

The psychophysiological differences between expert and novice rifle shooters during the aiming period

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Purpose: Determination of mental status of the rifle shooters during the shooting performance is critical for the development of mental training programs according to their skill levels. The purpose of this study was to investigate the psychophysiological differences of expert and novice rifle shooters.

Material: Fourteen expert (age: 28.08±9.12 years, height: 176.12±4.24 cm, weight: 73.56±5.28 kg) and twenty novice shooters (age: 21.08±3.12 years, height: 177.42±3.74 cm, and weight: 71.56±3.57 kg) participated in the current study. The participants performed five shootings from a distance of 10m. The averages of each shooter's five shooting scores, values of attention and meditation, and heart rate between 5-sec before shooting and shooting moment were obtained.

Results: It was determined that shooting scores (10.02 ±0.49 vs. 7.6±2.86, p<0.01, respectively) and meditation level (71.50±21.05 vs. 52.93±20.54, p<0.05, respectively) were significantly higher in the experts while attention level (73.63±21.11 vs. 59.76±21.26, p<0.05, respectively), and heart rate (105.34±12.12 vs. 98.67±7,12 bpm, p<0.05, respectively) were found higher in the novices.

Conclusions: The novices and experts present different psychophysiological responses during the aiming period. It is suggested that the psychophysiological differences can be useful to categorize shooters and to provide feedback in training because it is important to develop programs according to group levels, especially in the development of mental training programs. Besides, it is determined that the mobile EEG device is an effective method for determining the mental status of athletes in sports specific activities.

Keywords: rifle shooting, attention, meditation, novice, expert.

Introduction

Rifle shooting is an Olympic sport in which athletes shoot a fixed target at a distance of 10 meters. The athletes have to hit the target with 10 rings that are intertwined. The most successful shot is obtained by hitting the inner ring [1]. A successful shot depends on the rifle hold, aiming accuracy and trigger control [2, 3]. Therefore, it is necessary to use both motor skills and psychological factors in the shooting process [4]. In the related literature, it is reported that postural balance is the most important motor skill in rifle shooting [5]. The smallest change in posture can lead to significant changes in the score. In this context, it can be said that high postural balance and minimal movement of the rifle barrel are important determinants of the shooting performance [4]. However, It is well known that elite athletes enhance a range of sport-specific cognitive skills as well as possessing motor skills [6, 7]. Lee reported that attention and meditation are the most important psychological factors that affect performance in rifle shooting because shooting performance is very comprehensive and it requires high intense of focusing [7]. When a shooter directs his rifle to the target, he must focus on many different points (target, sight, trigger and so on). Therefore, the shooter must separate himself from the outside world and concentrate on what he does [8]. However, air rifle competitions are psychologically stressful situations for shooters. It is well known that expectations regarding performance

increase anxiety, heart rate and blood pressure in people [9]. Therefore, determination of the mental status of the athletes during the shooting performance of rifle shooters is critical for the development of mental training programs according to their skill levels. Berka et al. determined that when novices monitor their own learning progress effectively they can adopt and integrate advanced techniques in the learning process [10]. Moreover, elite athletes enhance a range of sport-specific cognitive skills [6, 7, 11]. Therefore, determining of psychophysiological differences of expert and novice athletes can be useful to categorize athletes according to group levels and to provide feedback in their mental status. Self-reports or visual assessment by an examiner are generally used to determine the mental status of athletes. However, these methods may not reliably and objectively reflect the mental status of athletes because of the implicit nature of motor learning [11].

For many years, Electroencephalography (EEG) method has been commonly used as a neurologic technique for determining psychophysiological measurements of athletes. In this application, the electrical potentials of the brain cells are recorded by the sensors placed on the head. In the EEG studies, it was found that the brain oscillation (alpha, beta, theta, and so on) was associated with specific frequency bands and mental states (calm, arousal, attention, and so on) [12]. In the EEG measurements, theta waves (4~7 Hz) are usually associated with early sleep while delta waves (0.1 ~ 3 Hz) are associated with deep sleep. Moreover, beta waves (13 ~ 30 Hz) are related with

mental focusing and active thought, while alpha waves (8 ~ 12 Hz) are related with relaxation or resting state [13].

The traditional EEG has to be conducted in well-controlled laboratory settings. Therefore, it is impossible measuring the mental status of athletes when performing sport specific tasks in the real world. Moreover, laboratory conditions and multi-channel wet EEG electrodes may be a stressful experience for some athletes (e.g. young or autistic children) when having a large number of electrolytes put onto their heads [11]. Due to the development in technology, it has become easier to measure the mental status of individuals using mobile EEG devices [7, 14]. Some of the EEG devices adopted a single channel dry sensor and offer a wireless, ergonomic and pain-free EEG monitoring solution to researchers. Therefore, it is extremely easy-to-use for measuring the mental status of athletes during sport specific tasks [15, 16, 17]. Mobile devices can analyse brain waves using various algorithms and give the level of attention and meditation of people as a ratio [7]. Therefore, we hypothesized that the novices and experts would present different psychophysiological responses during the aiming period. The purpose of this study was to investigate the psychophysiological differences of expert and novice rifle shooters during the aiming period using a mobile EEG device.

