THE ABILITY TO MAINTAIN ATTENTION DURING VISUOMOTOR TASK PERFORMANCE IN HANDBALL PLAYERS AND NON-ATHLETES

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Abstract. One of the important aspects of attentional processes in sport performance is sustained attention during task execution. The objective of this study was to analyze the ability to maintain attention during a serial reaction time task performance in expert handball players (n = 12) and non-athletes (n = 12). Participants perform a FitLight TrainerTM (Fitlight Sports Corp., Canada) test protocol configured by the PDA controller which consisted of 10 series of simple motor reaction task to visual stimuli appearing on 8 wireless light discs. Each of the 10 series included 22 reactions. Ability to maintain attention was determined by analyzing the variability in results during testing, e.g. the total time of test execution and the average reaction time to visual stimulus in each subsequent series. The main finding in our study was that Non-athletes in comparison to Athletes had: (1) longer total time of test execution; (2) longer reaction time; (3) and higher variability in results during task performance. The results indicate a higher level of ability to maintain attention in handball players.

Key words: sustained attention; handball; reaction time

Introduction

Cognitive and motor processes are essential for athletic performance. Among the cognitive processes involved in athletic performance, attentional functioning has been the main research topic in the recent years. Experimental studies have reported the superior cognitive abilities of expert athletes, who are capable of quickly extracting important information, encode and retrieve relevant information more efficiently in comparison with non-experts (e.g. Collins 2002; Mann et al. 2007; Memmert 2009 for review). In addition, experts can modulate their cognitive and motor resources according to specific task demands better (Castiello and Umilta 1992). Gilia et al. (2011) found the differences in visuospatial attention in athletes engaged in open-compared to closed-skill sports and non-athletes. Among participants who responded to a computerized line-length judgment task, those authors observed that volleyball players responded significantly faster and more accurately, making a statistically significantly lower number of errors as compared with rowers and controls.

Different motor behaviors have been used to analyze the attentional focus effects. For example, Shea and Wulf (1999) used a stabilometer task and presented two groups of participants with the same concurrent feedback while they practiced balancing on the platform. The frequency characteristics (mean power frequency) of the platform movements showed higher frequency adjustments for external than for internal focus participants. Porter et al. (2010) carried out an experiment in which low-skilled subjects were instructed to focus their attention at increasing distances before performing a standing long jump movement. Authors observed that jumping distance increased as the focus of attention was directed further from the body (an external focus of attention). Similarly, Zachry et al. (2005) reported that free throw accuracy in basketball was greater when participants adopted an external (basket) compared to an internal focus (wrist motion). This suggests that an external focus of attention enhances efficiency of motor behavior.

One of the important aspects of attentional processes in sport performance is sustained attention during task performance. Sarter et al. (2001) described 'sustained attention' as a state of readiness to respond to rarely and unpredictably occurring signals over prolonged periods of time. The ability to maintain attention on a particular stimulus or location for quite a prolonged period of time is important in ball sports. The present study examined these issues.

In handball, due to constant changes in the environment (e.g. alterations in the location of the ball, co-players and opponents), the player is forced to inhibit pre-planned motor responses, anticipate actions and coordinate corporal segments based on the complex and dynamic flow of sensorial information (Lage et al. 2011). This requires a constant readiness to motor response to unpredictably occurring signals. The aim of our study was to analyze the ability to maintain attention during a serial reaction time task performance in expert handball player and non-athletes. We expected that experience in training in open-skill sports, such as handball, would enhance attentional processes in athletes.

Methods

Participants

The study involved a group of handball players (n = 12) of Gaz-System Pogoń in Szczecin, participating in competitions of the Polish First Division and the University League, representing the University of Szczecin. The mean age of the players was 19.75 ±1.20 years. The average body height of the examined athletes was 189.38 ±10.09 cm, while the mean body weight was 89 ±13.18 kg. 11 athletes were right-handed and 1 was left-handed. The control group consisted of 12 students of the State Higher Vocational School in Wałcz, aged 20.01 ±1.3 years, who did not exercise regularly. Their average body height was 178.56 ±6.09 cm, while the mean body weight was 82.69 ±7.15 kg. All individuals in the control group were right-handed. All participants were informed about the testing protocol and each signed a consent form. The local Bioethical Committee approved the research project.

Procedure

Participants performed a FitLight Trainer™ (Fitlight Sports Corp., Canada) test protocol. The test protocol was configured by the PDA controller and consisted of 10 series of simple motor reaction task to visual stimuli appearing on 8 wireless light discs.

Light discs were placed on a plate with dimensions of 110 × 80 cm at intervals of 20 cm apart and 45 cm from the designated starting point, according to the scheme shown in Figure 1. The task was to perform the fastest hand movement in order to touch the disc surface and deactivate the lights.

