 2017 ; Kozina et al., 2018).

To date, there is no single point of view regarding the exact number of types of coordination abilities. The research substantiates the idea of the existence of 5-7 "fundamental" coordination abilities that are significant in sports games and other kinds of sports (Hirtz, 1995; Liakh, & Vitkovskij, 2006). Zimmerman K. (1988) identified from 11 to 13 types of coordination abilities. Bernstein N.A. (1967), in turn, formed the idea of a multilevel hierarchical system for the construction and management of human movements. In addition, Liakh V. (2001) divided the coordination abilities into two major classes. A class with a leading level C, backed up by lower background levels B, A ("physical agility") and a class with a leading level D backed up by levels C, B, A ("subject", or "manual dexterity"). Subsequent studies (Liakh et al., 2006; Kovačević, & Jachova, 2017) allowed the identification of general, special and specific types of coordination abilities. Special coordination abilities belong to homogeneous groups of holistic motor actions. For example, motor actions that occur in running, jumping, acrobatic and gymnastic exercises, sports games. According to other authors, the specific manifestations of coordination abilities can be said to be components that make up their internal structure (Mohammed, 2017; Ivashchenko, Prykhodko, & Cieslicka, 2018). General coordination abilities can be understood as human readiness for optimal control and regulation of motor and behavioral motions of various origin and content (Kolumbet, 2017; Gjinovci, Idrizovic, Uljevic, & Sekulic, 2017). Other authors point out that the indicators of psycho-physiological functions (sensorimotor, proprioceptive, perceptual, and intellectual) influence the level of manifestation of coordination abilities of a person to a large extent (Korobeynikov, Myshko, Pastukhova, & Smoliar, 2017; Heydari, Soltani, Mohammadi-Nezhad 2018; Shepelenko et al., 2018). In other studies, the need to establish evidence of the relationship between sensory-perceptual, mnemic, intellectual and sensory-motor spheres with indicators of coordination abilities of young athletes (Boychuk et al., 2017; Korobeynikov et al., 2017) is determined. As a result of several long-term experiments, there were no reliable positive correlations among among individual indicators of different coordination abilities and individual indicators of psycho-physiological functions of the majority of school-age children (Hirtz, 1995; Liakh, 2001). At the same time, the authors attempted to detect the relationship between sensory-motor, perceptual-intellectual and proprio-reciprocal processes and a total rank evaluation of coordination preparedness of children and youth of all ages. Rank correlation coefficients were different and their magnitude was structurally dependent on age, gender and individual differences of the subjects studied. The most significant interconnections are established between the sensomotorics and coordination abilities indicators.

The correlation of kinesthesia and coordination abilities indicators was confirmed (Ivashchenko et al., 2018). And the interconnection level here is two-way. On the one hand, a high level of kinesthetic sensations and perceptions predetermines a higher level of coordination abilities development. On the other hand, by improving the coordination abilities with special exercises, one can substantially increase specialized perceptions, such as the feeling of a ball, a ground, a partner, etc. (Fleddermann, Heppe, Eils, & Zentgraf, 2016; Boychuk et al., 2017). According to other data (Zimmerman, 1988; Hirtz, 1995), the indicators of perceptual and intellectual processes are related to the coordination abilities to a lesser extent than the indicators of kinesthesia and sensomotorism. Other authors (Liakh et al., 2006) report that intelligence functions in the structure of those coordination abilities that are more complex in terms of content are of great importance. Because they appear there in new and unusual conditions for the performer. However, it should be stated that the established laws about the relationship of coordination abilities and psycho-physiological functions are mainly referred to school age children. Unfortunately, the available references miss the systematic knowledge about the interconnection of these complex phenomena in volleyball players (girls) that are at the stage of specialized basic training.

