HEALTH, 2009, 1, 47-50

# Specificity and sensitivity of visual evoked potentials $P_{100}$ latency to different events exercise

**Jing-Guo Zhao[1], Shu-Juan Pang[1], Guang-Wei Che[2]**

[1]Physical Education College, Shandong Normal University, Jinan, 250014, P. R. China; [2]Physical Education College, Shandong University of Traditional Chinese Medicine, Jinan, 250014, P. R. China.
Email: zhaojg@sdnu.edu.cn

Received 6 April 2009; revised 26 April 2009; accepted 29 April 2009.

## ABSTRACT

**Visual evoked potentials (VEPs) are a series of signals about visual occipital cortex in response to visual stimuli and can be used as one of objective non-invasive neuro-physiological parameters to reflect the visual organs and central visual pathway's functional integrity. Previous studies have shown that acute and chronic exercise could affect VEPs independent from body temperature and other physiological parameters. VEPs may well be used as neuro-physiological criteria in defining the performances of the athletes. Different sports training have different effects on VEPs, but the results are not consistent. $P_{100}$ latency is the representative component of VEPs and it is of high, steady amplitude and of slight intra- and inter-individual variability so that the index is most commonly used. The purpose of this study was to investigate the specificity and sensitivity of $P_{100}$ latency to different physical activities. The neural electricity device of NDI-200 was used to measure the pattern reversal VEPs of all subjects, including the values of the resting state before and after different events exercise. Different events exercise contained an aerobic cycloergometric exercise (7 subjects were conducted to a Bruce Graded Exercise Test on the Monark Ergomedic 839E cycloergometer, THR (target heart rate) = 85% HRmax, 3 times/week, about 10 minutes once time, 6 weeks), tennis training (16 volunteers, 2 hours/day, 3 days/week, 8 weeks), aerobic Latin exercise (7 subjects, 1 hour/day, 3 days/week, 6 weeks) and the Baduanjin of Health Qigong training (6 subjects, 1 hour/day, 3 days/week, 6 weeks). The VEPs recordings of the control groups obtained synchronized with the experimental groups. SPSS 11.5 for windows was used for statistical analysis. A level of $P < 0.05$ was accepted as statistically significant. The VEPs $P_{100}$ latency of post-exercise of all experimental groups except Baduanjin group became shorter significantly compared with those of pre-exercise ($P < 0.05$). No significant difference was found between pre-and post-exercise for the control groups. This study showed that exercise could shorten the $P_{100}$ latency significantly. Moreover, it also indicated that VEPs were sensitive to exercise to a certain extent. We concluded that VEPs might well be used as neuro-physiological criteria in defining the performances of the athletes. It was found that the VEPs $P_{100}$ latency became shorter after most training programs; furthermore, it demonstrated that $P_{100}$ latency of VEPs had little specificity to different events.**

**Keywords:** visual evoked potentials; $P_{100}$ latency; specificity; sensitivity

## 1. INTRODUCTION

Visual evoked potentials (VEPs) are a series of signals representing the responses of the visual occipital cortex to visual stimuli including flash and pattern stimuli, and can be used as one of the objective non-invasive neuro-physiological parameters in the assessment of the functions of visual organs, visual pathways and the optical central nervous system [1]. Previous studies have shown that both acute and regular/chronic exercise could affect VEPs independent from body temperature and other physiological parameters. But all the results are not consistent [2,3,4,5,6,7]. $P_{100}$ latency is the representative component of VEPs and the most commonly used index for its high, steady amplitude and slight intra- and inter-individual variability. In order to investigate the specificity and sensitivity of $P_{100}$ latency to different physical activities, we recorded the efficacy of an aerobic cycloergometric exercise, tennis training, aerobic Latin exercise and Baduanjin of Health Qigong training for 6 to 8 weeks [8].

## 2. MATERIALS AND METHODS

### 2.1 Subjects

All subjects filled out the PARQ (Physical Activity Readiness Questionnaire) & YOU questionnaire and they have no optic or other systematic disease or other history of neurological disease or exercise taboos. Written consent was obtained from all subjects. The experiment was approved by the local ethics committee.

## 3. EXPERIMENTAL DESIGN

### 3.1 The Aerobic Cycloergometric Exercise

11 healthy volunteers [(average age, (24±1) years)] from Shandong Normal University were selected for this study from October to December, 2007. Of these, 8 students participated in the exercise including 4 boys and 4 girls. Meanwhile the 1st control group was consisted of 3 girls. This exercise was completed using the Monark Ergomedic 839E cycloergometer with Bruce Graded Exercise Test, THR (target heart rate) at 85% HRmax, and 10 min a time, 3 times/week, for 6 weeks. The 1st control group was measured synchronized with the experimental group.

