ORIGINAL RESEARCH

A descriptive assessment of the effect of acute bout of moderate exercise on P300 component of event related potential in young women during different phases of menstrual cycle: An observational study

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ABSTRACT

Aim: The aim of the present study was to determine the effect of acute bout of moderate exercise in cognitive processing in young women during different phases of menstrual cycle.

Methods: It was a cross-sectional observational study conducted on 50 young, normally menstruating women with normal auditory capability. Before the commencement of the study ethical approval was taken from the ethical committee of the institute and informed consent was taken from the patient. The study was conducted in a clinical physiology laboratory.

Results: There were significant changes in all cardiovascular parameters in post-exercise session in comparison to pre-exercise session in both phases of menstrual cycle. The P300 latency showed significant decrease in postexercise session when recorded at Cz as well as Pz position in both phases of menstrual cycle. However, P300 latency recorded at Fz position displayed no significant change at post- exercise session in comparison to pre-exercise session during both phases of menstrual cycle.

Conclusion: The present study concluded that an acute bout of moderate exercise caused significant decrease in latency of P300 ERP in the participants during both phases of menstrual cycle. That means even acute bout of moderate exercise enhances cognitive functioning of the individual.

Key words: Phases of menstrual cycle, P300 latency, exercise

INTRODUCTION

Increasing data indicates that ovarian hormones have a role not only in regulating reproductive activities and behaviour, but also operate as neurosteroids. Cognitive function encompasses the brain's capacity to analyse and interpret information, encompassing attention, pattern recognition, learning, memory, problem-solving, language processing, and abstract reasoning.[1] Oestrogen and progesterone are also involved in emotional and cognitive processes.[2,3] The hormones has the capacity to promote the development of neurons, the formation of synapses, and the branching of dendrites in neuroplasticity.[4] Synapse formation and turnover in cognitively relevant brain regions, such as the hippocampus and prefrontal brain regions, are influenced by both genomic and rapid, non-genomic mechanisms, which are regulated by oestrogen.[5]

Progesterone receptors are also found in brain areas that are important for cognition, such as the frontal cortex, hypothalamus, thalamus, hippocampus, amygdala, and cerebellum.[6] The administration of oestradiol without any opposition may improve prefrontal cognitive functioning, as shown by its beneficial impact on verbal working memory and attention.[7] Nevertheless, the findings of the research on the menstrual cycle do not provide compelling evidence to substantiate substantial cognitive changes

during different phases of the menstrual cycle due to the limited impact size.[8] Additionally, it is possible that the changes in cognition associated to the menstrual cycle are nuanced and hence may not be directly observable in performance, as previously examined. However, these changes may still impact cognitive methods used to get a desired outcome.[9]

Engaging in physical exercise has been shown to enhance an individual's focus and cognitive abilities. Extensive research indicates that monoamine systems, namely dopamine, norepinephrine, and serotonin, as well as hormones such as endocannabinoids and brain-derived neurotropic factor (BDNF), work together to improve several aspects of cognitive performance during exercise.[10] Multiple studies have recorded the impact of a single session of moderate exercise on the cognitive abilities of the brain in both pre-adolescent children and older individuals. The research on the impact of physical activity on the brain and cognition has gained significant attention in recent years. A growing number of papers suggest that both long-term engagement in physical activity and short-term, intense exercise sessions have positive effects on various cognitive functions.[11]

The latency of the P300 is employed for stimulus categorization and for assessment of speed, with increasing delay suggesting longer processing time.[12] Earlier investigations have reported greater amplitude and shorter latency, compared to a baseline state, after single acute bouts of fairly hard exercise.[13] However, other studies, testing a different element of cognition (other than cognitive P300), failed to find a favourable impact of acute aerobic exercise.[14]

The aim of the present study was to determine the effect of acute bout of moderate exercise in cognitive processing in young women during different phases of menstrual cycle.

MATERIALS AND METHODS

It was a cross-sectional observational study conducted on 50 young, normally menstruating women with normal auditory capability. The age group group of the 50 females in this study is (20-30years). Before the commencement of the study ethical approval was taken from the ethical committee of the institute and informed consent was taken from the patient. The study was conducted in a clinical physiology laboratory during the period of March 2023 to November 2023 (9 months).

