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Original research papers

VISUAL PERCEPTION AND ITS EFFECT ON REACTION TIME AND TIME-MOVEMENT ANTICIPATION IN ELITE FEMALE BASKETBALL PLAYERS

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Abstract

Introduction. The efficient collection and analysis of information from both the central and the peripheral field of vision may affect human coordination motor abilities. An analysis of the literature on the subject suggests that coordination motor abilities interact with one another, and it is only their combined effect that allows athletes to achieve technical mastery. The main aim of the study was to assess specific coordination motor abilities and to determine how visual perception and reaction time correlate with time-movement anticipation in elite female basketball players. ***Material and methods***. The study participants comprised 17 female basketball players from the Polish National Team aged 18.1 ± 0.8 years. The study involved three ability tests from the Vienna Test System: the Reaction Test (RT, S1), the Peripheral Perception test (PP), and the Time/Movement Anticipation test (ZBA, S2). ***Results***. The analysis of the results obtained proves that the best-developed ability in participants is reaction time, while the other abilities show average development. Study participants were able to develop their response abilities to such high levels by means of practice. A correlation coefficient was found between motor time and tracking deviation (r=0.56), and between time anticipation and the number of correct responses to stimuli appearing in the left (r=0.92) and right (r=0.88) field of vision. Athletes who achieved better results in time anticipation omitted fewer visual stimuli (r=0.7) in the peripheral field of vision. Statistically significant correlations were observed between movement anticipation and reaction time to stimuli in the central field of vision (r=0.58). ***Conclusions***. Perception abilities have a significant effect on time anticipation. The range of one's field of vision does not determine the reaction time to a visual stimulus. Perception efficiency and divided attention, in conjunction with time and movement anticipation, create a complex of specific psychomotor abilities that is indispensable for achieving success in team sports.

Key words: visual perception, coordination motor abilities, Vienna Test System, reaction time, time-movement anticipation, peripheral perception

Introduction

Achieving top results in sports is, without question, related to a high level of cognitive, perception, motor, and physical abilities. Compared to any other activity, sports competition sets extremely strict requirements for the functioning of the visual system [1].

The visual system is the most complex sensory system which is engaged in creating feedback and dominates the other sensory systems. Good sight requires extraordinary visual and perceptual abilities that involve providing information to the brain via the eyes. The brain interprets this information and initiates appropriate physical actions [2, 3]. The sense of sight gathers as much as 80% to 90% of all human sensory information, which is why researchers increasingly consider the importance of visual perception as a factor that influences the performance of athletes in sports. The efficient collection and analysis of data concerning both the central and the peripheral fields of vision can influence the coordination motor abilities (CMA) of athletes [4].

Visual perception is the ability to recognize and interpret visual stimuli in the context of previous experiences, although it is a process of creation rather than re-creation. It is an element of almost all human actions and is assessed through reaction time to a stimulus appearing in the central or peripheral field of vision [5].

Elite sports require that athletes show the highest possible level of reaction to stimuli in both the central and peripheral (left and right) fields of vision, because selecting key information about the opponent's movements is only efficient if the athlete observes the opponent's entire body and its surroundings [2, 4].

The first scholar to notice and describe a relationship between visual perception, the human body, and the ball was Galen (in the second century BCE). His findings motivated other authors to conduct further research on the correlation between visual perception and success in sports [6]. Today, we know that elite athletes have better visual skills and a higher level of coordination motor abilities (CMA) than persons not engaged in sports [7]. Visual perception may directly affect CMA by enhancing them, compensating for any deficiencies, or limiting them [8].

CMA play a key role in team sports because they allow athletes to carry out technically and tactically complicated actions that lead to achieving the goal in an economical and effective manner [9]. Consequently, emphasis is put on the comprehensive development of CMA as well as particular abilities crucial to a given discipline at the earliest stages of training. Achieving a high and comprehensive model of motor coordination is a prerequisite for learning the complicated techniques and tactics of play. Therefore, diagnosing abilities crucial to a given discipline is one of the most important aspects of sports training [10]. These abilities must be constantly stimulated if an athlete is to learn particular motor stereotypes that characterize the master model.