### 3.2 The Tennis Training

45 healthy volunteers from Shandong Normal University were selected for this study from April to June, 2007. 31 of them were majored in physical education. There were 21 male students [average age, (26±3) years; height, (177±6) cm; weight, (74±8) kg; sports life, (8±4) years] and 10 female students [average age, (24±1) years, height, (165±6) cm, weight, (59±10) kg; sports life, (5±3) years]. Of these, 11 males and 5 females participated in the tennis training for 8 weeks. The remained 14 students of them were studying as usual and had no professional sports history. There were 9 males [average age, (23±1) years; height, (170±3) cm; weight, (65±8) kg] and 5 females [average age (23±1) years; height, (157±3) cm; weight, (50±5) kg]. According to that whether they were majored in physical education or not, and whether they took part in tennis training, the students were divided into 3 groups: a tennis group of physical education students ($n$ =16), the 2nd control group (a non-tennis group of physical education students, $n$ =15), the 3rd control group (a non-tennis group of non-physical education students, $n$ =14). Although there were differences in age among the three groups, it could be overlooked, because some previous studies have reported that the latencies and amplitudes of VEPs are stable from the age of 18 to 49.

### 3.3 The Aerobic Latin Exercise and Baduanjin of Health Qigong Training

27 healthy girls from Shandong Normal University were selected to perform this experimental protocol. They were randomly divided into three groups. The aerobic Latin group contained 7 girls, the Baduanjin Health Qigong group included 6 volunteers and the 4th control group was consisted of 7 students. Both the aerobic Latin and Baduanjin Health Qigong group took exercise 1 hour/day, 3 days/week, for 6 weeks, respectively. In the experimental duration, the 4th control group was examined synchronized with the two exercise groups.

### 3.4 Instrument

VEPs in response to middle check stimuli were recorded and analyzed using an NDI-200 neural electricity tester, which was produced by Shanghai Haishen Medical Electronic Instrument Co., Ltd. This instrument is a kind of 4-channel, anti-shock-type neural electrophysiological system, which is safe and reliable, and which can be used for clinical application to record electromyograms and visual-, brainstem auditory-, and somatosensory-evoked potentials.

### 3.5 Measurement of VEPs

Prior to the study, all subjects were thoroughly informed about the details of the study to eliminate their fears, and they were comfortably settled in a quiet and dark room waiting for testing for 5 minutes.

#### 3.5.1 Recording Conditions

The sites where the electrodes were to be placed were cleaned with 75% alcohol, and then the electrodes were smeared with conductive paste and placed on the skin. The VEPs recordings were performed using bipolar electrodes on the head; the recording electrode was positioned 1.5 cm above the occipital bone, the reference electrode was placed on the middle forehead and the ground electrode was placed on the vertex. After the electrode impedance test, the electrode impedance was kept below 5kΩ.

#### 3.5.2 Recording Methods

All subjects were seated comfortably in a dark room 100 cm away from the monitor. After 5 min of dark adaptation, they were instructed to gaze at a fixed point in the middle of the screen with one eye (the advantage eye, that is the better visual acuity one), with natural pupil, but they couldn't blink throughout the test, while the other eye which was not tested was covered. In order to make the waveform reliable, we measured each subject two times and took the average of the two measurements.The VEPs recordings were accomplished using eyeglasses in subjects who were myopic.

#### 3.5.3 Stimulation

A chessboard pattern reversal method in middle check (25×25) $mm^2$ was displayed on a 12-inch screen. The stimulation frequency was at a speed of 2 Hz, lightness of 90 $cd/m^2$, contrast of 80%.

### 3.5.4 Wave Recording

The range of filters was 1-100 Hz, the sensitivity was 10 μV/div. In order to improve the SNR 100 responses were averaged.

### 3.5.5 Wave Recognition

Tests were performed strictly according to the requirements for recording stable VEPs. VEPs were three-phase composite waves. The first was a smaller negative wave, and its peak time was at about 75 ms, the second wave was a large and stable positive wave, which peaked at about 100 ms, and the last was a negative wave peaking at about 145 ms, which was not only unstable, but also be influenced easily by many other factors. This three-wave compound is also named the NPN complex, and it is the main waveform used for clinical observation. The waves were named separately as N75, P100 and N145, according to both their peak times and that whether they were negative or positive waves.

