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RESEARCH ARTICLE

Auditory-verbal memory function of women during the menstruation and ovulation periods

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Abstract

Background and Aim: Auditory-verbal memory (AVM) is the ability to learn, retain, and recall syllables and words. Memory has a strong relationship with the nervous and endocrine systems in humans. Changes in estrogen levels occur naturally at short (menstrual period) and long (pregnancy, menopause, and maturity) periods. Changes in estrogen levels are likely to affect memory function. This study aimed to evaluate the effects of hormone fluctuations on the AVM of women.

Methods: This cross-sectional study with a pretest/posttest design was conducted on 25 women aged 40−49 years with normal hearing and normal menstrual cycles of 28 ± 4 days, who were selected using a convenience sampling method. They were evaluated using two Persian versions of Rey Auditory-Verbal Learning Test (RAVLT). This test was performed twice and at two different menstrual periods (2-5 and 14−16 days).

Results: A significant correlation was observed between the mean of total recall score, recall score after interference, and delayed recall score at two different periods ($p < 0.01$). The scores of women in three areas on days 14−16 of the menstrual cycle were higher than on days 2−5.

Conclusion: Women's RAVLT scores on days 14−16 of the menstrual cycle are higher than on days 2−5, indicating the effect of hormonal fluctuations on their AVM function. Therefore, it is necessary to consider the changes in women's AVM in different days of the menstrual cycle.

Keywords: Auditory-verbal working memory; Rey learning test; menstrual cycle

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Introduction

Working memory is defined as online maintenance of updated or manipulated information for a relatively short period [1]. Because of the important role of this type of memory in cognitive activities such as understanding, learning, reading, reasoning, and comprehension, it is considered as the basis for cognitive activity [2]. The

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auditory-verbal memory (AVM) is the ability to receive, process, store, and recall verbal stimuli. This memory plays a key role in the development of skills such as learning and remembering words, understanding and applying grammar, expression, and writing language [3]. Due to its important role in communication, any impact (external or internal) on it can affect the quality of communications (interactions) in the world. So far, several tests such as the California Verbal Learning Test, the Hopkins Verbal Learning Test, and the Rey Auditory-Verbal Learning Test (RAVLT) have been introduced to assess AVM, among which the RAVLT is the most reliable and the most widely used neurophysiological test, due to its comprehensiveness, ability to evaluate different aspects of memory and learning, ease and high speed of administration [4,5]. This comprehensive test examines the ability of individuals to encode, combine, store, and retrieve verbal information in different stages of immediate memory, and to evaluate the effect of interfering stimuli, delayed memory, and recognition [6]. Studies have shown that the performance of RAVLT is influenced by various demographic factors including gender where women act better than men in performing auditory-verbal tasks. The superiority of women can be due to gender differences at different levels; from molecular to anatomic differences, in addition to hormonal differences [7-9]. Changes in estrogen levels (not in progesterone levels) that occur physiologically over the course of the menstrual cycle can affect memory performance [10]. The average length of a normal menstrual cycle is 28 ± 4 days, which is divided into bleeding, follicular, ovulation, and luteal phases. The rise in estrogen levels occurs in the mid-follicular phase and decreases after ovulation. In the early luteal phase, there is an increase in both estrogen and progesterone levels [11]. Some studies on young women with a regular menstrual cycle have revealed that high levels of estrogen are associated with improved AVM [12]. It has been found that the main site of estrogenic activity in adult female brains is the prefrontal cortex (PFC). The estrogen is several times higher in the PFC than in the hippocampus [13]. Some studies on the effect of hormonal fluctuations on memory performance have shown that high levels of estrogen improve memory performance in older and young women [10,14,15]. However, the other studies have reported no hormonal effect on memory performance [16]. In general, the effect of estrogen on AVM are not clear. Some of contradictions in the results of studies on human models can be attributed to differences in the characteristics of samples, the methods used for measuring estrogen levels, the types of memory and its measurement tools, and the applied tasks [12,17]. Therefore, due to inconsistency in the results of studies on the effect of menstrual cycle on different types of memory using different measurement tools, and given the important role of AVM in the establishment of social interactions, this study aimed to investigate the effect of menstrual periods (2−5 and 14−16 days) on AVM in women aged 40−49 years using the RAVLT.

