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KINESIOLOGY OF FIGHTING SKILLS

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Event related potentials after acute bouts of exercise in female judo players

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Key words: physical activity, P300, judo

Abstract: The aim of this study was to throw light on the influence of physical activity at different levels on the amplitude and latency of P300 component of cognitive potentials in female athletes. After registering cognitive event related potentials at rest participants underwent a controlled exercise on a cycle ergometer. Each exercise lasted for 10 minutes with successive increase of intensity up to 60%, 75% and 90% of maximal heart rate and holding this level of intensity for six minutes. Immediately after finishing each bout of exercise, event related potentials were registered again. The amplitude of P300 wave after exercise intensity achieved at 60% (Fz 14.02±6.33 μV; Cz 16.19±5.84 μV) and 75% of HRmax (Fz 13.22±4.68 μV; Cz 16.33±5.07 μV) were statistically higher ($p<0.05$) than the amplitude of P300 at rest (Fz 10.32±5.50 μV; Cz 12.41±3.43 μV) and after 90% of HRmax (Fz 10.38±5.68 μV; Cz 11.38±6.76 μV). In our study the effects of single bouts of exercise at different intensities seem to be positive on the amplitude of P300. Short duration medium intensity exercise corresponding to 60% and 75% HRmax facilitated cognitive processing in the CNS, whereas high-intensity exercise corresponding to 90% HRmax decreases cognitive functions.

Introduction

Several articles about physical activity in detail analyze the engagement of the whole body during acute bouts of physical exercise. Results of the overall arousal during exercise lead to systemic changes in physiological functions which are described under the term "alarm phase of stress" since Selye`s landmark work [Selye 1950]. Changes emerge in the cardiovascular system, endocrine control mechanisms, body temperature in order to lift the functions of the whole body to a higher level of functioning in order to fulfill the newly presented metabolic needs. The idea that physical activity directly influences cognitive functions is still not empirically confirmed.

Many studies have been dealing with the relation of cognitive functions and exercise [Collardeau 2001; Brisswalter 2002]. They have been using different approaches to evaluate mental processes such as cognition, including response time or complex reaction time [Brisswalter 1997; Collardeau 2001; Brisswalter 2002]. Recent studies used advanced techniques of EEG to seek the underlying mechanisms of cognition evaluating event related potentials [Grego 2004; Kamijo 2004]. During their registration several positive and negative waves emerge but the one differentiated around 300 ms after target presentation seems of great importance [Penny 2002]. This positive wave is called P300 and is independent of the physical characteristics of the signal itself. P300 amplitude is related to the amount of intentional resources devoted to a given task and context updating of working memory. P300 latency reflects the stimulus classification speed or stimulus evaluation time [Higashiura 2006]. These functions seem to be of utmost importance in sports where attention and fast decision-making is expected under strenuous conditions.

Martial arts are well known to be very demanding in both physical and psychical way. Judo as an Olympic sport is a good representative of combat sports. It is characterized with bouts of contact against the opponent lasting from 10 to 15 seconds followed by a short period of pause [Sterkowicz, Frachini 2000]. During the contact phase the player grips the opponent performing actions of high physical intensity [Degoutte 2003]. Since the opponent is constantly resisting it is of utmost importance to make swift decisions foreseeing the newly emerging situation [Callister 1991]. Cognitive functions of the individual are put to the highest demands throughout these situations.

Studies investigating the relation of exercise and cognitive functions utilizing ERP mainly engaged male participants [Brisswalter 2002; Kamijo 2004; Themanson 2006]. The chronic effects of physical activity on cognition are also mainly demonstrated on the male population [Polich 1997; Collardeau 2001]. The aim of this study was to throw light on the influence of physical activity at different levels on the amplitude and latency of P300 component of cognitive potentials in female athletes.

Method

Participants

Fifteen top ranking female athletes aged 20.61±3.09 years, members of the Serbian national judo team volunteered to participate in the study. All subjects were in self-reported good health, free from medications affecting brain activity and had medical histories free from hearing and cardiovascular problems. Informed consent was obtained prior to inclusion in the study for all participants. Approval for this study was granted by the University ethics committee.