For these reasons, CMA should constitute an important part of sports training. Among the five main CMA training blocks mentioned by Lyakh and Sadowski (2011, p. 193), only one block, that is, "Systematic learning of new (general and special) motor actions, perfection and their adjustment to various conditions of training and competitive activity with the purpose of influencing general and special CMA," is usually realized in the training program. The remaining blocks are not taken into consideration. According to the same authors, CMA training should be treated as a separate training block in the preparation of elite players. The specificity and determinants of CMA make these abilities extremely difficult to assess. This, in turn, makes it difficult to select appropriate training methods by which trainees can improve their CMA. Researchers unanimously suggest choosing special means for every skill in CMA training, as well as for developing them comprehensively [11].

One of the leading abilities in team sports, including basketball, is spatial orientation. Spatial orientation determines the management of one's movements in space and the management of changes to spatial parameters caused by these movements [10]. An inextricable part of this process is the ability to assess the position and direction of an object in space quickly and precisely, which enables an exact and effective motor action that guarantees success. Several forms of spatial orientation can be distinguished, e.g., the perception of shape, distance, depth, movement, and direction. Determining the actual time and distance of movement depends on perception abilities and imagination, while the other forms of spatial orientation depend on attention, emotions, and motivation [12]. Consequently, effective anticipation allows movements to be organized, planned, and controlled, which is indispensable in any sports activity. Research emphasizes that, especially in team sports, anticipating a movement even before it is initiated constitutes a great challenge for the nervous system because such anticipation relies on real-time visual information [13].

An analysis of the literature on the subject shows that CMA correlate with one another in a certain manner. Only when taken as a whole do they allow a player to achieve technical mastery [14].

The problem of structural connections between coordination abilities has been addressed by Lyakh [15]. The participants in his study comprised youth not engaged in competitive sports as well as children. Only a few studies of this kind have been conducted with professional athletes, and most of the research involved men. No research was found that addressed the levels and structural connections between critical coordination abilities in female basketball players.

Studies that address the changeability of CMA in a specific training cycle indicate a positive influence of targeted training on CMA development, both in the long term and in the short term. A study by Bodasiński (2008) concludes that the level of CMA depends on the training cycles and specific means characteristic for them. Furthermore, he points to the heterogeneous structure and the ambiguous direction of changes within the CMA.

Research has showed that some CMA progress during the annual training cycle while other CMA stagnate or decrease. The latter process is likely accompanied by compensation mechanisms [16]. Therefore, obtaining comprehensive information about the particular correlations between CMA and visual perception that would provide insight into their proportion, compensation mechanisms, and specific manifestations becomes even more important.

With these considerations in mind, the aim of this study was to assess special CMA and to determine the correlations between visual perception and time-movement anticipation and between reaction time and time-movement anticipation among elite female basketball players.

Material and methods

The study participants comprised 17 female basketball players aged 18.1 ± 0.8 years. All the participants were members of the Polish National Team from 2011 to 2013. All of them were right-handed. Their mean body height was 182.78 ± 0.8 cm and their mean body mass was 73.06 ± 9.71 kg. The participants' mean length of training experience was 8.83 ± 1.75 years.

The study was conducted during the competitive phase, when the participants attended 10 practice sessions a week. The tests were conducted in the morning on days without practice sessions.

The study involved three tests from the Vienna Test System: the Time/Movement Anticipation test (ZBA), the Reaction Test test (RT), and the Peripheral Perception test (PP).

The PP test assessed peripheral perception and central tracking. During the test, each participant focused her attention on the centre of her field of vision while computer software gener-ated 40 stimuli (20 stimuli from the right side and 20 from the left side) on the side panels of the device. The participant per-formed a tracking task, at the same time responding to visual stimuli in the peripheral field of vision. The results of the test also provided information about divided attention. The test lasted 10 minutes.

The primary variables assessed in the test were the viewing angle of the left eye, the viewing angle of the right eye, and the total field of vision (i.e., the sum of the left and right viewing angles of the eye).

The control variable was the tracking displacement, which characterized the displacement of the crosshair from the moving target.

Auxiliary variables comprised the following: the number of correct responses to stimuli in the left and right field of vision (the participant pressed a pedal when a flashing line appeared on the right or left panel of the device); the number of incorrect responses (i.e., the number of times the participant pressed the pedal when no stimulus appeared); the number of omitted responses (i.e., the number of times the participant failed to press the pedal when a stimulus appeared); and mean reaction time from the left and right side (i.e., the time of correct responses to a stimulus) [17].

