Pakistan Journal of Neurological Sciences (PJNS)

Volume 15 | Issue 1 Article 7

3-2020

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MEMORY AND COGNITIVE FLEXIBILITY IN PHYSICAL THERAPY STUDENTS OF KARACHI

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Date of submission: *January 4. 2020* ***Date of revision:*** *February 15,2020* ***Date of acceptance:*** *February 20,2020*

ABSTRACT:

BACKGROUND
Memory allows us to remember the skills that we have learnt and retrieve valuable information stored in the brain. Physical therapy is a multidimensional profession which demands efficient cognitive flexibility and decision-making skills with an excellent memory to help the therapist to multi-task.

AIMS & OBJECTIVES; This study was proposed to find out the level of memory and cognitive flexibility among physical therapy students.

METHODOLOGY: This cross-sectional study was conducted on 227 DPT students of both the gender (age 19-25) from two different institutes of Karachi between February 2019 to July, 2019. Five standard tests were used; Free Recall, Brown- Peterson and Delayed Recall, Stroop Test and Month Backward Test for STM, LTM and cognitive flexibility respectively. Test scores were divided into four categories (average, good, very good, excellent). The data was analyzed using SPSS 21.

RESULT: The result showed that the mean age of participants was 22.3 ± 2.7 years. Out of 227 participants, 172 (75.77%) were females, while 55(24.22%) were males. Only the highest scores of each test are being reported here. 71.1% of participants scored 'good' in Free Recall Test. 45.6% of participants achieved 'very good' in Brown Peterson Test, The maximum score of Delayed Recall Test, was 57.8%. For cognitive flexibility, 65.7% of participants scored 'very good' in the Stroop Test. While only 25.6% of students scored 'very good' in Month Backward Test. When the influence of gender was observed, it was found that 67.54% females but only 38.47% of males scored 'very good' in the Stroop Test. In contrast, 76.42% males while only 6.46% of females scored 'good' in Free Recall Test.

CONCLUSION: The result highlights two crucial aspects. One is that improvement is required in the short-term and long-term memory of physical therapy students. Secondly, that females have better cognitive flexibility while males have better memory retention.

KEYWORDS: Doctor of Physical therapy (DPT), Short term Memory (STM), Long Term Memory (LTM), Stroop Test, Cognitive Flexibility, Delayed Recall Test, Brwon Peterson Test.

INTRODUCTION: Memory is a complex phenomenon and to answer the questions related to human behavior, cognition, nature and development an understanding about memory is required. The study of human memory has rapidly progressed in the course of recent decades[1]. It is a compound, diverse and heterogeneous entity which is possibly the most central aspect of human thought[2]. Tulving and Craik, characterized memory as a methods by which we hold and draw on our past encounters to utilize that information in the present[3]. Evidently, memory has a significant role in knowledge retention and any acquired information is vulnerable hence, can easily slip away from the human memory[4, 5]. Similarly, memory, as described by Bjorklund and Schneider, is the dynamic process related with storing, holding , and calling information about past encounters[6]. The processes that determine whether something is remembered or forgotten are encoding, storage, and retrieval. Numerous theories exist to explain how and why we

forget. The brain is wired in such a way that forgetting becomes ubiquitous. Three primary procedures are accepted to cause forgetting - decay, interference, and unavailability of retrieval cues[7]. Ebbinghaus described the decrease in ability of the brain to retain memory over time. He hypothesized a 'forgetting curve' which demonstrated how people forget newly acquired information. The curve states that an average of 50% of the information is forgotten within one hour of acquiring the information, 70% of it in 24 hours, and within a week, forgetting claims an average of 90%[8]. Researchers have separated human memory into numerous systems after examining it scientifically expressing that human memory has various forms and it depends upon distinct neural systems[9, 10]. Concerning non-permanent storage, two hypothetical models have been proposed: short-term memory (STM) and working memory (WM). Based on William James introspection, the core assumption of modern cognitive psychology is the idea that there are short-term and long-term memories[11]. Short-term memory, is the part of the memory system that retains the information such as numbers, words, names or other items for as long as 30 seconds[12, 13]. George Miller suggested that normal individual can hold retain seven ± two pieces of information in STM[14]. Prefrontal areas of the brain plays an important role in STM processes. A human lesion research gives exclusive proof for the role of the dorsolateral prefrontal cortex in working memory [15].