Apparatus

In the standard two tone auditory oddball task tone pips (90dB) of 1 kHz (80%, common) and 2kHz (20%, rare) were presented binaurally at random intervals and in random order over headphones. Subjects were instructed to ignore the common low pitch tones and press a button with the dominant hand each time the rare high pitch tone occurred.

Measurements were carried out on an EMNG equipment Keypoint, Medtronic from Denmark. Brain electrical activity was recorded from an array of two midline electrodes (Fz and Cz) of the International 10-20 system referenced to linked ears. Electrode impedances were kept below 5 kΩ. Data were amplified with a gain of 30.000, bandpassed 1-100Hz and sampled for 1000ms epoch on each trial. Trials were administered until data from 60 target trials and approximately 200 non-target trials were collected. Only data from target trials were analyzed further.

Processing, which consisted of P300 identification and measurement was performed blind to experimental conditions. ERP waveforms were 15 Hz low pass filtered. The P300 peak was identified individually at each electrode site as the highest positivity within a 220-450 ms latency window, and the latency and amplitude of the P300 peak were measured. Alongside these parameters, false reactions, percentage of hits after target pitches and response time were also registered.

Design

After registering cognitive event related potentials at rest participants underwent a controlled exercise on a cycle ergometer (SECAcardiotest). Each exercise lasted for 10 minutes with succesive increase of intensity up to 60%, 75% and 90% of maximal heart rate (HRmax) and holding this level of intensity for six minutes. Pedaling cadence was set at 60 per minute. Immediately after finishing each bout of exercise, event related potentials were registered again. Between two successive bouts a rest lasting for 20 minutes was given for active recovery of the participants. Results were statistically processed in software Statistica for Windows. Descriptive statistics was used to describe average and standard deviation. Statistical significance of difference between parameters after intervention was analyzed by one-factor (exercise intensity) ANOVA.

Results

In the present study participants were engaged in single bouts of exercise on a cycle ergometer. The amplitude of P300 wave after exercise intensity achieved at 60% (Fz 14.02±6.33 μV; Cz 16.19±5.84 μV) and 75% of HRmax (Fz 13.22±4.68 μV; Cz 16.33±5.07 μV) were statistically higher ($p<0.05$) than the amplitude of P300 at rest (Fz 10.32±5.50 μV; Cz 12.41±3.43 μV) and after 90% of HRmax (Fz 10.38±5.68 μV; Cz 11.38±6.76 μV). There were no differences ($p>0.05$) between the amplitudes after 60% and 75% of HRmax, as well as between the values obtained at rest and after 90% of HRmax. There were no statistically significant differences ($p>0.05$) among the latencies of P300 registered at rest (Fz 329.72±26.58 ms; Cz 329.83±26.89 ms) and after 60% of HRmax (Fz 327.76±17.02 ms; Cz 327.94±16.75 ms), 75% (Fz 324.47±25.34 ms; Cz 324.47±25.34 ms) and 90% of HRmax (Fz 320.81±29.49 ms; Cz 320.50±29.50 ms).