Figure 1. Station for the measurement of visuomotor task

The plate with light discs was placed on a table at a height of 110 cm. Participants were standing and holding their dominant hands on the designated start point. After each deactivation of light the hand was supposed to return to the original position on the desktop. In the applied procedure, the maximum duration of the light stimulus of one disc was programmed for 3 seconds. The study used a yellow light, appearing in the central portion of the disc with a diameter of 10 cm. Each of the 10 series included 22 reactions, occurring at intervals of 0.1 to 3.0 seconds. The participants were given 5 seconds of rest between each series. In total, each of the respondents completed 220 tasks, i.e. responses to stimuli appearing in randomized order.

Prior to the testing session, participants performed a pre-test, which consisted of making 5 responses to light stimuli. Participants were instructed to deactivate the lights as fast as possible by placing one hand in close proximity to the activated light. Analysis concerned the total time of 22 reactions and the average response time to stimuli during each of the 10 series.

Data analyses

All data are expressed as means ± standard errors. The assumption of normality was examined using the Shapiro-Wilk test. The dependent measures were analyzed using a two-way repeated-measures analysis of variance (ANOVA) with a group (athletes vs. non-athletes) as the between participants factor, and series of reaction (10 subsequent series) as the within participant factor. Post-hoc tests were performed using a Bonferroni correction with a P-value <0.05 considered significant.

Results

Ability to maintain attention was determined by analyzing the variability in results during testing, e.g. the total time of test execution and the average reaction time to visual stimulus in each subsequent series. We investigated the effect of (1) Group (Athletes vs. Non-athletes) and (2) test series (1 to 10) on ability to maintain attention.

Effects on the total time of test execution

Data showed that there was a main effect of Group ($F_{(1,22)} = 12.18$, $p < 0.01$), a main effect of test series ($F_{(9,198)} = 3.45$, $p < 0.01$), as well as a significant interaction between Group and test series ($F_{(9,198)} = 1.96$, $p < 0.05$) for the total execution time. Post-hoc tests indicated a differential effect between Athletes and Non-athletes on the total time of test execution (Series 1: 43.13 vs. 41.56 s, $p < 0.01$). The total time execution of each test series in Athletes did not vary significantly with 10 subsequent repetitions ($p > 0.05$). In contrast, the total time execution was significantly shorter (delta series 1 and series 2: –1.447 s, $p < 0.01$) in Non-athletes after the first series (Figure 2).

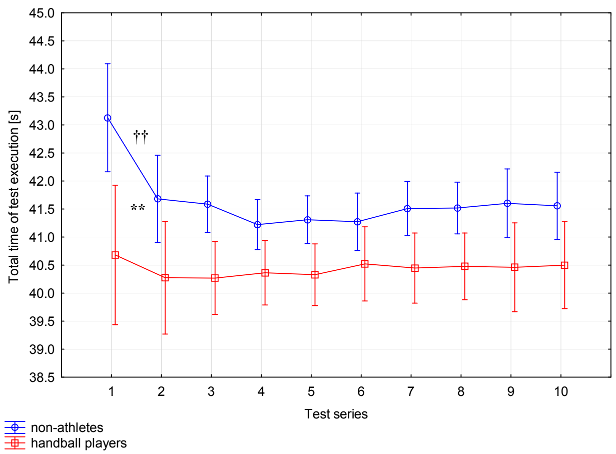

Figure 2. Subsequent values of total time execution during 10 test series in Athletes and Non-athletes are presented as means and ±SEM. A significant difference ($p < 0.01$) between Athletes and Non-athletes for series 1 is denoted with **. A significant intragroup difference ($p < 0.01$) in Non-athletes (Series 1 vs. series 2) is denoted with (††)

Effects on reaction time

The analysis showed that there was a main effect of Group ($F_{(1,22)} = 14.21$, $p < 0.01$) and a main effect of test series ($F_{(9,198)} = 3.04$, $p < 0.01$) for reaction time. However, we did not observed significant plot of interaction between analyzed factors ($F_{(9,198)} = 1.73$, $p > 0.05$). A significant difference between the Groups was noted in the case of series 1 (0.56 vs. 0.44 s, $p < 0.01$). Athletes had significantly shorter reaction time compared to Non-athletes. Post-hoc tests indicated a differential effect in intragroup factor. Reaction time of each test series in Athletes did not vary significantly with 10 subsequent repetitions ($p > 0.05$). In contrast, reaction time was significantly shorter (e.g. delta series 1 and series 2: –0.07 s, $p < 0.01$) in Non-athletes after the first series. However, the data showed no significant differences between Series 1 and Series 10 in Non-athletes group (Figure 3).