Methods

This cross-sectional study with pretest/posttest design was conducted on 25 women aged 40–49 years referred to an audiology clinic in central Iran, who were selected using a convenience sampling method during six months. The inclusion criteria were: age 40–49 years, normal peripheral hearing, being right-handed, monolingual (Persian), no history of medical problems or any illness affecting their cognitive health (e.g. chronic neurological disorder, mental disorder, head trauma, speech impairment, and psychiatric disorders), no consumption of psychiatric drugs or the drugs affecting the central nervous system, a regular menstrual cycle of 28 ± 4 days, no hormonal disorders, and having university education. A checklist was prepared to check the above-mentioned criteria. Before collecting data, the study objectives and methods were explained to the participants and a written informed consent was obtained from them. This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences (Code: IR.SBMU.RETECH.REC.1396.180).

The devices used for evaluation included: Mini 2000 HEINE otoscope (HEINE Co., Germany),

the 901 GSI tympanometer (GSI Co., USA), and AC40 audiometer (Interacoustics Co., Denmark) for pure tone audiometry at 250–8000 Hz and speech audiometry in the acoustic chamber. Then, the two Persian versions of the RAVLT [16], was administered (two-word lists of A and B), during which the speaker's voice level was at the most comfort level of the participants. The words were presented using a standard presentation rate of one word per second in each trial. Before the test, the participants were asked to say the name of the words they recalled after presentation and immediately tell the announcer to go on to the next trial if they could not recall the words (different trials were presented by the same method). Responses were recorded in a form after each presentation. Consisting of 9 different recall trials, the first five trials of RAVLT (from word list A) are summed into the recall score. To assess the stimuli repetition effect and the individuals' learning ability, the mean total recall score (average score of the first five trials) was used. The 6th trial (interference list) was also presented once under the same conditions as those in the first five trials. The 7th (intervention phase) and 8th (delayed phase) trials were presented once immediately after the 6th trial and once with delay. After 20 min, the participants had to recall the words of the lists A or B. During this time, the participants should not have high mental and verbal activity as much as possible; hence, they were advised to rest. In the 9th trial (recognition phase), they should be able to identify the words of list A or B from among 50 words (15 out of 50). The above-mentioned trials were performed at two menstrual periods of 2–5 and 14–16 days. Of 25 participants, 13 were first randomly assigned to version A of RAVLT and then to its version B in the second period, while 12 first randomly assigned to version B of RAVLT and then to its version A in the second period. The data collected from these two time periods were analyzed in SPSS 20 software. Since the data had abnormal distribution, Shapiro-Wilk test was used. The relationship between the total recall score, recall score after interference, and delayed recall score at the two different menstrual periods was examined using the Wilcoxon test. Since we have one test group, to compare the statistical results before and after the menstruation and ovulation, we used the Wilcoxon test (rather than Mann-Whitney U test) for comparing the two separated groups. The significance level was set at 0.05.

Results

The mean age of participants was 43.67 ± 3.30 years. Their educational level was the same and, therefore, had no effect on the results of this study. The mean scores of participants in each nine recall trials of RAVLT (at both time periods) are shown in Table 1. The scores from the first trial to the 5th trial at both time periods were increased (7.68 ± 1.79 and 8.29 ± 1.86 to 13.12 ± 1.12 and 13.92 ± 1.07, respectively). The total recall scores on days 2–5 and 14–16 of the menstrual cycle were 10.91 ± 1.44 and 11.88 ± 1.43, respectively. Results of Wilcoxon test revealed that hormonal changes affected the total recall score, recall score after interference, and delayed recall score. The mean of all these scores were significantly higher on days 14–16 than on days 2–5 of the menstrual cycle ($p < 0.001$).

Discussion

Baddeley introduced a new pattern of working memory in 1974. This pattern is not a single structure but consists of several interconnected components. This pattern originally had the following three components: central executive, phonological loop, and visual–spatial sketchpad. The fourth component "episodic buffer" was added later. The central executive component, as the main component, is responsible for supervising other three components and coordinating all the cognitive functions involved in working memory including allocation of attention resources. The visual–spatial sketchpad component is responsible for temporary maintenance and manipulation of visual–spatial information. The episodic buffer component is responsible for integrating information from several sources to create a unified memory. The phonological loop component is involved in the temporary storage of verbal information. This component of the working memory is related to verbal memories [18,19].