Material and Methods

Participants. A total of 34 male rifle shooters including 14 experts (age: 28.08±9.12 years, height: 176.12±4.24 cm, weight: 73.56±5.28 kg) and 20 novices (age: 21.08±3.12 years, height: 177.42±3.74 cm, and weight: 71.56±3.57 kg) participated in this study. The experts were chosen from a group of national athletes having experiences of at least four years and the novice shooters were chosen from beginners (2-8 months). The participants did not have any health problems. The current study was approved by the local ethical council and applied in accordance with the Declaration of Helsinki. All the participants were informed of the objectives and risks of the study. All participants signed a voluntary participation form.

Research Design. To determine the psychophysiological differences between expert and novice rifle shooters during the aiming period the shooters performed five shootings from a distance of 10m. The averages of each shooter's five shooting scores, values of attention and meditation, and heart rate between 5-sec before shooting and shooting moment were obtained.

Procedure. The study was performed in a standard indoor shooting area. Firstly, descriptive statistical data of the participants were obtained. The shooters performed a

total of 10 shots for familiarization. Furthermore, external viewers were placed in the competition area to create a competition environment. It was reported that athletes would be rewarded according to their performance.

Measurements.

Attention and meditation. A single-channel mobile and wearable electroencephalogram (EEG) device (MindWave®, NeuroSky, Inc., U.S.A.) was placed to the participants' head. Usability of detecting attention levels in an assessment exercise using NeuroSky portable EEG device has been demonstrated in many studies [18, 19, 20]. The EEG device was connected to the computer via Bluetooth to determine the attention and meditation levels of the participants. The attention level represents the intensity of the participant's mental focus. Meditation level shows the mental and calmness levels of the participants. The attention and meditation levels are scored between "0" and "100". "0" represents the lowest level, and "100" represents the highest level. "10.9" is the highest score, and "0" is the lowest score in rifle shooting. A mini software was developed in MATLAB program for the analysis of the raw data (attention and meditation) obtained from the Mobile EEG device. In this software, while a participant was shooting (shooting moment), a mark was placed between the data. Thus, the data of 5 seconds before the shot were analysed.

Heart rate. In order to determine the heart rate of the participants, the polar M400 (Polar Electro Oy, Kempele, Finland) was placed on the chest area of the participants. In order to synchronize the data, one of the researchers held the heart rate monitor behind the participant and when a participant shot, the investigator pressed the lap button of the monitor. The data obtained from the heart rate monitor were analysed by the Polar Protrainer5 software. The average heart rate of pre-5s of shooting was analysed.

Statistical Analysis.

SPSS 18.0 software was used for the statistical analysis of the data. Kolmogorov Smirnov test was used to determine whether the data were distributed normally. Mann-Whitney U was used in order to detect the difference between the groups. A value of $p < 0.05$ was taken as the significance value. Cohen's d values were calculated to determine effect sizes. Cohen's d values were classified as small ($0.00 \leq d \leq 0.49$), medium ($0.50 \leq d \leq 0.79$), and large effects ($d \geq 0.8$) [21].

Results

It is seen in Table 1 that shooting scores (10,02 ±0,49 vs. 7,6±2,86, $p < 0,01$, effect size 1.179) and meditation level (71,50±21,05 vs. 52,93±20,54, $p < 0,05$, effect size

Table 1. Comparison of the psychophysiological responses of the expert and novice rifle shooters during the aiming period.

Variables	Expert $\bar{X} \pm SD$	Novice $\bar{X} \pm SD$	Effect size
Attention (level)	59.76±21.26	73.63±21.11*	0.655
Meditation (level)	71.50±21.05*	52.93±20.54	0.892
Heart rate (bpm)	98.67±7.12	105.34±12.12*	0.671
Shooting score (points)	10.02±0.49**	7.6±2.86	1.179

Notes: **: $p < 0.01$, *: $p < 0.05$

0.892) are significantly higher in the expert shooters, whereas attention level ($73,63 \pm 21,11$ vs. $59,76 \pm 21,26$, $p < 0,05$, effect size 0.655), and heart rate ($105,34 \pm 12,12$ vs. $98,67 \pm 7,12$ bpm, $p < 0,05$, effect size 0.671) are found higher in the novice shooters.

Discussion

The purpose of this study was to investigate the psychophysiological differences of expert and novice rifle shooters. At the end of the current study, it was seen that shooting scores and meditation level were significantly higher in expert shooters while attention level and heart rate were found higher in the novice shooters.

