Does perceptual-motor training improve behavioral abilities of handball players?

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Abstract

Problem Statement: Handball is becoming more dynamic and complicated. The athlete must therefore use his or her cognitive abilities, especially perception and sensorimotor coordination, to remember, evaluate, conclude and react immediately. Perceptual-motor training can stimulate perception processes, coordination, and attention. It uses an information system through peripheral perception, increased sensorimotor coordination of limb work, general attention, and precision in analyzing the perception of sensory signals. **Approach:** The following tests from the Vienna Test System were performed for all the individuals from the study group (VST handbook): peripheral perception test (PP), sensorimotor coordination test (SMK), and general attention test (COG). The measurements were performed before and after 20 perceptual-motor training sessions (PMT BLINK PRO) conducted twice a week. **Purpose:** The aim of the study is to determine the effect of perceptual-motor training using the Blink Pro reflexometer on peripheral perception, sensorimotor coordination, and general attention of handball players. It was examined whether and to what extent the applied perceptual-motor training improves sensorimotor coordination, peripheral perception, and general attention in handball players. **Results:** Changes in the sensorimotor coordination test that evaluates eye-hand-foot coordination observed for two indicators at $p = 0.000$, i.e. time in ideal area% throughout the test and time in ideal area% after five minutes. The relationship between peripheral perception and general attention after perceptual motor training was observed at $p < 0.010$. Visual field, positively correlates with the sum of correctly accepted answers ($r = 0.844$). **Conclusions:** Perceptual-motor training improves sensorimotor coordination, and peripheral perception also positively correlates with general attention of handball players.

Keywords: sensorimotor coordination, peripheral perception, general attention, sport.

Introduction

In modern cognitive theories, attention has played a central role, while in the field of psychomotor skills, coordination is most emphasized (Alves et al., 2013, Petersen and Posner 2012; Posner, 2012; Posner and Rothbart, 2007). To explain the mutual relationships between perception and coordination, an assumption should be made about the anatomical and functional differentiation of the pre-motor cortex (Aftanas and Golocheikine, 2001; Corbett et al., 2005), which is part of two functional neural circuits controlling motor activity. This enables the processing of exteroceptive sensory information captured in spatial coordinates of the environment and planning the direction of movement. The athlete must therefore use his or her cognitive abilities (Kiss and Balogh, 2019), especially perception and sensorimotor coordination, to remember, evaluate, conclude and react immediately (Roy et al., 2016) under heavy physical exertion and high emotional tension. In team activities, peripheral perception plays a large role because in over ninety percent the athlete on the field receives visual information in a wide field of view (Zwierko et al., 2018). It is characteristic of the perception associated with the game of handball that from the entire spectrum of rapidly changing stimuli affecting the player after processing perceptual information in a wide field of view, the player quickly chooses those that are important (Zwierko et al., 2014). The function of perception is to direct one's activity towards the achievement of a specific goal. The more perceptive an athlete is and the faster he or she notices elements on the pitch, the higher his or her effectiveness. The senses play an important role in perceiving information about the external conditions in the environment and coordinating limb movements (Porac and Coren, 1981). These are complex sensorimotor transformations that must constantly integrate a large number of sensorimotor input signals and coordinate numerous movements (Ting, 2007). Guy Azemar et al., (2007) consider success in competitive sports to be related to laterality, brain dominance, sensorimotor coordination, and coordination of visual movements (Bruhn, 2004). It is assumed that the human body can control the movements in which it is involved based on the feedback. The discrepancy between the planned and the achieved value is determined and appropriately corrected. Lisenchuk et. al., (2019) write that handball expedite the thought processes

