Neurofeedback for the enhancement of dynamic balance of judokas

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ABSTRACT: Physical balance is an important factor in sport. Neurofeedback (EEG biofeedback) can be used to improve concentration and focus. The present study investigated and determined the impact of neurofeedback training on dynamic balance in judo. Eighteen judokas voluntarily participated in this study. The participants were divided into two groups: experimental (EG) and control (CG). In the experimental group subjects were trained to inhibit 3-8 Hz while they were also trained to reinforce 14-19 Hz brainwave activities at points O1 and O2 for ten sessions and 25 minutes per session. The participants in the control group were exposed to the same conditions but instead were provided with sham feedback. EEG and dynamic balance tests were executed before and at the end of the fifteenth session of training. The one-way ANOVA with repeated measures revealed that dynamic balance scores significantly improved at the post-test (F=12.4, p=0.001) in the EG group. The findings demonstrate that neurofeedback training can enhance dynamic balance of judokas.

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INTRODUCTION

It is obvious that competitive sport aims to ensure achieving the best results. Psychologists doing research over the decades on what determines why only some players, despite the fact that in terms of physical, technical and tactical skills are prepared the same as the others, are more successful. It should also be noted here that the basis of sport success is optimum preparation in pure terms of sport, and mental work such as biofeedback can strengthen the preparation, and enable sources resulting from its potential. Neurofeedback is a more sophisticated form of biofeedback. Researchers in the past three decades have studied the effect of modifying brain waves or electroencephalography (EEG) on the mental aspect of the players. The person subjected to neurofeedback training learns to control their own brain waves. This is done on the basis of biofeedback. The sensors attached to the scalp receive current brain waves and transmit them to the EEG, which are amplified and presented in the form of e.g. video games. Neurofeedback training has different functional areas. Hammond's research [1, 2] focused on reducing anxiety and Walker and Kozlowsky [3] dealt with the treatment of epilepsy, while Monastra [4] conducted research on the treatment of ADD/ADHD. Others, such as Chung-Hee et al. [5], tried to find effects of concentration training with brainwave biofeedback on tennis performance. Gould and Maynard [6], in their research, determined what mental skills are necessary for athletes to succeed at the highest level of competition. It was found that most important is the ability to control the level of stimulation, evaluated by heart rate variability (HRV). Another important ability is focus and emotional control, which were judged by neurofeedback (NF).

In post-intervention analyses, Srilekha et al. [7] revealed marked improvement in the bilateral shooting performance of soccer players who received Sc and electromyographic (EMG) biofeedback intervention training, which were capable of modulating autonomic indices of emotionality as well as the muscle potentiality in the form of enhanced maximal voluntary contraction in the players.

Salazar et al. [8] showed increased attention (balance) while aiming at archers who were enrolled in neurofeedback training in T3, compared to the group in which the aim of neurofeedback training was to increase the frequency of alpha T4. Landers et al. [9] also found that the alpha frequency control neurofeedback session at time T3 is much more optimal for archery in regard to the improvement of concentration, as compared to training in alpha wave T4. Expert marksmen showed increased alpha power across all regions, but particularly at T3, compared with novices. The authors suggested that the increased alpha may reflect a refinement in analytical or better self-talk strategies during the pre-shot time [10].

Dziembowska et al. [11] proved that athletes using biofeedback training showed substantial and statistically significant improvement in heart rate variability indices and changes in power spectra of both theta and alpha brain waves, and alpha asymmetry. These changes suggest better self-control in the central nervous system and better flexibility of the autonomic nervous system in the group that received biofeedback training. A HRV biofeedback-based stress management tool may be beneficial for stress reduction for young male athletes.

Balance, especially dynamic, is one of the most important motor skills. Static balance refers to the ability of a stationary object to balance. It happens when the object's centre of gravity is on the axis of rotation. Dynamic balance, on the other hand, is the ability of an object to balance while in motion or switching between positions. Improving the dynamic balance can improve the overall physical performance in most sports, such as judo, gymnastics, skiing, basketball, weightlifting, etc. In 2005 Hammond published results of his two studies with neurofeedback in dynamic balance enhancement [1, 2]. He used a specific protocol. Significant improvements occurred in all cases after 8-10 sessions.

