SECTION – SPORT SCIENCES

(1.1) DOI: 10.5604/17310652.1192076

THE EFFECT OF VISUAL PERCEPTION TRAINING ON SENSORIMOTOR FUNCTION IN HANDBALL PLAYERS

Beata Florkiewicz[ABDE], **Sławomir Fogtman**[ABD], **Piotr Lesiakowski**[F], **Teresa Zwierko**[ACDEG]

Faculty of Physical Culture and Health Promotion, University of Szczecin, Poland

Authors' contribution:

A. Study design/planning
B. Data collection/entry
C. Data analysis/statistics
D. Data interpretation
E. Preparation of manuscript
F. Literature analysis/search
G. Funds collection

Key words: visual perception, reaction time, handball

Abstract

Aim. The present study is aimed at investigating the efficiency of a specific perceptual training program used to enhance visuomotor processing in athletes.

Material and methods. The experimental group involved 15 university handball players. The control group included 13 non-athletic students. Both groups were homogeneous in terms of age and gender. The simple and differential reaction time included in the Vienna Test System (Schuhfried, Austria), eye-hand coordination test and visuospatial specific run test (Fitlight Sports Corp., Canada) were performed three times: before the experiment, after six weeks of perceptual training, and a retention test at intervals of four weeks. The perceptual exercise methodology was based on vision enhancement and specific visual-motor reaction training.

Results. Following the training period, the majority of visuomotor parameters improved. The greatest effect was observed in the differential reaction time test ($p<0.01$), eye-hand coordination test ($p<0.001$) and visuospatial specific run test ($p<0.001$). Perceptual training does not affect the results of the simple reaction task ($p>0.05$). The results of the retention test confirmed the visual training effects.

Conclusion. The six-week training period suggests that perceptual skills are trainable and can be improved by means of appropriate training. The positive effects obtained after a period of six weeks of training are limited. Proper implementation of the perceptual training program into sports practice in handball is recommended.

Introduction

Sensorimotor mechanisms of visual efficiency are determined by the speed of visual spatial location, discrimination of moving objects in central and peripheral vision, hand-eye coordination, and by the ability to maintain visual attention stability[1]. In sports demanding visual sensorimotor functions, such as handball, speed detection of proper stimulus is a factor conditioning the efficiency of motor response.

Research conducted to evaluate visual function and motor skills in athletes showed that advanced professionals, in comparison to beginners and persons who do not train at all, are characterised by: (1) more efficient coding and collecting of relevant information, (2) faster, more accurate detection and location of objects and patterns of motor behaviour, (3) more efficient use of available information, i.e. making optimal decisions during motor activities, and (4) faster processing of information [2–9]. From the viewpoint of cognition, as well as direct relevance to sports training, it seems important to recognise the adaptability range of sensorimotor functions as far as demands of sports training are concerned.

Thus far, the results of experimental studies conducted mainly using laboratory methods pointed to the possibility of improving certain sensorimotor functions. For example, Maman et al. [10] conducted an 8-week training program (3 times a week, sessions of 45 minutes) among table tennis players, which perfected the visuomotor functions (visual fixation, the speed of eye movement), accommodation, peripheral vision, the time of reaction to visual stimuli, the speed of target movement and hand-eye coordination. The results of the experiment indicated a significant improvement ($p < 0.05$) in levels of both sensory and motor variables studied, with a lack of significant variability of the parameters ($p > 0.05$) in the control group and the placebo group. Similarly, Wimshurst et al. [11] observed significant improvement in visual function (static and dynamic visual acuity, saccade, peripheral vision, the speed of discrimination of moving stimuli) among hockey players, as a result of a 10-week visual stimulation through exercises based on a computer program. The mean improvement of the studied sensory and motor function was over 30%. On the other hand, Schwab and Memmert [12] found a positive effect of a 6-week training perfecting visual function in young field hockey players (improved reaction time to visual stimuli, better peripheral vision).

One of the key issues associated with the effects of interventions for the improvement of visual-motor function is the possibility of utilising them in conditions of a particular sports discipline. Some studies confirm the possibility of transferring the effect of visual perception training conducted in the laboratory directly into the improvement of athletic performance [10, 13, 14]. Other reports, however, indicate little to no effect of the training programmes applied in relation to sports results [12, 15]. The ambiguity in the results of research suggests a need to seek new directions of methodological solutions.