directed at finding efficient ways of problem solving. Thus, one of the most important cognitive factors determining effectiveness on the handball field is peripheral perception and sensorimotor coordination, associated with purposeful behavior aimed at performing a task characterized by shifting attention and reaction speed. Peripheral perception is presented in conjunction with three functions: 1. speed evaluation (high angular velocities appear in the peripheral ranges of the field of view); 2. Streams of information from nearby objects; 3. tracking of the environment (by detecting events and other objects). Typological features of the nervous system (Boichuk et al., 2019) that impede the effective implementation of motor coordination processes of the female players can be compensated for by the purposefully formed compensatory mechanisms. During the training (Boichuk et al., 2020), the psychological function of players, which is linked to the development of coordination skills, should be guaranteed. Athletes who participate in regular training sessions (Gruzelier 2008, Raymond et al. 2005) are characterized by a better psychophysical status. The operations of moving the object can be controlled as long as the feedback in the form of sensorimotor information about the state of the object at any moment is obtained. As a result, any deviations between the target (required) and actual values can be noticed and then corrected. Reliability coefficients obtained based on the test carried out with the use of the Batak Lite reflexometer (Gierczuk and Bujak, 2014) ranging from 0.58 to 0.83 and the accuracy coefficients in the majority of cases above 0.30 mean that they meet the reliability requirements within the criteria used. This proves their usefulness in the diagnosis of sensorimotor coordination of athletes. According to experts in the field of diagnosis of sensorimotor coordination (Raczek et al., 2002), the values of 0.50 for reliability index and 0.30 for accuracy index should be considered sufficient. Validity coefficients ranged from 0.27 to 0.54. Most likely, the convergence of the testing procedure (Gierczuk and Bujak, 2014), the homogeneity of the test group in terms of coordination, and sports skill level contributed to similar accuracy coefficients. Perceptual-motor training using the reflexometer may be an element of training to evaluate perception skills and coordination. This research procedure allows for the evaluation of the level of peripheral perception, sensorimotor coordination, and general attention in athletes using tests (Schuhfried 2004). These include perception and coordination of movements. This is consistent with the key abilities identified by other authors (Gierczuk and Bujak 2014, Gierczuk et al., 2012; Nuno et al., 2017, Razmi et al., 2015; Posner and Gilbert, 2000).

Handball is one of the most popular sports in globally and especially in Europe. The athletes need to perform outstandingly in sensorimotor coordination, peripheral perception and general attention. Despite the fact that even today sport activities are determined primarily by motor skills, the key to achieving the highest level of athletic performance may be found in the possession of cognitive skills at a high level (Tenenbaum, et. al., 2015). The aim of the study is to determine the effect of perceptual-motor training using the Blink Pro reflexometer on peripheral perception, sensorimotor coordination, and general attention of handball players. The aspects of attention and perception are key areas of study of handball players. It was examined whether and to what extent the applied perceptual-motor training improves sensorimotor coordination, peripheral perception, and general attention in handball players. In our research we studied the above-mentioned performance indicators among youth and adult handball players using the relevant tests of the Vienna Test System (VTS), it provides a valid and reliable testing procedure that can identify the cognitive and psychomotor activities (Schuhfried, 2013).

Materials and Methods

Participants

The examinations were carried out in the Interfaculty Laboratory of Neuropsychophysiology. The study covered handball players (n=10). Participation in the study was anonymous. The players trained a few days a week and took part in sports competitions, tournaments, and league tournaments. All the participants gave their informed written consent to take part in the experiment.

Design and Procedures

All the procedures were approved in accordance with the standards of the Senate Ethics Committee of Scientific Research at the University of Physical Education in Warsaw and the standards specified in the Declaration of Helsinki. The following tests from the Vienna Test System were (Schuhfried, 2013) performed for all the individuals from the study group (VST handbook): peripheral perception test (PP), sensorimotor coordination test (SMK), and general attention test (COG). The measurements were performed before and after 20 perceptual-motor training sessions (PMT BLINK PRO) conducted twice a week. The results were subjected to statistical and qualitative analysis. The participants performed the PP, SMK, and COG tests of the Vienna Test System twice. The first measurement was performed before the perceptual-motor training PMT Blink Pro, while the second measurement was carried out after the training. Each training session lasted 24 minutes, with twelve 1-minute rounds. There was a 60-second rest after each round.