Long-term memory, alludes to what can be retrieved from the past when the information to be learned no longer possess the present stream of thought, either because that working memory limit was surpassed or in light of the fact that attention was redirected[16]. Basically it is the process by which procured memories are believed to gain firmness or are fortified over time, and gradually becomes impervious to interference [17-19]. Two components of LTM are described in literature – declarative and non-declarative memory.

Declarative memory is the capacity to store and recall both personal information i.e., episodic memory and general information i.e., semantic memory[20]. It basically involves the medial temporal lobe, and especially the hippocampus. Non-declarative memory incorporates all oblivious memories including certain capacities and skills and recruits the cerebellum. The differentiation among WM and LTM is basic to the comprehension of how the mind has sorted out its memory functions[21-24]. The term WM became mainstream due to the classic WM model proposed by Baddeley and Hitch. According to his definition, it is a brain framework that gives brief storage and control of the information essential for complex intellectual tasks as language cognizance, learning and thinking[25]. The WM model states three different components of WM: central executive function, the phonological loop and visuospatial sketch pad. The central executive is not itself a memory process however it rather arranges the processes of the two slave systems[26]. By and large we can say that the central executive control is a framework of attention control with restricted processing capacity, the phonological loop guarantees retention of verbal information and the visuospatial sketchpad is in charge for storage of visual and spatial information[27]. Baddeley and Logie expressed that central executive is the aftereffect of the integration of few processes: the ability to focus attention, the capacity to divide consideration between two or more errands, and the capacity to control long-term memory approach[28-30]. Cognitive flexibility is an significant part of executive function that may be characterized as the ability to efficiently adapt to changing task requirements It is otherwise called "set-switching" which alludes to our capacity to switch between various mental sets, errands, or procedures[31]. As mentioned above, rehearsal of information is required to retain it, without which information would not be stored in the long-term memory and forgetting would become inevitable. A study conducted on the college students in University of East Anglia, United Kingdom suggested that the students only remember 40% of their studies by the first week at university[32]. The students of University of Saskatchewan undergraduate program in medicine reported that they did not remember much from their first year[33]. Custers and his colleagues stated that medical students forget about 25–35% of fundamental science information following one year and over half by the following year, and 80–85% following 25 years[34, 35]. Moreover, a study conducted by M.E Watt on Oral Biology Group, University of Glasgow Dental School stated that when the same oral biology test was administered 20 months later, there was a 21.5% decline on preclinical knowledge of the subject[36]. Similarly, R.Krebs and J.J. Guilbert examined the retention of biological facts and concepts over a multi-year time frame in a group of 37 volunteers and found that more than 33% of the information is lost following two years and that medical students held just 65% of what was instructed to them[37]. Despite of the nature of the aptitude and material being taught, students fail to recall information taught in the academic setting when they started the clinical affiliations[38]. For medical students to make competent clinical choices based on sound logical standards, they should be able to hold knowledge from the preclinical phase of their medical course[39].

The objective of the study was to test the memory retention and cognitive flexibility in the physical therapy students. To the best of our insight, this is the first ever study conducted in Karachi to investigate the memory retention and cognitive flexibility in physical therapy students. With an increased pressure on physical therapy education programs to graduate clinicians who can adjust to the developing nature of physical therapy practice, the students must be able to comprehend multi- dimensionally, demonstrating their critical thinking skills and memory retention in their course work both in the university and clinical environment[38, 40]. Because physical therapy is a multidisciplinary profession which is the main pillar for the restoration of movement after an injury, illness or if someone has a disability while ensuring optimal health and functioning of the body, it demands excellent cognitive skills and memory which is necessary for comprehensive problem-solving activities must be done in an adequate time allotment to guarantee client-safety[40]. Task-switching is also an important skill for a physical therapist in clinical setting which has received limited research attention[41]. In the healthcare environment, clinicians and physical therapists are called upon to multi-task to manage multiple patients at once[42]. As described previously, how well a person can switch between two tasks depends on the cognitive flexibility. Therefore, in order to produce high-quality patient outcomes, clinician job satisfaction, improvement in efficiency, quality and safety of the healthcare environment, the need to investigate the memory retention abilities and cognitive flexibility of a physical therapist become inevitable.