In our opinion, studies on identifying determinants of sensorimotor processes in athletes are essential for understanding the mechanisms of adaptation of visual function to the conditions determined by the demands of sports training. It is interesting as well to evaluate the sustain ability of the potential effects of the training. It seems that from the methodological point of view, the most accurate way of increasing the efficiency of exercises improving visual sensorimotor functions is to create a programme based on the methods that can be used in the conditions of specific sports discipline and its appropriate motor activities. The aim of this study was to evaluate the effectiveness of an exercise program for sensory and motor functions, implemented in handball sports training. Perceptual training methodology was based on vision enhancement exercises and specialised handball training. The study sought to verify the hypothesis that a 6-week training intervention is sufficient to achieve positive results in terms of improving the timing of the sensorimotor functions studied.

Material and methods

The study was conducted among a group of 28 students of the Faculty of Physical Education and Health Promotion at the University of Szczecin. The average age of subjects was 20.32 ± 1.39 years. Experimental research was attended by male (n = 10) and female athletes (n = 5) from the academic handball section AZS Uniwersytet Szczeciński. The average sports seniority was 6.2 ± 3.1 years. The control group consisted of students (5 womenand 8 men) not participating in regular physical activity outside of the curriculum. The experimental group took part in perceptual training programme – 1 hour three times a week over a period of 6 weeks. The study involved individuals characterized by proper assessment of the basic functions of the eye. All candidates were subject to routine sight examination.

Before the experiment – 6 weeks after the period of stimulation with training and 4 weeks after the end of the study – both groups were rated for the following parameters:

(1) Time of a simple and complex motor reaction to visual stimuli, measured using the Vienna Test System v. 29.01 (Schuhfried, Austria). To evaluate the reaction time, the S1 version of the test was used – measurement of the reaction time to simple visual stimuli (yellow light). The reaction cycle consisted of 28 light stimuli generated in randomly selected time intervals (2.5 sec. –6 sec.) The exposition time was 1 second. The reaction time test was performed with the index finger of the dominant hand. To assess the time of a complex reaction, the S4 version of the test was used – measurement of the reaction time to complex visual stimuli. A total of 48 stimuli were presented on the computer screen, displayed in the form of different combinations of yellow and/or red light combined with a sound signal. Of all the combinations of stimuli, only 16 required a reaction from the subject. The exposition time was 1.2 s. The intervals between successive stimuli varied from 1.5 to 4.0 s.

(2) Target movement speed, measured in eye-hand coordination test, performed using a FitLight Trainer™ device (Fitlight Sports Corp., Canada),in accordance with the procedure described by Zwierko et al. [16]. The subject was positioned in front of the measurement position with one leg forward, with their dominant hand placed on the starting point (Fig. 1.). At the time of the appearance of stimulus, by moving the dominant hand, the subject was trying to deactivate light discs as soon as possible (touch function).Two series of tests were carried out,each consisting of 22 reactions. The intervals between successive stimuli ranged from 0.3 s to 3.0 s.

(3) Movement speed in a specific test for visual-spatial perception (Fitlight Sports Corp., Canada.) Eight light discs were programmed and placed 50 cm above

Figure 1. Station for data measurement of the eye-hand coordination test

the ground within a handball court, as shown (Fig. 2.) The test used blue light blue, appearing on the whole surface of the disc. The subject was set on the starting position. The task was to reach the lit disc as fast as possible, deactivate it (touch function) and return to the starting position. The average time of deactivation of the discs (s) in 30 seconds was measured. The maximum duration of the activation of a single disk was 5 seconds. The reliability of the test as measured in a pilot study was $r = 0.72$ ($p < 0.05$.).

The methodology of the training programme was based on vision enhancement exercises (10 min.) and specialized handball training with elements of reaction speed forming, visual searching and visual-motor co-ordination. The methods of orthoptic exercise had been prepared by a specialist in vision training. Examples of exercise profiles include:

(1) Exercising extraocular muscles: smooth eye movements in different directions, with closed and open eyelids (central fixation, lateral moves to the right/left, up/down; up right/left, down right/left, circular eyeball motion), rest.

