

Visual Memory Recovery by Gender in Young Athletes with a Sport-Related Concussion (SRC)

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Abstract

Objective: This study aimed to determine 1) whether there are gender differences in the post-concussion (PC 1-3) recovery process in visual memory after a concussion, and 2) whether there is interaction between two gender groups and the number of concussions.

Method: 75 athletes with sports-related concussion in two groups by gender. The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) performance was compared between and within subjects from post-concussion test 1 (PC1) to PC3. The visual memory composite scores were obtained from ImPACT.

Results: Two gender groups were significantly different in visual memory: female athletes were higher than male athletes in visual memory composite scores. Two gender groups also exhibited different recovery pattern: female group showed early recovery from PC1 to PC2 as well as from PC1 to PC3, while male athletes showed significant recovery from PC1 to PC3 only. There was no significant interaction between visual memory scores and the number of concussions.

Conclusions: We can conclude that two gender groups differed in visual memory composite scores. Additionally, the timing of the recovery was different by gender. There was no interaction between the visual memory scores and the number of concussions sustained.

Keywords Sports-related concussion (SRC), Visual memory, Gender

INTRODUCTION

Gender has consistently been a significant topic in concussion research with numerous studies investigating gender differences, especially in the context of sports-related concussions. The primary view of previous studies is that female athletes are more symptomatic, vulnerable, and affected than male athletes, but the results are vary depending on the tasks. According to a review (20), males were favored on mental rotation (16, 23, 28) and navigation (2, 23, 30), but females performed better on object location (1, 5, 21) and verbal memory (17, 25-26) .

Although there are numerous studies on gender differences with concussion, there is limited literature on visual memory processes, and specifically on the process of recovery by gender after a concussion. Recent studies (29, 31) reported that visual memory is more impaired in females than in males, while other studies found no difference in gender for visual memory (6). In addition, there was no interaction between the number of concussions and the visual scores (6, 29) regardless of the presence of gender difference in visual memory.

However, these studies on visual memory following a concussion did not indicate whether the difference was exhibited throughout the recovery process. Therefore, it is important to explore the gender differences in visual memory throughout the recovery after a concussion and to verify whether the interaction does not exist between visual memory and the number of concussions sustained. This study examined the following issues: 1) whether there are gender differences in the post-concussion recovery processes in visual memory following a concussion, and 2) whether there is an interaction effect between the gender and the number of concussions.

METHODS

Participants

75 athletes with sports-related concussion were divided into two groups by: female ($N=27$, Age: $M=17.61\pm.45$, Age range: 14-21, Education: $M=11.31\pm.44$, Number of Concussion= $.7\pm.26$), and male ($N=48$, Age: $M=17.83\pm.38$, Age range: 14-23, Education: $M=11.15\pm.33$, Number of Concussions= $.83\pm.16$). Participants' age, years of education, and number of concussions were not significantly different between female and male groups (Table 1).

Table 1. Descriptive Information of Participants

Gender Group	N	Age	Years of Education	Number of Concussions
Female	27	17.61(0.45)	11.31(0.44)	0.7 (0.26)
Male	48	17.83 (0.38)	11.15 (0.33)	0.83 (0.16)

This study was conducted at the Concussion Management Clinical Research Lab in the Speech-Language Pathology Program in the Department of Rehabilitation Sciences College of Health Sciences at the University of Texas at El Paso. The study was approved by the Institutional Review Board (IRB) of the University of El Paso, and informed consent was obtained from all participants.

All participants were selected based on the following selection criteria: They (a) were native speakers of American English; (b) did not have history in speech-language therapy; (c) did not have learning disability and other special education issues; (d) did not have other neurological diseases; (e) were referred by team coaches, trainers or medical doctors for a post-concussion assessment at the Concussion Management Lab at the University of Texas at El Paso. Table 1 provides the demographic information for all participants in this study.

Materials & Procedures

The visual memory composite score from the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT) Version 2 was compared between and within subjects from post-concussion test 1 (PC1) to PC3. The scores were the average of total percent correct score from module 2 (Design Memory) and total correct memory score from module 3 (X's & O's).