There are a limited number of studies in the literature examining psychophysiological factors in rifle shooters. In the present study, it was observed that the heart rate during the shooting was higher in the novice rifle shooters. Similar to the current study, Neumann & Thomas investigated heart rate differences of the elite and novice golf athletes during hitting the ball. They reported that the elite players had a lower heart rate when compared with novice players [16, 17]. Similarly et al reported that elite archers exhibited a lower heart rate when they were compared with novice archers during shooting [22]. Tremayne & Barry demonstrated that there was a slower reduction in heart rate levels prior to the shot in the experts pistol shooters when compared with the novice shooters [23]. It is well known that cognitive procedures increase or decrease heart rate during motor performance [24]. The reason of heart rate increment during shooting activity in novice shooter may be due to the turning of external attention (focusing on the effect of the movement) to internal attention (focusing on a person's body movement). It is well known that while external attention leads to a decrease in heart rate, inner attention leads to an increase in heart rate [25]. The best scores are managed during the external attention with a lower heart rate [26, 27]. Moreover, external attention facilitates the automatization of the movement [28]. With the focus on the inside, novice athletes might talk to themselves leading to an increased heart rate. Supporting this idea, in the current study, the meditation values of the novice shooters were found lower than the expert shooters [26]. This may mean that anxiety levels of the novice shooters are higher than the expert shooters. Moreover, it is well known that there is a relationship between elevation of anxiety and heart rate [29].

In the current study, the attention and meditation levels of the shooters were analysed with the mobile EEG measurement. It was determined that the novice shooters had higher attention levels than the expert shooters. In the literature, different results were found in the studies conducted to determine the attention differences according to the athletes' levels. Similar to the present study, Hauffer et al. reported that elite shooters exhibited lower cortical activation during aiming in 15 elite and 21 novice shooters [30]. In another study, Deeny et al. reported that the elites exhibited lower alpha and beta values [8]. Hatfield et al. stated that the elite shooters had

lower activation of the cerebral cortex compared to the novice shooters [31]. In contrast to the current study, Lee (2009) stated that the elite archers had a greater attention level at the release of the arrow than the novice archers [7]. Del Percio et al. also reported high levels of alpha and beta bands which were directly related to attention and meditation in elite pistol shooters [32]. Fronso et al. stated in a review study that elite and novice shooters used different strategies during aiming, and especially the elites increased their attention during the shooting [27]. The most important reason for finding different results is the use of different protocols in the measurements. In the present study, the average of the psychophysiological values between 5-sec before shooting and shooting moment were obtained and analysed. However, other investigators found higher attention levels in experts just before release or shot [7, 32]. The most important reason for lower attention in the expert shooters before shooting may be the long period of sports specific practice. The shooters can focus on the movement economically after a long period of repetition and adapt to sport specific movements because effective motor performance is characterized by the biomechanical and metabolic act of performing the movement economically [33, 34, 35, 36]. Serrien and Brown demonstrated a decline in the alpha and beta band EEG activities when the athletes became more familiar with a motor task [37]. Experienced shooters exhibit more precise focusing strategies and more effective visual screening models [38]. Unlike experts, novices focus more on related or irrelevant points (not selectively). This means more cognitive processing. However, as practice increases, irrelevant stimuli are eliminated and environmental stimuli and clues related to the task are processed [39].

Other data obtained in the mobile EEG measurements were that the meditation levels of the expert shooters were higher than the novice shooters. Similarly, Lee determined that the meditation levels of the expert archers were higher than the novices. Doppelmayr et al. found that only experienced gun shooters had a steady increase in theta power in the last three seconds prior to shooting [40]. Lange et al. determined a lower coherence in the alpha band when began to draw with the nondominant hand compared to the dominant hand [41]. This may be explained by the fact that expert shooters have more external attention and novice shooters have more internal attention. The higher heart rate and lower meditation level before the shot indicated that the novice shooters were under high stress and anxiety during shooting. However, in the expert shooters, emotions seemed more controllable under stress. It is well known that equilibrium performance is the most important factor affecting shooting performance [3, 4, 5]. Era et al. found that a change of less than 10% of postural control affected shooting score of elite rifle shooters [42]. Moreover et al. determined a significant association between low tension and the results in the test shootings ($r = 0,42$, $P < 0,001$) [43]. As a result, it is estimated that the increase in the internal attention of the novice shooters and the decrease

of the meditation level may affect the balance control, and, therefore, the shooting scores are affected negatively.

Conclusion

It was determined that the expert and novice rifle shooters presented different psychophysiological responses during the aiming period of shooting activities. According to these results, it was seen that while shooting scores and meditation level were significantly higher in the expert shooters, attention level, and heart rate were found higher in the novice shooters. It is suggested that the psychophysiological differences can be useful to categorize shooters and to provide feedback in training because it is important to develop programs according to group levels, especially in the development of mental training

programs. In order to improve performance in novice shooters, focusing on psychological training (relaxation, and external attention) methods is recommended. In the future, studies can be carried out in rifle shooters together with the parameters of psychophysiological factors and balance control. Besides, it is determined that a mobile EEG device is an effective method for determining the mental status of athletes in sports specific activities. In the future, studies can be carried out in rifle shooters together with the parameters of psychophysiological and balance control.

Conflict of interests

The authors declare that there is no conflict of interests.

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Cite this article as:

Yıldız M., Fidan U. The psychophysiological differences between expert and novice rifle shooters during the aiming period. *Pedagogics, psychology, medical-biological problems of physical training and sports*, 2019;23(6):313-317. <https://doi.org/10.15561/18189172.2019.0606>

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Received: 19.06.2019

Accepted: 25.07.2019; Published: 30.09.2019