(2) Tracking movements of the eye (e.g. following the movements of partner's finger, "drawing" shapes/ figures at different speed; tracking moving objects, for example a Marsden's ball with specific optotypes, marked handball balls, tennis balls).

(3) Horizontal and vertical saccades (e.g. searching for numbers/letters on boards with eye tracking, searching for selective light signals, searching for particular optotypes on boards, balls or the court).

(4) Exercise in increased focusing of visual attention (e.g. searching for optotypes placed on boards within time limit;visual control over objects held (balls placed on gymnastic canes held in both hands); visual control, in an out-of-balance position, over moving objects).

Figure 2. Scheme of the visuospatial perception test course

(5) Specialized training program based on exercises that require focusing visual attention, fast visual searching, reaction time, spatial orientation, agility, movement speed (with and without the ball). Profile of the training, both individual and group training, contained a diverse setof exercises to enhance visual attention and improve eye-hand coordination. Among the devices used were indoor trainers (in the form of programmed versions of the light discs), optotypes, marked balls, balls of different sizes, balls of reduced pressure, tennis balls etc.

The scope and methodology of the experimental work received a positive opinion from Bioethical Committee at the Regional Medical Chamber in Szczecin (decision No. 11/KB/V/2013).

Statistical methods

In order to determine the significance of differences between dependent variables, a double classification analysis of variance was performed for repeated measurements (ANOVA). Analysis of variance included the inter-group factor "Group" (experimental group vs. control group) and the intra-group factor "Training" (effects of training: T1 – the measurement before the experiment; T2 – the measurement after the 6-week training period; T3 – the measurement 4 weeks after the end of the study). In the case of a significant effect of the variance analysis the Bonferroni correction ($p<0.05$) was used to estimate the differences between chosen variables.

Results

The effect of perceptual training on reaction time

The results of variance analysis for repeated measurements indicate no significant impact of either "Training" ($F_{(2.52)} = 2.48$, $p = 0.315$; $\eta^2 = 0.08$) or "Group" factors ($F_{(2.52)} = 1.04$, $p = 0.093$; $\eta^2 = 0.03$) on variability of the results of simple reaction time. In contrast, a statistically significant effect of both factors was found in the case of complex reaction time – the results ofthe variance test for the "Training" factor were $F_{(2.52)} = 9.32$; $p = 0.0003$; $\eta^2 = 0.26$, and for the factor "Group" $F_{(1.26)} = 4.46$; $p = 0.044$; $\eta^2 = 0.14$. Moreover, important interaction between the two factors (Training × × Group) ($F_{(2.52)} = 3.22$, $p = 0.048$; $\eta^2=0.11$) confirms the different course of results' variation for the test that evaluated complex reaction time in the experimental group compared to the control group. Analysis of post-hoc tests shows significant changes ($p = 0.001$) in complex reaction test results (changes that stem from the perceptual training programme (T1 vs. T2), and a significant drop ($p = 0.045$) in control measurement results (T2 vs. T3) (Figure 3).