### 3.5.6 Index Analysis

The latencies of N75, P100 and N145 waves were tested separately. Measurements of the latencies were made from the beginning of stimulation to the peak response time.

### 3.5.7 Reliability of VEPs Measurements

All the subjects took part in the exercise according to the coach strictly and completed the examinations actively. The operator of this study had regular special training and operated the procedure seriously.

## 4. STATISTICAL ANALYSIS

The experimental data were analyzed by SPSS for windows 11.5. The Independent-Samples and Paired-Samples T Test were used for testing the significant differences of inter-group and intra-group. A level of $P<0.05$ was accepted as being statistically significant. Measurement data are expressed as Mean±SD.

## 5. RESULTS

Comparisons of VEP $P_{100}$ latencies before and after different events are shown in **Table 1**.

Obviously, $P_{100}$ latency shortened significantly after the aerobic cycloergometric exercise for 6 weeks, tennis training for 8 weeks and aerobic Latin exercise for 6 weeks compared with those of pre-exercise ($P<0.05$) except Baduanjin of Health Qigong program for 6 weeks. However, no significant difference was found in corresponded control group between the first and the second measurement ($P>0.05$).

## 6. DISCUSSION

VEPs are a family of signals induced in response to visual stimuli (flashed or patterned stimulus) within the visual occipital cortex; they mainly reflect the conductive function from retinal nerve cells to the optic central system. Pattern-reversal VEPs (also named PR-VEPs) were adopted by this study; they were acquired to use stimuli with the same brightness, namely a black and white checkerboard (25mm×25mm), which was reversed at a certain frequency. In the visual pathway, the retina makes a rough analysis of stimuli information; while the lateral geniculate body is the relay station of the central visual pathway. $P_{100}$ latency is the typical component of VEPs NPN complexes and it is the most commonly used index for its high, steady amplitude and slight intra- and inter-individual variability. The $P_{100}$ latency is measured from the beginning of stimulation to the peak response time and it could reflect the information processing and conduction velocity from ganglion cells to optic center of visual system. Previous studies demonstrated that VEPs latencies of athletes' were significantly shorter than those of non-athletes. Many factors could influence VEPs, such as stimuli, recording parameters and individual differences between subjects [9]. Visual reaction time has been shown to be much shorter in athletes training in the types of sports that demand rapid eye activity (such as tennis, volleyball and squash) than other types of sports (for example, cycling) [2]. Recent studies have shown that both acute and chronic exercise could affect VEPs independently of body temperature and other physiological parameters. The capability and level of visual function are important to athletes so that VEPs can well be used as neuro-physiological criteria in classifying the performances of the athletes [2,3,11,12].

**Table 1**. Comparisons of VEPs $P_{100}$ latencies of pre- and post-exercise.

| Events | N | Weeks | The $P_{100}$ latencies (ms) | | P |
|---|---|---|---|---|---|
| | | | Pre-exercise | Post-exercise | |
| Aerobic Cycloergometric Group | 7 | 6 | 96.0±4.8 | 92.7±7.6 | <0.05 |
| The 1st Control Group | 3 | 6 | 94.5±8.8 | 95.4±10.4 | >0.05 |
| The tennis Group | 16 | 8 | 97.9±3.9 | 96.3±3.7 | <0.05 |
| The 2nd Control Group | 15 | 8 | 99.3±10.8 | 101.2±11.0 | >0.05 |
| The 3rd Control Group | 14 | 8 | 99.4±6.1 | 99.7±5.5 | >0.05 |
| The Aerobic Latin Group | 7 | 6 | 98.4±5.7 | 97.3±5.7 | <0.05 |
| Baduanjin Group | 6 | 6 | 97.9±2.5 | 96.2±2.4 | >0.05 |
| The 4th Control Group | 7 | 6 | 99.4±6.1 | 99.7±5.5 | >0.05 |

In order to use VEPs as an index in evaluating physical training and classifying the performance of athletes, especially the P100 latency, it is necessary to investigate both the sensitivity and specificity to different exercise. Therefore, we observed the efficacy of an aerobic cycloergometric exercise, tennis training, aerobic Latin exercise and Baduanjin of Health Qigong training for 6 to 8 weeks in the basis of our previous studies [10,11,12].