Data analysis

Between and within group analyses were computed for the data analyses. Multivariate analysis of variance (MANOVA) analyses were performed to compare PC1-3 in between groups. Arepeated measures ANOVA was used to compare recovery from PC1 to PC3, and interactions were performed to examine the interaction effects between the visual memory scores PC1-3 and the number of concussions. IBM SPSS Statistics 28 was used for the data analyses.

RESULTS

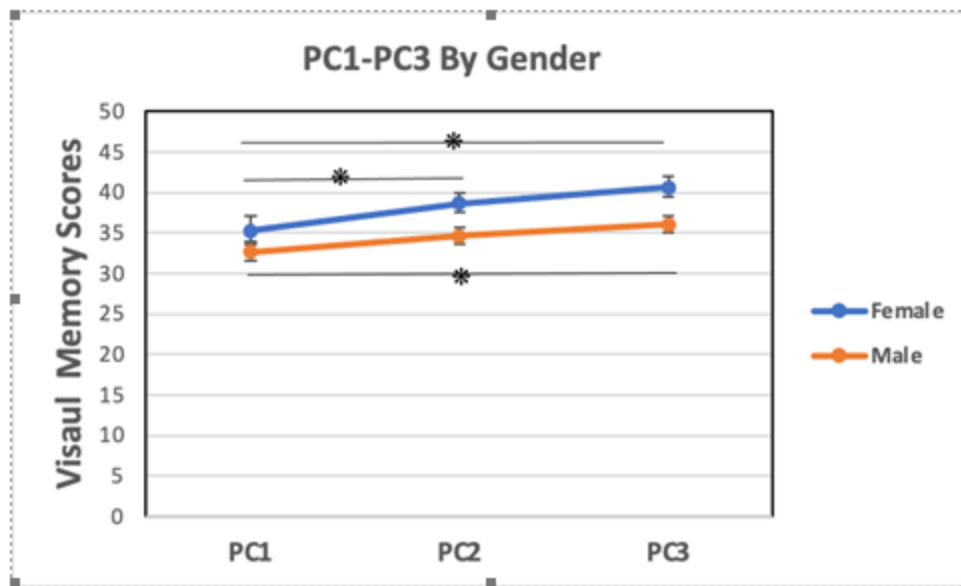
MANOVA analyses were conducted to compare the effect of gender groups on the PC1-3 scores. The results MANOVA analyses in between group showed that the effect of gender was statistically significantly different in PC2 ($F(1, 73) = 5.766, p = .019$) and PC3 ($F(1, 73) = 7.082, p = .01$), but not in PC1 ($F(1, 73) = 1.862, p > .05$): The female group was significantly higher than the male group in PC2 and PC3.

Table 2. Visual Memory Composite Scores by Gender

Gender Group	N	PC1	PC2	PC3
Female	27	35.27 (9.75)	38.61(7.25)	40.57 (7.34)
Male	48	32.63(6.95)	34.62 (6.72)	36.68 (6.9)

The results of a repeated measures ANOVA with a Greenhouse-Geisser revealed that PC1-PC3 scores differed significantly ($F(1.795, 216.393) = 10.436, p < .001$) in female athletes. Post hoc tests using the Bonferroni correction revealed that the visual memory scores from PC1 to PC2 (35.27 ± 1.88 vs 38.62 ± 1.40 , respectively) were significantly different ($p < .05$) (see Table 2 and Figure 1).

Figure. 1. Post-Concussion (PC) 1-3 By Gender



The visual memory scores in PC3 (40.58 ± 1.49) were also statistically significantly different from the visual memory scores in PC1 ($p = .001$). However, the visual memory scores in PC2 (38.62 ± 1.4) were not statistically significantly different from the scores in PC3 ($40.58 \pm 1.49, p < .05$).

The results of a repeated measures ANOVA with a Greenhouse-Geisser revealed that PC1-PC3 scores differed significantly ($F(1.866, 152.652) = 7.135, p < .005$) in male athletes. Post hoc tests using the Bonferroni correction revealed that the visual memory scores both from PC1 to PC2 (32.63 ± 6.95 vs 34.62 ± 6.73 , respectively) and PC2 to PC3 (34.62 ± 6.73 vs 36.06 ± 6.9 , respectively) were not significantly different ($p > .05$) (see Table 2 and Figure 1).