• SMK – sensorimotor coordination

The measurement of sensorimotor coordination (eye-hand-foot coordination) was designed for diagnostic purposes to assess abilities. The operations of moving an object may be controlled as far as there is feedback in the form of sensorimotor information concerning the condition of the object at a given time. The present deviation between the target (required) values and the real ones may thus be first observed and later

corrected. The time necessary for coordination of the movements depends on the necessary amount of feedback and determines the entire operation. The screen presents a room with the target point (green, inverted “T”) and an object that should be controlled (a yellow circle section). The yellow circle section starts performing unpredictable (but identical for all the subjects) movements in three different directions (VST handbook). Empirical indices in the SMK test: SMK1 - time in the ideal area in the whole test, SMK2 - time in the ideal area after the first five minutes.

- PP – Peripheral perception

The PP test assesses the ability to receive and process peripheral visual information by recognizing the stimuli appearing in the peripheral visual field in the appropriate time. The PP test is composed of two types of tasks performed simultaneously: peripheral perception and central tracking tasks, which allow the subject's attention to be focused on the center of the visual field. The peripheral perception task consists of the secondary observation of blinking vertical lines, which are displayed from time to time in the peripheral visual field. Such a line should be recognized and the participant should react by pressing the pedal. The task involves controlling the “point” using the right knob on the panel so that it aligns with the right dot (point and dot – on the screen). When the point is in the correct position, the dot blinks. Completely new and innovative measurement methods were utilized to enable proper assessment of the angle of sight. Among others, a remote measurement of the head (eyes) position of the participant in relation to the observation field was used (VST handbook). Empirical indices in the PP test were PP1 (visual field) and PP2 (tracking deviation with peripheral perception).

- COG (Cognitrone) General attention test

The test analyses attention and concentration and measures a general ability to be alert. The program displays four squares constituting one row (display field) and one field below (task field). Since the subtests are not limited by time, the subject is supposed to determine whether an abstract figure presented at the bottom is of the same shape as that of the figures presented in the top row and press the appropriate button (VST handbook). The test evaluates the following indices: the sum of correctly accepted answers (COG1), the sum of correctly rejected answers (COG2), the mean time of correctly accepted answers (s) (COG3), and the mean time of correctly rejected answers (s) (COG4).

- Perceptual-motor training (PMT)

Perceptual-motor training PMT using the Blink Pro reflexometer consists of visual-motor stimulation to develop the ability of peripheral vision and improve sensorimotor coordination of limb work, general attention, and precision in analyzing signals received by the sense of sight. Example of instructions: “If you see a brief flash, respond immediately by pressing the button”. Perceptual-motor training Blink Pro is a professional diagnostic tool which, with its structure and software, allows for testing athletes' fitness, focusing on basic psychophysical characteristics: reaction time, visual-motor coordination, eye-hand coordination, peripheral vision, and ability to concentrate. Perceptual-motor training Blink Pro develops an athlete's peripheral vision through visual-motor stimulation and improves his or her motor coordination and precision in analyzing signals received by the eye. Athletes who participate in regular sessions of Blink Pro training achieve better psychophysical status. The effects of such training can be observed on the field, mat, or in the ring, where they really matter. Test results following the Blink Pro training are available to coaches for assessment and analysis. A coach can compare athletes from a group, e.g. during training camps or national team camps, and analyze the training progress of an athlete within a longer time or in changing circumstances, e.g. after recovery or rehabilitation following an injury. Apart from reports and analyses being part of Blink's software, a coach may also export data and analyze them using specialist sports and medical software.

Figure 1. Device for perceptual-motor training (PMT) Blink Pro.

Statistical analysis

Analysis of the test results was performed using Statistica software (version 13). After categorization of the measurement data, we calculated means and standard deviations. Research problems were verified using the t-test for dependent samples and Cohen's d. The goal of the analysis was to evaluate changes in peripheral vision, sensorimotor coordination, and general attention of handball players following the perceptual-motor training.

