CHRONIC ATTENTION IMPAIRMENTS IN AMATEUR BOXING: EFFECT OF REPEATED BLOWS TO THE HEAD

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Abstract  Boxing is one of the organized, high contact sports which imply premeditated punches to the opponent’s head and body in order to achieve victory, both at professional and amateur levels; therefore, head injury is highly expected. When this kind of injury happens, it is possible that in spite of intact cognitive functions, overall cognitive productivity may suffer due to inattentiveness, defective concentration, and consequent mental fatigue. Therefore, the purpose of the present study is observing attention impairments in experienced and novice amateur boxers. The study was conducted on an experimental group of 30 male amateur boxers (24.0±3.1 years old) with more than 4 years experience, a control group of 30 male novice amateur boxers (25.0±4.2 years old) with less than one year experience, and 30 male runners in 400 and 800 m (24.0±2.7 years old). DAUF – the differential attention test – Sustained Attention, as a component of the Vienna Test System was used for monitoring attention. Data were analyzed through the One-Way ANOVA statistical method with a 0.05 probability error. The results showed no significant difference between paired groups (p>0.05), meaning that probably practicing amateur boxing for more than 4 years does not lead to the impairment of the attention components. We concluded that the intensity of the blows in amateur boxing did not cause brain damage, at least not in the regions responsible for attention control.

Key words: Amateur boxing, attention impairment, brain injury

INTRODUCTION  Boxing is one of the organized high contact sports which implies premeditated punches to the opponent’s head and body in order to achieve victory, both at professional and amateur levels [16], therefore, different physical injuries as well as chronic and acute brain damage can occur to its participants [19]. Studies in professional boxing have revealed that it implies a serious risk of brain injuries, neuropsychological disorders and attention deficits [5, 13]. However, studies in amateur boxing do not reveal any certainty of these occurrences [6, 15, 19, 26]. For example, while some studies express no doubt on irreversible brain damage and even death [6] caused by blows to the head in amateur boxing in spite of using head protection, other studies have reported that there is no strong proof of amateur boxers suffering brain damage [15], and that transitional and rotational acceleration of punches in amateur boxing does not reach the threshold that causes diffuse axonal injuries [26]. They agree on the fact that such an effect in this sports branch is less possible to occur than in other sports [19, 20, 23, 30].

Slight brain damage can be followed by psychological and neurological impairment in arousal, concentration, memory, judgment, amnesia, conclusion making and planning [19, 20]. From the psychological point of view, the debate about attention is prior to related issues involving other mental processes because, in all of these processes, attention comes first and is considered to be an input channel [9]. Attention, as the ability of diagnosing, selecting, maintaining focus and disregarding some stimuli, plays an important part in all mental processes [14]. Moreover, in real life and in occupational situations, especially in advertisement, the importance of attention cannot be denied [9]. Being inattentive and...
distracted causes unawareness of certain environment, the mind becomes absent and distracted from the subject and thus unable to remember all details; working becomes hard and the probability of making errors increases. These issues show that attention disorders have irretrievable results on almost all imaginable life aspects of an individual, such as daily activities, training, working, driving and others [14].

In the above conditions, research into different aspects of this mental process gains high priority. But, despite a lot of contradictory studies in relation to amateur boxing, attention has not been studied as much. Studies on this subject were mainly focused on acute effects of boxing punches during a match on attention and orientation reflexes [3, 20]. Although head injury rates during training sessions are higher than during matches because of longer duration, in previous research head injuries during training sessions have been disregarded [30]. In addition, studies show that blows to the head have a cumulative effect [1]. This means, the more blows to head, the more damaging effects in the long run. Therefore, the question on whether practicing amateur boxing for a long time can or cannot cause attention disorders remains. On the other hand, according to previous studies, neuropsychological testing and attention measurements represent some of the most sensitive techniques to detect neurologic dysfunction associated with boxing [13]. Therefore, using attention tools in studying amateur boxing allows us to discuss more precisely the possibility of brain damage in amateur boxing and probably find an answer to the existing contradictions about it.

MATERIALS AND METHODS

Subjects

According to the previous studies reporting that a period of 4 years amateur boxing does not cause neuropsychological impairments [19], the present study was conducted on an experimental group of 30 male amateur boxers (21.0±3.1 years old) with more than 4 years experience, a control group of 30 male novice amateur boxers (25.0±4.2 years old) with less than one year experience, and 30 male runners at 400 and 800 m (24.0±2.7 years old). It must be mentioned that all of the participants had signed a written consent before taking part in the study. The study was conducted using a stratified random sampling method. The reason for selecting 400 and 800 meter runners was that not only that they received no head punches but also because the main energy source in this kind of sport is anaerobic lactic acid so the metabolic accommodation in the brain and in the central nervous system is controlled.

