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SENSORY MECHANISMS FOR PRECISE MOVEMENT CONTROL OF ATHLETES

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Abstracts

Purpose. To establish the variability of the state of sensory systems and the dependence of control on the precise movements of basketball players from various sensory functions. ***Investigate.*** 30 basketball players of the student league at the age of 17–18 years who had a level of preparation of the first sports category and candidate for the master of sports. ***Result.*** Established a reliable level of communication between the functions of kinesthetic, visual, vestibular analyzer and the dependence of the accuracy of ball throwing into the basket from individual sensory functions. ***Conclusion.*** Results of the conducted researches have determined the sensory regularities of the control by precision throw movements. Studies have established that the accuracy depends on the intensity of the training exercises. Game activity of basketball players occurs at a very high intensity. Therefore for improving the accuracy of throwing the ball requires sensory functions to train with intensity of the exercises, close to the competitive activity.

Key words: sensory systems, accuracy of sensory functions, precision of ball throws.

Анатолій Ровний, Анатолій Цьось, Владлена Пасько. Сенсорні механізми управління точнісними рухами спортсменів. ***Мета*** роботи – установити варіативність стану сенсорних систем і залежність управління точнісними рухами баскетболістів від різних сенсорних функцій. ***Досліджувані.*** 30 баскетболістів студентської ліги у віці 17–18 років, які мали рівень підготовки першого спортивного розряду й кандидата в майстри спорту. ***Результати.*** Установлено достовірний рівень зв'язку між функціями кінестетичного, зорового, вестибулярного аналізаторів і залежність точності кидків м'яча в кошик від окремих сенсорних функцій. ***Висновки.*** Результати проведених досліджень визначили сенсорні закономірності управління точнісними кидковими рухами. Дослідженнями встановлено, що точність залежить від інтенсивності виконання тренувальних вправ. Ігрова діяльність баскетболістів відбувається за дуже високої інтенсивності. Тому для покращення точності кидків м'яча потрібно тренувати сенсорні функції за інтенсивності вправ, наближених до змагальної діяльності.

Ключові слова: сенсорні системи, точність сенсорних функцій, точність кидків м'яча.

Introduction. The modern level of athletic achievement in the opinion of scientists and researchers sport [6, 9, 11] sports competition exacerbated in the competitive activities of different levels. This puts forward higher requirements for the system of training athletes. It is proved that the increase in the level of efficiency of the training process is carried out in the presence of a system-structural approach [2, 4, 31, 32].

In modern times it is proved that the system of training in game sports is based on subjective approaches, and not on objective information about the functional state and the level of special preparedness of athletes [7, 14, 21]. However, we conducted in-depth studies [22, 33, 34], which is determined that the training process control must be performed under conditions as close to competitive and based on the quantitative characteristics of special physical, functional and technical readiness.

Modern basketball places high demands on the level of physical qualities, the state of sensory functions that ensure a high level of accuracy of movements. The motor activity of basketball players is characterized by great variability of the performed movements, different in character and structure. This – individual, group, team actions, which are performed in a constant change in the game situation [10].

Continuous motor situation lasts 30–50 seconds, which is provided by anaerobic work capacity. Therefore, the performance of training assignments must occur with maximum intensity [13, 16, 30]. The lack of objective data on the role of sensory functions in the execution of precision toss movements and determined the direction of the studies.

Material and Methods. Participants. The study involved 30 basketball players aged 17–18 years who had the level of preparation the first sports category, candidates for master of sports and master of sports. Participation in the study was voluntary and it did not involve any form of incentive. Design of the study was

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intended to investigate the state of sensory functions, their interrelation and the role of these functions in the management of precision ball throws.

Following research methods were used:

Kinesthesia – determination of the number of difference thresholds increase in weight from 40 g to 1000 g [29]; determine the accuracy of the given force; determination of the accuracy of a given spatial motion parameter.

Visual Sensory Sensitivity – the difference sensitivity was determined by increasing the brightness of light with the help of the ADM-2 adaptometer according, as well as the dark adaptation. Investigation of deep vision occurred with the help of a slit-rod apparatus of Sachsenweger.

Vestibular Sensitivity was determined by recording the nystagmus which, when rotated on the Barani chair at a speed of 3º to 45º per second. Vestibular stability was determined in points on the basis of changes in heart rate and blood pressure after rotation on the Barani chair.

Establishing the Level of Vestibular Stability. Basketball players performed the test task – 40 ball throws in 4 minutes: 20 ball throws from 3 points and 20 ball throws from 2 points zone. The number of points scored was calculated. To determine the role of sensory mechanisms in the management of precision ball throws in the ring, a statistical regression analysis method was used that determines the role of each factor in the control of movements.

Statistical Analysis. Statistical processing of the research results was car-ried out using the Statistica program, the following methods were used: descriptive statistics, correlation and regression analysis.