Results

Computer assessment included measures of visual sensitivity, transient spatial attention, and continuous attention. The test results confirmed the usefulness of perceptual-motor training PMT and testing of sensorimotor coordination, peripheral perception, and general attention in the control of handball training. The results revealed that the training led to much greater improvements in re-test results of sensorimotor coordination and general attention. After 20 perceptual motor training sessions using the Blink Pro device, significant improvements were observed in sensorimotor coordination and general attention. There was a significant change in the sensorimotor coordination test (SMK, $p < .000$) that evaluates eye-hand-foot coordination in two indicators: time in the ideal area in the whole test (SMK1) and time in the ideal area after the first five minutes (SMK2); and one indicator in general attention (COG): mean time of correctly rejected answers (COG4, $p < .020$). No significant training benefit was observed in terms of peripheral perception sensitivity. The analysis showed that the change in the visual field (PP1) and the change in tracking deviation with peripheral perception (PP2) in the peripheral perception (PP) test are not significant. There was also no significant improvement in general attention (COG) in other indicators after perceptual-motor training (PMT) with insignificant differences in all variables (Table 1).

Table 1. Changes in sensorimotor coordination (SMK) after perceptual-motor training (PMT). N=10.

Variable	T test for dependent samples $p < .000^{**}$, $p < .020^{*}$					
	Mean $\pm$ SD BEFORE	Mean $\pm$ SD AFTER	t	df	Cohen's d	p
SMK1 time in ideal area %	3.40 $\pm$ 1.26	7.20 $\pm$ 3.22	-5.58	9	1.55	0.000**
SMK2 time in ideal area % after 5 minutes	4.80 $\pm$ 2.34	10.20 $\pm$ 4.44	-5.86	9	0.15	0.000**
PP1 visual field	179.22 $\pm$ 8.45	181.71 $\pm$ 8.66	-1.58	9	0.29	0.147
PP2 tracking deviation with peripheral perception	8.74 $\pm$ 0.80	8.75 $\pm$ 1.22	-0.08	9	0.00	0.936
COG1 sum of correctly accepted answers	72.70 $\pm$ 4.83	73.80 $\pm$ 4.66	0.80	9	0.02	0.442
COG2 sum of correctly rejected answers	111.00 $\pm$ 6.18	112.90 $\pm$ 5.40	-1.11	9	2.32	0.295
COG3 mean time of correctly accepted answers	1.81 $\pm$ 0.37	1.70 $\pm$ 0.39	1.34	9	4.31	0.212
COG4 mean time of correctly rejected answers	1.91 $\pm$ 0.38	1.74 $\pm$ 0.33	2.80	9	0.47	0.020*

A relation between peripheral perception (PP) and general attention (COG) after perceptual motor training (PMT) was observed at $p < 0.010$ (Table 2). Visual field correlated positively with the sum of correctly accepted answers (PP1 & COG1, $r = 0.844$). The other correlation coefficients were not significant.

Table 2. Changes in peripheral perception (PP) after perceptual-motor training (PMT). N=10.

Variable	PP1 visual field	PP2 tracking deviation with peripheral perception
COG1 sum of correctly accepted answers	0.844**	-0.292
COG2 sum of correctly rejected answers	0.147	0.111
COG3 mean time of correctly accepted answers	0.425	-0.534
COG4 mean time of correctly rejected answers	0.567	-0.381

A positive correlation coefficient means that the sum of correctly accepted answers significantly correlated with the visual field of handball players (Figure 2). Therefore, the research results show that perceptual motor training (PMT) can effectively improve some aspects of visual perception.

Figure 2. Relationships between peripheral perception (PP) and general attention (COG) following the perceptual-motor training (PMT). Visual field positively correlates with the sum of correctly accepted answers (PP1 & COG1, $r = 0.844$).