Apparatus and Procedures

In order to assess attention components we used DAUF-Sustained Attention Test under Vienna Testing System [25]. The application of this test is for over-15-year-old individuals. In this test, a row of seven triangles appear on the monitor screen whose position is either up right or upside down. When the expected numbers of these triangles are upside down, the subjects should push the reaction button as quickly as possible.

This test has three forms, including S1 clinical form (rows of 5 triangles with a fixed time gap), S2 clinical form (rows of 5 triangles with a variable time gap), and S3 standard form (rows of 7 triangles with a variable time gap). The clinical forms are done in 20 min but the standard form is done in 35 min. We used S3 form in our study because of its completeness. In this form, one stimulus appeared every second and calculations were done for variables of the sum of correct responses (accuracy), the sum of incorrect responses (impulsivity and behavioral disinhibition), the sum of omitted responses (inattention), the average of correct reaction time (speed of information process and movement speed), and the distribution of reaction times. Cranach’s alpha coefficient or split half obtained from 0.76 to 0.98 related to test forms and validity of the test was verified [25].

Statistical Analysis

Descriptive and inferential statistical methods were used to analyze the gathered data. Normality of data assessed by K-S test, one way ANOVA test was used to analyze the data; besides, post-Hoch Tukey test under SPSS software version 17 was used for comparing each pairs of groups at the significant level of p>0.05.

RESULTS

Some demographics of the subjects are shown in Table 1. After finishing the measurements, the K-S test was done, and it was observed that the distribution of all variables was normal. Since data were normal, we used parametric statistics. Mean and standard deviations of research variables are shown in Table 2.

Results of comparing variables by one way ANOVA in the control and the experimental groups are shown in Table 3. Results in Table 3 show that there was no significant difference between the groups except consistency of attention (p=0.03). Further analysis using Tukey post-Hoch test showed that even in this variable there was no significant difference between the groups. Results of Tukey test for consistency of attention are summarized in Table 4.
Table 1. Demographic information on the participants

<table>
<thead>
<tr>
<th>Group</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>Age (year)</th>
<th>IQ</th>
<th>Annual income ($)</th>
<th>Educational status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced boxers</td>
<td>70.0±5.3</td>
<td>174.0±3.4</td>
<td>24.0±3.1</td>
<td>110.0±2.2</td>
<td>4800</td>
<td>High school</td>
</tr>
<tr>
<td>Novice boxers</td>
<td>71.0±4.4</td>
<td>173.0±3.8</td>
<td>25.0±4.2</td>
<td>109.0±3.4</td>
<td>4600</td>
<td>High school</td>
</tr>
<tr>
<td>Runners</td>
<td>70.0±4.7</td>
<td>174.0±4.5</td>
<td>24.0±2.7</td>
<td>110.0±2.7</td>
<td>4750</td>
<td>High school</td>
</tr>
</tbody>
</table>

Table 2. Mean and SD of variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experienced boxers</th>
<th>Novice boxers</th>
<th>Runners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum correct (N)</td>
<td>299.03±4.3</td>
<td>297.53±0.43</td>
<td>297.67±5.92</td>
</tr>
<tr>
<td>Sum incorrect (N)</td>
<td>33.29±3.92</td>
<td>35.53±3.10</td>
<td>34.55±4.4</td>
</tr>
<tr>
<td>Sum omission (N)</td>
<td>21.29±2.25</td>
<td>22.07±2.13</td>
<td>21.65±2.16</td>
</tr>
<tr>
<td>Average correct RT (Sec)</td>
<td>0.590±0.02</td>
<td>0.600±0.025</td>
<td>0.598±0.024</td>
</tr>
<tr>
<td>Distribution of RT (Sec)</td>
<td>0.249±0.042</td>
<td>0.225±0.43</td>
<td>0.224±0.033</td>
</tr>
</tbody>
</table>

Table 3. Results of comparing research variables through one way ANOVA

<table>
<thead>
<tr>
<th>Variables</th>
<th>df</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum correct</td>
<td>2, 87</td>
<td>0.655</td>
<td>0.522</td>
</tr>
<tr>
<td>Sum incorrect</td>
<td>2, 87</td>
<td>2.717</td>
<td>0.079</td>
</tr>
<tr>
<td>Sum omission</td>
<td>2, 87</td>
<td>0.964</td>
<td>0.385</td>
</tr>
<tr>
<td>Average of correct RT</td>
<td>2, 87</td>
<td>1.447</td>
<td>0.241</td>
</tr>
<tr>
<td>Distribution of RT</td>
<td>2, 87</td>
<td>3.727</td>
<td>0.030</td>
</tr>
</tbody>
</table>

* Significant difference (p<0.05)

The results of one way ANOVA show that there was no significant difference between the groups in the variables of correct responses (p=0.522), sum incorrect responses (p=0.079), omission error (0.385), and mean correct reaction-time (p=0.241). It means that amateur boxing does not lead to impairment in accuracy, impulse inhibition, attention concentration, and information processing speed and motor response even though it was observed that the sum of incorrect responses by experienced boxers was less than that of the control groups, but not significantly (p>0.05).