Result of Research and Their Discussion. The conducted studies confirm the necessity of searching for methods of management of the training process. During the training camp for two months, the dynamics of the intersensory links during the training session was observed.

Optical-kinesthetic relationships are characterized by considerable variability (table 1).

Table 1

Dynamics of Optical-Kinesthetic Relationships During the Training Camp in Basketball Players (n=30)

Ratio of Sensory Systems During the Training Session		Values of Coefficients		
		Correlations, *r*	Curvilinear Dependence, *n*	Determination, *R*
Before Training Camp	KS_1-ZS_1	0,01±0,29	0,32±0,01	0,10±0,01
	KS_2-ZS_2	0,02±0,21	0,39±0,01	0,15±0,01
	KS_3-ZS_3	0,41±0,11*	0,51±0,01*	0,26±0,08
After Training Camp	KF_1-ZF_1	0,54±0,09*	0,62±0,06*	0,39±0,01
	KF_2-ZF_2	0,49±0,12*	0,22±0,01	0,05±0,01
	KF_3-ZF_3	0,64±0,16*	0,40±0,01*	0,16±0,01

** – reliable indicator,*

where KS – kinesthetic sensitivity at the beginning of training camp; KF – kinesthetic sensitivity at the end of training camp; ZS – visual sensitivity at the beginning of training camp; ZF – visual sensitivity at the end of training camp.

An analysis of the results shows that at the end of the session there is a reliable combination of sensitivity levels. This is due to the fact that the special motor activity of basketball players is related to the accuracy of perception of visual information on the basis of which precise movements are formed [10, 14].

The dynamics of the optical-vestibular ratio is of great interest for the theory and practice of sports training. Materials of the study of the optic-vestibular relationships show the relationship, which varies during the training removal at the beginning and at the end of the training camp (table 2).

The materials of the study show that the ratio of the visual and vestibular systems is of a variation nature. During the collection, active muscular activity stimulates the activity of all sensory and vegetative systems, contributes to a gradual increase in the level of interrelation that at the end of the collection reaches a reliable value ($p<0,05$).

Constant irritation of the vestibular apparatus during training activity creates a heterosensory effect on all sensory systems. A comparison of the vestibular and cognitive sensory systems shows a reliable value of the curvilinear dependence of the course of a sport activity (table 3).

Table 2

Dynamics of Optical-Kinesthetic Relationships During the Training Camp for Basketball Players (n=30)

Ratio of Sensory Systems During the Training Session		Values of Coefficients		
		Correlations, *r*	**Curvilinear Dependence, *n***	**Determination, *R***
Before Training Camp	ZS_1-CHS_1	-0,11±0,12	0,26±0,02	0,07±0,02
	ZS_2-CHS_2	-0,39±0,17	0,26±0,01	0,09±0,02
	ZS_3-CHS_3	-0,47±0,09*	0,70±0,09*	0,48±0,07
	ZS_1-VS_1	0,31±0,13	0,39±0,01	0,28±0,02
	ZS_2-VS_2	0,29±0,12	0,37±0,01	0,29±0,02
	ZS_3-VS_4	0,42±0,12	0,40±0,01	0,35±0,01
After Training Camp	ZF_1-CHF_1	0,36±0,18	0,40±0,01	0,36±0,01
	ZF_2-CHF_2	0,47±0,15*	0,604±0,01*	0,37±0,01
	ZF_3-CHF_3	0,44±0,12*	0,49±0,02*	0,33±0,02
	ZF_1-VF_1	0,42±0,21*	0,48±0,01*	0,28±0,08
	ZF_2-VF_2	0,62±0,20*	0,51±0,01*	0,30±0,02
	ZF_3-VF_3	0,48±0,17*	0,54±0,08*	0,30±0,01

** – reliable indicator,*

where ZS – visual sensitivity at the beginning of training camp; ZF – visual sensitivity at the end of training camp; CHS – vestibular sensitivity at the beginning of training camp; CHF – vestibular sensitivity at the end of training camp; VS – vestibular resistance at the beginning of training camp; VF – vestibular resistance at the end of training camp.