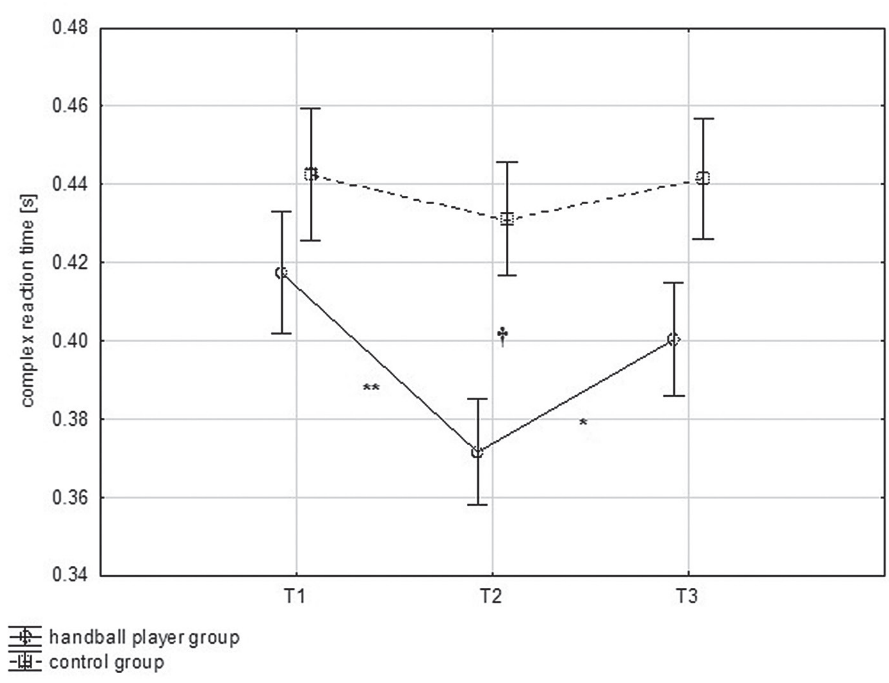

Figure 3. Significant interaction of Training x Group factors ($F_{(2.52)} = 3.22$; $p = 0.048$; $\eta^2 = 0.11$) in the complex reaction time test measurements. Significant intra-group differences were observed (**p = 0.001; *p = 0.045), (T1 vs. T2, and T2 vs. T3in the experimental group), as well as significant differences ($p = 0.031$) between athletes and non-athletes in post-test differential reaction time, which is marked with †.

The effects of perceptual training on eye-hand coordination

Analysis of variance of the eye-hand coordination test results indicates a highly significant impact of “Training” factor on the variability of the results of three consecutive measurements ($F_{(2.52)} = 23.21$, $p = 0.000$; $\eta^2 = 0.47$). The “Group” factor also showed a significant impact on result variability ($F_{(1.26)} = 5.98$, $p = 0.021$; $\eta^2 = 0.19$). The interaction of factors Training × Group has been confirmed ($F_{(2.52)} = 39.49$, $p = 0.000$; $\eta^2 = 0.60$). Examining the differences in detail, it can be noted that significant changes in the results of research are related to the experimental group, in which there was observed a highly significant decrease in time of test completion after a 6-week training simulation (T1 vs. T2, p = 0.000E), then a significant deterioration (T2 vs. T3, $p = 0.026$), with a simultaneous lack of significant variability in the control group ($p > 0.05$). Significant inter-group differences were confirmed in the results of the T2 ($p = 0.0001$) and T3 ($p = 0.049$) tests (Fig. 4).

The effects of perceptual training on the speed of visuospatial perception

Analysis of variance shows that both the factor “Training” ($F_{(2.52)} = 21.63$ and $p = 0.000$; $\eta^2 = 0.45$) and the factor “Group” ($F_{(1.26)} = 15.35$, $p = 0.0002$; $\eta^2 = 0.377$) had significant impact on the variability of visuospatial perception speed test results. The interaction of both factors in this case equals ($F_{(2.52)} = 3.30$, $p = 0.044$; $\eta^2 = 0.11$). Analysis of the post-hoc tests indicates presence of inter-group differences in T1 ($p = 0.028$) and T2 ($p = 0.0007$) measurements. The effects of perception training was seen in the group of handball players as a significant difference ($p = 0.002$) in the results of the average time of deactivation of the light disks. In control measurement (T3) the test results did not differ with respect to the measurement from before the training intervention (T3)(Fig. 5, next page).

Discussion

The aim of the research was to evaluate the effectiveness of the exercise programme meant to improve visual sensorimotor functions. The initial assumption that a 6-week training intervention programme is sufficient to achieve improved times of the studied functions has been confirmed. In the vast majority of the variables tested, significant improvements in the times of the analysed tests were reported as a result of systematic stimulation with training.