This modified (15-session) protocol has been used in this study. The main aim of this study was to investigate and determine the impact of neurofeedback training on dynamic balance in judokas.

MATERIALS AND METHODS

Participants

Eighteen judo athletes (age: 21 ± 1.5 years, height: 178 ± 7.5 cm, weight: 74 ± 6 kg) participated in the study. Participants were randomly assigned to the experimental group or the control group (EG-n = 8; CG-n = 8). The study was conducted based on the consent of the Bioethics Committee of the Academy of Physical Education in Katowice.

Procedure

A double-blind design with pre- and post-test was employed in this study. Dynamic balance and EEG measures were assessed three times as pre-test (before training), mid-test (at the end of the fifth session) and post-test (at the end of the tenth session). For dynamic balance, an electronic balance plate CQStab2P was used. The balance test included maintaining dynamic balance in a standing position on a mobile plate as long as possible. The total time of balance, imbalance, and the percentages for any period were calculated automatically.

The EEG was recorded in an eyes-open resting condition using bipolar montage on O1-O2. The ground electrode was placed on the right earlobe. The EEG was amplified by an 8-channel Enobio wireless and portable EEG/EOG/ECG monitoring device (with bandwidth: 0 to 125 Hz and sampling rate: 500 SPS) and Neuroelectrics Instrument Controller, v 1.1 - NIC 1.1 with Biograph Infiniti Software, sampling rate 256 Hz. For the purpose of EEG processing, artefacts were rejected based on both subjective choices as well as computer selection. The amount of specific EEG tests were also visually analyzed by an expert psychologist who accepted or rejected them accordingly each time. Finally a total of 38 EEG tests were selected. The time intervals of EEG frequency were converted into the fast Fourier transform (FFT) algorithm. Frequency bands are defined as follows: delta (1-5 Hz), theta (3-8 Hz), alpha (6-13 Hz), SMR (11-16 Hz) and beta (14 and 19 Hz). Then, the absolute value was calculated for each frequency band. Protocol training was based on that described by Hammond (2007). Placing the electrodes was similar to the distribution of the EEG. Subjects in the experimental group were trained to inhibit 3-8 Hz (theta), while they were also trained to reinforce 14-19 Hz (beta) brainwave activities at points O1 and O2 for ten sessions and 25 minutes per session. The participants in the control group were exposed to the same conditions as the experimental one, but were non-contingent. Conducting research, he watched the recording of information in each of these bands on a monitor, and gave audio-visual feedback to the participant via a second monitor. Feedback consisted of negative feedback and positive feedback. Two racing boats were displayed to the participants. Each boat advanced when the corresponding bar graph signal was over the threshold. The goal was to make the boat, which was connected to the reward band (beta), advance while keeping the other

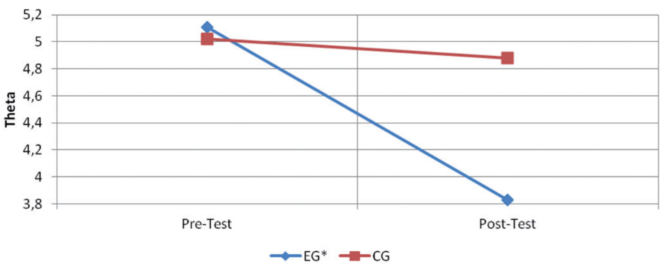

FIG. 1. Differences between pre- and post-test theta values.

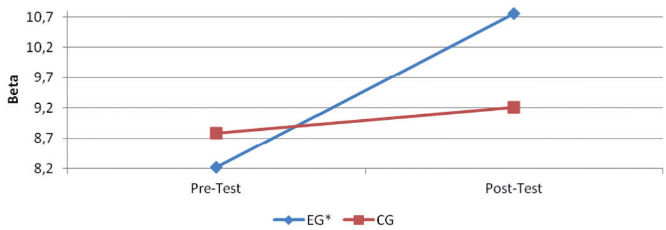

FIG. 2. Differences between pre- and post-test beta values.

boat, which was connected to the inhibitory band (theta), from advancing. When the boat reached the finish line (right edge), a green light (reward) or a red light (failure) turned on to indicate the winner. Fifteen neurofeedback training sessions were conducted over a period of 5 weeks. Each session consisting of 25 minutes lasted about 45 minutes including the time for preparation.