METHODOLOGY

This cross-sectional study was done in two physiotherapy institutes of Karachi during February, 2019 to July, 2019. A systematic sampling technique was employed to recruit 227 participants of both genders. Physiotherapy students, with no mental or physical illness and aged between 19-25 years were included in the study through General Health Assessment Questionnaire, while students with traumatic history, color blindness, physical deformity and any health-related issue which affect the cognition were excluded from the study.

Written consent was taken from the participants before the session. Each participant attended a single session. Five cognitive tests were used to assess the participants' memory and cognitive flexibility. The tests are shown in table #1

Table 1: List of Memory & Cognitive Flexibility Tests.

Tests for Cognitive Flexibility	Tests for Short Term Memory	Test for Long term Memory
Stroop Color Word Test	Free Recall Test	Delayed Recall Test
Month Backward Test	Brown Peterson Test	

These tests were conducted in a quiet and peaceful environment. The participant was seated approximately 65 cm in front of the screen. The researcher sat on the right of the participant. Instructions were made clear for each of the cognitive tests.

Free Recall Test

The Free Recall Test was a similar test to that developed by Nielson and colleagues[43]. A 40-item word list was created using concrete and imageable nouns. A "ready" cue was presented in the center of computer screen at the start. Each word was separately presented in 50-point Arial font on the computer screen. Each word appeared for 5 seconds. After the 40th word, a 100 seconds consolidation period was given to the participant and then the participant was asked to recall the nouns in any order. The test took 5 minutes on an average. The scores of the participants were recorded according to a self-administered score sheet which divided them into four groups on the basis of the number of words recalled shown in table 2.

Table 2: Rating of the participants showing the number of words recalled in the Free Recall Test.

Number of Words Recalled	Rating
1-10	Average
11-20	Good
21-30	Very Good
31-40	Excellent

Brown Peterson Test

Brown Peterson Test was conducted soon after the Free Recall Test. It was created by Brown and Peterson[44, 45]. It comprised of a sequence of 8 trigrams (e.g. BHY). The consonant trigram was introduced for 2 seconds in a 50-point Arial style in the center screen, trailed by a 3-digit number followed by prompts. In the prompts, the participants were asked to subtract 3 from the given number. This was done to forestall the practice. After prompts disappeared, the researcher asked the trigram that was shown to the participant. The short-term memory was characterized as number of trigrams recalled in correct order of letters. It took approximately 2 minutes and 40 seconds. The participants were scored according to a self-administered score sheet which divided them into four groups on basis of number of trigrams recalled

shown in table 3.

Table 3:. Rating of the participants showing the number trigrams recalled in the Brown Peterson Test.

Number of trigrams recalled	Rating
1-2	Average
3-4	Good
5-6	Very Good
7-8	Excellent

The Stroop Test

The Stroop test[46] consists of three subtasks and the stimulus for each of these subtasks was shown. Subtask 1, which was named the Word Card had color words written in random order (red, yellow, green etc.) in black and white. Subtask 2, which was named the Color Card, displayed the color words written in random order (red, yellow, green etc.) in the same ink color as the color word. For example, red written with red ink, blue written with blue ink. Subtask 3, which was named the Color-Word Card, had color words (red, yellow, green etc.) written in an incongruous ink color. For example, the color-word yellow written with red ink or blue written with green ink. The participants were instructed to read the words in Subtask 1, name the colors in Subtask 2, and name the ink color of the words in Subtask 3 as quickly as possible. There was no time limit given to the participants to complete a subtask. The times needed to complete each Stroop subtask served as dependent measures (Stroop I, Stroop II, and, Stroop III, respectively). An interference measure was calculated by subtracting the average time needed to complete the first two subtasks from the time needed to complete the third subtask (Interference = Stroop III – [(Stroop I + Stroop II) / 2])[47]. The researchers did not point out the errors made during the test. Although many participants spontaneously corrected themselves when they noticed an error. The minimum and the maximum time taken by participants were noted and then the time span was divided in to four class intervals to divide into four groups shown in table 4.