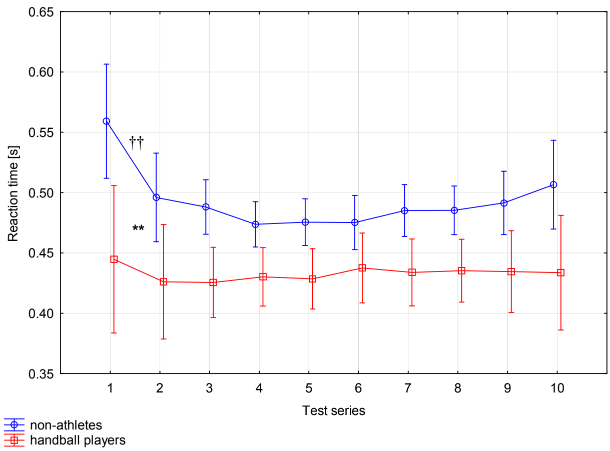

Figure 3. Subsequent values of reaction time during 10 test series in Athletes and Non-athletes are presented as means and ±SEM. A significant difference ($p < 0.01$) between Athletes and Non-athletes is denoted with **. A significant intragroup difference ($p < 0.01$) in Non-athletes is denoted with (††).

Discussion

We investigated the effect of prolonged visuomotor task performance on ability to maintain attention in Athletes and Non-athletes. The main findings in our study are that Non-athletes in comparison to Athletes have: (1) longer total time of test execution; (2) longer reaction time; (3) higher variability in results during task performance.

Similar to our results, most studies have shown that athletes have shorter reaction time when responding to visual stimuli compared to non-athletes (Ando et al. 2001; Kokubu et al. 2006). Previous studies have identified marked differences between elite and non-elite sport performers in a variety stage of visual sensorimotor processing including the speed of signal conductivity in the visual pathway (Delpont et al. 1991; Özmerdivenli et al. 2005; Zwierko et al. 2010; Zwierko et al. 2011), simple and choice reaction time to stimuli appearing in the central field of vision (Bańkosz et al 2013; Doğan 2009; Wimshurst et al. 2012; Zwierko et al. 2010) and reaction time to peripheral stimuli (Muiños and Ballesteros 2014; Zwierko 2008). Moreover, it has been reported that reaction times in athletes depend on the type of sport activity. Open-skill sports players have significantly shorter reaction times than athletes in other types of sports (Doğan, 2009; Erickson 2007).

However, the mechanism determining these processes is rather unknown. Athletic training is often accompanied by high activation of the visuomotor system, especially in sports that require the processing of dynamic visual information. For example, ball sport players must process and integrate complex visual information, including the flight of a ball and movements of the opponent or partner. In many dynamic reactive sports, such as handball, the speed of detection and discrimination of visual stimuli is a crucial factor in executing successful motor responses. Given the critical importance of dynamic visual input in team sports, one might predict that good performance in elite athletes might be supported by neuroplastic changes in sensorimotor processing. Results of experimental studies suggest that neural processing in sensorimotor-related activities can be modulated by extensive physical training (Jin et al. 2010; Nakata et al. 2010; Zwierko et al. 2014).

Our study showed that Athletes represented more stability in prolonged visuomotor test results indicating higher ability to maintain attention than Non-athletes. Dynamic sports such as handball require high attention skills because many stimuli are acting simultaneously in very short time units. The attentional focus adopted during the execution of a skilled motor action can have a profound effect on performance outcomes. Our results suggest the possibility of changing the distribution of visuospatial attention by training in open-skill sports. Previous studies of perceptual-cognitive expertise in sports demonstrated that experts, in comparison with non-experts, make more use of available information; encode and retrieve relevant information more efficiently; detect and locate objects and patterns in the visual field faster and more accurately; use situational probability information better; make more rapid and appropriate decisions; and perform better on measures of processing speed and a category of varied attentional paradigms (Alves et al. 2013; Mann et al. 2007; Voss et al. 2009). In relation to our findings, it is possible that the attentional skills adopted during the execution of a player's motor action in handball training can be transferred to other behaviors, i.e. outside sport. In contrast, in Non-athletes we observed higher variability of results, especially in analysis of the effect of prolonged visuomotor task execution on reaction time (Figure 3). The curve of results illustrates an inverted-U relationship. The inverted U hypothesis argues that performance will not be at its highest with low levels of arousal/attention and that as arousal/attention increases so does performance to an optimum level. The experimental data shows that the inverted-U function applies for non-athletes but disappears in team sports experts. For example, Hüttermann and Memmert (2014) compared the athletes' and non-athletes' cognitive performance on a measure of attentional behavior under three different physical exercise intensities. Their results show an increase of non-athletes' attentional breadth right up to a certain level of maximal aerobic power before decreasing, as expected according to an inverted-U curve. In contrast, athletes' attentional breadth continued to increase with higher physical exercise intensities. Similarly, Zwierko and Lesiakowski (2014) note an inverted-U relationship between attentional functioning and the intensity of physical exercise in non-athletic subjects. The results of our present study in some way confirm those observations. Cognitive effort during prolonged visuomotor task induced similar effect on performance as a physical effort.

In summary, this study offers some insight into mechanisms explaining several aspects of attentional functioning in handball players. Given the importance of understanding the influence of sustained attention on expert performance in sport, this should be addressed in future research.

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