Visuospatial attentional functioning in amateur boxers

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Summary

Introduction. Attention is an activation state of cerebral cortex that impact the ability to process information. In boxing attention adopted during the execution of a skilled motor action can have a profound effect on performance outcomes. However, boxing is associated with a risk of concussion often leading to cognitive impairments. The aim of this study was to investigate the visuospatial attentional functioning in amateur boxers compared to nonathletes.

Material and methods. The research involved 15 elite polish, amateur boxers (10 male and 5 female). All participants are or were the members of National Team in variety of age groups. The control group included 15 nonathletic students of Szczecin. Both groups were homogeneous in terms of age and gender. Special Ability Signal Test included in the Vienna Test System (Schuhfried, Austria) was used to examine long-term selective attention. The test measured the visuospatial differentiation of a relevant signal within irrelevant signals. The main variables calculated were the numbers of correct, omitted and incorrect reactions and the median reaction time as a measure of the speed of the detection process.

Results. There was no significant difference between boxers and controls in the variables of numbers of correct responses (p=0.40), reaction time (p=0.07), numbers of omitted reactions (p=0.40), and numbers of incorrect reactions (p=0.87).

Conclusions. Amateur boxing does not lead to impairment in visuospatial attentional functioning as well as information processing speed.

Introduction

Open-skill sports, such as boxing, are performed in constantly changing environments. Athletes must be able to move in a variety of ways and adapt to rapidly changing situations. Boxing requires sustained attention (vigilance) because athletes must perform while in motion at near viewing distance from which most of the visual information is received [1]. The attention adopted during the execution of a skilled motor action can have a profound effect on performance outcomes. Experimental data showed that optimal level of attention increases the perceptual sensitivity for the discrimination of target stimuli [2], reduces information processing time [3], and improves decision making processes in sport specific targets [4,5]. It has been speculated that one of the key factor affected the effectiveness of attention processes in sport is an expertise gained from participating in systematic exercise demanding a high level of visual attention during fast motor responses to external stimuli. Studies of perceptual-cognitive expertise in sports, using sport-specific as well as laboratory methods, demonstrated that expert athletes, in comparison with non-athletes and novice, make more use of available information, encode, and retrieve relevant information more efficiently, visually detects 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 [6,7,8]. It is possible that the attentional skills adopted during the execution of an athlete's motor action in boxing training can be transferred to other behaviors outside of sport.

On the other side, it is known that boxing is associated with a risk of chronic neurological injury. Studies indicated that participation in this sport may cause clinical sequelae of chronic traumatic encephalopathy [9], neuropathologic injury [10] as well as cognitive impairment such as attention, concentration and memory [11]. However, in amateur boxing, the exposure to repeated head impact is less than that seen in professional boxing, especially because of the shorter duration of the bouts and the use of protective headgear [12]. For example, Breton et al. [13] investigated amateur boxers' attention and orienting mechanisms by using event-related brain potential recordings, before and after a fight. This study did not reveal any abnormalities of attention or detection processes. Khani et al. [14] analyzed several variables of attention (e.g. accuracy, impulsivity and behavioral disinhibition, inattention, speed of information process) in amateur boxers, novice amateur boxers and runners. The authors also did not
found any differences in attentional functioning between groups. In contrary, several studies of boxers diagnosed with concussion suggested that participation in amateur boxing bouts may decrease neurocognitive function, e.g. planning, attention, and memory capacity [15,16]. To date, experimental studies on amateur boxers have been inconclusive.

The current study was conducted to address this issue by systematically investigating the attention processes in boxers who participated in training with more than 4 years of experience. The aim of this study was to investigate the visuospatial attentional functioning in amateur boxers compared to nonathletes.

**Material and methods**

The research involved 15 elite polish, amateur boxers (10 male and 5 female). All participants are or were the members of National Team in variety of age groups. One of them was the World and European Youth Champion, five boxers participated in the European Championships and ten boxers achieved medallist position at the National Championships (five hold a National titles). The mean age of athletic group was 20.40±5.19 years and their mean sports experience was 6.8±2.43 years. The control group included 15 nonathletic students of Szczecin University (mean age 21.09±1.96 years). Both groups were homogeneous in term of gender.