Each participant attended two laboratory sessions, one of which was in the early follicular phase (initial 3 days post-menstruation) and the other was in mid-luteal phase (days 21-24). Phases were determined by taking menstrual history. Both sessions were attended preferably at the same time of the day. The participants were requested to refrain from tea, coffee at least 2 h before laboratory session. They were asked to fill up Godin Leisure-Time Exercise Questionnaire (GLTEQ) to understand their leisure time exercise habit.[9]

The data collection pro forma was utilised to document anthropometric measurements, specifically height, weight, body mass index (BMI), waist-hip ratio, and comprehensive menstrual history. Subsequently, physiological parameters were recorded. The basal brachial artery's systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a mercury sphygmomanometer according to a standard protocol. From these measurements, the mean arterial pressure (MAP) and pulse pressure (PP) values were calculated. The measurement of central blood pressure (BP) and heart rate (HR) was conducted using the USCOM BP+® device. Subsequently, the basal P300 was measured. Subsequently, the participants were instructed to engage in a step test until they reached a heart rate that corresponded to 60-80% of their maximum heart rate, calculated using the formula: maximum heart rate = 220-age.[10] The subjects' heart rate was monitored using a pulse oximeter after exercise, and the P300 event-related potential (ERP) was recorded once their heart rate returned to its baseline level. Following the completion of the activity, the participants were asked to complete the Borg perceived exertion scale questionnaire. The P300 event-related potentials (ERPs) and stimuli were recorded and analysed using the Neuropack X1 MEB-2300K. Electrodes made of silver-silver chloride were positioned at specific locations [A1, A2 (reference electrodes), FPz (ground electrode), Fz (medial frontal), Cz (medial central), and Pz (medial parietal)] on the subject's scalp according to the international 10-20 system. Prior to placement, the desired areas on the scalp were appropriately abraded. The electrodes were attached to their respective slots in the jack box. The jack box was ultimately linked to the amplifier of the recording device. All electrode impedances were maintained at levels below 5 kΩ. The ERP signals were converted into digital form with a sampling rate of 1000 Hz and were enhanced through amplification within the frequency range of 0.1 to 40 Hz. The subject was instructed to wear headphones while audio stimuli were delivered to her in a 'odd ball paradigm' manner. The subject was asked to respond to target auditory stimulus (40 dB at 2 KHz tone, 20% rare) in the background of nontarget auditory stimuli (40 dB at 1 KHz tone, 80% frequent). The participant was exposed to two auditory stimuli at a frequency of 0.5 Hz. There were 30 trials conducted in each session. Ultimately, the waveform of each trial was computed as an average. A positive potential with its latency approximately 300 ms (200–400 ms) was scored as P300 ERP after the target stimulus, which the subject was directed to pay attention to. The magnitude of the P300 waveform was determined by measuring the distance between the N200 and P300 peaks.

RESULTS

Table 1:Comparison of various physiological variables of the study participants recorded in pre- and post-exercise session during early follicular and mid-luteal phase

Variables	Phases			
	Follicular		Luteal	
	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise
Central systolic blood pressure (mmHg)	97.0	114.6	97.0	112.6
Central diastolic blood pressure (mmHg)	68.0	75.0	66.0	72.0
Peripheral SBP (mmHg)	107.0	121.6	107.0	122.0
Peripheral DBP (mmHg)	67.0	71.4	66.0	71.0
Heart rate (bpm)	83.0	103.0	85.0	95.7
P300 amplitude (µv)	19.5	17.7	19.5	18.8
P300 latency at Fz (ms)	307.0	304.0	309.0	309.0
P300 latency at Cz (ms)	307.0	297.3	307.0	294.0
P300 latency at Pz (ms)	307.0	297.3	307.0	294.0

There were significant changes in all cardiovascular parameters in post-exercise session in comparison to pre-exercise session in both phases of menstrual cycle. The P300 latency showed significant decrease in postexercise session when recorded at Cz as well as Pz position in both phases of menstrual cycle. However, P300 latency recorded at Fz position displayed no significant change at post- exercise session in comparison to pre-exercise session during both phases of menstrual cycle.