The ZBA test assessed the ability to predict the spatiotemporal position of an object. The short (task-based) version of the test was used, i.e., S2, 12. Time anticipation was measured by means of a green ball that appeared on the screen and began to move slowly. At some point, the ball disappeared and two red lines appeared. One line crossed the point where the ball disappeared, while the other line was the target. The participant's task was to indicate when the ball would reach the target line by pressing a key at the time she deemed correct. In addition, the participant was asked to indicate the spot in which the ball would cross the target line, which would make it possible to assess her movement anticipation. This was done by rotating two dials on the main panel that controlled the pointer on the screen. In the trial phase, the participant received feedback in the form of her response and the correct response appearing together on the screen. In the testing phase, the participant was not shown the correct response. The test lasted 10 minutes [17].

The RT test assessed reaction time to visual stimuli (yellow light) appearing on the screen. The participant held her finger on the rest key located on the response panel. When a yellow light appeared on the screen, she responded by moving her finger and pressing the reaction key (a black, rectangular key located above the rest key).

The primary variables assessed in the RT test were reaction time (ms) (i.e., the time between a stimulus appearing on the screen and the participant moving the finger away from the rest key) and motor time (MRT; ms) (i.e., the time between the participant moving the finger away from the rest key and pressing the reaction key).

Auxiliary variables comprised reaction time dispersion (i.e., the measurement of the reaction time dispersion after transforming the standard deviation of reaction time values using the Box-Cox transformation) and motor time dispersion (i.e., the measurement of the motor time dispersion after transforming the standard deviation of motor time values using the Box-Cox transformation). This study used the S1 form of the test (simple reaction to yellow light). The test lasted four minutes and was performed with the right (dominant) hand [17].

The results obtained were analysed statistically, using the STATISTICA PL v.10 program. The Spearman's rank correlation coefficient was used to check for any correlations between the skills. Our test results were compared with the T-score available in the VTS software. The T-score (T) is a result of comparing the test results with the standardization sample, which takes into account a respondent's age and gender. Values between 40 and 60 are considered to indicate that the value is within the norm [17].

Results

The study of individual skills started with the peripheral perception test (PP). Its complexity allowed for the assessment of both the complete field of vision (174.61° ± 4.01) and the range of left (86.47° ± 2.99) and right (88.14° ± 1.99) peripheral perception, as well as tracking deviation (12.42° ± 2.88). In addition, the number of correct reactions (reaction accuracy) to 40 visual stimuli was assessed. During the exercise, 20 stimuli appeared on the right side of the field of vision (correct: 18.83 ± 2.07); another 20 stimuli appeared on the left side of the field of vision (correct: 17.17 ± 3) (see tab. 1.).

Table 1. Average values achieved in studies of players' specific coordination motor abilities

Variables	Units	$\overline{x}$ ± SD	Reliability
Visual perception			
Tracking deviation	-	12.42 ± 2.88	0.98
Overall field of vision	°	174.61 ± 4.01	0.96
Visual angle – right	°	86.47 ± 2.99	-
Visual angle – left	°	88.14 ±1.99	-
Number of hits left	n	17.17 ± 3.00	-
Number of hits right	n	18.83 ± 2.07	-
Number of omitted reactions	n	3.5 ± 3.26	-
Median reaction time left	s	0.63 ± 3.26	-
Median reaction time right	s	0.59 ± 0.08	-
Ability of quick reaction			
Mean reaction time	ms	222.22 ± 23.67	0.961
Mean motor time	ms	96.39 ± 42.86	0.983
Reaction time dispersion	ms	22.56 ± 6.53	0.961
Motor time dispersion	ms	14.39 ± 6.47	0.983
Anticipation of time and movement			
Anticipation of time	s	1.11 ± 0.62	0.94
Anticipation of movement	piksel	63.94 ± 19.70	0.55

It was noted that the participants answered correctly for more stimuli appearing on the right side. The minimal times obtained in the exercise are almost equal: 0.50 s for the right side and 0.51 s for the left side. The slowest reaction, 0.77 s, was noted when the signal appeared on the left side.

Linking together a number of exercises performed simultaneously by each study participant allowed for the assessment of a participant's divided attention. However, the average value of the central tracking deviation showed the worst result among the abilities studied.

Another area of analysis was the Reaction Test (RT). The players' average reaction time to the visual stimuli equalled 222.22 ± 23.67 ms. The best (shortest) result was 182 ms; the worst was 269 ms. The average measure of the reaction time dispersion (MRTD) also suggests a high stimulus reaction readiness throughout the whole exercise (fig. 1).