Table4: Rating of the participants showing the time taken (seconds) in the Stroop Test.

Time taken (seconds)	Rating
>31	Average
21-30	Good
11-20	Very good
1-10	Excellent

Month Backward Test

The Month Backward Test (MBT) has been described a primary test of attention, cognitive flexibility and central processing speed[48]. The participants were asked to list the months of the years backwards from December to January, meanwhile the researcher recorded the taken to complete the test. The total time a participant took to complete this test was scored according to the Wechsler memory scale III[49] shown in table 5.

Table5: Ratings of the participants showing the time taken (seconds) in the Month Backward Test

Time taken (seconds)	Score on Wechsler scale	Groups
>17	0	Average
12-16	1	Good good
10-11	2	Very good
1-9	3	Excellent

Delayed Recall Test

Long-term memory was assessed approximately 12 minutes later using Delayed Recall test. During the delayed memory task the participants were given 100s to recall as many words from the list they were shown in Free-recall test[50]. The number of nouns correctly recalled were considered as final delayed recall test score. All the minor pronunciation errors were ignored. The participants were scored according to self-administered score sheet which divided them into four groups on the basis of number of words recalled shown in table 6.

Table 6:Ratings of the participants showing the number of words recalled in the Delayed Recall Test

Number of words recalled	Rating
1-10	Average
11-20	Good
21-30	Very good
31-40	Excellent

In the session the order of the test remained the same. The scores of these five tests were statistically analyzed using SPSS 21. Descriptive statistics was used to explore means, frequencies and percentages of study variables and group comparison of each gender was done for all memory and cognitive flexibility tests.

Result

The result showed that the mean age of participants was 22.3 ± 2.7 years. Out of 227 participants, 172

(75.77%) were females while 55 (24.22%) were males. The scores of Free Recall test and Brown Peterson test analyze the short-term memory of the participants. Scores were divided into four categories -'average', 'good', 'very good' and 'excellent'. The details of these categories are explained in Table 7. In the Free Recall Test, 22.20% students recalled 1-10 words therefore, they were categorized 'average' and 71.1% scored 'good' (11-20 words). Meanwhile, only 6.7% participants were able to score 'very good' (21-30 words) while none of the participant recalled 31-40 words shown in figure 1.

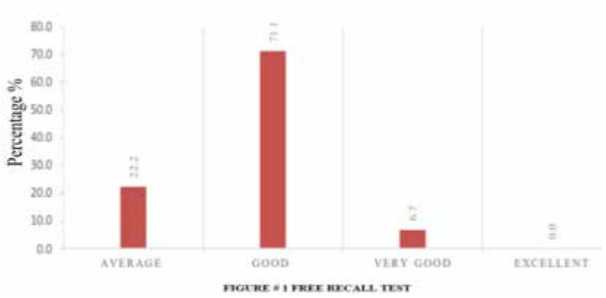

FIGURE # 1 FREE RECALL TEST

In the Brown-Peterson test, 6.7% participants recalled 1-2 trigrams scoring 'average', 33.4% participants recalled 3-4 trigrams scoring, 'good'. 45.6% participants were able to score a 'very good' with 5-6 trigrams recalled. On the contrary, only 14.5% students scored an 'excellent' with the maximum number of trigrams recalled i.e., 7-8 trigrams shown in figure 2.