However, the visual memory scores in PC1 (32.63 ± 6.95) were statistically significantly different from the scores in PC3 (36.06 ± 6.9 , $p < .05$). There was no significant interaction between visual memory scores and the number of concussion ($F(3, 69) = 0.832$, $p > 0.05$).

DISCUSSION

The primary goal of this study was to investigate the gender differences in the post-concussion recovery process in visual memory after a concussion. Specifically, the current study examined 1) whether there are differences in the post-concussion recovery stages, PC1-3 in visual memory between and within male and female groups after a concussion, and 2) whether there is an interaction effect between the gender factor and the number of concussions.

The results exhibited that there were partially significant gender differences in visual memory and the female group's scores were significantly higher than the scores in the male group. This result is consistent with some of the previous studies (12-13, 24) showing that females performed better on the verbal memory composite than males. This pattern is opposite to most of the previous studies showing that the female group was more affected by visual memory than the male group in the post-concussive testing (10-11, 14, 27, 29, 31). According to several studies (3-4, 7, 8-9, 10-15), female athletes exhibit more symptoms than male athletes and the female athletes' symptoms sustained their symptoms longer than males.

However, several other gender studies in the literature have shown heterogeneous patterns in visual memory (22). According to the study (22), neuropsychological studies generally found that males perform better than females on visual memory measurements, even though the findings are not consistent, mixed, and heterogeneous. The results in previous literature on visual memory are 1) there are no statistically significant gender differences (6, 18-19, 32), 2) a male group is better than a female group (10-11, 14, 27, 29, 31), or 3) a female group performs better than a male group (12-13, 24). Considering these heterogeneous patterns from the literatures, the findings of the study herein showing gender differences in the current study are consistent with one of the typical patterns in the literature showing that the female group's score was higher than the male group's score.

In addition, the recovery pattern was also different in each gender group. The female group's recovery appeared earlier than the male's group's recovery: The female group's improvement showed the steep change from PC1 to PC2, while the male group's improvement was continued slowly PC1 to PC3. More specifically, the steep recovery appeared first in the female group between PC1 and PC2, so there were significant changes between PC1 and PC2. However, there was no steep recovery pattern in the male group's recovery even though the PC1 and PC3 are significantly different. Therefore, the interpretation might indicate that the recovery patterns of each gender could possibly be

different depending on gender. This interesting pattern could possibly indicate that there might be different recovery mechanism between male and female group following a concussion; Timing of recovery after a SRC may differ by gender in recovery processes.

Consistent with the previous studies (6, 29), there was no interaction between visual memory scores and the number of concussions sustained. Therefore, the overall results of the present study indicate that the visual memory scores are affected by the gender factor, not by the number of concussions.

Limitations & Suggestions for Future Studies

The current study has a few limitations and suggestions for future studies on this topic. First, the present study did not investigate any mechanisms regarding gender difference. Pathophysiological differences might be underlying mechanisms affecting the behavioral differences in gender. In future studies, adding some physiological aspect to the study would complete the explanation on the potential underlying mechanism. Second, the baseline testing was not included in this study. Thus, the comparison in two gender groups including the baseline data might provide solid argument of gender differences in the future studies.

CONCLUSION

The current study is aimed to investigate the gender difference in visual memory. To address this issue, visual memory scores in PC1-3 were compared two gender groups, and the number of concussions was computed with visual memory scores. Findings revealed the two gender groups were significantly different from each other in visual memory: female athletes with concussions were statistically significantly higher in the visual memory composite scores than male athletes. The visual memory scores did not interact with the number of concussions.

[1] Following information provides general descriptions of each term:

- Visual memory pertains to the cognitive ability to remember and recall visual images or information that has been previously seen or observed.
- Mental rotation is the cognitive ability to mentally manipulate stimuli, rotating them either clockwise or counterclockwise from their original orientations.
- Object location refers to a specific aspect of spatial cognition involving the ability to locate and remember the positions of items within spatial arrays.
- Verbal memory relates to the cognitive capacity to retain and recall information that was previously learned through written or spoken means.

Author(s) Disclosures

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