It is known to all that VEPs P100 latency is sensitive to physical exercise. Considerable studies have revealed that an acute exercise could shorten the P100 latency significantly but the values returned to the basal level after exercise [3,11,12]. In this study, the VEPs P100 latency shortened significantly compared with those of pre-exercise ($P<0.05$) after an aerobic cycloergometric exercise for 6 weeks, tennis training for 8 weeks and aerobic Latin exercise for 6 weeks, but no statistical difference was found between the values measured firstly and secondly in all the control subjects corresponding to the experimental groups. These results indicated that not only an acute exercise but also a period time of exercise (6 to 8 weeks) could shorten the VEPs P100 latency significantly. The results further supported the viewpoint that VEPs may well be used as neuo-physiological criteria in classifying the performances of the athletes. However, there were no reports about correlation between VEPs P100 latency and the athletes' performances. Further studies should be done in the future about feature of VEPs P100 latency in athletes of different training level.

Some studies have reported that VEPs were different among different events athletes, but all the findings are not consistent [2,3,4,5,6,7]. In this study, we mainly examined the representative component of VEPs NPN complexes-the P100 latency of inter-and intra-subjects. Our results showed that the P100 latency was shorter significantly after an aerobic cycloergometric exercise for 6 weeks, a tennis training for 8 weeks and an aerobic Latin exercise for 6 weeks compared with those values of pre-exercise ($P<0.05$) except the Baduanjin of Health Qigong exercise for 6 weeks. We thought that the difference might be due to its lower intensity of the Baduanjin of Health Qigong exercise. This demonstrated that VEPs P100 latency was sensitive to most physical exercise, which was to say that its specificity to different training programs was poor. As a result, it was difficult to reflect the feature of different sports training with a single VEPs examination. Our findings suggested that both transversal and longitudinal studies should be done so as to investigate the VEPs specificity to different events, including the VEPs P100 waveforms, amplitudes and latencies.

## 7. CONCLUSIONS

The present study demonstrated that VEPs P100 latency became shorter significantly after most physical exercise. That was to say VEPs P100 latency was sensitive to different events training to a certain extent, but its specificity is very poor.

## REFERENCES

[1] Y. G. Ozkaya, A. Agar, G. Hacioglu, *et al*., (2007). Exercise improves visual deficits tested by visual evoked potentials in streptozotocin-induced diabetic rats, Tohoku J Exp Med, **213(4)**, 313−321.

[2] R. Ozmerdivenli, S. Bulut, H. Bayar, *et al*., (2005) Effects of exercise on visual evoked potentials, Int J Neurosci., **115(7)**, 1043−1050.

[3] Y. G. Ozkaya, A. Agar, G. Hacioglu, *et al*., (2003) Training induced alterations of visual evoked potentials are not related to body temperature, Int. J. Sports Med., **24**, 359−362.

[4] E. Delpont, C. Dolisi, G. Suisse, *et al*., (1991) Visual evoked potentials: differences related to physical activity, Int J Sports Med, **12(3)**, 293−298.

[5] F. Taddei, M. P. Viggiano, and L. Mecacci, (1991) Pattern reversal visual evoked potentials in fencers, Int J Psychophysiol, **11(3)**, 257−260.

[6] N. G. Thomas, L. M. Harden, G. G. Rogers, (2005) Visual evoked potentials reaction times and eye dominance in cricketers, Sport Med Phy Fitness, **45(3)**, 428−433.

[7] M. N. Magnie, S. Bermon, F. Martin, *et al*., (1998) Visual and brainstem auditory evoked potentials and maximal aerobic exercise: Does the influence of exercise persist after body temperature recovery? Int. J Sports Med, **19(4)**, 255−259.

[8] J. H. Wilmore and D. L. Costill, (1994) Physiology of sport and exercise, Human Kinetics, 300−316.

[9] Z. N. Lu, Q. X. Zeng, C. Y. Li, *et al*., (2000) Practical electromyography, Beijing: People's Health Publishing House, 703−710.

[10] J. G. Zhao, Y. Z. Zhu, and Y. S. Lan, (2007) Visual evoked potentials differences between the students of physical and non-physical education, J Clin Rehabil Tissue Eng Res., **11(13)**, 2534−2536.

[11] Y. Z. Zhu and J. G. Zhao, (2007) The application of visual and brainstem auditory evoked potentials in defining the function of the athletes, Laboratory of Somatic Science, Physical Education College, Shandong Normal University, Jinan, Shandong Province, China.

[12] G. W. Che and J. G. Zhao, (2007) Longitudinal studies about visual and brainstem auditory evoked potentials in defining the function of the athletes, Laboratory of Somatic Science, Physical Education College, Shandong Normal University, Jinan, Shandong Province, China.

 