The results of one way ANOVA show that there was significant difference between the experimental and the control groups in consistency of attention (p=0.03) but regarding the results in Table 4, comparing pairs of groups through Tukey post Hoch test revealed that this difference between experienced and novice boxers, and experienced boxers and runners, was nearly significant; however, from statistical viewpoint it is not significant, meaning that amateur boxing does not cause impairment in consistency of attention (p>0.05).

Table 4. Comparison of RTs Distribution between paired groups through Tukey post-Hoch test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Paired groups</th>
<th>Mean Difference</th>
<th>Standard Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution of RT</td>
<td>Experienced boxers</td>
<td>Novice boxers</td>
<td>0.024</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>Runners</td>
<td>0.025</td>
<td>0.010</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>Novice boxers</td>
<td>runners</td>
<td>0.000</td>
<td>0.010</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Findings of our study about the effect of blows to the head on boxers’ attention in amateur boxing are in contradiction with some research. Some of the studies have proved that memory and attention problems are the commonest cognitional impairment in athletes who have experienced brain concussion with or without losing alertness [7, 16]. Zahn and Mirsky [29] reported that under all experimental conditions, Chronic Head
Injury (CHI) group showed slow and more variable reaction time than the control group, maybe as a result of frontal lobe damage. This difference proves that brain injury decreases the speed of attention transmission process.

Nevertheless, the findings of the present study are in line with some other research. Studies have shown that in spite of individual differences in performance, the ability of dividing attention in CHI patients was almost similar to that of the control group [4]. In addition, even though Traumatic Brain injury (TBI) group had more difficulties in doing two simultaneous tasks compared to control subjects, they were able to allocate available attention resources to one of the tasks, the same as control subjects [2]. Moreover, research shows that millions of bumps to the head, from childhood to adulthood, that cause moments of dizziness followed by quick recovery to the normal state without following clinical signs, remind us of the danger of eagerly using clinical labels and spreading information to the society [18].

Although according to our findings participation in amateur boxing did not cause significance impairment in attention, we should carefully interpret these results. This is because our findings showed that attention consistency between groups was nearly significant (but not significant); besides, according to research literature, whereas allocating attention in healthy people was shown by RT, among the TBI subjects it was variability of RT that was sensitive to attention impairment [22].

Regarding previous studies and our results, three issues are important in explaining these findings. First, long intervals after head injury may give opportunity to the injured individual to recover to the point that effect of inattention become less clear [27]. Second, according to Azouvi et al [2] it is possible that individuals suffering from TBI provide for the need of clinical tests and even perform better than the control group using compensatory method of maximum psychological effort. Finally, punches to the head in amateur boxing may not cause brain damage, at least not in the regions which control attention.

In relation to the first possibility, it should be explained that Elson and Ward [8] confirmed that the CNS was able to compensate minor anatomical impairments through different mechanisms of neuronal plasticity. Also, studies show that TBI patients recovered in orienting component of attention a week after injury [10]. Boxers are not an exception to this and even if they suffer from TBI because of purposeful blows to the head, with the passing of time and provided that such accidents do not occur again during recovery period, they can recover from small anatomical impairments using unknown mechanisms [20]. Thus, it is possible that boxers in this study had become immune to hard punches to the head for a while and had time to recover to the natural state. Additional interviews after the testing process confirmed this possibility. So it seems that if amateur boxing have some negative consequences, these outcomes are contemporary and blows to the head do not have an accumulative effect.

Regarding the second possibility, compensating performance using maximum psychological effort, it must be said that CHI patients expend more psychological effort and this may explain why TBI patients complain about mental fatigue [2]. Also, Riese et al [21] found psychological expense and mental disturbance in TBI patients using a long term dual task that can be related to the mental fatigue. Recent studies show that moderate and severe TBI patients maintain their attention and arousal at appropriate level using compensatory strategies at least where little effort is needed [William et al., 2004]. However, we should keep in mind that according to Stuss et al [1989], CHI patients can temporarily improve their attention focus by preventing abundant information, and since focal attention is demanding, it definitely cannot be maintained for a long time. Berberich (as cited in Leclercq & Zimmermann, [14]) reported that such a test assessing sustained attention has more predictive power than vigilance task and its results are a good predictive of occupational performance when these people return to their work. So, it seems that the second possibility is rejected because the sustained attention test shows that even if in the first steps of the test individuals hid their attention impairment using maximum effort, with the passing of time, they could not do the test properly and their impairment would be discovered.