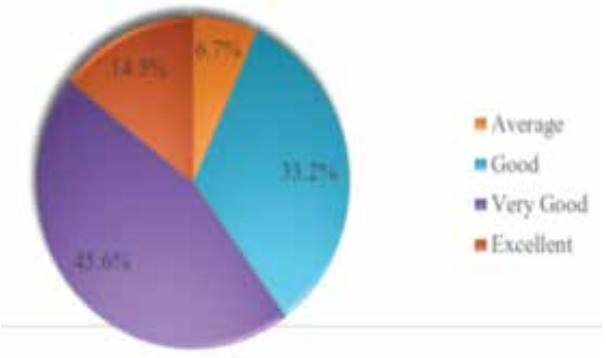

FIGURE # 2 BROWN PETERSON TEST

Analyses of the cognitive flexibility was made using the Stroop test and the Month Backward test. Of the 227 participants, 6.3% students scored 'average' which represents that they took >31 seconds to complete the Stroop test. 20.3% participants took approximately 21-30 seconds; Hence, they were categorized as 'good'. Majority of the participants (65.6%) scored 'very good' indicating that they took at least 11-20 seconds shown in figure 3. However, unimpressive results were concluded for the 'excellent' category; with only 7.8% participants taking a minimum of 1-10 seconds to complete the test. This indicates that the Stroop effect demonstrates the phenomenon that the brain's reaction time decreases when deals with a conflicting information. This slowed reaction time occurs because of interference, or a delay in the processing of information caused by competing or incompatible functions in the brain.

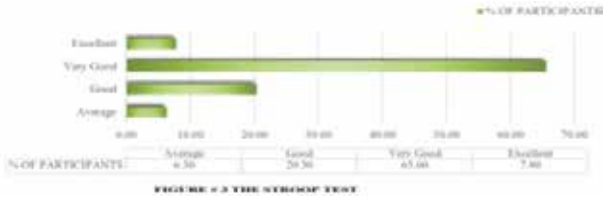

FIGURE # 3 THE STROOP TEST

In the figure# 4, the scores of the Month Backward test represents that 20.0% participants scored 'average', 33.3% scored 'good' and 25.6% scored a 'very good'. Nonetheless, 21.1% participants scored 'excellent' in this test.

FIGURE # 4 MONTH BACKWARD TEST

A comparison between the results of Delayed Recall test and Free Recall test showed the fact that this test was administered after 12 minutes using the same list before as in the Free Recall test. There was a significant difference in the result because a majority of the participants didn't remember the words after the time delay. Having said that, the percentage of the participants in the 'average' group increased to 40.0% as compared to 20.0% in the Free Recall test. From 71.1% in the Free Recall test, the percentage of the 'good' group decreased to 57.8% in the Delayed Recall test. Similarly, in the 'very good' group, while there were 6.7% participants in the Free Recall test, Delayed Recall test had only 2.2% participants.

Likewise, none of the participants were able to score 'excellent' in this test shown in figure 6.

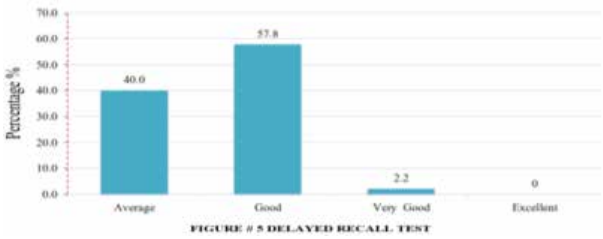

FIGURE # 5 DELAYED RECALL TEST

Table 7: Summary of all the five tests and the scores obtained.

Score	Percentage of participants (%)				
	Short-term memory		Long-term memory	Cognitive flexibility	
	Free Recall Test	Brown-Peterson Test	Delayed Recall Test	Stroop Test	Month Backward Test
Excellent	-	14.5	-	7.8	21.1
Very Good	6.7	45.6	2.2	65.6	25.6
Good	71.1	33.2	57.8	20.3	33.3
Average	22.2	6.7	40	6.3	20

A statistical comparison was made according to the academic level of the physical therapy students and no significant results were identified. However, interesting results were found when an influence of gender was tested on memory and cognitive flexibility. In figure 6, the Free Recall test, 23.37% females scored 'average' and 70.17% of females scored 'good', while 6.46% females scored 'very good'. In contrast, males scored better. 15.3% males scored 'average' while majority of the males (76.42%) scored 'good'. Moreover, 7.69% males were able to score 'very good'. Contrarily, no male and female scored 'excellent'