Hypothesis. It is assumed that the definition of the degree of influence of psychophysiological functions indicators on the level of specific coordination abilities manifestation in volleyball players (girls) at the age of 15-17 will allow implement the process of their coordination preparation of volleyball players (girls) at a more qualitative level to. It will help to increase the effectiveness of the training process and competitive activities of athletes at this stage of multiyear sport improvement.

Purpose of the study is to establish the peculiarities and degree of correlation between the indicators of psychophysiological functions and coordination readiness of volleyball players (girls) at the stage of specialized basic training.

Material and methods.

Participants. In an experiment volleyball players (girls) who are at a stage of specialized basic training participated (n=20, age – 15–17 years) participated. Organization of the research. For evaluation of the general

coordination abilities were used indicators of abilities to balance, a rhythm, reaction, kinesthetic differentiation, spatial orientation, coherence of motor actions and reorganization of different by origin motor actions. The corresponding tests were used for evaluation of the general **coordination** abilities of volleyball players (girls) (Boychuk et al., 2017).

Tests to assess the level of development of psychophysiological functions indicators

Test 1: Estimation of the rate of attention distribution was carried out using a table with 25 cells, with randomly placed numbers from 1 to 40 (15 numbers are omitted). The subject was asked to find the numbers that are not found in the table. Time of performance is 1.5 minutes (Korobeynikov et al., 2017).

Test 2-3: quality and speed of operational thinking was evaluated using "Game -3" according to methodology of A.V. Rodionov (Korobeynikov, Mazmanian, Korobeynikova, & Jagiello, 2011). In the first case, the number of moves while solving the task was fixed, in the second one - the total time for solving the task. In this model, the playing field consists of five cells painted in different colors. Initial positions are taken as task conditios, depending on the location of the three chips. All ases are of a similar goal: the subject, by rearranging the chips in the "rook move", should place them on the field of their color at the top of the model (Figure 1)

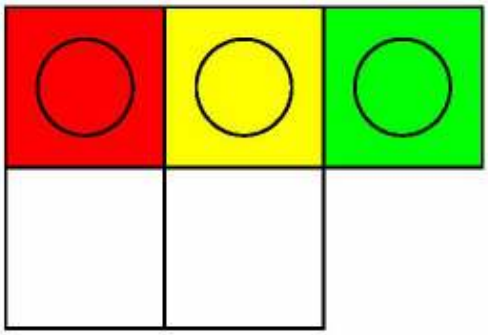
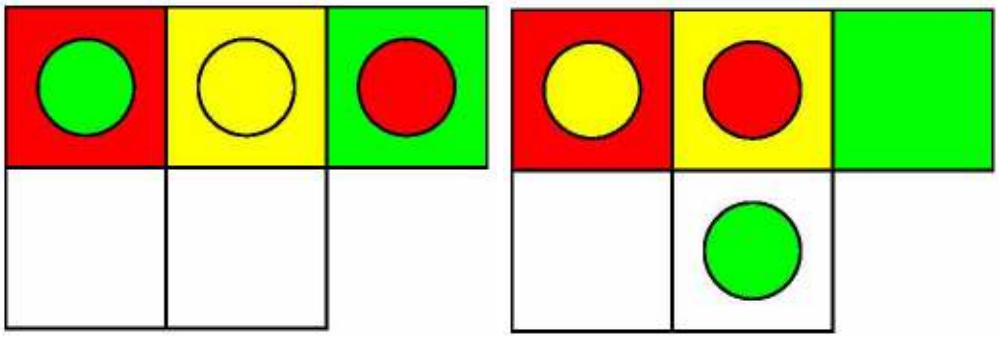
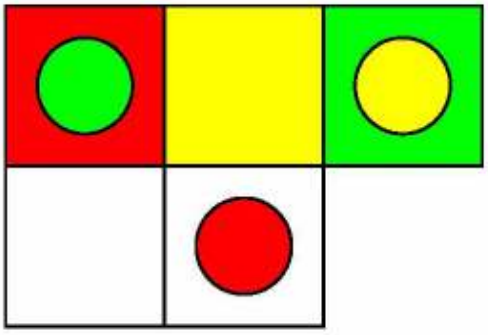