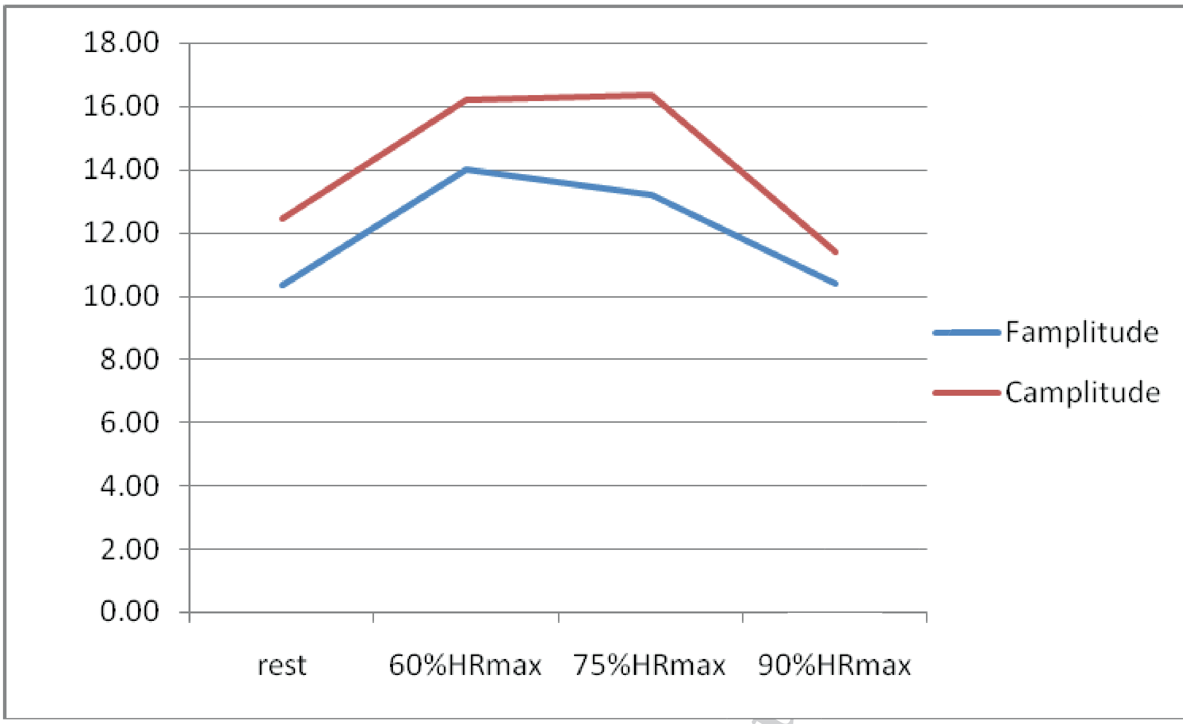

Figure 1. Amplitude of P300 (expressed in µV) over frontal (Famplitude) and central (Camplitude) cortical regions in microvolts showed at rest, and after cycle exercise at 60%, 75% and 90% of maximal heart rate (HRmax)

There were no statistical differences (p>0.05) among the rates at which the participants reacted on the rare pitch before and after the three levels of exertion on the cycle ergometer (98.72±1.13 %, 99.00±0.91 %, 98.89±1.71 % and 99.17±1.10 %, respectively). False reactions (pressing the button when a frequent pitch appears) appeared with almost the same frequency regardless of the time of measurement, i.e. before and after the single bouts of exercise (1.83±1.20, 0.89±0.90, 1.00±1.19 and 1.11±1.02) (p>0.05). Response time did not change either throughout the experimental conditions (300.39 ±68.88 ms, 306.00±80.40 ms, 301.56±60.58 ms and 290.94±52.96 ms) (p>0.05).

Discussion

In the present study we found that acute bouts of exercise at different intensities make an impact on cognitive functions of female judo players. Results of some laboratory research tried to connect cognitive capabilities to the level of physical effort. Most of these studies witnessed an inverted-U shape relationship of simple and complex reaction time with levels of physical extortion [Levitt, Gutin 1971; Samela, Ndoye 1986]. Similar relationship was presented by Brisswalter et al. who recorded reaction time performance at different imposed pedal rates performed at same power output. Best results were obtained at medium cadence (50 rpm) and worst at high speed cadence (80 rpm) [Brisswalter 1997]. Aerobic exercise of medium intensity and longer duration (up to 90 min) leads to selective improvements in the cognitive sphere. Gutin and DiGennaro presented mathematical equations to the participants after 20 and 40 minutes of running at velocities equivalent to 55% VO2 max, increasing the promptness of problem solving without loss in precision [Gutin, DiGennaro 1968].

Recent publications use more objective parameters of ERPs as a method to evaluate cognitive functions after different intensities of exercise. Higashiura investigated the interactive effects of exercise intensity and duration of cognitive processing in the central nervous system. His findings suggested that low intensity exercise corresponding to 50% HRmax might not affect cognitive processing, such as attentional allocation, in the CNS. Short duration, high intensity exercise corresponding to 80% HRmax on the other hand facilitated cognitive processing in the CNS [Higashiura 2006]. Kamijo in his paper showed that P300 amplitude after medium intensity exercise was significantly larger than in the control condition and after low and high intensity exercise [Kamijo 2006]. P300 amplitude is considered to be closely related to intensity of processing and especially proportional to the amount of attentional resources given to a particular task [Yagi 1999].