Special Ability Signal Test included in the Vienna Test System (Schuhfried, Austria) was used to examine long-term selective attention. The test measured the visuospatial differentiation of a relevant signal within irrelevant signals. In our experiment we used standard version S1with white signals (dots) on a black background. Dots were displayed over the entire screen area; pseudo-randomly some of the dots disappeared and others came into view. The participants were requested to perform a key press response to programmed stimulus constellation whenever it occurred. This critical stimulus constellation consisted of four dots forming a square (Fig. 1). Each of the participants was prepared for the main task by participating in pre-tests that allowed them to familiarise themselves with the apparatus and the nature of the task. The total testing time was between 13 and 14 minutes (including instruction and practice phase). The main variables calculated were the numbers of correct, omitted and incorrect reactions and the median reaction time as a measure of the speed of the detection process.

All data are expressed as mean and standard deviation. The normality of distribution of results was estimated using Shapiro Wilk tests. Data analysis was performed using one way ANOVA variance analysis. A p value less than 0.05 was considered significant.

**Results**

The results of one way ANOVA showed that there was no significant difference between the groups in the variables of numbers of correct responses (p=0.40), reaction time (p=0.07), numbers of omitted reactions (p=0.40), and numbers of incorrect reactions (p=0.87). It means that amateur boxing does not lead to impairment in visuospatial attentional functioning as well as information processing speed even though it was observed that the reaction time by boxers was longer than that of the control groups, but not significantly (p>0.05). The results are presented in Table 1.

**Figure 1. White signals (dots) on a black background and critical stimulus constellation in Special Ability Signal Test**

**Table 1. Test results concerning attentional functioning tests in the groups of boxers and nonathletes**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Boxers</th>
<th>Non-athletes</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>numbers of correct reactions</td>
<td>49.35±4.63</td>
<td>50.67±3.58</td>
<td>0.73</td>
<td>0.40</td>
</tr>
<tr>
<td>reaction time [s]</td>
<td>0.85±0.10</td>
<td>0.78±0.10</td>
<td>3.58</td>
<td>0.07</td>
</tr>
<tr>
<td>numbers of omitted reactions</td>
<td>10.64±4.63</td>
<td>9.34±3.57</td>
<td>0.73</td>
<td>0.40</td>
</tr>
<tr>
<td>numbers of incorrect reactions</td>
<td>1.84±1.23</td>
<td>1.73±1.17</td>
<td>0.02</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Discussion

Findings of our study showed non difference in visuospatial attentional functioning between amateur boxers and non-athletes. Our results confirmed some previous observation that at an amateur level, participation in boxing does not expose the individual to harmful neuropsychological damage [17]. Khani et al. [14] by using Sustained Attention Test, similarly to our results, did not find any differences in attentional functioning between amateur boxers, novice amateur boxers and runners. The authors concluded that the intensity of punches in amateur boxing may not reach the threshold that causes brain damage, at least in the regions that control attention. In an event-related potential study of attention and orienting reaction in boxers before and after a fight, Breton et al. [13] found no abnormalities of attention or detection processes. However, a slight deficit was observed in the orienting reaction toward stimuli delivered to the right ear, an effect that was related to a greater number of blows delivered on the left side of the head.

Amateur boxing differs from professional boxing with duration of fights, nature of rules, and use of protective devices (i.e. headgear). It seems that risk of the neuropsychological consequences of participation in amateur boxing is lower than participation in professional boxing. However, Matsen et al. [15] examined neuropsychological function of 38 amateur boxers before and shortly after a boxing match and compared with a control group of 28 amateur boxers who were tested before and after a physical test. The main outcome measures were neuropsychological tests (memory, mental and fine-motor speed, planning, and attention). The boxers who competed exhibited impaired performance in planning, attention, and memory capacity when compared with controls. Authors indicated that participation in amateur boxing matches may diminish neurocognitive functioning despite the use of headgear and supposed that observed neurocognitive impairment were resemble to the cognitive symptoms due to concussions. The cumulative long-term neurological consequences of repetitive concussive and sub-concussive blows to the head is clinically characterized by chronic traumatic brain injury or chronic traumatic encephalopathy (CTE) [18]. Studies showed that CTE has been documented, beyond combat sports, also in other sport activity such as football, ice hockey, rugby, horse racing and soccer [19,20]. Zahn and Mirsky [21] reported that under experimental conditions, CTE group showed decreased the speed of attention transmission process. Our results confirmed some previous observation that at an amateur level, participation in boxing does not expose the individual to harmful neuropsychological damage [17]. However, a slight deficit was observed in the orienting reaction toward stimuli delivered to the right ear, an effect that was related to a greater number of blows delivered on the left side of the head.