Figure 1. Final chip position in the test of A.V. Rodionov "Game -3"

Final positions are selected in such a way that they give the maximum possible number of possible solutions. A short way to the solution shall be veiled by parallel moves (with a large number of moves). The subject (girl) was asked to choose three positions of chips in the "Game-3" test (see Figure 2) in turn, and the instruction: "A field consisting of five cells is in front of you. Three of them are painted, and three chips of the same color are given. Your task is to move the chips on their fields from the proposed positions. The chip can be moved only by "rook move": right-left, up-down. The player can neither move out the field by the chip, nor move diagonally. The player should act as soon as possible. If you get confused when trying to solve this task, you shall try not to stop and rearrange the chips until you put them in place." The subject was given one test attempt. The time taken for the task and the number of moves are taken into account.



1 2



3.

Figure 2. Variants for the chip positions in the test of AV. Rodionov "Game -3"

Test 4: speed of information reception and processing was carried out using Anfimov correction task method (Korobeynikov et al., 2017). The subject was provided with the correction table and task was – when quickly scrolling the lines of letters horizontally, to strike the letters C and K for 1 minute. The purpose was to determine the work performance in 1 minute.

According to the parameters, the work accuracy was determined – (A)

$$A = \frac{M}{M + O}$$ (calculation accuracy was up to 0.1)

and net productivity (E):

E = H x A (calculation accuracy was up to 0.1).

To do this, the number of revised characters was calculated - H, the number of crossed out letters - M, the number of errors - O. Mistake was considered to be the missing of those letters, which should be striketh out, as well as the incorrect strikethrough.

Test 5-6: measurement of the simple and complex visual-motor reaction. The computer program "Psychodiagnostics" (Kozina et al., 2011) was used to determine the latent period of a simple and complex visual-motor reaction. The testing procedure is described in detail (Boychuk, Iermakov, M. Nosko, Kovtsun, & Y. Nosko, 2017).

Test 7: assessment of the subject ability to kinesthetic sensations was carried out using the test: "Ball throws to the goal standing with one's back to it" (Liakh, 2001). Testing procedure is described in detail in work by (Boychuk et al., 2017).

Statistical analysis. The obtained data was processed using the statistical computer program SPSS 17.0. A multiple correlation analysis was carried out.

Results.

Correlation analysis of the relation of psychophysiological indicators with coordination preparedness showed that sensorimotor abilities were interrelated at a low level (from r = 0.39 to r = 0.49, p <0.05) with the ability to spatial orientation, coherence of movements, a sense of rhythm and balance (Table 1). Indicators of simple and complex visual-motor reaction show reliable interconnections of the average level (from r = 0.54 to r = 0.67, p <0.05) with the index of 3x10 m running, with one's back to the running direction and the time difference between 3x10 m running with one's face and back in the movement direction, which characterized the ability of volleyball players (girls) to quickly rebuild motor action.

Table 1. Interconnection of coordination preparedness and sensory-motor and proprioceptive ability indicators of volleyball players (girls)

Indicators of coordination preparedness	**Indicators of psychophysiological functions**				
	SVMR, ms	RCh 1-3, ms	RCh 2-3, ms	Throw the ball to the target, the number of hits	Integral indicator
Crossing through the gym stick (movement coordination), s	,103	-,021	-,025	-,031	,-,052
"Ten eights" test (movement coordination), s	,079	,242	**,480**	**-,375**	-,**681**
Running to the numbered balls (orientation), s	-,049	**-,394**	**-,**146	**-,350**	-,100
Time difference between running to the numbered balls and shuttle run 5×3 m (orientation), s	-,099	-,240	,053	-,075	-,221
Stand on one leg with closed eyes (static equilibrium), s	-,252	-,217	-,150	,193	,287
Turns on the gymnastic bench (dynamic equilibrium), number of turns	,**396**	,085	,002	,**371**	,178
Running 3×10 m with one's back to the movement direction (rearrangement of movements), s	**-,544**	**-,665**	-,299	-,113	**,338**
Time ratio of running 3×10 m with one's face and with one's back to the movement direction (rearrangement of movements), s	-,**497**	**-,517**	,030	-,015	**,**251
Hoop running 30 m, s	**-,305**	**-,538**	**-,471**	-,059	**,343**
Difference in running 30 m and hoop running 30 m, s	,107	**-,496**	**-,399**	**-,435**	,236
Integral indicator of coordination abilities	,182	**,392**	-,005	,**515**	**,**116