Finally, there is the possibility that blows to the head in amateur boxing do not lead to brain damage at least in the regions that control attention. It should be explained that most of the studies in amateur boxing support this possibility. Studies show that compared to most of the other sports, the rate of acute injuries in amateur boxing is lower [30]. By comparing amateur boxers with fewer matches (0-15 matches) and boxers with higher number of matches (25-230 matches), Murelius and Haglund [17] showed that the only difference between the groups was fine motor coordination (whereas these scores were in normal range) and it seems that boxing period does not affect neuropsychological performance. Regarding the effect of amateur boxing on cogntional performance of boxers, Stojish et al [23] found that after an amateur boxing match, all psychological scores except delayed memory either increased or did not show a significant decrease compared to the base line scores and most of the effects experienced by both genders were under threshold of mTBI (minor Traumatic Brain Injury). In relation to this, Wallikko et al [26] reported that translational acceleration for left jab and left hook strikes were respectively 21.5±4.5 and 43.6±15.7 g and rotational acceleration for these strikes were respectively 292.7±72.2 and 675.9±230.6 rad/s².

According to the tolerable acceleration of 200 g for translational and 4500 rad/s² for rotational acceleration, researchers concluded that neither translational nor rotational acceleration produced by blows...
in amateur boxing reach a level that is harmful to boxers. So, considering the evidence, we conclude that amateur boxing probably has no effect on attention impairment. Thus, even if the blows in amateur boxing are harmful, the boxers will recover after a short period of rest. The rules of international federation of amateur boxing (AIBA) support this issue, because, in either training or match, both the referee and the coach are instructed to stop the fight if they see even the minor pressure signs on one of the boxers. Moreover, a boxer who has been punched heavily does not have permission to take part even in high mobility trainings for a period of 28 days [11]. Considering previous research that has shown negative effect of amateur boxing we should say that although more than 1200 studies have been published since 1897 about the medical and moral aspects of boxing [16], they usually have made no difference between professional and amateur boxing. It is logical to expect amateur boxers to receive fewer cuffs to the head because amateur boxing has 3 × 3 min rounds (compared to 15 rounds of professional boxing). Therefore, they rarely suffer brain damage. Also, most of the research that reported negative effects of amateur boxing had methodological problems: the subjects were few, there were no appropriate control groups, in most cases boxers were more than 60 years old and they did boxing in the era when there were no safety rules or medical supervision, and researchers did not make any difference between recent blow effects and aging processes or other factors, such as alcohol drinking that produced some similar clinical and morphological changes [12]. But, according to Jako [12], for the 2 last decades amateur and professional boxing has changed a lot. In amateur boxing the referees observe the match from very near distance in comparison to other sports, and if a boxer could not continue the match, the contest would be stopped immediately. Increasing RSC (Referee Stop Contest) rate shows extended control in the ring. Even though studies show that amateur boxers do not display neuropsychological symptoms or dysfunction in cerebral blood flow [16], in order to decrease these possibilities after repeated knockouts or RSCH (Referee Stop Contest because of heavy blows to the Head) one year compulsory resting period or even retiring is considered [11]. Nowadays, knockout rarely occurs because in amateur boxing the emphasis is more on technical winning rather than on heavy cuffs. For example, in the Barcelona Olympic Games boxing competitions, only 6 out of 327 matches ended in knockout (1.8%) [5], and in 2008 Beijing Olympic Games boxing competitions, only 1 match out of 274 (0.36%) ended in knockout, the latter because of a blow to the body not to the head.

**CONCLUSION**

On the whole, according to the findings of this study, we conclude 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.

**PRACTICAL APPLICATION**

The results of this study support the research that introduces amateur boxing as a neurologically acceptable activity. Thus, boxers can participate in boxing without concern about neurologically aftermaths if they keep up to the safety issues that AIBA advises both in competitions and training sessions. Although in this research some results about neuropsychological aspects of amateur boxing were found, it is clear that generalizing the findings of the present study to all the population of amateur boxers is impossible. Applying a test that would measure auditory attention as well as visual attention would help to interpret the finding better since an individual's visual attention may be healthy while his auditory attention is impaired; besides, there are special mechanisms for controlling visual and auditory inputs [14]. In addition, since special mechanisms control a single sensory modulation (for example there are special mechanisms and systems for the analysis of shape, color, and movement aspects of a visual stimulation), it is suggested that these differences must be regarded in every sensory modulation and tested as such.

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