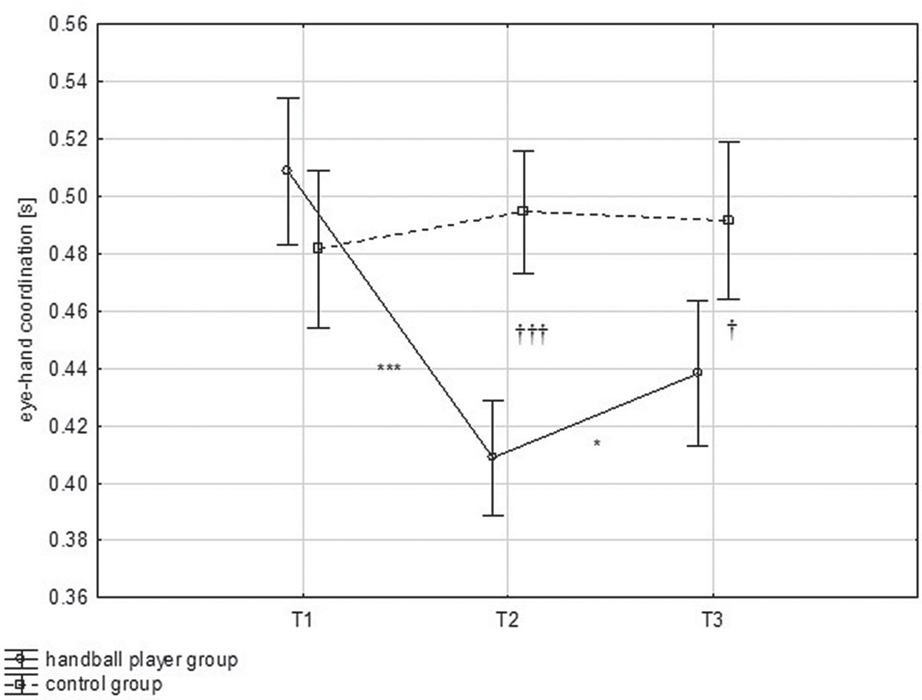

Figure 4. Significant interaction of Training x Group factors ($F_{(2.52)} = 39.49$ p = 0.000E; $\eta^2 = 0.60$) for eye-hand coordination test. ***Statistically significant (p = 0.000E) changes in the experimental group between T1 and T2 measurements, and *statistically significant changes between T2 and T3 measurements ($p = 0.026$). †††Statistically significant differences ($p = 0.001$) between handball player group and control group in eye-hand coordination post-test measurements (T2) and †significant inter-group differences ($p = 0.049$) in eye-hand coordination retention test (T3).