Discussion

To determine whether perceptual-motor training (PMT) with Blink Pro offers overall benefits, we used computerized methods for assessing perceptual and cognitive skills (VST). The main advantage of VTS is that it studies the competences of athletes objectively, providing a valid and reliable assessment tool (Wilczyńska, 2016). We proved that the time needed for coordinated motion depends on the feedback and thus determines the entire operation. The results of the study verify the common views and the current state of knowledge in the field of the development of these skills (Sadowski and Gierczuk, 2009; Raczek et al. 2002, Starosta and Pawłowa, 2011; Starosta and Rynkiewicz, 2011). It should be noted, however, that the comprehensive control of leading perceptual tests in sport remains one of the least understood areas in the theory of sport. This problem especially concerns sports with a complex movement structure, such as team games. Only a few studies to date have proven that modified perceptual training can effectively improve sports performance (Hadlow et al., 2018). Gierczuk and Bujak (2014) examined wrestlers and confirmed the reliability and validity of perceptual-motor training using the Batak Pro reflexometer. Nuno et al. (2017) proved an improvement in the reaction time after training using the Batak Pro reflexometer in basketball players. No improvement in the eye-hand reaction time was found in rugby players following the training (Razmi et al., 2015, Gabbet 2003). Earlier and Williams (2003) proved an improvement in reaction time of young players of team sports. Demonstrating the effect of perceptual-motor training (PMT) brings the knowledge in the field of the psychology of sport about the possibilities of using this training in team sports. Such training yields the expected results regarding sensorimotor coordination being the basic cognitive ability of handball players.

Further in-depth analyses require additional research and the development of appropriate training programs. It is worth developing appropriate standards for using the Blink Pro reflexometer by precisely defining testing procedures, instructions, and norms. With the aforementioned advantages of the device, it is also worth organizing interdisciplinary research teams (sports theorists, physiologists, psychologists, biomechanical scientists, and others). A comprehensive analysis of the available data and results will provide a more complete picture of the functioning of athletes and will allow for the precise development of guidelines for further training. It can be used both during enrollment and at various stages of selection, operational and periodic control to determine changes in the level of development of peripheral perception, sensorimotor coordination, and general attention induced by training loads applied at each stage of training (Hadlow et al. 2018). It can also be used to determine the interrelationships of peripheral perception, sensorimotor coordination, and general attention with other psychological traits of athletes.

It is reasonable to indicate several limitations of the present study. First, the small sample size limits the generalization of the results, which may not be applicable to the general population or other age groups. Because of the observed gender differences, results collected in the male population may differ from those obtained in women. Other measurement tools may also be used as criteria in future research. However, despite its limitations, this study can inspire coaches to assess indicators of attention, peripheral perception, and sensorimotor coordination in their athletes and to offer them professional perceptual-motor training (PMT) using the reflexometer.

Long-term and regular training can improve attention, peripheral perception, and sensorimotor coordination to a large extent. However, in professional sport, this is insufficient as it is necessary to use specialized attention exercises during mental training, under conditions similar to those of sports training. To train attention or peripheral perception and sensorimotor coordination, professional training sessions based on perceptual-motor training (PMT) using the Blink Pro reflexometer can be used. Through visual-motor stimulation, such sessions develop coordination of the limbs and precision in analyzing signals received by the

vision. The athletes who participate in regular training sessions on these devices improve their psychophysical fitness. With its design and the applied measurement software, they also allow for testing the abilities of athletes in terms of basic psychophysical characteristics: reaction speed, eye-hand coordination, reaction time and precision on the eye-hand-leg line, and range of peripheral vision. This can also help examine the progress in the athletes, compare their results in a group, monitor the improvement of fitness during rehabilitation after an injury, or verify the effectiveness of various training methods during long-term work. Player performance is immediately available to the coach for detailed evaluation and analysis. The selector can make comparisons of many athletes in the available group, e.g. during training camps or national team camps, and analyze the training progress of individual players over a longer period of time, or under changing circumstances, e.g. during recovery from injuries.

Conclusions

Perceptual-motor training (PMT) improves sensorimotor coordination (SMK) and peripheral perception (PP) positively correlates with general attention (COG) of handball players.

Implications for Practice:

1. To train attention or peripheral perception and sensorimotor coordination, professional training sessions based on perceptual-motor training (PMT) using the Blink Pro reflexometer can be used.
2. Blink Pro reflexometer, with its design and the applied measurement software, allows for testing the abilities of athletes in terms of basic psychophysical characteristics: reaction speed, eye-hand coordination, reaction time and precision on the eye-hand-leg line and range of peripheral vision.
3. The selector can make comparisons of many athletes in the available group, e.g. during training camps or national team camps, analyze the training progress of individual players over a longer period of time, or under changing circumstances, e.g. during recovery from injuries.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

These data have not been published before and are not submitted elsewhere.

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