Note: SVMR – simple visually quick reaction, RCh1-3 – choice reaction of one signal from three, RCh2-3 – choice reaction of two signals from three.

Tennis ball drop to assess the accuracy, which determined the degree of proprioreceptal abilities of volleyball players (girls), showed an interconnection at the level (from r = 0.35 to r = 0.44, p <0.05) with the ability to coordinate the movements, spatial orientation, rhythm. The integral index of coordination abilities showed a reliable relationship (r = 0.515, p <0.05) with an indicator of proprioreceptal abilities. Indicators of running along hoops and running 3x10 m with one's back to the movement direction that characterized the ability of the subjects to sense the rhythm and rearrangement of movements were interrelated at a low level (r = 0.34, p <0.05) with an integral index of psychophysiological functions. This indicator showed a reliable interconnection of the average level (r = 0.68, p <0.05) with the ability of volleyball players (girls) to coordinate the movements, which was manifested in the "ten eights" test.

Table 2. Relationship between indicators of coordination preparedness and indicators of perceptual and intellectual abilities of volleyball players (girls)

Indicators of coordination preparedness	**Indicators of psychophysiological functions**			
	Speed of operational thinking	Quality of operational thinking	Speed of information processing	Speed of attention distribution
Crossing through the gym stick (movement coordination), s	-,196	-,266	-,021	-,215
"Ten eights" test (movement coordination), s	**,615**	**,373**	-,270	,233
Running to the numbered balls (orientation), s	,073	**,390**	**-,449**	-,041
Time difference between running to the numbered balls and shuttle run 5×3 m (orientation), s	**-,346**	-,220	-,082	,059
Stand on one leg with closed eyes (static equilibrium), s	**-,486**	-,239	**-,366**	-,079
Turns on the gymnastic bench (dynamic equilibrium), number of turns	**,335**	-,038	**,339**	-,085
Running 3×10 m with one's back to the movement direction (rearrangement of movements), s	-,220	**,317**	**-,588**	,034
Time ratio of running 3×10 m with one's face and with one's back to the movement direction (rearrangement of movements), s	-,298	-,049	**-,553**	-,246
Hoop running 30 m, s	,115	,**417**	-,085	-,084
Difference in running 30 m and hoop running 30 m, s	-,027	,144	,055	,072
Integral indicator of coordination abilities	-,010	**-,367**	**,439**	-,126

Speed of operational thinking of volleyball players (girls) shows a relationship between of low level (from r = 0.39 to r = 0.49, p <0.05) with the ability to spatial orientation, static and dynamic equilibrium. The average level of correlation found between this indicator and the ability to quickly coordinate movements, manifested in the "ten eights" test. The quality of the operational thinking of the subjects shows an interconnection at the level (from r = 0.37 to r = 0.41, p <0.05) with indicators that characterize the ability to coordinate movements, spatial orientation and rhythm sensation.

Speed of information processing shows a low level of interconnection (from r = 0.34 to r = 0.45, p <0.05) with the ability to spatial orientation, static and dynamic equilibrium. Reliable interconnection of the average level (from r = 0.55 to r = 0.58, p <0.05) was found between the rate of information processing and the ability to spatial orientation of volleyball players (girls).

Discussion.