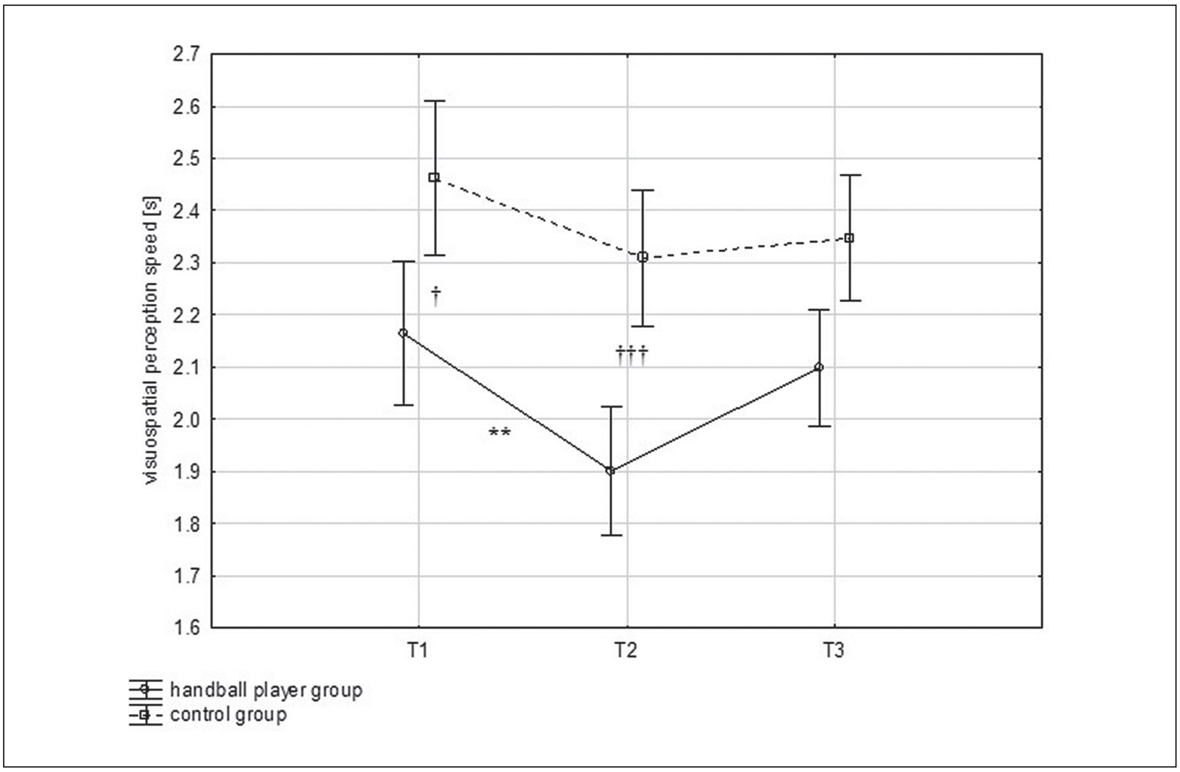

Figure 5. Significant interaction of Training x Group factors ($F_{(2.52)} = 3.30$; $p = 0.044$; $\eta^2 = 0.11$) in visuospatial perception speed test. **Statistically significant result improvement (p=0.002) in the experimental group (T1 vs. T2). †Significant inter-group differences (p = 0.028) in visuospatial specific pre-test measurements (T1), and †††greatly significant difference (p = 0.000E) between handball player group and control group in visuospatial specific post-test measurements (T2).

The only instance of no post-training change (p > 0.05) in the experimental group are the results of the laboratory test evaluating the simple reaction time. In this case, the results of the study may suggest lesser sensibility to perceptual training for simple sensorimotor tasks. Nevertheless, previous observations conducted by Ando et al. [17, 18] show that a 3-week training for better simple reaction time to visual stimuli (appearing in the central and peripheral vision) caused a significant decrease in the EMG-RT time measurement. What is more, there appeared transfer of the effects of the training – of the better reaction time to stimuli appearing in the central field of view to the results of a simple reaction time to peripheral stimuli (and vice versa). Perhaps an explanation of the results of the present study is the usual lesser stimulation of the body(and thus lesser focus), which is observed while performing simple tasks as compared to complex perceptual tasks [19].

In the other analysed tests, i.e. the laboratory measurement of complex reaction time, eye-hand coordination, the speed of visuospatial perception in specific conditions, positive effects of the implemented training were observed. From a methodological point of view, results of the study confirmed that the 6-week training intervention is sufficient to achieve the positive effects of exercises improving visual sensorimotor functions. The results of other experiments conducted to improve cognitive function while implementing 6-week, 8-week and longer periods of training stimulation proved the positive effects of training, similarly to the present study [10, 12, 13, 20–23]. In the case of perceptual stimulation, shorter periods seem to be less effective. For example, Abernethy and Wood [15] found no significant changes in either sensory parameters or the analysed motor parameters in the case of implementing a 4-week programme of visual functions training.

It seems that the mechanisms of sensorimotor processes are conditioned by many factors, and the possibility of their formation depends on individual adaptability of oculomotor function, as well as the ability to shape cognitive functions. Attention processes can be identified as crucial for effective processing of visual stimuli. The results of experimental studies indicate that attention affects the perceptual sensitivity during discrimination of stimuli [24], increases contrast sensitivity [25], improves visual acuity [26], affects the conductivity of visual signals [27]. In sports, very important roles can be ascribed to: information selection (which selects stimuli from a particular field of perception), the ability to flip visual attention and divisible attention (the ability to monitor concurrent activities [28, 29]). Experimental studies pointed to the differences of attention mechanisms of athletes in team and individual sports [30]. It should be remembered, however, that despite the variety in the field of perception and the number of stimuli at work, attention functions as an integrated cognitive system. Earlier research shows that sports training can model certain attention features [6, 8]. It seems, therefore, that creation of training programs shaping attention for the specific conditions of motor performance is fully justified. The proposed perceptual training used in the present study stressed the ability to maintain attention in wide range, as a state of readiness for a motor response to unforeseen visual signals (in longer and shorter periods of time); it also included a diverse range perception. In can be said that the effectiveness of the programme used largely was to a large extent a result of exercise demanding readiness for motor reaction.