Table 3

Dynamics of the Vestibular-Kinesthetic Relationships Among Basketball Players During the Training Camp (n=30)

Ratio of Sensory Systems During the Training Session		Values of Coefficients		
		Correlations, *r*	**Curvilinear Dependence, *n***	**Determination, *R***
Before Training Camp	KS_1-CHS_1	0,36±0,15	0,36±0,21	0,24±0,12
	KS_2-CHS_2	0,42±0,23*	0,43±0,02	0,23±0,02
	KS_3-CHS_3	0,41±0,18*	0,47±0,02	0,18±0,17
After Training Camp	KF_1-CHF_1	-0,45±0,18*	0,43±0,13*	0,28±0,11
	KF_2-CHF_2	0,42±0,91*	0,42±0,11*	0,18±0,01
	KF_3-CHF_3	0,52±0,12	0,42±0,19	0,28±0,21
Before Training Camp	ZS_1-VS_1	0,38±0,28	0,26±0,18	0,16±0,02
	ZS_2-VS_2	0,49±0,15*	0,52±0,09*	0,28±0,21
	ZS_3-VS_3	0,37±0,27	0,44±0,12	0,21±0,02
After Training Camp	ZF_1-VF_1	0,42±0,18	0,41±0,07	0,25±0,22
	ZF_2-VF_2	0,44±0,21	0,42±0,16	0,37±0,18
	ZKF_3-VF_3	0,36±0,19	0,30±0,14	0,29±0,02

** – reliable indicator,*

where KS – kinesthetic sensitivity at the beginning of training camp; KF – kinesthetic sensitivity at the end of training camp; CHS – vestibular sensitivity at the beginning of training camp; CHF – vestibular sensitivity at the end of training camp; VS – vestibular resistance at the beginning of training camp; VF – vestibular resistance at the end of training camp; ZS – visual sensitivity at the beginning of training camp; ZF – visual sensitivity at the end of training camp.

Analysis of the presented materials shows that at the beginning of the collection in the middle of training vestibular-kinesthetic communication is equal to 27,11 % of a reliable level, and after the session 21,4 %.

Of great importance is the relationship between vestibular stability and kinesthetic sensitivity. This is due to the vegetative and sensory reactions that occur in the process of sports activity against the background of constant vestibular stimuli.

Estimating the applied value of the obtained research results, we draw attention to the high diagnostic value of indicators reflecting the state of the system organization of functions. On the one hand, they change during a functional state under the influence of loads. And on the other hand, they are in a clear quantitative dependence on the initial state of the functions. Thus, the obtained data allow predicting the nature of the systemic changes that underlie the determination of the functional state of the organism.

In controlling the movements of athletes a significant role belongs to the sensory correction. Their fundamental necessity is conditioned by the changing external and internal conditions for performing arbitrary movements. Analyzing these theoretical positions of sensory corrections it is appropriate to say that their influence varies according to the environmental conditions and the need for motor actions.

For the theory and practice of sports training, it is of considerable interest to construct mathematical models of the dependence of the accuracy of the motor actions of athletes on the functional state of various sensory functions. In order to establish the accuracy of ball throws in basketball players, the method was used for a set of linear regression.

Thus, at the beginning of the collection, the model of the accuracy of motor actions shows numerical parameters whose weight coefficients characterize the significance of each sensory function.

The calculated coefficient of determination shows that this multiple model explains 99,4 % of the variation in the precision of the ball's throwing into the ring. Thus, at the beginning of the collection, the mathematical model is expressed by the following equation:

$$TS=3{,}52CHS+4{,}06FS+0{,}11GS–0{,}44KS+1{,}09PS–0{,}87VS–0{,}19ZS,$$

were *TS* – accuracy of throwing a ball into the ring; *CHS* – vestibular sensitivity at the beginning of training camp; *FS* – threshold of deep vision; *KS* – kinesthetic sensitivity at the beginning of training camp; *PS* – threshold of accuracy of spatial motion parameter; *VS* – vestibular resistance at the beginning of training camp; *ZS* – visual sensitivity at the beginning of training camp.

Thus, the presented model allows to evaluate each sensory function in achieving the accuracy of ball throws in the ring of basketball players.

Applying the method of stepwise regression, you can determine the most significant factors that determine the accuracy of movements.

The final mathematical model looks like:

$$TS=2{,}059CHS+4{,}387FF,$$

TS – accuracy of throwing a ball into the ring; *CHS* – vestibular sensitivity at the beginning of training camp; *FF* – threshold of accuracy of a given force at the beginning of the training camp.

In the future, we present only the final mathematical model.

At the end of the collection, the mathematical model determines two factors:

$$TF=8{,}45FF+7{,}527VF,$$

where *TF* – accuracy of throwing a ball into the ring; *FF* – threshold of accuracy of a given force; *VF* – vestibular resistance at the end of training camp.

Here are the dynamics of the dependence of the accuracy of throws the ball during a training session at the beginning and at the end of the training camp.

Stepwise regression equation at the beginning of training session at the beginning of training camp to determine such parameters:

$$TS_1=3{,}066GS+1{,}243PS,$$

where TS_1 – accuracy of throwing a ball at the beginning of training session; *GS* – threshold of deep vision; *PS* – threshold of accuracy of spatial motion parameter.

In the middle of training, the mathematical model determines three factors that determine the accuracy of ball throws:

$$TS_2=1{,}864GS_2–5{,}748VS_2+0{,}237TA_2,$$

where TS_2 – accuracy of throwing a ball in the middle of training session; GS_2 – threshold of deep vision; VS_2 – vestibular resistance; TA_2 – adaptation to darkness.