Table 1. Mean distribution and standard deviation of each of the nine different trials of the Rey test and the mean difference between total recall, recall after interference, and delayed scores in women aged 40−49 years at two different time periods (2−5 and 14−16 days of menstrual cycle)

	Mean score ± SD		
Trial	**2−5 days of menstrual cycle**	**14−16 days of menstrual cycle**	**p**
Ⅰ	7.68 ± 1.79	8.92 ± 1.86	< 0.001
Ⅱ	10.28 ± 2.07	11.12 ± 2.10	< 0.001
Ⅲ	11.20 ± 1.60	12.16 ± 1.57	< 0.001
Ⅳ	12.28 ± 1.33	13.32 ± 1.65	< 0.001
Ⅴ	13.12 ± 1.12	13.92 ± 1.07	< 0.001
Total recall score	10.91 ± 1.44	11.88 ± 1.43	< 0.001
B	6.60 ± 1.97	7.48 ± 1.82	< 0.001
Ⅵ (Recall after interference score)	12.56 ± 1.87	13.28 ± 1.42	< 0.001
Ⅶ (Delayed score)	12.12 ± 1.87	12.68 ± 1.88	< 0.001
Recognition	13.64 ± 1.11	14.20 ± 0.95	< 0.001

The effect of hormones, especially sex hormones, on cognitive function and memory has been well documented in previous studies [10]. Using the two Persian versions of RAVLT, this study evaluated the effect of two different menstrual periods on the total recall score, recall score after interference, and delayed recall score of RAVLT in women aged 40–49 years. The first finding of this study was the higher scores of women in all three areas on days 14–16 compared to days 2–5 of the menstrual cycle. A relatively similar study conducted by Islam et al. [12] showed that the performance of individuals in the RAVLT was better in the immediate and delayed recall trials when they were taking soy-derived phytoestrogens during the bleeding phase compared to those who did not use soy supplements during this phase. The effect of hormonal fluctuations on the different types of memory has been emphasized in numerous studies [10,12,15,16,20-24]. Some of these studies indicated the effect of hormonal fluctuations on memory performance [12,17,21,22], while others reported no effect of these fluctuations on memory performance [16, 23,24]. Moreover, some studies have mentioned the effect of estrogen levels on the AVM [12,17], while some reported no relationship between them [23,24]. In general, the effect of estrogen on AVM function is not clear, yet. Existing contradictories can have different reasons. One reason may be this, that the majority of previous studies were conducted on postmenopausal women. To achieve more accurate results for evaluating memory performance in adult women, it is necessary to consider the influence of hormonal effects and the age of women [25]. Another possible reason may be the use of various methods for measuring estrogen levels as well as the evaluated cognitive functions [17]. Another reason may be the difference in the tasks preformed in various studies. When the applied task requires extensive manipulation of information, the possibility of the effect of hormonal fluctuations on the study results increases compared to when a simple task (e.g. encoding and maintenance of information) is used [12]. Another possible

reason is the effect of women's perception of memory ability and its effect on memory performance [16]. Some of these contradictions in these studies may be due to difference in the characteristics of study populations [8].

Considering the high estrogen levels on days 14–16 of the menstrual cycle compared to those on days 2–5, and given the better AVM function of women in this study, it can be stated that PFC is the important site of estrogenic activity in the brain of adult women [13]. On the other hand, it has been proven that the AVM tasks are related to the frontal lobe function [26]. Studies using functional magnetic resonance imaging method have confirmed the effect of hormonal changes on the frontal lobe function [27]. Hence, it seems that estrogen can affect the function of PFC by affecting the function of frontal lobe. The RAVLT can help monitor the AVM when it is affected by changes in estrogen levels. The effect of hormonal fluctuations on the RAVLT scores can be due to the appropriateness of the particular memory domain affected by its test. The effectiveness or ineffectiveness of estrogen can somehow be predicted depending on the types of memory and different parts of the brain involved with memory, and using different methods for evaluation of memory performance.

Due to the limitations of this study, it is suggested that similar studies be conducted on more samples, younger age groups (< 40 years), longer menstrual periods, and using more accurate instruments for measuring estrogen levels.

Conclusion

Women's Rey Auditory-Verbal Learning test scores on days 14–16 of the menstrual cycle are higher than on days 2–5, indicating the effect of hormonal fluctuations on their auditory-verbal memory (AVM) function. Therefore, it is necessary to consider the changes in women's AVM in different days of the menstrual cycle.

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Conflict of interest

The authors declare no potential conflict of interest.

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