DISCUSSION

Cognitive function encompasses the brain's capacity to analyse and interpret information, including attention, pattern recognition, learning, memory, problem-solving, language processing, and abstract thinking.[15] Event-related potential (ERP) refers to the measurement of electrical signals in the brain (EEG) that evaluate the cortical responses during the processing of visual or cognitive events.[16] Event-related potentials (ERP) measurement is a noninvasive method used to evaluate the functioning of the central nervous system (CNS).[17] ERPs, or event-related potentials, are distinct patterns of neuroelectric activity that arise in reaction to a specific stimulus. The magnitude of the P300 is closely correlated with the distribution of attentional resources during stimulus engagement.[18]

There were significant alterations in all cardiovascular parameters during the post-exercise session compared to the pre-exercise session in both stages of the menstrual cycle. There was a substantial reduction in P300 latency when measured at both the Cz and Pz positions during the postexercise session in both stages of the menstrual cycle. However, the P300 latency obtained at the Fz location did not show any significant difference during the post-exercise session compared to the pre-exercise session, regardless of the period of the menstrual cycle. The existing research does not provide consistent evidence about changes in the latency and amplitude of P300 event-related potentials (ERPs) during the menstrual cycle. Prior reports indicate that event-related potentials (ERPs), namely the P300 component, evoked using an auditory discrimination task, showed no alterations in amplitude or latency in women on both the first day of their menstrual cycle and around 14 days later. Furthermore, no discernible difference was seen in the reaction among the women who were using oral contraceptive pills (OCP) and those who were not. Consequently, the research determined that the menstrual cycle and the use of oral contraceptives had no impact on P300 and other ERP components.[19] Subsequently, cross-sectional research was performed to investigate the alterations in the P300 component of visual event-related potentials (ERPs) and brainstem auditory evoked potentials (BAEPs) during the menstrual cycle in women who are in good health. Research has shown that the delay of P300 was extended during the ovulatory phase.[20] A different research found that the amplitude of the P300 event-related potential (ERP) was considerably higher during the menstrual period compared to the ovulatory phase. The research revealed that the processes responsible for updating context, as measured by P300 ERP, are responsive to cyclic hormonal variations.[21]

Zhou and Qin showed that engaging in acute moderate-intensity aerobic exercise improved attentional resources associated with perceptual processing by increasing the amplitude of the P2 component.[22] A different research found that the amplitude of the P300 event-related potential (ERP) was considerably higher during the menstrual period compared to the ovulatory phase. The research revealed that the processes responsible for updating context, as shown by P300 ERP, are responsive to cyclic hormonal variations. The lack of consensus about changes in amplitude and latency of P300 event-related potentials (ERPs) at various stages of the menstrual cycle is comprehensible.[23]

Several research studies have proven the positive impact of a single session of exercise on enhancing several aspects of cognitive function in the brain, including response inhibition, cognitive flexibility, selective attentionand working memory. Earlier

reports indicated that light, moderate, and high-intensity pedalling exercises had varying effects on P300 ERP. The researchers noted that the allocation of attentional resources to a specific task reduced during high-intensity pedalling activity, whereas it rose during moderate intensity pedalling exercise. Nevertheless, there was no discernible alteration after the low-intensity pedalling activity. Therefore, it was deduced that variations in exercise intensity had an impact on information processing in the central nervous system (CNS).[24] A further research carried out in India observed that the latency of P300 was notably reduced in inactive persons after engaging in a single session of moderate exercise.[25] Additionally, it has been shown that a brief episode of intense physical activity leads to a decrease in P300 ERP latency and response times in both those who are athletes and those who are not athletes.[26]

CONCLUSION

The current research determined that a single session of moderate exercise resulted in a significant reduction in the latency of P300 event-related potentials (ERPs) in participants, regardless of the period of their menstrual cycle. Therefore, even a short period of moderate activity improves the cognitive abilities of the person.

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