Like Higashiura, Kamijo chose exercise intensity according to the Borg scale rate of perceived exertion [Higashiura 2006; Kamijo 2006]. In our experiment exercise grading was assessed according to the participant's maximal pulse which might lead to a more objective evaluation of the level a physical stress.

P300 amplitude varies with transient exercise and arousal level is an important influencing factor. Kamijo adopted the observations of previous studies reporting an inverted U-shaped curve of arousal in function of physical effort level. As physical arousal increases, performance is predicted to improve up to an optimal point, and then to deteriorate with further increases in physical activity [Tomparovski 1986; Kamijo 2004].

The relationship between fitness and ERPs is yet not well understood. Physical training has been proposed as affecting brain functions by several mechanisms: enhanced cerebral blood flow, improved cerebral neurotransmitter release, and enhanced neuroendocrine and autonomic tone [Magnie 2000; Hillman 2002].

Reaction time did not correlate with P300 latency. Probable explanation for this might be the hypothesis that RT can be decomposed to include components such as stimulus evaluation, response selection and response execution, while P300 latency is considered a measure of stimulus classification speed of stimulus evaluation time [Kamijo 2004].

Generally positive relationship of exercise on ERP and neurophysiologic measures of mental processing speed has been reported [Tomparovski, Ellis 1986; Polich, Kokb 1995]. Polich and Kokb (1995) investigated the long term effects of physical activity on mental processes and demonstrated that young adult low-exercise subjects show smaller P300 amplitudes than high exercise subjects. They concluded that exceptional amounts of physical exercise can alter the P300 ERP component from simple auditory and visual stimuli, but these effects are variable across subjects and most evident only with very high amounts of weekly aerobic exercise [Polich, Lardon 1997].

In our study the effects of single bouts of exercise at different intensities seem to be positive on the amplitude of P300 component of ERP. Short duration medium intensity exercise corresponding to 60% and 75% HRmax facilitated cognitive processing in the CNS, whereas high-intensity exercise corresponding to 90% HRmax decreases cognitive functions.

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Potencjały związane z wydarzeniami poznawczymi po intensywnych turach ćwiczeń wśród zawodniczek dżudo

Słowa kluczowe: zajęcia fizyczne, fala P300, judo

Strszczenie

Celem pracy było naświetlenie wpływu różnego poziomu aktywności fizycznej na amplitudę i latencję komponentu P300 potencjałów poznawczych zawodniczek. Po rejestracji potencjałów poznawczych związanych z wydarzeniami w stanie spoczynku uczestnicy przeszli ćwiczenia kontrolne na ergometrze rowerowym. Każde ćwiczenie trwało 10 minut ze stopniowym zwiększeniem intensywności do 60%, 75% i 90% (HRmax) maksymalnej częstotliwości uderzeń serca i utrzymanie tego poziomu intensywności przez sześć minut. Natychmiast po zakończeniu każdej tury ćwiczeń, potencjały związane z wydarzeniami zostały zarejestrowane ponownie. Amplituda fali P300 po wysiłku osiągnęła 60% (Fz 14.02±6.33 μV; Cz 16.19±5.84 μV) i 75% uderzeń serca HRmax (Fz 13.22±4.68 μV; Cz 16.33±5.07 μV) były statystycznie wyższe ($p < 0,05$) niż amplituda fali P300 w spoczynku (Fz 10.32±5.50 μV; Cz 12.41±3.43 μV)) i po 90%HRmax (Fz 10.38±5.68 μV; Cz 11.38±6.76 μV)). W badaniu rezultaty jednej tury ćwiczeń o różnym natężeniu wydawały się być pozytywne na amplitudzie P300. Krótki czas trwania tury ćwiczeń o średniej intensywności treningów korespondujący z 60% i 75% HRmax wspomagał procesy poznawcze w ośrodkowym układzie nerwowym, podczas gdy ćwiczenia o wysokim natężeniu intensywności korespondujące z 90% HRmax zmniejszały funkcje poznawcze.