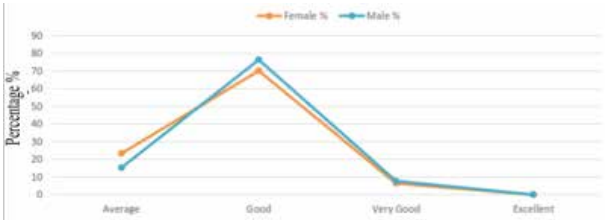

FIGURE # 6 GENDER DIFFERENCE IN FREE RECALL TEST FOR SHORT TERM MEMORY

Evidently, males also scored better in Brown Peterson test with 23.07% scoring 'good', 46.16% scoring 'very good' and 30.76% scoring 'excellent', no male was found to score an 'average'. Conversely, 7.79% females scored average, while 35.08% females scored 'good'. Though a majority as high as 45.45% scored 'very good', only 11.68% scored 'excellent' in Brown- Peterson Test shown in figure 7.

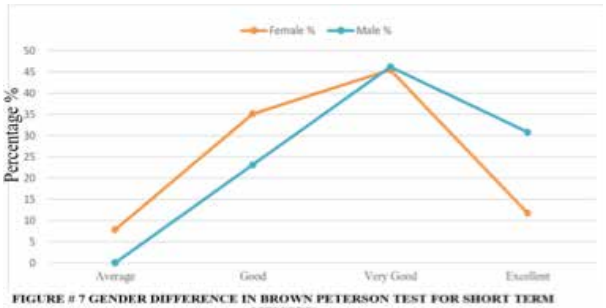

FIGURE # 7 GENDER DIFFERENCE IN BROWN PETERSON TEST FOR SHORT TERM MEMORY

Comparing the influence of gender on the Stroop test, it was concluded that most of the females had performed better than males highlighting that 7.79% of them scored 'average' while 16.88% scored 'good'. Nevertheless, 67.54% females performed 'very good' and 7.79% performed
'excellent'. 53.84% males did 'good' but only 7.76% did 'average' and 38.47% did 'very good'.
Unlike females, no male was able to score 'excellent' in Stroop test shown in figure 8.

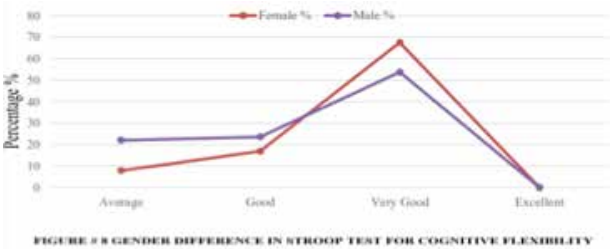

FIGURE # 8 GENDER DIFFERENCE IN STROOP TEST FOR COGNITIVE FLEXIBILITY

Males dominated females in Month Backward Test too. 18.18% females scored 'average' and 36.36% were 'good'. 22.07% and 23.37% females were 'very good' and 'excellent' respectively. Apparently, 30.78% males did 'average', 15.38% did 'good' and a greater percentage of males (46.13%) scored 'very good'. However, only a few males (7.69%) scored an 'excellent' shown in figure 9.

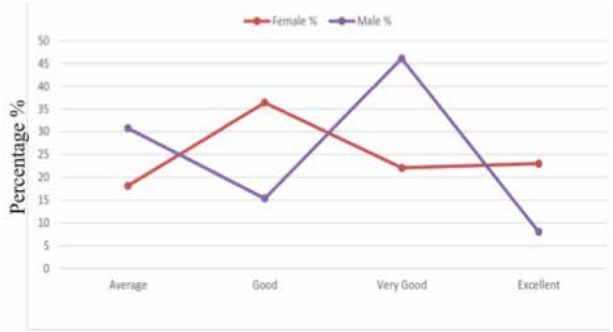

FIGURE # 9 GENDER DIFFERENCE IN MONTH BACKWARD TEST FOR COGNITIVE FLEXIBILITY

When the scores for Delayed Recall test were compared between the two genders, it was found that 41.55% females performed an 'average' and 57.14%

performed 'good'. Meanwhile, only 1.3% were scored 'very good'. In contrast, 30.76% males did 'average' but 61.53% scored 'good'. Unlike females, more males (7.69%) were able to do 'very good'. No males and females were found to be in the 'excellent' group.