Statistical analyses

Dynamic balance and EEG measures were examined as dependent variables. Pre-test and post-test dynamic balance scores were analysed by one-way ANOVA with repeated measures.

RESULTS

The one-way ANOVA with repeated measures revealed statistically significant interaction in EG, between pre-test and post-test ($F=16.01$, $p=0.001$) with balance values, as well as no significant difference between EG and CG in post-test values ($F=2.22$, $p=0.062$) with the same variable.

Similarly the one-way ANOVA with repeated measures revealed statistical significant differences in theta (Figure 1), alpha and beta (Figure 2) values between pre-test and post-test in EG, respectively: $F=22.11$, $p=0.001$; $F=17.89.11$, $p=0.002$; $F=19.94$, $p=0.001$. There were no statistically significant differences between EG and CG in theta, alpha and beta post-test values.

Furthermore, as presented in Table 1, the one-way ANOVA with repeated measures revealed no significant difference between pre- and post-tests with SMR and delta variables, as well as between EG and CG post-tests values with the same variables.

TABLE 1. Mean and standard deviation of dynamic balance and EEG measures.

Variables	Group	Pre-test	Post-test
Balance	EG*	63.12 (11.51)	95.11 (12.24)*
	CG	64.11 (14.25)	82.34 (15.85)
Theta	EG*	5.11 (0.89)	3.83 (0.62)*
	CG	5.02 (0.91)	4.88 (0.82)
Alpha	EG*	8.12 (1.88)	6.01 (1.69)*
	CG	8.75 (3.21)	7.80 (2.81)
Delta	EG	4.77 (1.12)	4.32 (1.08)
	CG	4.71 (1.21)	4.44 (1.22)
Beta	EG*	8.22 (2.51)	10.75 (1.02)*
	CG	8.79 (2.51)	9.21 (1.71)
SMR	EG	1.26 (0.21)	1.22 (0.44)
	CG	1.30 (0.44)	1.37 (0.38)

EG – experimental group, CG – control group.

DISCUSSION

Neurofeedback training is brainwave biofeedback. During typical training, a couple of electrodes are placed on the scalp and one or two are usually put on the ear lobe. Then, high-tech electronic equipment provides you real-time, instantaneous audio and visual feedback about brainwave activity.

Neurofeedback research has documented its value in different areas such as the treatment of a variety of symptoms relevant to individuals with brain injuries, sports psychology including concentration and attention enhancement, anxiety reduction, and improvements in controlling one's emotions (e.g. anger) and physical balance. In 2005 and 2007, Hammond published his findings on the use of neurofeedback methods – in order to improve balance [1, 2, 12]. The research material comprised athletes who had experienced collisions during combat sport. He used 8-10 sessions, after which a marked improvement in balance was observed. This study was an attempt to verify, in a sense, Hammond's research, but the research material comprised the results of training in a group of trainees judokas. Results obtained by Hammond showed improvement in dynamic balance in the experimental group. Despite some advantages in the mean values in the control group, the test initial studies have shown that neurofeedback training may imply an improvement of balance in training of healthy athletes. Monitoring of each session showed that from 6-7 sessions an improvement in the experimental group was seen very clearly. These observations support, at the same time, the results of analyses of the neurofeedback training by other researchers such as Landers [13], Vernon et al. [14] and Hoedlmosera et al. [15].

CONCLUSIONS

The findings of this study support earlier findings on neurofeedback application to enhance physical balance among normal and healthy people.

The one-way ANOVA with repeated measures revealed statistically significant differences in theta (EG), alpha (EG) and beta (EG) values between pre-test and post-test. It was observed that theta and alpha values decreased, whereas the beta values increased in the experimental group, which caused a significant positive change in dynamic balance.

The results of the analysis demonstrate that neurofeedback training can enhance dynamic balance of judokas. The importance of these results is the usage of this technique for special settings in sports and any other areas that require high-level physical balance. However, it is noteworthy that there are still many unanswered questions regarding the techniques, duration and kinds of neurofeedback training.

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