The important value of the applied sensorimotor exercise programme is definitely its application function. The proposed exercises, those of orthoptic character and those characteristic for a handball game, can certainly complement the process of sports training. The present study shows that the 4-week period of no stimulation of visual perception implemented in the research lowers the level of the effects of training. On the one hand, the results of the control test confirm the efficacy of the 6-week exercise period. On the other hand, lack of maintaining of the effects of the intervention indicates the need to implement a systematic programme to support the level of visual sensorimotor functions. However, the question of optimising the intensity of perceptual exercise during the macrocycle still requires further study. There are relatively few theoretical concepts describing the methodology of visual training [31].We believe that the practical implication of current as well as future studies will act as a guideline for training process improvement.

Conclusions

1. Six weeks of the visual perception training program is sufficient enough to induce positive changes in the investigated aspects of visual sensorimotor processes in a group of handball players.
2. The significant effects of the visual perception exercise program carried out under conditions of specific handball activities occurred in the case of complex perceptual tasks, while no effects of the perceptual training were noticed on changes in test results evaluating simple reaction time.
3. The period of maintaining the positive effects of perception training is limited. After a one month break in the use of intervention with the exercise program improving visual sensorimotor functions, a gradual reduction in the level of the post-training positive effects obtained during the study could be observed.
4. In order to maintain a stable level of visual sensorimotor functions in athletes, there is a need to implement a systematic perception exercise program into the process of sports training.

Acknowledgments

This scientific work isfunded from the 2013–2016 sciencebudgetas a research project within the program entitled “Development of Academic Sport”, grant number RSA201852.

References

[1] Erickson G: Sports *Vision: Vision Care for the Enhancement of Sports Performance*. St. Louis: Butterworth-Heinemann; 2007.

[2] Ando S, Kida N, Oda S: *Central and peripheral visual reaction time of soccer players and nonathletes*. *Perceptual and Motor Skills, 2001 Jun;* 92 (3): 786–94.

[3] Kokubu M, Ando S, Kida N, Oda S: *Interference effects between saccadic and key press reaction times of volleyball players and nonathletes*. Perceptual and Motor Skills. 2006 Dec; 103 (3): 709–16.

[4] Mann DTY, Williams AM, Ward P, Janelle CM: *Perceptual-cognitive expertise in sport: A meta-analysis. Journal* of *Sport* and *Exercise Psychology,* 2007 Aug; 29: 457–478.

[5] Zwierko T: *Differences in peripheral perception between athletes and nonathletes*. Journal of Human Kinetics, 2008 Jan; 23: 21–27.

[6] Voss MW, Kramer AF, Basak C, Prakash RS, Roberts B: *Are expert athletes "expert" in the cognitive laboratory? A meta-analytic review of basic attention and perception and sport expertise*. *Applied Cognitive Psychology,* 2010 Sep; 24 (6): 812–826.

[7] Zwierko T, Osiński W, Lubiński W, Czepita D, Florkiewicz B: *Speed of Visual Sensorimotor Processes Conductivity of Visual Pathway in Volleyball Players*. Journal of Human Kinetics, 2010 May; 23: 21–27.

[8] Alves H, Voss MW, Boot WR, Deslandes A, Cossich V, Salles JI, et al: *Perceptual-cognitive expertise in elite volleyball players.* Frontiers in Psychology. 2013 Mar; 7 (4): 1–9.

[9] Muiños M, Ballesteros S: *Visuospatial attention and motor skills in kung fu athletes*. Perception, 2013; 42 (10): 1043–1050.