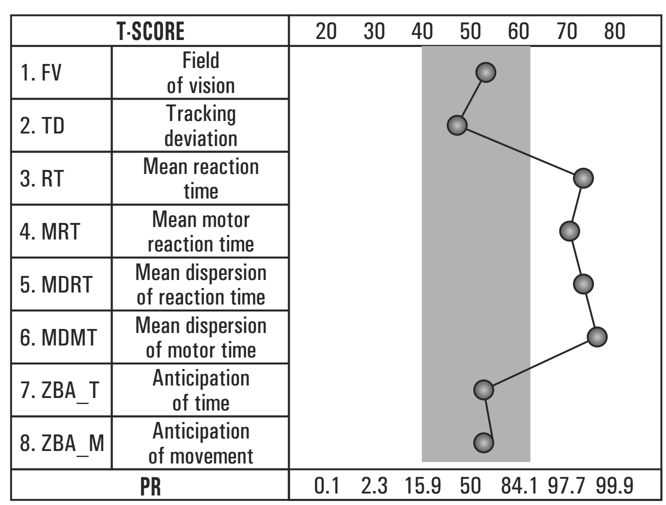

Figure 1. Profile of anticipation of time and movement, reaction time and visual perception according to T-score (T) and percentage scale (PR) of elite female basketball players

The average motor time also received very high scores on the T-score, though they are slightly lower than the reaction time scores. Also, in this case the measurement of the motor time dispersion (MMTD) indicates high motor reaction stability (tab. 1, fig. 1).

The last test the players undertook was the time-movement anticipation test (ZBA). The analysis of the test results indicated that for the players the correct anticipation of the movement direction proved more difficult than the time anticipation. The average value of errors made by the study participants in the case of movement anticipation reached 63.94 ± 19.70 pixels; the time error equalled 1.11 ± 0.62 s (tab. 1). The level of both abilities was classified according to the T scale and the PR percentage scale, within the normal range for the population (fig. 1).

Discussion

The main disadvantage of conducting studies involving elite athletes is the usually small number of participants, which frequently makes it difficult to normalize the results obtained or to discuss them in the context of similar studies. The wide range of research tools and techniques used to investigate CMA makes conducting research on the subject even more difficult.

Research using the Vienna Test System (VTS) has so far been conducted among athletes from different sports disciplines, including racquet sports (badminton and table tennis), martial arts (taekwondo ITF, wrestling, and fencing), and team sports (volleyball, football, and handball) [18, 19, 20, 21]. From among the vast selection of VTS tests, researchers have always used those that took into account the specificity of a given discipline and the most important CMA for it. The research results in print also include those that emphasize the correlation between visual capability and other motor abilities. Hence, a number of publications state an urgent need to train perception, as it directly affects performance in sports [22, 23].

In order to obtain reliable information about the level of CMA in the study participants, the results of this study were compared to those obtained in studies conducted using the VTS among the National Representation of male badminton players aged 22.33 ± 2.35 years and among male second-league handball players aged 21.86 ± 1.09 years [18, 21]. No studies conducted among women were found to date. The participants of this study showed a greater range of the field of vision (174.61° ± 4.01) than male badminton players (172.9° ± 4.45) and male handball players (170.95° ± 9.15) [21]. They also displayed the lowest difference between the viewing angles of the left and the right eye (female basketball players: a difference of approximately 2°, male badminton players: approximately 7°, and male handball players: approximately 10°). No statistically significant difference in the lateralization of reaction time to stimuli in the peripheral field of vision was observed. However, the study participants responded correctly more frequently to stimuli appearing from the right side (tab. 1). The female basketball players reacted more quickly to stimuli in the peripheral field of vision (left side: 0.63 ± 0.26; right side: 0.59 ± 0.08) than male badminton players (left side: 0.66 ± 0.07; right side: 0.66 ± 0.05) and slightly more slowly than male handball players (left side: 0.55 ± 0.07; right side: 0.54 ± 0.05) [18, 21].

Research done by other authors indicates that a higher level of perception abilities results from the skill to quickly recognize and respond to stimuli more than from the functioning of peripheral vision [7]. Most studies conducted among athletes and persons not engaged in sports support this thesis. Moreover, a wider range of vision does not guarantee a quicker reaction to stimuli in the peripheral field. Athletes react more quickly and more accurately to stimuli than persons not engaged in sports [5, 7, 24].