Although according to our findings participation in amateur boxing did not cause significance impairment in attentional functioning, it seems to be important to indicate that the boxers’ reaction time in comparison to reaction time of non-athletic group was a slight longer, and the difference between groups was nearly significant. It is generally known that in fast paced sports, such as boxing, the speed of reaction time is an important attribute. Previous electrophysiological studies showed that long-term sport training demanding a high level of visual attention improved efficiency of visuomotor processing [22,23,24]. For example, Di Russo et al. [22] investigated the neural mechanisms responsible for fencers’ fast and flexible behaviour recording event-related potentials in discriminative reaction task and simple reaction task to visual stimuli. The results indicated that (1) attentional modulation of the visual processing was enhanced in the athletes group, (2) the activity in the posterior cingulate gyrus, associated with the stimulus discrimination stage, started earlier in fencers than controls, and (3) the activity at the level of the prefrontal cortex, associated with response selection stage and particularly with motor inhibition process, was stronger in fencers. Similarly Zwierko et al. [24] investigated visual evoked potentials in female volleyball players who participated in extensive training for 2 years compared to nonathletes. Recording the latency of N75, P100 and N135 components of the visual evoked potentials waveform assessed the effect of athletic training on visual signal conductivity. Extensive experience with volleyball training reduced signal conductivity time through visual pathway. Specifically, the latency of P100 was reduced significantly during binocular viewing. In turn, Borysiuk and Sadowski [25] analyzed the effect of focusing attention on anticipatory visual cues by athletes who participated in combat sport and martial arts (fencing, taekwondo and karate). Authors observed significantly reduction of visuomotor processing time, e.g. reaction time and movement time, when the time as well as spatial anticipatory cues were present. Importantly, this study found that athletes have shorter latencies even when the laboratory task was not connected with their sporting environment.

According to findings of Di Russo et al. [22], Zwierko et al. [24] and Borysiuk and Sadowski [25] it seems, that an expertise gained from participating in training in fast-pace sports promoted faster and more efficient processing. However, the results of current study did not confirm this suggestion. Interesting findings found Di Russo and Spinelli [23] who measured event-related potential of professional boxers in a discriminative reaction task (Go/No-Go) task in comparison to fencers and nonathletes. Results showed that fencing improved attention and motor response, but boxing did not. In boxers the P3 component (an event related potential component originates from stimulus-driven frontal attention mechanisms during task processing) was delayed and reduced. The P3 delay of boxers was correlated with the amount of performed sport exercise. Additionally, boxers showed increased intra-individual variability of reaction time. The authors suggested that these results are caused by the cumulative effect of blows to the head. Certainly, this issue needs further investigation.

In summary, despite its exploratory nature, this study offers some insight into mechanisms explaining several aspects of attentional functioning in amateur boxing. However, a limitation of this study is that the numbers of participants was relatively small and the findings of the present study cannot be generalization to all the population of amateur boxers. In our opinion, the present study makes certain noteworthy contri-
buttions to training practice in boxing. Specifically, (1) for the prevention of cognitive impairments in boxers a regular assessment of cognitive function should be performed, and (2) to improve the effectiveness of visuomotor processing, boxers need to participate in training including exercises enhanced attentional skills.

Conclusions

According to the findings of the present study, we conclude that:

1. Amateur boxing does not lead to impairment in visuospatial attentional functioning as well as information processing speed. The intensity of punches in amateur boxing may not reach the threshold that causes brain damage, at least in the regions that are responsible for attention functioning.

2. The athletes did not present an advantage in attentional skills compared to nonathletic group. The behavior adaptation that may occur to attentional skills as a result of ongoing involvement in practice and training in boxing has not been confirmed.

3. Systematic training that optimizes the visuospatial attentional functioning in boxers to improve the effectiveness of their visuomotor processing is suggested.

References


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