[10] Maman P, Gaurang S, Sandhu JS: *The effect of vision training on performance in tennis players*. Serbian Journal Sports Sciences, 2011; 5 (1): 11–16.
[11] Wimshurst ZL, Sowden PT, Cardinale M: *Visual skills and playing positions of Olympic field hockey players*. Perceptual and Motor Skills, 2012 Feb; 114 (1): 204–216.
[12] Schwab S, Memmert D: *The impact of a sports vision training program in youth field hockey players*. Journal of Sports Sciences and Medicine, 2012 Dec; 11 (4): 624–631.
[13] Quevedo L, Sole J, Palmi J, Planas T, Saona C: *Experimental study of visual training effects in shooting initiation*. Clinical and Experimental Optometry, 1999 Jan–Feb; 82 (1): 23–28.
[14] Campher J: *The role of visual skills and its impact on skills performance of cricket players*. Dissertation, 2008; University of Pretoria.
[15] Abernethy B, Wood JM: *Do generalized visual training programs for sport really work? An experimental investigation*. Journal of Sports Sciences, 2001 Mar; 19 (3): 203–222.
[16] Zwierko T, Florkiewicz B, Fogtman S, Kszak-Krzyżanowska A: *The ability to maintain attention during visuomotor task performance in handball players and non-athletes*. CentrEur J Sport Sci Med, 2014; 7 (3): 99–106.
[17] Ando S, Kida N, Oda S: *Practice effects on reaction time for peripheral and central visual fields*. Perceptual and Motor Skills, 2002 Dec; 95 (3): 747–751.
[18] Ando S, Kida N, Oda S: *Retention of practice effects on simple reaction time for peripheral and central visual fields*. Perceptual and Motor Skills, 2004 Jun; 98 (3): 897–900.
[19] Brisswalter J, Collardeau M, René A: *Effects of acute physical exercise characteristics on cognitive performance.* Sports Medicine, 2002; 32 (9): 555–566.
[20] Zupan MF, Arata AW, Wile A, Parker R: *Visual adaptations to sports vision enhancement training*. Optometry Today, 2006; 1: 43–48.
[21] Paul M, Biswas SK, Sandhu JS: *Role of sports vision and eye hand coordination training in performance of table tennis players*. Brazilian Journal of Biomotricity, 2011; 5 (2): 106–116.
[22] Rezaee M, Ghasemi A, Momeni M: *Visual and athletic skills training enhance sport performance*. European Journal of Experimental Biology, 2012; 2 (6): 2243–2250.
[23] Krzepota J, Zwierko T, Puchalska-Niedbał L, Markiewicz M, Florkiewicz B, Lubiński W: *The efficiency of a visual skills training program on visual search performance*. Journal of Human Kinetics, 2015 Jun; 27 (46): 231–240.
[24] Lu ZL, Dosher BA: *External noise distinguishes attention mechanisms*. Vision Research, 1998 May; 38 (9): 1183–1198.
[25] Cameron EL, Tai JC, Carrasco M: *Covert attention affects the psychometric function of contrast sensitivity*. Vision Research, 2002 Apr; 42 (8): 949–967.
[26] Carrasco M, Yeshurun Y: *Attention improves or impairs visual performance by enhancing spatial resolution*. Nature, 1998; 396: 72–75.
[27] Palacz O, Lubiński W, Penkala K: *Clinical electrophysiological diagnosis of visual system* [in Polish], Warszawa: Oftal; 2003.
[28] Memmert D, Simons DJ, Grimme T: *The relationship between visual attention and expertise in sports*. Psychology of Sport Exercise, 2009 Jan; 10 (1): 146–151.
[29] Gronek P, Tomczak M, Daniłowski B: *Focus attention in fencers – designing of exercises* [in Polish], Sport Wyczynowy, 2010; 1 (533): 55–63.
[30] Fontani G, Lodi L, Felici A, Migliorini S, Corradeschi F: *Attention in athletes of high and low experience engaged in different open skill sports*. Perceptual and Motor Skills, 2006 Jun; 102 (3): 791–805.
[31] Helveston EM: *Visual training: current status in ophthalmology*. Am J Ophthalmol, 2005; 140: 903–910.

Address for correspondence:
PhD Beata Florkiewicz
Faculty of Physical Culture and Health Promotion,
University of Szczecin, Poland
Al. Piastów 40 b blok 6
71-065 Szczecin
E-mail: b-t@go2.pl
Tel. 91 4442787