DISCUSSION

As noted above, the primary purpose of this study was to investigate the difference in long-term and short-term memory of physical therapy students. In this study, we examined individual and gender-related differences in cognitive flexibility and memory by using apparently simpler component tasks which were gender-fair but their combined performance required a higher degree of task coordination. This study constituted of five tests for memory and cognitive flexibility making it the first study to explore the two variables at such a depth in Pakistan. The results suggest that there is a considerable difference in the short-term and long-term memory of physical therapy students and improvement is required to retain the information and skills necessary to function in a complex clinical environment. An important aspect that was examined in this study was the influence of gender on the memory recall and cognitive flexibility. While males outperformed females in Free Recall test and females outperformed males in the Stroop Test, it supports the notion that the short-term memory of males is better than females but females work better in tasks that demand a stronger command over cognitive flexibility. Estrogen has an influence on the neurophysiology of hippocampus in the brain and subsequently on the cognition. Estradiol enhances cognition in humans and animals[51]. In the Stroop Test, 67.54% females scored "very good" as opposed to 38.47% males, while 7.79% females scored "excellent" as opposed to none of the male participants. The improved performance of females against males in cognitive flexibility may be due to the higher estrogen levels in females. However, the analysis which are provided in this study do not account for the natural fluctuations of estrogen throughout the menstrual cycle because females were examined at different times and other factors like birth control were also not considered. In any case, it can be reasonably assumed that females had more estrogen than males leading to better results obtained for their cognitive flexibility. In the Brown-Peterson Test, males outperformed females by a decent margin with 30.76% males being able to successfully recall 7/8 or 8/8 trigrams as opposed to only 11.68% of the female participants recalling the same. This is in consistency with previous studies where men were able to answer significantly more equations correctly than females ($p<.003$)[52]. In contrast, another study done previously showed that a female advantage was observed for both episodic and semantic memory. For recall, recognition, fluency and knowledge, sex differences in episodic memory were apparent for both recall and recognition, whereas the differences in semantic memory were driven by a female superiority in fluency[53]. However, in the current study males outperformed females with 61.53% males being able to recall 11-20 out of the 40 words in the delayed recall test with only 57.14% females being able to recall the same. This difference is results could be due to the different age group recruited in the previous study of 35-85 years. In the current study, the age group of the participants was 19-25 years.The sample of this study comprised of only physiotherapy students therefore the results cannot be generalized to students of other fields. Another point to note would be that this study constituted of more female participants than males. A future study should be conducted exploring the gender differences and its effect on memory keeping equal number of male and female participants. Another aspect to conduct a future research could be on auditory memory as previous studies have found out that women outperform men on auditory memory tasks, whereas male adolescents and older male adults showed higher level performances on visual episodic and visual working memory measures[54]. This lays down a foundation for future research to explore aspects of auditory memory.

CONCLUSION

In conclusion, our results emphasized that gender does play a role in the memory and cognitive flexibility and that physical therapy students need to improve their memory to have better clinical knowledge and skills. We suggested that adjustment in time management and regular revision of academics will improve their memory and help them to multi-task.

Acknowledgement

We are very thankful to Ms. Farah Deeba (Assistant Professor of Liaquat National School of Physiotherapy) for helping us in data collection and providing invaluable guidance throughout this research.

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Conflict of interest: There is no conflict of interest..
Funding disclosure: Nil
Author's contribution:
Sonya Arshad; concept, data collection, data analysis, manuscript writing, manuscript review
Muhammad Faisal Qureshi; data collection, data analysis, manuscript writing, manuscript review
Syed Hasan Abbas Rizvi; data collection, data analysis, manuscript writing, manuscript review
Javeria Rizvi; data collection, data analysis, manuscript writing, manuscript review
Kanza Imtiaz; data analysis, manuscript writing, manuscript review
Kisa Hussain Rizvi; data analysis, manuscript writing, manuscript review
Khushbakht Ahmed; data collection, data analysis, manuscript review
Khola Noman; data collection, data analysis, manuscript review
Vishal Kumar; data collection, data analysis, manuscript writing, manuscript review