At the end of the training session at the beginning of the training camp of accuracy of ball throws depends on two factors:

$$TS_3=1{,}271VS_3+0{,}146TA_3,$$

where TS_3 – accuracy of throwing a ball at the end of the training session at the beginning of training camp; VS_3 – vestibular resistance; TA_3 – adaptation to darkness.

After the preparatory training camp, the system of sensory control of the accuracy of ball throwing into basketball players has changed somewhat. At the beginning of training stepwise regression equation establishes five factors on which the accuracy of the ball throw depends on:

$$TF_1=2{,}473CHF_1+4{,}744FF_1+1{,}826GF_1+0{,}3809KF_1+ZF_1,$$

where TF_1 – accuracy of throwing a ball at the beginning of the training session at the end of training camp; CHF_1 – vestibular sensitivity at the beginning of training session; FF_1 – threshold of accuracy of a given force; GF_1 – threshold of deep vision; KF_1 – kinesthetic sensitivity; ZF_1 – visual sensitivity.

Mathematical model of accuracy throwing the ball in the middle of the training determines the two factors on which depends on the accuracy of the shots.

$$TF_2=1{,}195GF_2+0{,}149VF_2,$$

where TF_2 – accuracy of throwing a ball in the middle of the training session at the end of training camp; GF_2 – threshold of deep vision; VF_2 – vestibular resistance.

At the end of training session at the end of training camp, accumulation of fatigue is traced. This causes a decrease in the functional activity of sensory systems, which significantly reduces the accuracy of ball-throwing into the ring. The constant irritation of the vestibular apparatus causes a significant redistribution of the muscle tone, which significantly affects the accuracy of movements. Mathematical model defines four factors on which the accuracy of movements depends.

$$TF_3=3{,}649VF_3+1{,}91KF_3+0{,}97GF_3+0{,}712PF_3,$$

where TF_3 – accuracy of throwing a ball at the end of the training session at the end of training camp; VF_3 – vestibular resistance; KF_3 – kinesthetic sensitivity; PF_3 – threshold of accuracy of spatial motion parameter.

Thus, research materials indicate that each of the functions of sensory systems under study contributes to the management of precision movements and changes during training in accordance with the intensity of physical exertion.

Discussion. Summarizing the results of the study, it is necessary to specify that the object of the study was three sensory systems and three functions of each system under the conditions of the training process. The problem of studying the physiological mechanisms of controlling the accuracy of athletes movements was, is and will be actual [1, 12, 20]. At the same time, the question of the role of sensory systems in the control of precision movements only acquires significant relevance. Existing very little research on this problem is characterized by contradictory views, as well as the lack of factual materials that could explain the mechanisms of managing precision movements from the position of system analysis [14, 18].

The reason for the separation of views from our point of view is that in the study of this problem, methods that reflect the average, functionally stable levels of activity of sensory systems [5, 8, 17, 19]. In addition, previous studies did not study the complex of sensory functions, and, under laboratory conditions, and not in conditions of sports training and competitions [3, 26].

In our studies, a comprehensive study of sensory systems, their individual functions in the management of movements accuracy in the conditions of the training process, close to the competitive activity.

Studies [24, 28] indicate that the main mechanism of indices of the differential thresholds of the motor sensory system are metabolic processes that change under conditions of athletic training.

In the studies of A. S. Rovniy [25, 27] shows how the variability of sensorometry varies depending on the different orientation of the training sessions. At the same time, metabolic processes change significantly, and this in turn changes the activity of sensory systems, disrupting the constant average consistency between them and establishes a single main system in the control of motions.

The load during the training of basketball players occurs against a background of constant vestibular stimulus. With the accumulation of training capacity at the end of the collection in the process of training helps to increase vestibular stability and reduce the vestibular sensitivity, it is appropriate adequate reaction. This ratio is indicative of the highly qualified preparedness of athletes whose motor activity is associated with the implementation of complexly coordinated movements against the background of the vestibular stimulus [23].

Conclusions. Functional state of the sensory systems and the level of their correlation varies during the training session. To establish the control mechanism of precision movements, it is necessary to apply the system-structural approach, which makes it possible to establish the significance of the contribution of each sensory function in the control of the precision movements.

Motor activity in modern sports games requires high biological stability of the sensory sphere of the brain, which provides high accuracy of motor activity in conditions of time deficit. The use of special exercises only in conditions close to the competitive ones promotes an increase in the biological stability of sensory systems and their interdependence by improving the adaptive mechanisms of the sensory sphere of the brain and also the internal interaction within each sensory system. This contributes to the establishment of a new, more stable level of functional activity of sensory systems.

Conflict of Interest. The authors declare that there is no conflict of interests.

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