36 out of the 99 considered correlations between the indicators of psychophysiological functions and the coordination readiness of the subjects, turned out to be statistically significant. The percentage of reliable interconnections was 36.4%. This, in our opinion, suggests that the high level of coordination abilities of volleyball players (girls) does not depend on one, even highly developed psychophysiological function. This is the result of a combination of all or most psycho-physiological functions. Because due to the mechanism of compensations, poorly developed functions (for example, perceptual, intellectual) can be compensated by others (for example, sensory-motor ones). Therefore, the level of athlete coordination abilities development can be

evidenced not only by the results of motor tests, but also by the change in the values of psychophysiological indicators. But, not some of them, but all together. In its turn, a sufficiently high level of coordination preparedness allows to predict the presence of a high level of development of psychophysiological functions, which are associated with the manifestation of these abilities.

The correlation analysis carried out by us revealed a greater number of reliable relationships between coordination preparedness and sensomotor performance in comparison with other indicators of psychophysiological functions. This shows, in our opinion, the greatest significance of sensory-motor indicators in the structure of coordination abilities of volleyball players (girls) at the stage of specialized basic training. Our data are compared with the results of studies conducted by other authors (Liakh et al., 2006; Ivashchenko, 2017). Researchers will also point out the closer interconnections between these indicators in males compared to females.

Reliable interconnection of the average level between the integral indicator of coordination preparedness and the indicator of proprio-receptive functions can be regarded as a fact of kinesthesia (muscle sensation) significance in the structure of coordination readiness of volleyball players (girls) at the age of 15-17. The results obtained by us confirmed the experimental data of other authors (Ivashchenko et al., 2018; Malikova, Doroshenko, Symonik, Tsarenko, & Veritov, 2018), on the greater kinesthesia significance for females compared to males.

Indicators of perceptual-intellectual processes and total rank evaluation of coordination preparedness are less conspicuous. (Liakh et al., 2006) indicate that the intellectual ability shows a greater significance in those motor tasks that are more complex in terms of their content. The data we receive are in agreement with the ideas and experimental studies of other authors (Kovačević et al., 2017; Kozina et al., 2018). Researchers in particular indicate that the more distant from each signs of different levels of human individuality are, the less probability of obtaining unambiguous positive relationships between them is.

Thus, the data obtained by us allowed us to investigate the features of the relationships between the indicators of psycho-physiological functions and coordination readiness of volleyball players (girls). The small number of reliable positive interactions was confirmed by the dependence of the level of coordination preparedness of volleyball players (girls) on all or most psycho-physiological functions. The increased significance of sensorimotorics and kinesthesia in the structure of coordination readiness of volleyball players (girls) at the age of 15-17 in comparison with other psychophysiological functions has been confirmed. Along with this, further study is required on participation of such psychological components as emotional and motivational, value-orientation, constituent, volitional ones in the management and regulation of complex coordination movements of volleyball players (girls). Undoubtedly, they play a role in the processes of movement management. However, what kind of their specific influence on the processes of coordinating the movements of volleyball players (girls) is still unknown in the theory and methods of sports training and movement psychophysiology.

Conclusions.

Correlation analysis made it possible to conclude that there are no reliable positive correlations of high and average levels between the indicators of psycho-physiological functions and the coordination abilities of volleyball players at the age of 15-17 in the overwhelming majority. That is, it is an indication that a high level of coordination abilities does not depend on one's psycho-physiological function. It is the result of a combination of all or most of them.

A greater number of reliable interrelationships between coordination abilities and sensory-motor and kinesthesia indicators in comparison with other psychophysiological functions have been revealed. This testifies to their greater significance in the structure of coordination readiness of volleyball players (girls) at the stage of specialized basic training.

The more significant perceptual and intellectual indicators of psychophysiological functions are determined in those motor tasks that are complex in terms of content and are manifested in unusual conditions for players.

Conflict of interests

The authors declare that there is no conflict of interests.

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