Presenting the results of this study in relation to the findings of other researchers proves more difficult as far as the reaction time test is concerned, due to the vast number of research tools used to assess this ability. Mean human reaction time to a visual stimulus amounts to approximately 250 ms, with athletes showing lower values. Systematic training reduces reaction time in both healthy young persons and elderly persons. Nonetheless, the general level of reaction time abilities decreases with age [25]. The best reaction time is observed between the ages of 17 and 20, i.e., the age of the participants of this study, whose reaction time showed above-average development compared to the other abilities studied, as determined by the T-score and on the PR percentage scale (fig. 1).

The role of the anticipation ability as a determining factor of effective play is being addressed more frequently on the international level [26, 27, 28, 29]. Success in sports is defined by one's ability to predict decisions made by the opponent(s). Many studies with players of different sports disciplines (tennis, squash, baseball, badminton, and soccer) prove that elite athletes perform better in movement anticipation tests [26]. Furthermore, elite athletes do not limit themselves to only one source of information when predicting the opponents' intentions, which means that their perception is a global, rather than local, process [27]. Recent research indicates that focusing on the opponent's trunk does not provide all the information necessary to efficiently predict the final direction of the opponent's movements. A study by Fuji et al. suggested that enhancing one's defence against the attacker is only possible if the trunk is observed in the central field of vision and the feet position is simultaneously observed in the peripheral field of vision [29].

An analysis of the results obtained in this study showed that the ability to quickly assess the position and direction of an object in space correlated significantly with reaction time and motor time. Players who were better at predicting the position of an object in space and time reacted faster to visual stimuli.

Pawelak, Lyakh, and Witkowski [14] obtained similar results in their study, which involved conducting fitness tests in a group of female handball players and in a study with female soccer players [9]. Both studies observed average correlations, primarily between the indicators of spatial orientation and reaction rate. With respect to the other abilities studied, 70% to 95% of the cases showed no statistically significant correlations.

A study that used the Vienna Test System with a badminton team proves that the time anticipation ability also correlates significantly with total field of vision (r=-0.82) [18]; this was not confirmed by our study. However, an analysis the results of the test in the group of basketball players showed a correlation between the number of omitted responses to stimuli appearing in the peripheral field of vision and time anticipation (r=0.7) (tab. 2), as was the case in the study with badminton players (r=0.89).

Table 2. Correlation (Spearman rank coefficient correlation) between visual perception, reaction time, and time-movement anticipation

Variables	Anticipation of time (ZBA_T)	Anticipation of movement (ZBA_M)	Tracking deviation (PP)
Overall field of vision (PP)	-0.24	0.01	-0.02
Visual angle – left (PP)	-0.36	-0.23	-0.12
Visual angle – right (PP)	0.01	0.17	0.01
Number of hits left (PP)	**0.92***	-0.35	-0.27
Number of hits right (PP)	**0.88***	-0.27	-0.30
Number of omitted reactions (PP)	**0.70***	0.31	0.37
Number of incorrect reactions (PP)	-0.10	-0.44	-0.22
Mean reaction time [ms] Central field of view (RT)	0.42	**0.58***	0.22
Mean motor time [ms] Central field of view (RT)	0.38	0.09	**0.56***

* – statistically significant correlation ($p<0.05$).
Legend: ZBA_T – Time Anticipation Test, ZBA_M – Movement Anticipation Test, PP – Peripheral Perception Test, RT – Reaction Time Test.

Furthermore, a correlation was found between motor time and tracking deviation (r=0.56), and between time anticipation and the number of correct responses to stimuli appearing in the left (r=0.92) and right (r=0.88) field of vision. Statistically significant correlations were also noticed between movement anticipation and reaction time to a stimulus in the central field of vision (r=0.58). This study proves that highly-developed ability to analyze visual stimuli in the central and peripheral fields of vision results in a better ability to predict the spatiotemporal position of an object, which in turn directly affects athletes' defensive and offensive abilities during play, as also found by other researchers [29].

Conclusions

The range of field of vision did not determine reaction time to a visual stimulus in the group studied. Visual perception abilities were found to significantly affect time anticipation. This proves that perception efficiency and divided attention, in conjunction with time and movement anticipation, create a complex of specific psychomotor abilities that is indispensable for achieving success in basketball.

The study participants were able to develop their response abilities by practice. It may be concluded that the high level of reaction time in the study participants may have compensated for the average level of other abilities.

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